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SCIENCE OUTLOOK

Academy of Sciences Malaysia

Unlocking the Future

SCIENCE OUTLOOK 2020

Unlocking the Future

AKADEMI SAINS MALAYSIA

Science Outlook 2020
Unlocking the Future

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FOREWORD

Professor Emerita Datuk Dr Asma Ismail FASc
President, Academy of Sciences Malaysia

In the 26 years of its establishment, the Academy of Sciences Malaysia (ASM) has built its name as the nation's thought leader in matters related to science, engineering, technology and innovation. One of the Academy's key objectives is to galvanise the science, technology, and innovation (STI) agenda as an accelerator of Malaysia's development into an agile and competitive high-tech nation.

We do these through our strategic advisory inputs and advocacy to the Government and other STI partners. Among them is the Science Outlook, which is one of ASM's flagship reports that provide evidence-based insights of Malaysia's STI landscape. The findings and recommendations of this biennial report are highly regarded at national and international levels to inform policymakers on strategic alignments of STI policy frameworks and the nation's interest. The first edition was launched in 2015 followed by the second edition in 2018.

The Science Outlook 2020: Unlocking the Future may be the third edition of this flagship report but it is a trailblazer document on many fronts. This is the first Science Outlook report that has adopted the ecosystem approach to scan Malaysia's progress in terms of economic development, societal well-being as well as environmental conservation and sustainability through the lens of STI, in the last thirty years. It is the first report to evaluate the challenges outlined in Vision 2020 from the STI perspective – for Malaysia to become a socially cohesive and developed country and chart the STI progress and development in the country since the Vision was launched. We take pride that the Science Outlook 2020 is the first ASM report to include growth trajectory modelling and strategic foresighting to future-proof Malaysia's STI policy development and implementation. The report's findings have been calibrated against national STI strategies and the United Nation's 2030 Agenda for Sustainable Development Goals to assess the nation's sustainable development approach.

Although we have made the most of our strengths to advance the nation, the STI ecosystem gaps identified in this report have contributed to Malaysia falling short of achieving the ideals of Vision 2020. The ripple effects arising from the gaps have widened socio-economic inequities and allowed unchecked damage to the environment. Malaysia is part of the open market which means we must deal with multiple pressures from the tech-driven global economy; the lacklustre STI ecosystem can endanger the progress we have made on many aspects.

For Malaysia to become an advanced nation by 2030, we need systemic changes across the board. All stakeholders – from the Government to researchers to businesses, civil society organisations to individuals – are part of institutions that make up the STI ecosystem that nurture Malaysia's progress. Everyone has a vested interest to engage in the Whole-of-Government and Whole-of-Society endeavours to reorientate and strengthen the nation's STI ecosystem so that we can achieve the Shared Prosperity Vision 2030 aspirations with no one left behind.

On behalf of ASM, I would like to thank all ministries, agencies, industry partners, civil society organisations, professional bodies, and the numerous individuals who have unstintingly shared data and ideas that made this study possible. Warmest congratulations and a big thank you to the Science Outlook 2020 team led by Professor Dato' Ir Dr Mohd Saleh Jaafar FASc along with the Deputy Chair, Professor Dr Nik Meriam Nik Sulaiman FASc and the pillar Chairs: Professor Dr Mahendhiran Sanggaran Nair FASc on Economic Impact Pillar, Professor Dr Rofina Yasmin Othman FASc on Societal Impact Pillar and Dr Helen Nair FASc on Environmental Impact Pillar. Highest appreciation also to all Working Group Members; the ASM Management; and all the analysts for your hard work and commitment, going beyond the call of duty in producing this report.

I hope that the analyses and recommendations of Science Outlook 2020: Unlocking the Future will feed the efforts to mainstream STI and consolidate the ecosystem toward Malaysia becoming a high-tech nation by 2030. ASM welcomes subsequent dialogue with stakeholders on the findings and recommendations of this report.

PREFACE

Professor Dato' Ir Dr Mohd Saleh Jaafar FASc, FIEM, F.APM
Chairperson, Science Outlook 2020

The transformative power of science, technology, and innovation (STI) on life in the 21st century is undeniable; from propelling the economy to influencing social progress, as well as providing the solution for conserving the environment for the future. Harnessing STI for positive outcomes require all key players to operate collectively in harmony, creating an ecosystem where STI and the economy (STIE) are interlinked together. In order for Malaysia to shift from an upper-middle income into a high-income economy, the nation must have a robust STIE ecosystem that is responsive rather than reactive, flexible and dynamic in the face of uncertainties and disruptions in the global economy. The optimised STIE ecosystem encourages talent, creativity, and innovation to intensify Malaysia's competitiveness in the knowledge economy, and calls for ministries, agencies, business entities, civil societies, and assorted partners to work together collaboratively in this ecosystem to achieve the aspirations of the Shared Prosperity Vision 2030.

Science Outlook 2020: Unlocking the Future is the latest of the Science Outlook series that provide evidence-based review of STIE in Malaysia. This edition adopted a challenging framework to examine STIE progress and development in Malaysia from the inception of Vision 2020 in 1991 up to year 2020. The ecosystem approach of this report analysed the inputs, outputs, outcomes, and impact of STI on the economic, societal, and environmental dimensions of the country for the past 30 years to come up with the way forward to unlock an inclusive, prosperous, and sustainable future for Malaysia.

The study was carried out by three Working Groups: Economic Impact Pillar, Societal Impact Pillar and Environmental Impact Pillar, headed by Professor Dr Mahendhiran Sanggaran Nair FASc, Professor Dr Rofina Yasmin Othman FASc and Dr Helen Nair FASc, respectively. Each Working Group was made up of subject matter experts, with the support of ASM analysts and research assistants for data gathering and synthesis.

Numerous national documents such as Malaysia Plans, policies, miscellaneous national plans, blueprints, and roadmaps were reviewed and cross-referenced against hundreds of peer-reviewed publications and data compiled from relevant agencies. The output was compared against global benchmarks followed by global best practice analyses to determine Malaysia's position. Unlike the previous editions, this study employed a sequential mixed-methods approach which consist of qualitative and quantitative research elements, where the findings from the qualitative stage helped the development of the path model for the micro-level analysis.

The views and recommendations presented in this report are evidence-based; supported by verified primary and secondary data, case studies, and interviews with relevant stakeholders. I would like to thank Professor Dr Nik Meriam Nik Sulaiman FASc, who helped to guide the study as Deputy Chair, as well as the Working Group Chairs, Working Group Members, industry practitioners, analyst team and Editor, as well as the graphic designers for their efforts in making Science Outlook 2020 possible. It is hoped that this reflection of the state of STIE in our country for the last 30 years will become a reference that will transform the STIE ecosystem in Malaysia.

We wish to also thank ASM for the trust given to us to conduct this study and everyone who helped make this report possible.

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3. International Islamic University Malaysia
4. Jabatan Meteorologi Malaysia
5. Jabatan Standard Malaysia
6. Malaysia Airlines Berhad
7. Malaysian Agricultural Research and Development Institute (MARDI)
8. Malaysian Development Economy Corporation (MDEC)
9. Malaysian Industry-Government Group for High Technology (MIGHT)
10. Malaysian Investment Development Authority (MIDA)
11. Malaysian Palm Oil Board (MPOB)
12. MIMOS Bhd
13. Monash University Malaysia
14. NanoMalaysia Bhd
15. SIRIM Bhd
16. SME Corporation Malaysia
17. Southeast Asia Disaster Prevention Research Initiative (SEADPRI UKM)
18. Sunway University Malaysia
19. Universiti Kebangsaan Malaysia
20. Universiti Malaya
21. Universiti Putra Malaysia
22. Universiti Teknologi Malaysia
23. UTM Ocean Thermal Energy Centre (UTM OTEC)
24. Vitrox Corporation Bhd
25. World Wildlife Fund Malaysia (WWF Malaysia)
26. Yayasan Inovasi Malaysia
27. Young Scientist Network - Academy of Sciences Malaysia (YSN-ASM)

DATA SOURCE

1. Academy of Sciences Malaysia (ASM)
2. AIA Group
3. ASEAN Cooperation on Environment
4. Department of Environment Malaysia (DOE)
5. Department of Fisheries Malaysia (DOF)
6. Department of Statistics Malaysia (DOSM)
7. Economic Planning Unit (EPU)
8. Education Performance and Delivery Unit (PADU)
9. Emergency Events Database (EM-DAT)
10. Energy Commision
11. European Research Centre for Anti-Corruption and State-Building
12. Food and Agriculture Organization of the United Nations (FAO)
13. Forestry Department of Peninsular Malaysia (FDPM)
14. Havard College
15. IMD World Competitiveness Center (IMD)
16. Institute for Global Environmental Strategies (IGES)
17. Institute for Public Health-Ministry of Health
18. Intergovernmental Panel on Climate Change (IPCC)
19. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)
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21. International Labour Organization (ILO)
22. International Monetary Fund (IMF)
23. International Union for Conservation of Nature (IUCN)
24. John Hopkins Bloomberg School of Public Health
25. Khazanah Research Institute (KRI)
26. Knoema
27. Knowledge Resources for Science Technology Excellence Malaysia (KRSTE)

28. Legatum Institutes
29. Maddison Project Database
30. Malaysia Energy Information Hub (MEIH)
31. Malaysian Palm Oil Board (MPOB)
32. Malaysian Administrative Modernisation and Management Planning Unit (MAMPU)
33. A Study on Knowledge Content in Key Economic Sectors in Malaysia (MyKE-III Phase I and Phase II)
34. Malaysian Science and Technology Information Centre (MASTIC)
35. Ministry of Education Malaysia (MOE)
36. Ministry of Energy & Natural Resources (KeTSA)
37. Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC)
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45. Monash University Malaysia & CPA Australia
46. My Local Stat (Mycensus)
47. MyIPO Statistics
48. Norwegian Institute of International Affairs (NUPI)
49. OECD iLibrary
50. OECD Statistics
51. Ookla - Speedtest
52. Our World in Data
53. Penn World Tables
54. Portulans Institute
55. Prime Minister's Department
56. Reef Check Malaysia (RCM)
57. Scimago Institutions Rankings
58. SciVal
59. Southeast Asia Disaster Prevention Research Initiative (SEADPRI) Database-UKM
60. Social Progress Imperative
61. Statista
62. Suruhanjaya Perkhidmatan Air Negara (SPAN)
63. Sustainable Energy Development Authority Malaysia (SEDA)
64. The Economist Group
65. The Growth Lab at Harvard University
66. Transparency International
67. UNESCO Institute for Statistics
68. United Nation Statistic Division
69. United Nations Conference on Trade and Development
70. United Nations Environment Programme (UNEP)
71. United Nations for Children's Fund (UNICEF)
72. United Nations Framework Convention on Climate Change (UNFCCC)
73. WIPO statistics database
74. World Bank
75. World Development Indicators Database
76. World Economic Forum
77. World Economic Outlook
78. World Wildlife Fund for Nature Malaysia (WWF-Malaysia)
79. Yale University

Acronyms, Abbreviations & Glossary

ABBREVIATIONS

CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon Dioxide
e.g.	exempli gratia
etc.	et cetera
GW	Giga Watt
i.e.	id est
kg	Kilogram
km	Kilometre
MT	Million Tonne
$PM_{2.5}$	Particulate Matter with the Size of Less Than 2.5 Micron ($PM_{2.5}$)
PM_{10}	Particulate Matter with the Size of Less Than 10 Micron (PM_{10})
RM	Ringgit Malaysia
USD	United States Dollar

ACRONYMS

3-D	Three Dimensions
4G	Fourth Generation of Broadband Cellular Network Technology
5G	Fifth Generation Mobile Network
AAIBE	Akaun Amanah Industri Bekalan Elektrik
ADSL	Asymmetric Digital Subscriber Line
AELB	Atomic Energy Licensing Board
AI	Artificial Intelligence
AIDS	Acquired Immunodeficiency Syndrome
AIM	Agensi Inovasi Malaysia
ALMP	Advanced Leadership and Management Programme
AMS	Aerosol Monitoring Systems
AMSs	ASEAN Member States
API	Air Pollutant Index
APITD	Action Plan for Industrial Technology Development
ARE	Asian Rare Earths Plant
ASEAN	Association of Southeast Asian Nations
ASM	Akademi Sains Malaysia (Academy of Sciences Malaysia)
ATUR	Automatic Telephone Using Radio
B40	Bottom 40%
BE	Business Enterprises
BELB	Bekalan Elekrik Luar Bandar
BERD	Business Enterprise Expenditure on R&D
BMI	Body Mass Index
BNM	Bank Negara Malaysia
BRPRA	British Rubber Producers' Research Association
BTP	Bioeconomy Transformation Programme
CAGR	Compound Annual Growth Rate
CBD	Convention on Biological Diversity
CBRN	Chemical, Biological, Radiological, and Nuclear Disaster
CCC	Certificate of Completion and Compliance
CEB	Central Electricity Board
CFCs	Chlorofluorocarbons
CIDB	Construction Industry Development Board
CLG	Companies Limited by Guarantee
CMCO	Conditional Movement Control Order
CMMI	Capability Maturity Model-Integration
COMBI	Communication for Behavioural Impact

COP21	21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change
CPI	Consumer Price Index
CPKO	Crude Palm Kernel Oil
CPO	Crude Palm Oil
CRDF	Commercialisation of R&D Funds
CREST	Collaborative Research in Engineering, Science and Technology
CRM	Clinical Research Malaysia
CTRM	Composites Technology Research Malaysia
CSF	Centre for Strategic Futures, Singapore
CVD	Cardiovascular Disease
DAGS	Demonstrator Application Grant Scheme
DFTZ	Digital Free Trade Zone
DOE	Department of Environment
DOF	Department of Fisheries
DOSM	Department of Statistics Malaysia
DSD	Department of Skills Development
E&E	Electrical and Electronics
EAC	Economic Action Counsel
EAP	East Asia & Pacific
EC	Environmental Credits
ECER	East Coast Economic Region
EFB	Empty Fruit Bunch
EIA	Environmental Impact Assessment
EPI	Environmental Performance Index
EPR	Extended Producer Responsibility
EPSA	E-Pembelajaran Sektor Awam
EPU	Economic Planning Unit
EQA	Environmental Quality Act
ES	Enterprise Surveys
ESET	Emerging Science, Engineering and Technology
ETS	Electric Train Service
EXCO	Executive Councillor
FACE	Food and Agro Council for Export
FAIR	Findable, Accessible, Interoperable and Reusable
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FELCRA	Federal Land Consolidation and Rehabilitation Authority
FELDA	Federal Land Development Authority
FFB	Fresh Fruit Bunches
FiT	Feed-in Tariff
FMM	Federation of Malaysian Manufacturers
FPK	Falsafah Pendidikan Negara
FRGS	Fundamental Research Grant Scheme
FRIM	Forest Research Institute Malaysia
FTE	Full-time Equivalent
GaaP	Government as a Platform
GCI	Global Connectivity Index
GCRF	Global Challenge Research Fund
GDP	Gross Domestic Product
GeGaLo Index	Index of Geopolitical Gains and Losses
GERD	Gross Expenditure on R&D
GHG	Greenhouse Gas
GLC	Government Linked Company
GST	Goods and Services Tax
GOVERD	Research Expenditure by Government
GPS	Global Positioning System
GRA	Graduate Research Assistant
GRI	Government Research Institutes
GRIPS	National Graduate Institute for Policy Studies
GVA	Gross Value Added
HERD	R&D Expenditure by Higher Learning Institute
HIP2	High Impact Programme 2
HIV	Human Immunodeficiency Virus
HLI	Higher Learning Institution
HQ	Headquarters
HRDF	Human Resources Development Fund
IBS	Industrialised Building System
ICP	Industrial Collaboration Programme
ICR	Institute for Clinical Research
ICT	Information and Computer Technology
IDD	International Direct Dial
IDFR	Institute of Diplomacy and Foreign Relations
IGS	Industry Grant Scheme
IIGW	Iskandar International Gateway

ACRONYMS

IIUM	International Islamic University Malaysia
IMD	Institute for Management Development
IMF	International Monetary Fund
IMP1	First Industrial Master Plan
IMP2	Second Industrial Master Plan
IMP3	Third Industrial Master Plan
INTAN	Institut Tadbiran Awam Negara (National Institute of Public Administration)
IoT	Internet of Things
IP	Intellectual property
IPC	Industry-Led Professional Certificate
IR4.0	Industrial Revolution 4.0
IRDA	Iskandar Regional Development Authority
IRPA	Intensification of Research in Priority Areas
ISC	International Science Council
IT	Information Technology
ITU	International Telecommunication Union
IUCN	International Union for Conservation of Nature
JENDELA	Jalinan Digital Negara
KASA	Kementerian Alam Sekitar dan Air
KATS	Kementerian Air, Tanah dan Sumber Asli
KBS	Kementerian Belia dan Sukan
KETARA	North Terengganu Integrated Agriculture Development
KeTSA	Kementerian Tenaga dan Sumber Asli
KeTTHA	Kementerian Tenaga, Teknologi Hijau dan Air
KHTP	Kulim High-Tech Park
KKLW	Kementerian Pembangunan Luar Bandar dan Wilayah
KKMM	Kementerian Komunikasi dan Multimedia
KLIA	Kuala Lumpur International Airport
KOMTAR	Kompleks Tun Abdul Razak
KPI	Key Performance Indicator
KPKT	Kementerian Perumahan dan Kerajaan Tempatan
KPLB	Kementerian Pembangunan Luar Bandar
KPM	Kementerian Pendidikan Malaysia
KRI	Khazanah Research Institute
KRSTE	Knowledge Resource for Science and Technology Excellence
KSI	Keyless Signature Infrastructure
KTM	Keretapi Tanah Melayu
LAMP	Lynas Advanced Materials Plant
LC	Lanthanide Concentrates
LCDA	Land Custody and Development Authority
LFPR	Labour Force Participation Rate
LI	Legatum Prosperity Index
LKIM	Lembaga Kemajuan Ikan Malaysia (Fisheries Development Authority of Malaysia)
LRGS	Long Term Research Grant Scheme
LRT	Light Rail Transit
LTE	Long Term Evolution
LULUCF	Land-Use Change and Forestry
M40	Middle 40%
MADA	Muda Agricultural Development Authority
MaGRIs	Mainstreaming Grassroots Innovations
MARDI	Malaysian Agricultural Research and Development Institute
MAREC	Malaysian Rare Earths Corporation
MASCO	Malaysia Standard Classification of Occupation
MASTIC	Malaysian Science and Technology Information Centre
MATRADE	Malaysia External Trade Development Corporation
MAVCAP	Malaysia Venture Capital Management Berhad
Mbps	Megabits per Second
MCMC	Malaysian Communication and Multimedia Commission
MCO	Movement Control Order
MDC	Multimedia Development Corporation
MDEC	Malaysia Digital Economy Corporation
MDV	Malaysian Debt Venture
MEA	Ministry of Economic Affairs
MEB	Malaysia Education Blueprint
MESDAQ	Malaysian Exchange of Securities Dealing and Automated Quotation
MESITA	Malaysian Electricity Supply Industries Trust Account
MESTECC	Ministry of Energy Science, Technology, Environment and Climate Change
MESTR	Ministry of Education, Science and Technological Research
MetMalaysia	Malaysian Meteorological Department
MFN	Most Favoured Nations
MGS	Malaysia Grant Scheme

MHLG	Ministry of Housing and Local Government
MIDA	Malaysian Investment Development Authority
MiGHT	Malaysian Industry-Government Group for High Technology
MIMOS	Malaysian Institute of Microelectronic System
MITI	Ministry of International Trade and Industry
MMU	Multimedia University
MNCs	Multinational companies
MNTR	Malaysia National Trade Repository
MOE	Ministry of Education
MOF	Ministry of Finance
MOFA	Ministry of Foreign Affairs
MOH	Ministry of Health
MOHE	Ministry of Higher Education
MOHR	Ministry of Human Resources
MOSP	Malaysia Open Science Platform
MOSTE	Ministry of Science, Technology and Environment
MOSTI	Ministry of Science, Technology and Innovation
MP	Malaysia Plan
MPIC	Ministry of Plantation Industries and Commodities
MPOB	Malaysian Palm Oil Board
MPOC	Malaysian Palm Oil Certification
MQA	Malaysian Qualifications Agency
MRG	MOH Research Grant
MRT	Mass Rail Transit
MRUs	Malaysian Research Universities
MRUN	Malaysia Research University Network
MSC	Multimedia Super Corridor
MSE	Malaysia Science Endowment
MSI	MESTECC/MOSTI Social Innovation
MSMEs	Micro, Small and Medium Enterprises
MSPO	Malaysian Palm Oil Certification Council
MSW	Municipal Solid Waste
MTCP	Malaysian Technical Cooperation Programmes
MTDC	Malaysian Technology Development Corporation
MTUN	Malaysian Technical University Network
MTVET	National TVET Council
MyBIS	Malaysia Biodiversity Information System
MyDigital	Malaysia Digital Economy Blueprint
MyHRSTI	Malaysian Human Resources in STI
MyICMS886	Malaysian Information, Communications and Multimedia Services 886
MyIPO	Malaysian Intellectual Property Organisation
MyKE	A Study on Knowledge Content in Key Economic Sectors in Malaysia
MyLAB	Malaysia Laboratories for Academia-Business Collaboration
***My*STIE**	Malaysian Science, Technology, Innovation and Economy
MyWI	Malaysian Well-being Index
NAFP	National Agro-Food Policy
NAP3	Third National Agriculture Policy
NBI	National Broadband Initiative
NBOS	National Blue Ocean Strategy
NCDs	Non-Communicable Diseases
NCER	Northern Corridor Economic Region
NDTS	National Dual Training System
NEB	National Electricity Board
NEC	National Employment Council
NEM	New Economic Model
NEP	New Economic Policy
NFCP	National Fiberisation and Connectivity Plan
NGO	Non-Governmental Organisation
NHMS	National Health Morbidity Survey
NITA	National IT Agenda
NITC	National Information Technology Council
NiV	Nipah Virus
NKEA	New Key Economic Areas
NPSTI	National Science Technology and Innovation Policy
NRE	Ministry of Natural Resources & Environment
NRW	Non-revenue Water
NSC	National Science Council
NSFE	National Scientific Facilities & Equipment
NSRC	National Science and Research Council
NST	New Straits Times
NSTP	National Science and Technology Policy
NVP	National Vision Policy

ACRONYMS

OECD	Organisation for Economic Co-operation and Development
OIC	Organisation of Islamic Conference
OOP	Out-of-Pocket
OPP	Outline Perspective Plan
OTEC	Ocean Thermal Energy Conversion
PdPR	Pengajaran dan Pembelajaran di Rumah
PEMUDAH	Pasukan Petugas Khas Pemudahcara Perniagaan
PETRONAS	Petroliam Nasional Berhad
PhD	Doctor of Philosophy
PID	Pusat Internet Desa
PKD	Pusat Komuniti Desa (Rural Community Centres)
PLI	Poverty Line Income
PLUS	Projek Lebuhraya Utara Selatan
PMI	Project Management Institute
PMO	Prime Minister Office
POME	Palm Oil Mill Effluent
PORIM	Palm Oil Research Institute of Malaysia
PPP	Purchasing Power Parity
PRGS	Prototype Research Grant Scheme
PROTON	Perusahaan Otomobil Nasional
PSD	Public Service Department
PSS	Program Susu Sekolah
PSP	Program Sarapan Pagi
PTPTN	Perbadanan Tabung Pendidikan Tinggi Nasional
PWDs	Persons with Disabilities
R&D	Research and Development
R0	R-naught
RCEP	Regional Comprehensive Economic Partnership
RDI	Road Development Index
REDD+	Reducing Emissions from Deforestation and Forest Degradation Plus
REE	Rare Earth Element
RIMUP	Rancangan Integrasi Murid Untuk Perpaduan
RISDA	Rubber Industry Smallholder Development Authority
RISE	Researcher-Industry Scientific Exchange
RMU	Research Management Unit
RMT	Rancangan Makanan Tambahan
ROI	Return on Investment
ROV	Return on Value
RSF	Residual Storage Facilities
RSPO	Roundtable on Sustainable Palm Oil
RTC	Rural Transformation Centre
RU	Research University
S&T	Science and Technology
SAC	Shariah Advisory Council Malaysia
SALCRA	Sarawak Land Consolidation and Rehabilitation Authority
SARS	Severe Acute Respiratory Syndrome
SCORE	Sarawak Corridor of Renewable Energy
SDC	Sabah Development Corridor
SDGs	Sustainable Development Goals
SEDA	Sustainable Energy Development Authority
SESB	Sabah Electricity Sdn Bhd
SLDB	Sarawak Land Development Board
SMEs	Small Medium Enterprises
SO2015	Science Outlook 2015
SO2017	Science Outlook 2017
SO2020	Science Outlook 2020
SPAN	Suruhanjaya Perkhidmatan Air Negara
SPI	Social Progress Index
SPM	Sijil Pelajaran Malaysia
SPU	Science Planning Unit
SPV2030	Shared Prosperity Vision 2030
SS	Suspended Solids
SSL	Self-Sufficiency Level
SSR	Self-Sufficiency Ratio
SST	Sales and Services Tax
STAR Grant	Strategic Thrust Areas in Research Grant
STD	Subscriber Trunk Dialling
STI	Science, Technology and Innovation
STIE	Science, Technology, Innovation and Economic
STMB	Syarikat Telekom Malaysia Berhad
STTCL	Special Tax Treatment Control Law
SWCorp	Solid Waste and Public Cleansing Management Corporation
TAF	Technology Acquisition Fund
TARRC	Tun Abdul Razak Research Centre

TCA	Technology Commercialisation Accelerator
TDA	Technology Depository Agency Berhad
TECHMart	Technology Market
TFP	Total Factor Productivity
TM	Telekom Malaysia
TMRND	Telekom Research & Development Sdn Bhd
TNB	Tenaga Nasional Berhad
TPM	Technology Park Malaysia
TPP	Trans-Pacific Partnerships
TRGS	Trans-disciplinary Research Grant Scheme
TRIPS	Trade-Related Aspects of Intellectual Property Rights
TVET	Technical and Vocational Education and Training
UDHR	Universal Declaration of Human Rights
UK	United Kingdom
UKM	Universiti Kebangsaan Malaysia
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNOOSA	United Nations Office for Outer Space Affairs
UPM	Universiti Putra Malaysia
USA	United States of America
USFDA	US Food and Drug Administration
USIM	Universiti Sains Islam Malaysia
USM	Universiti Sains Malaysia
UTC	Urban Transformation Centres
UTeM	Universiti Teknikal Malaysia Melaka
UTM	Universiti Teknologi Malaysia
VC	Vice Chancellor
VET-system	Vocational Education and Training system
VSAT	Very Small Aperture Terminal
WEF	World Economic Forum
WEPA	Water Environment Partnership in Asia
WFH	Work from Home
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WOG	Whole-of-Government
WOS	Whole-of-Society
WQI	Water Quality Index
WtE	Waste-to-Energy
WTO	World Trade Organization
WWF	World Wide Fund for Nature
YIM	Yayasan Inovasi Malaysia

SYMBOLS

£	Pound Sterling
$\mu g/m^3$	Microgram per Meter Cubic
%	Percentage

Affordable Housing Housing of an acceptable minimum standard can be obtained and retained leaving sufficient income to meet essential non-housing expenditure. A house also considered as affordable when the median multiple is below 3.0.

Anxiety Disorder Involve excessive fear or anxiety. There are several types of anxiety disorders, including generalized anxiety disorder, panic disorder, specific phobias, agoraphobia, social anxiety disorder and separation anxiety disorder.

3D Printing The construction of a three-dimensional object from a computer-aided design CAD model or a digital 3D model.

Absolute Poverty The state in which a subject lacks the means to meet his or her basic needs.

Absorptive Capability The ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends ... the ability to evaluate and utilise outside knowledge is largely a function of the level of prior knowledge.

Adaptive Capabilities A firm's ability to identify and capitalise on emerging market opportunities.

Advanced Intellige Systems Provides an open access home for high quality scientific and engineering research on artificial systems that recognize, process, and respond to stimuli/instructions and learn from experience.

Advanced Technology A new or developing IT innovation that still has relatively few users, yet promises to provide future, significant value.

Aichi Biodiversity Targets A set of 20 global targets under the Strategic Plan for Biodiversity 2011-2020.

Analysers Firms Cautious and risk averse firms, who make transitions to new ways of doing things only after the flux in the environment has faded.

Aquaculture Also known as aquafarming is the cultivation of marine or freshwater organisms, especially food fish or shellfish such as salmon or oysters, under controlled conditions.

Artificial Intelligence Machines that respond to stimulation consistent with traditional responses from humans, given the human capacity for contemplation, judgment, and intention.

Augmented Reality An interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.

B20 B20 is a blending of 20% palm methyl esters with 80% of petroleum diesel in the transport sector in Malaysia which is proven to be environmentally friendly and can reduce greenhouse gas emissions.

B30 B30 is a blending of 30% palm methyl esters with 80% of petroleum diesel in the transport sector in Malaysia which is proven to be environmentally friendly and can reduce greenhouse gas emissions.

B40 B40 is a blending of 40% palm methyl esters with 80% of petroleum diesel in the transport sector in Malaysia which is proven to be environmentally friendly and can reduce greenhouse gas emissions.

Big Data Analytics Big data analytics is the use of advanced analytic techniques against very large, diverse data sets that include structured, semi-structured and unstructured data, from different sources, and in different sizes.

Bilateral Trade An agreement where two countries agree to have equal amounts of trade between each other.

Biodiversity The variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems, as well as the ecological complexes of which they are part. Biodiversity includes diversity within species, between species and of ecosystems.

Biogas Biogas is defined as a gas produced by the anaerobic digestion or fermentation of indigenous organic matter under anaerobic conditions including but not limited to manure sewage sludge municipal solid waste and biodegradable waste originating from Malaysia.

Biomass Biomass is defined as non-fossilised and originating from indigenous plants animals and micro-organisms including but not limited to products biodegradable organic material by-products residues and waste from agriculture industrial and municipal wastes originating from Malaysia.

Biotechnology The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.

Blue Sky Research Research that is driven by a desire to further our scientific understanding, without necessarily considering specific real-world applications.

BOD Biochemical oxygen demand is the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic conditions.

Brain Drain The loss of the academic and technological labour force through the moving of human capital to more favourable geographic, economic, or professional environments.

Business Analytics An attempt to leverage data and statistics into optimized business practices in the future. It gives users a high-level overview of their business by mashing together all the available pertinent information.

Business Model A simplified representation of the elements of an organisation and the interaction between these elements for the purpose of its systemic analysis, planning, and communication in face of organisational complexity.

Carbon Footprint Carbon footprint, amount of carbon dioxide (CO_2) emissions associated with all the activities of a person or other entity (e.g., building, corporation, country, etc.). It includes direct emissions, such as those that result from fossil-fuel combustion in manufacturing, heating, and transportation, as well as emissions required to produce the electricity associated with goods and services consumed. In addition, the carbon footprint concept also often includes the emissions of other greenhouse gases, such as methane, nitrous oxide, or chlorofluorocarbons (CFCs).

Carbon Sink Any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. A carbon sink is a natural or artificial reservoir that absorbs and stores the atmosphere's carbon with physical and biological mechanisms. Forests and other vegetation are considered sinks because they remove carbon dioxide through photosynthesis.

Circular Agriculture Based on the concept of circular economy where the aim of a circular system is to use no more acreage or resources than strictly necessary. This can among others be achieved by closing resource loops. In circular agriculture, waste is seen as a raw material to produce new valuable products, including crops, food, feed and energy. Another characteristic of the concept is the need to reduce resource consumption and discharges into the environment.

Citation Rate The average number of citations received by a group of papers published in one research field in a given year.

Climate Change Change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Climate-Smart Agriculture Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible.

Cluster An agglomeration of inter-linked or related activities comprising industries, suppliers, critical supporting business services, requisite infrastructure and institutions.

COD Chemical oxygen demand is defined as the amount of oxygen equivalents consumed in the chemical oxidation of organic matter by strong oxidant (e.g., potassium dichromate).

Commodity A basic good used in commerce that is interchangeable with other goods of the same type. Commodities are most often used as inputs in the production of other goods or services.

Communicable Disease Illness caused by an infectious agent or its toxins that occurs through the direct or indirect transmission of the infectious agent or its products from an infected individual or via an animal, vector or the inanimate environment to a susceptible animal or human host.

Contagion Effect The spread of an economic crisis from one market or region to another and can occur at both a domestic and international level.

Coral Bleaching Coral bleaching, whitening of coral that results from the loss of a coral's symbiotic algae (zooxanthellae) or the degradation of the algae's photosynthetic pigment. Bleaching is associated with the devastation of coral reefs, caused by the rising water temperatures of global warming is occurring and is the greatest threat to the future of the reefs. With the ocean environment changes—if it gets too hot, for instance—the coral stresses out and expels the algae. As the algae leaves, the coral fades until it looks like it's been bleached. If the temperature stays high, the coral won't let the algae back, and the coral will die. The leading cause of coral bleaching is climate change. A warming planet means a warming ocean, and a change in water temperature—as little as 2 degrees Fahrenheit—can cause coral to drive out algae. Coral may bleach for other reasons, like extremely low tides, pollution, or too much sunlight.

Coupe An area of felled trees in a forestry harvesting operation that may be large (as in a clearfell) or small (as in various other silvicultural systems).

Current Expenditure on Health per Capita (in Current USD) Estimate of current health expenditures that include healthcare goods and services consumed during each year.

Cyber-Physical Systems Systems of collaborating computational entities which are in intensive connection with the surrounding physical world and its on-going processes, providing and using, at the same time, data-accessing and data-processing services available on the internet.

Defender Firms Attempt for high quality provision in their selected market by focusing on operational efficiency instead of innovation.

Deforestation Conversion of forested to non-forest land use.

Dengue Dengue fever is caused by a virus transmitted through the bite of one of two types of mosquitoes, called Aedes aegypti and Aedes albopictus.

Devops An approach which results in collaboration between two teams where they work with a shared passion to achieve a common goal.

Digital Content Information available for download or distribution on electronic media.

Digital Economy An economy that is based on digital computing technologies, conducting business through markets based on the internet and the World Wide Web.

Digital Infrastructure The digital technologies that provide the foundation for an organization's information technology and operations.

Driver Condition The richness condition deepens knowledge intensity in a society.

Dynamic Capabilities The ability to absorb, adapt and innovate new ideas, knowledge and STI discoveries. For more details on dynamic capabilities, which encompasses absorptive, adaptive and innovative capabilities.

E-commerce The buying and selling of goods and services, or the transmitting of funds or data, over an electronic network, primarily the internet.

Ecosystem	Key stakeholders in a community that live in and interact with each other in a specific environment that nurture, use, share and develop information and knowledge for the betterment of society.
Ecosystem	A dynamic complex of vegetable, animal and microorganism communities and their non-living environment that interact as a functional unit. Ecosystems may be small and simple, like an isolated pond, or large and complex, like a specific tropical rainforest or a coral reef in tropical seas.
E-government	Utilisation of Information Technology (IT), Information and Communication Technologies (ICTs) and other web-based telecommunication technologies to improve and/or enhance on the efficiency and effectiveness of service delivery in the public sector.
Endosulfan	Endosulfan is an organochlorine insecticide and acaricide that is commonly used for agricultural pest control. Endosulfan poses problems due to its persistence in the environment. The pesticide may travel long distances in the air before it lands on crops, soil, or water.
Epigenetic Effects	Behavioural and environmental changes that affect gene activity and expression.
Feed-in Tariff	Feed-in Tariff (FiT) is Malaysia's financial mechanism under the Renewable Policy and Action Plan to catalyse generation of Renewable Energy (RE), up to 30 MW in size. The mechanism allows electricity produced from RE resources to be sold to power utilities at a fixed premium price for a specific duration to enable financial viability of RE plant development.
Fixed Broadband	An ultra-fast business internet connection that beams through radio signals. It encompasses any high-speed data transmission to a residence or a business (fixed location) that use variety of technologies, including cable, DSL, fibre optics, and wireless. Essentially, it refers to high-speed internet connections that are "always on" in fixed locations.
Flagship Projects	Research and development projects that are strategically and scientifically defined and are of substantial size with regard to their scientific and financial volume, the number of project partners and the running time.
Foreign Direct Investment (FDI)	Direct investment equity flows in the reporting economy. It is the sum of equity capital, reinvestment of earnings, and other capital.
Fossil Fuels	Fossil fuels are hydrocarbons, primarily coal, fuel oil or natural gas, formed from the remains of dead plants and animals.
Foundation Condition	The reach factor is the basic building block that connects people, goods, information and knowledge for all stakeholders in society. It enhances the reach to information, knowledge and markets.
Full-time Equivalent (FTE) of R&D Personnel	The ratio of working hours actually spent on R&D during a specific reference period (usually a calendar year) divided by the total number of hours conventionally worked in the same period by an individual or by a group.
GERD as a Percentage of GDP	The total intramural expenditure on R&D performed in the national territory during a specific reference period expressed as a percentage of GDP of the national territory.

GERD per researcher Total intramural expenditure on R&D performed during a specific reference period per researcher.

Gig Economy The demand and supply of short-term or task-based working activities matched through online labour platforms and on-demand apps.

Greenbelts Coastal greenbelts as the measure to prevent coastal erosion and reduce other natural hazards by planting trees and creating forests along the coasts.

Greenhouse Gases The atmospheric gases responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), less prevalent, but very powerful. Greenhouse gases also include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Gross Domestic Product (GDP) The standard measure of the value added created through the production of goods and services in a country during a certain period.

Gross Domestic Product (GDP) per Capita Measures the sum of marketed goods and services produced within the national boundary, averaged across everyone who lives within this territory.

Gross Expenditure on R&D (GERD) The total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. It includes R&D funded from abroad but excludes domestic funds for R&D performed outside the domestic economy.

Habitat A habitat is an ecological or environmental area that is inhabited by a particular species of animal, plant or other type of organism. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilised by) a species population.

High-income Household High-income household or T20 are considered to be high-income earners, exceeding RM10,971 a month.

Household A person or group of people whether related or unrelated who usually live together in a living quarter and make provisions (expenses) for food and necessities of life together.

Household Income Refers to total income accrued to members of a household, both in cash and/or in-kind on regular basis in one year or more often.

Hyper-connectivity The use of many systems and devices so that you are always connected to social networks and other sources of information.

Incidence of poverty The percentage of households that has a gross monthly household income lower than the predetermined Poverty Line Income.

Incidence (rate) The number of new cases that develop in a given period of time.

Inclusiveness The quality of including many different types of people and treating them all fairly and equally.

Industrial Cluster Geographic concentration of interconnected firms, suppliers, and institutions in a particular field. It has the potential to affect competition by increasing the productivity of the companies in the clusters, driving innovation, and stimulating new businesses in the specific field.

GLOSSARY

Industry 4.0	The current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things and cloud computing. Industry 4.0 creates what has been called a "smart factory".
Information and Communications Technology (ICT)	All communication technologies, including the internet, wireless networks, cell phones, computers, software, middleware, video conferencing, social networking, and other media applications and services enabling users to access, retrieve, store, transmit, and manipulate information in a digital form.
Innovative Capabilities	A firm's ability to develop new products and/or markets, through aligning strategic innovative orientation with innovative behaviours and processes.
Internet of Things (IoT)	The network of physical objects— "things" or objects—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.
Knowledge-based Economy	An expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors.
Knowledge Economy	Production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence.
Knowledge Transfer	Disseminating knowledge and providing inputs to problem solving.
Labour Force	Comprises all persons who fulfil the requirements for inclusion among the employed (civilian employment plus the armed forces) or the unemployed.
Labour Productivity	The total volume of output (measured in terms of Gross Domestic Product, GDP) produced per unit of labour (measured in terms of the number of employed persons or hours worked) during a given time reference period.
Land Use, Land Use Change	A greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities.
Leachate	Leachate is the fluid percolating through the landfills and is generated from liquids present in the waste and from outside water, including rainwater, percolating though the waste.
Legatum Prosperity Index	The index comprises of 12 pillars with 65 elements, using publicly available data sources from public opinion to executive opinion surveys. The 12 pillars in this 2019 index are safety and security, personal freedom, governance, social capital, investment environment, enterprise conditions, market access and infrastructure, economic quality, living conditions, health, education, and natural environment.
Literacy	Ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts.
Low-income household	Low-income household or B40 are considered to be low-income earners, less than RM4,850 per month.
Low-skilled	Elementary Workers.
Malnutrition	Deficiencies, excess or imbalances in intake of energy and/or nutrients. It covers undernutrition, which encompass stunting, wasting and being underweight. Malnutrition also covers overweight and obesity.

Marine Protected Areas	Marine Protected Areas (MPAs) involve the protective management of natural areas according to pre-defined management objectives. MPAs can be conserved for a number of reasons including economic resources, biodiversity conservation, and species protection. They are created by delineating zones with permitted and non-permitted uses within that zone.
Materials Science	An interdisciplinary field involving the properties of matter and its applications to various areas of science and engineering.
Median Household Income	Important criteria in identifying the index level of ability to own a house.
Median Multiple	The approach developed by Demographia International to assess the housing market in urban areas, a house is considered affordable purchased if the price of the house is less than three times median annual household income. A median multiple between 4.1 and 5.0 and above 5.1 categorises Malaysia's housing market as "seriously unaffordable" and "severely unaffordable", respectively.
Mega-diverse Countries	Megadiverse It is a term that is related to the concept of biodiversity and that refers to the great variety of life forms that exist on Earth, that is, both terrestrial and marine animals, and plants.
MFN Tariffs	Specific tariff concessions and other commitments negotiated and agreed upon by each ASEAN Member State within the framework of the WTO. These commitments are transposed into domestic legislation.
Middle-Income Country	They are defined as lower middle-income economies - those with a GNI per capita between USD1,036 and USD4,045; and upper middle-income economies - those with a GNI per capita between USD4,046 and USD12,535.
Mittlestand	Small and medium-sized enterprises in German-speaking countries, especially in Germany, Austria and Switzerland.
Mobile Broadband	A phrase that is typically used by a wireless carrier to describe its mobile Internet access service that uses the mobile phone infrastructure, or cellular network
Multilateral Environmental Agreements (MEAs)	A multilateral environmental agreement (MEA) is a treaty set up between three or more countries with the purpose of reaching an environmental goal.
MyOrganic	Rebranding of the Malaysian Organic Scheme (SOM) developed by the Department of Agriculture to give recognition to farms that practice organic farming based on Malaysian Standard MS 1529: 2015 Plant-based organically produced foods-requirements for production, processing, handling, labelling and marketing (First Revision).
Nanotechnology	Science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometres.
Natural Capital	Natural Capital is the environmental stock or resources of natural assets that provide goods, flows and ecological services required to support life. Such assets include forests, water, fish stocks, minerals, biodiversity and land. Natural capital has financial value as the use of natural capital drives many businesses.
Natural resources	Natural resources are natural assets (raw materials) occurring in nature that can be used for economic production or consumption.
Non-alcoholic fatty liver disease	The term used for a range of conditions caused by a build-up of fat in the liver. It's usually seen in people who are overweight or obese.

Non-communicable Disease Disease that is not passed from person to person, is of long duration and generally slow progression.

Non-revenue Water (NRW) Non-revenue water (NRW) is water that has been produced and is lost before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies). NRW is typically measured as the volume of water "lost" as a share of net water produced.

Non-sanitary Landfill Non-sanitary landfills are constructed without proper engineering plan and land-fill bottom line system.

Open Access An integral part of our commitment to a collaborative, inclusive and transparent world of research where authors, researchers and academic institutions can share knowledge and build on each other's work to advance outcomes.

Open Economy A significant percentage of its goods and services are traded internationally. The degree of openness of an economy usually depends on the amount of overseas trade in which the country is involved or the political policies of its government.

Open Innovation A situation where an organisation doesn't just rely on their own internal knowledge, sources and resources (such as their own staff or R&D for example) for innovation (of products, services, business models, processes etc.) but also uses multiple external sources (such as customer feedback, published patents, competitors, external agencies, the public etc.) to drive innovation.

Organic Farming Organic farming is defined as production of crop, animal, and other products without the use of synthetic chemical fertilizers and pesticides, transgenic species, or antibiotics and growth-enhancing steroids, or other chemicals.

Organic Fertiliser A carbon-rich fertilizer derived from organic materials, including treated or untreated livestock manures, compost, vermicompost, sewage sludge and other organic materials or mixed materials used to supply nutrients.

Out-of-Pocket Expenditure Expenditures borne directly by a patient where insurance does not cover the full cost of the health good or service. They include cost-sharing, self-medication and other expenditure paid directly by private households.

Overhang Residential Units The total number of completed housing units with Certificate of Completion and Compliance (CCC) and remained unsold for more than 9 months after it was launched.

Palm Tocotrienols Tocotrienols are the major form of vitamin E in the seeds of most monocots (i.e., oil palm) and a limited number of dicots. Palm oil is one of the most abundant natural sources of tocotrienols, with crude palm oil (also referred to as the "tocotrienol-rich fraction") containing up to 800 mg/kg weight of α- and γ-tocotrienol isotypes. The distribution of vitamin E in palm oil is 30% tocopherols and 70% tocotrienols.

Patent An exclusive right granted for an invention, which is a product or a process that provides a new way of doing something or offers a new technical solution to a problem.

Peri-urban	Areas that surround metropolitan areas and cities. They are neither urban nor rural in the conventional sense but are the fastest growing regions in many countries.
Photonics	The physical science of light waves. It deals with the science behind the generation, detection and manipulation of light.
Physical Resources	Tangibles which include buildings and supporting infrastructures such as water supply or energy networks, etc. that provide the setting for human activities.
POME	Underutilized liquid waste stream from palm oil mills which is generated during the palm oil extraction/decanting process and often seen as a serious environmental issue, but it is a very good source for biomethane production.
Post-Harvest Loss (PHL)	Any losses occurring after the separation of the product from the site of immediate growth (harvest) to the moment it reaches the consumer.
Poverty Line	Minimum level of income deemed adequate in a particular country.
Pre-commercialisation Activities	Activities aiming towards the successful commercialization of a technology or knowledge asset, either internally or externally, that are performed prior to the actual active commercialization phase.
Prevalence (rate)	The proportion of individuals in a population having a disease or characteristic. It is a statistical concept referring to the number of cases of a disease that are present in a particular population at a given time (MedicineNet).
Prospector Firms	Highly innovative and are prepared to take risks in seeking out new markets and opportunities in unchartered territories.
Purchasing Power Parity	The rates of currency conversion that try to equalise the purchasing power of different currencies, by eliminating the differences in price levels between countries.
Quantum Computing	Harnesses the phenomena of quantum mechanics to deliver a huge leap forward in computation to solve certain problems.
R0	A mathematical term that indicates how contagious an infectious disease is.
Reactor Firms	Tend to only respond and adapt to changes in the marketplace when their existence is threatened.
Regional Comprehensive Economic Partnership	An agreement to broaden and deepen ASEAN's engagement with Australia, China, Japan, Korea and New Zealand.
Relative Income Gap	A relative income gap refers to the difference between groups in terms of the share of total income going to different groups.
Relative Poverty	Relative poverty is when households receive 50% less than average household incomes, so they do have some money but still not enough money to afford anything above the basics. This type of poverty is, on the other hand, changeable depending on the economic growth of the country.

Research Personnel All persons engaged directly in R&D, whether employed by the statistical unit or external contributors fully integrated into the statistical unit's R&D activities, as well as those providing direct services for the R&D activities (such as R&D managers, administrators, technicians and clerical staff).

Researchers per Thousand Labour Force Number of professionals engaged in the conception or creation of new knowledge (who conduct research and improve or develop concepts, theories, models, techniques instrumentation, software or operational methods) during a given year expressed as a proportion of a labour force of 1,000 people.

Return on Value (ROV) The ongoing commitment to truly making a difference in the customer's business, and a proxy for determination, hard work, service, attention to detail, generosity and value creation.

Sanitary Landfill A properly engineered landfill where solid waste is safely isolated from the environment with lining materials and designs to prevent leakage of leachate and contamination of groundwater and surrounding soils as well as making it possible for landfill gas to be captured and converted into a renewable energy resource.

Science Attaché A member of a diplomatic mission, usually an embassy. A science attaché traditionally had three primary functions: advise the ambassador on scientific and technical matters, report scientific and technological events, and represent his or her country in scientific and technical matters to foreign scientific and technical academies, industry, and government bodies.

Semi-skilled Worker Clerical support workers, Service and sales workers, Skilled agricultural, forestry, livestock and fishery workers, Craft and related trades workers, Plant and machine operators and assemblers.

Skilled Worker Manager, Professionals, Technician and Associate Professionals.

Small Hydro In Malaysia, small hydropower refers to run-of-river schemes up to 30 MW in capacity. Two Small hydropower usually is broken down into three sizes: full scale, mini and micro. Three a full scale small hydropower scheme has a capacity of more than 10 MW, which is enough electricity for large areas and extensive grid supplies (up to 30 MW). Mini hydro schemes make a smaller contribution to national grid supplies, typically in the range of 500 kW to 10 MW. Micro hydro schemes usually range from 5 kW to 500 kW, do not supply the national grid and produce just enough power to provide domestic lighting to a group of houses through charging a battery.

Smart School A learning institution that has been systemically reinvented in terms of teaching-learning practices and school management in order to prepare children for the Information Age.

Spillover Impact A positive or a negative economic, social or political impact, but more often negative, that is experienced in one region or across the world due to an independent event occurring from a seemingly unrelated event.

STI Ecosystem — The symbiotic relationship between the stakeholders that contribute to the multiplier effect in community- and nation-building through the nurturing, exchanging, developing, and utilising STI towards shared prosperity and sustainability.

Structural Changes — A change in the relative weight of significant components of the aggregative indicators of the economy, such as national product and expenditure, exports and imports, and population and the labour force.

Structural Transformation — The reallocation of economic activity across three broad sectors (agriculture, manufacturing, and services) that accompanies the process of modern economic growth.

Stunting — Children having low height-for-age because of chronic or recurrent undernutrition.

Suicidal Ideation — Thoughts of suicide. Passive suicidal ideation refers to thoughts of dying.

Supply Chain — An entire system of producing and delivering a product or service, from the very beginning stage of sourcing the raw materials to the final delivery of the product or service to end-users.

Sustainable Forestry Management (SFM) — The process of managing permanent forest areas to achieve one or more management objectives for purposes of producing clearly defined goods and services in perpetuity without any reduction in value and productivity while generating no undesirable effects on the social and physical environment.

Technological Singularity — Convergence of human decision processes and artificial intelligence that model biological systems.

Technology Transfer — The process of conveying results stemming from scientific and technological research to the marketplace and to wider society, along with associated skills and procedures, and is as such an intrinsic part of the technological innovation process.

Terrestrial Areas — Terrestrial protected areas are totally or partially protected areas that are designated by national authorities as scientific reserves with limited public access, national parks, natural monuments, nature reserves or wildlife sanctuaries, protected landscapes, and areas managed mainly for sustainable use.

Total Factor Productivity (TFP) — The portion of output not explained by the number of inputs used in production.

Uncertainty — Inability to foretell consequences or outcomes because there is a lack of knowledge or bases on which to make any predictions.

Underweight — Children with low weight-for-age. Underweight children may be stunted, wasted or both.

Urbanisation — Increase in the proportion of a population living in urban areas; process by which a large number of people becomes permanently concentrated in relatively small areas, forming cities.

GLOSSARY

Vertical Farming
The practice of producing food on vertically inclined surfaces. Instead of farming vegetables and other foods on a single level, such as in a field or a greenhouse, this method produces foods in vertically stacked layers commonly integrated into other structures like a skyscraper, shipping container or repurposed warehouse. Using Controlled Environment Agriculture (CEA) technology, this modern idea uses indoor farming techniques. The artificial control of temperature, light, humidity, and gases makes producing foods and medicine indoor possible. In many ways, vertical farming is similar to greenhouses where metal reflectors and artificial lighting augment natural sunlight. The primary goal of vertical farming is maximizing crops output in a limited space.

Voice and Accountability
Reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

Volatility
A measure of the rate of fluctuations in the price of a security over time. It indicates the level of risk associated with the price changes of a security.

Water-borne Disease
Diseases caused by pathogenic microbes spread via contaminated water

Whole-of-Government (WOG) Approach
Public service agencies work across portfolio boundaries, formally and informally, to achieve a shared goal and an integrated government response to particular issues.

Whole-of-Society (WOS) Approach
Acknowledge the contribution of and important role played by all relevant stakeholders, including individuals, families and communities, intergovernmental organizations and religious institutions, civil society, academia, the media, voluntary associations and, where and as appropriate, the private sector and industry, in support of national efforts for noncommunicable disease prevention and control, and recognize the need to further support the strengthening of coordination among these stakeholders in order to improve the effectiveness of these efforts.

Zoonotic Viruses
Zoonoses are the 'diseases and infections that are naturally transmitted between vertebrate animals and man,' as defined in 1951 by the World Health Organization (WHO) Expert Committee on Zoonoses. It is a disease that can be transmitted from animals to people or, more specifically, a disease that normally exists in animals but that can infect humans. There are multitudes of zoonotic diseases.


Age
80 or older
8.0
6.9
6.2
4.8
4.0
Less than 5,000
5,000 to 9,999
10,000 to 14,999
15,000 to 19,999
20,000 to 24,999
25,000 to 29,999
30,000 to 34,999
35,000 to 39,999
40,000 to 44,999
45,000 to 49,999
50,000 to 74,999
Income (dollars)

SO2020:
Conduct of Study

About the Science Outlook

Science Outlook is one of Academy of Sciences Malaysia's (ASM) flagship studies that aim to present insights based on relevant data on Malaysia's Science, Technology and Innovation (STI) landscape. The findings of the report shed lights on how to increase STI proficiency and to transform the coordination of STI policies as part of the efforts to mainstream STI at all levels in the country. These efforts are needed to catalyse the nation's productivity, enhance competitiveness, and promote inclusive growth in order to realise Malaysia's aspiration of becoming one of the top innovation-led nations in the world.

This flagship study was initiated in 2013 with its first report the Science Outlook 2015 – Action towards Vision (SO2015) launched in 2015. This **evidence-based independent review** on key STI trends in Malaysia was specifically introduced as a yardstick for Malaysia's performance. Response to SO2015 indicated the necessity to keep a finger on the pulse of national STI trends at national and global level to evaluate possible future implications; hence a biennial review was proposed. The second report, Science Outlook 2017 - Converging towards Progressive Malaysia 2050 (SO2017) was launched in April 2018. The progressive outcomes of SO2015 and SO2017 are outlined in Prelude Section of this chapter. Below is the philosophy guiding the Science Outlook reports:

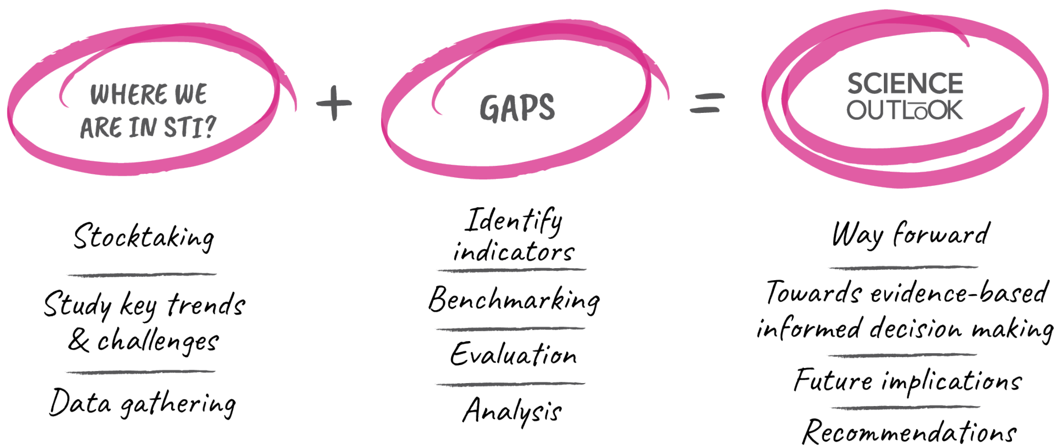


Figure 1: Philosophy of the Science Outlook

Science Outlook 2020 (SO2020) explored the progress and development of STI in Malaysia since the declaration of Vision 2020. The report probed selected STI-related indicators and the impact of national-level programmes, frameworks and initiatives from the year 1991 to 2020. This data is used to identify the strengths and shortfalls of the present STI ecosystem **(Chapter 6)** and how the ecosystem can be stimulated to drive Malaysia's sustainable growth.

Methodology

The global landscape has undergone unprecedented changes over the last 30 years, powered by the forces of globalisation, liberalisation, regionalisation, and digitisation. One of the key features of these forces is the speed at which they are transforming society and economies around the planet. Rapid STI developments and convergence of technology platforms are integrating multiple countries, sectors of the economy, as well as society and stakeholders to create complex flows of information and knowledge networks. Countries and communities that can create vibrant STI ecosystems could benefit from these knowledge networks, while those with weaker STI are at the mercy of the global players and pace-setter countries who set the rules of engagement and define the new world order.

To find out what does the Malaysian STI ecosystem looks like and how to describe its framework, SO2020 employed a mixed methods approach. The mixed methods research entails using multiple methods – qualitative and quantitative research approaches – as part of its research inquiry (Tashakkori & Teddlie, 2010; Venkatesh, et al., 2016) to draw a comprehensive understanding of the industry, public and the key stakeholders' perspectives. This data was used to forecast the nation's growth trajectory towards becoming a high-income nation by 2030, as encapsulated by the Shared Prosperity Vision 2030.

The following methods were undertaken to achieve the objectives and complete the study:

a. Desktop analysis to review reports, plans, and policies related to Malaysia's STI development

b. Qualitative analysis (interview with stakeholders)
   This design comprises qualitative interviews with industry experts to obtain a more comprehensive insight into the state of the Malaysian STI ecosystem, at both industry and public level. Subsequently, the qualitative stage responses were used to develop the path model for the quantitative analysis.

c. Quantitative analysis (micro and macro level analysis)
   The micro level analysis entails two separate online questionnaire survey-one for the firm-level participants and another for the public. The questionnaires were designed to capture the impact of the STI ecosystem on dynamic capabilities, economic, social and environment outcomes. The macro level analysis will use global dataset to construct the STI ecosystem index to benchmark Malaysia's economic, social and environmental performance vis-à-vis other countries.

Scope

In 1991, Tun Dr Mahathir Mohamad, the 4th Prime Minister then, unveiled Vision 2020; a bold new long-term goal for Malaysia to be a "fully developed country" by year 2020 (Mahathir, 1991). Outlining nine goals encompassing economic, political, social, spiritual, psychological and cultural dimensions of our growth, this Vision was drafted under the leadership of the late Tan Sri Noordin Sopiee, the former Director-General of the Institute for Strategic and International Studies (ISIS). This report provides a review of the nine challenges of Vision 2020 from the perspective of STI.

Since the unveiling of Vision 2020, unprecedented changes had swept the global landscape due to rapidly expanding technological innovations as well as trade liberalisations that opened new opportunities for Malaysia and the developing world. These sea changes raised major challenges in the global competition for resources and market intensification over the years. Countries, communities, and industries that invested in developing their STI ecosystem were able to mitigate the risks associated with increasingly cut-throat competition and stratospheric volatility in the global markets.

Malaysia's most signification transition from an agrarian-based economy to an industrial-based economy accelerated over this period, yet significant gaps in the STI ecosystem which hinders Malaysia from moving sustainably up the global innovation value chain still exist. These gaps pose major constraints on sustainable economic development, social transformation, and sound environmental management of the natural resources of the country. Hence, Tun Dr Mahathir has taken the ideals associated with Vision 2020 and formulated a new ethos in the Shared Prosperity Vision 2030 (SPV2030) to address the structural weaknesses that hampered Malaysia's progression to become a high-income nation during his second tenure as Malaysia's prime minister.

SPV2030 was launched in 2019 to guide the national policies for restructuring Malaysia's low value- added economy to move up the value chain to become a knowledge-based economy so that the nation's citizens can enjoy a better living standard (MEA, 2019). This roadmap placed a huge emphasis on holistic growth of the nation for equitable development that can be enjoyed by the *Rakyat* regardless of their ethnicity and socioeconomic group. Policies formulated to attain this vision take into consideration three major aspects of the country's development, i.e. the economy, the people, and the country's natural capital.

Figure 2: STI for Sustainable Development Forming the Framework and Pillars for SO2020

This study reviewed systematically the impact of tangible and intangible effects of STI on the inputs, activities, outputs, and outcomes of the economic, societal, and environmental activities in Malaysia. This report aligned to the Shared Prosperity initiative to encompass three dimensions: the nation's economy, environment, and social progression. The inter-linkages and integrated nature of the three dimensions lay the foundation of Malaysia's growth progression in parallel to the United Nation's 2030 Agenda for Sustainable Development. This agenda encompasses 17 major Sustainable Development Goals (SDGs) that serve as a framework for nations of the world to balance peace and prosperity for the people and the planet from today onwards to 2030.

At present, Malaysia is largely a production-based economy; homegrown innovation has yet to play a significant role in uplifting the economic base of the nation. To achieve the goals of becoming a high-income nation by 2030, the country urgently needs to move away from low-cost production mode towards knowledge driven, innovation-based economy outlined in the national master plans. The goals of the Shared Prosperity Vision 2030 are inclusive in focus with aspirations for ensuring progressive participation for everyone, addressing wealth and income disparities to create a united, prosperous, and dignified nation. These ingredients are crucial for Malaysia's metamorphosis into an egalitarian, advanced, and resilient developed nation by 2030.

Conceptual Framework – Characterising the STI Ecosystem

An ecosystem is simply described as key stakeholders in a community that live in and interact with each other in a specific environment that nurture, use, share and develop information and knowledge for the betterment of society.

An effective national STI ecosystem fosters 'Open Innovation', allowing firms, government agencies, and communities to use knowledge to accelerate internal innovation and expand market for external use of innovation. Such an ecosystem allows external technologies, ideas and knowledge to enhance the internal dynamic capability of people and organisation. The enabling environment also fosters internal innovation and knowledge to create value for all stakeholders in society.

There are many ways to characterise the STI ecosystem. Here, we characterise the STI by eight enablers, shown in Figure 3 (hereafter referred to as the STI ecosystem). This ecosystem consists of two important building blocks called the foundation condition and driver condition.

STI ecosystem is defined as the symbiotic relationship between the stakeholders that contribute to the multiplier effect in community- and nation-building through the nurturing, exchanging, developing, and utilising STI towards shared prosperity and sustainability. Dynamic Capabilities is defined as the ability to absorb, adapt and innovate new ideas, knowledge and STI discoveries. For more details on dynamic capabilities, which encompasses absorptive, adaptive and innovative capabilities.

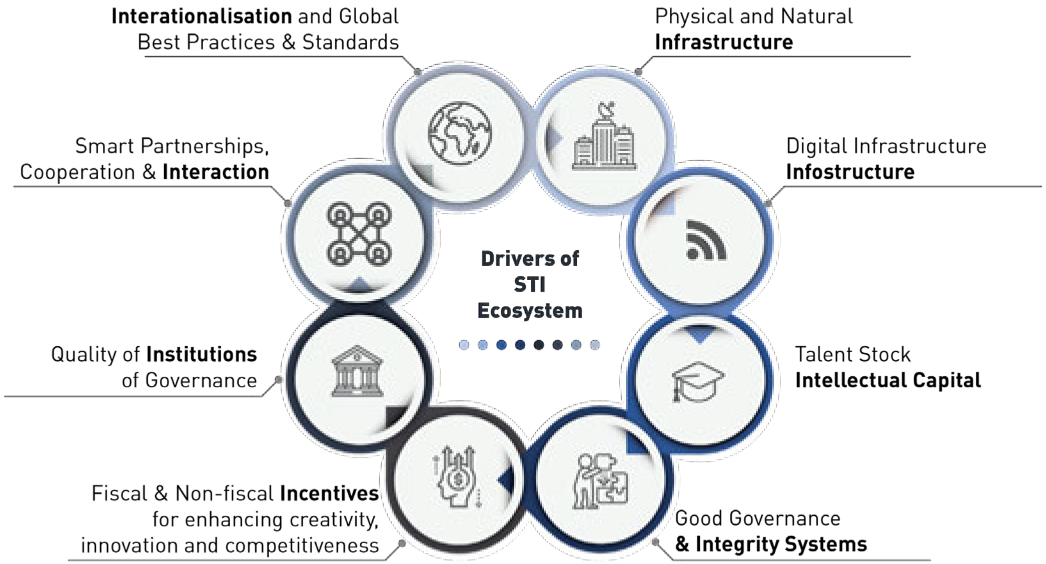
Reference:
Wang and Ahmed, (2007)

The first set of enablers of the STI ecosystem are the foundation conditions that foster connectivity of people, goods, services and information, which are:

- *Physical and natural Infrastructure* – quality of the physical infrastructure such as roads, railways, buildings, transportations and other public facilities to ensure seamless movement of people, good and services. The natural infrastructure entails the nation's natural environment, rivers, ponds, seas, oceans, estuaries, wetlands lakes, forests, mountains and natural resources in the country.
- *Digital Infrastructure and Infostructure* – is the digital communication network that connects people to the global community. These include telecommunication infrastructure and relevant software systems that fosters ICT connectivity, use of big data, and seamless integration of multiple digital and data analytic systems.

The second building-block of the STI ecosystem is the driver conditions which is defined by the following factors:

- *Talent and Intellectual Capital Development* – the skill sets and entrepreneurial acumen for a knowledge society which include general and specialised knowledge, as well as technical, entrepreneurial, and leadership skills that can raise the ROV.
- *Good Governance and Integrity Systems* – governance systems that manage resources efficiently and raise the ROV for all stakeholders in a transparent and accountable manner. These include policies, regulatory architecture, legislative framework, global best practices and standards that ensure rules of engagement are effectively developed, managed, implemented and outcome tracked.
- *Fiscal and Non-Fiscal Incentives* – Fiscal incentives include grants, subsidies, tax incentives, cash transfers and other financial support. Non-fiscal incentives include access to R&D, testing centres and specialist facilities, mentorships and other support schemes to encourage the adoption of new technology, innovation and knowledge systems.
- *Institutions of Governance* – quality of institutions of governance (federal, state and local council), including regulatory framework and standards bodies that ensures transparency and accountability for industry associations, community organisations, institutions of learning, and research institutes. These include the role of these institutions in ensuring effective formulation and implementation of economic, industrial, social, and other



Reference: Adapted from Nair (2011)

Figure 3: Framework to Characterise the STI Ecosystem

The foundation condition is also known as the Reach factor is the basic building block that connects people, goods, information and knowledge for all stakeholders in society – the condition that enhance the reach to information, knowledge and markets.

The driver condition, also known as the richness condition that deepens knowledge intensity in a society.

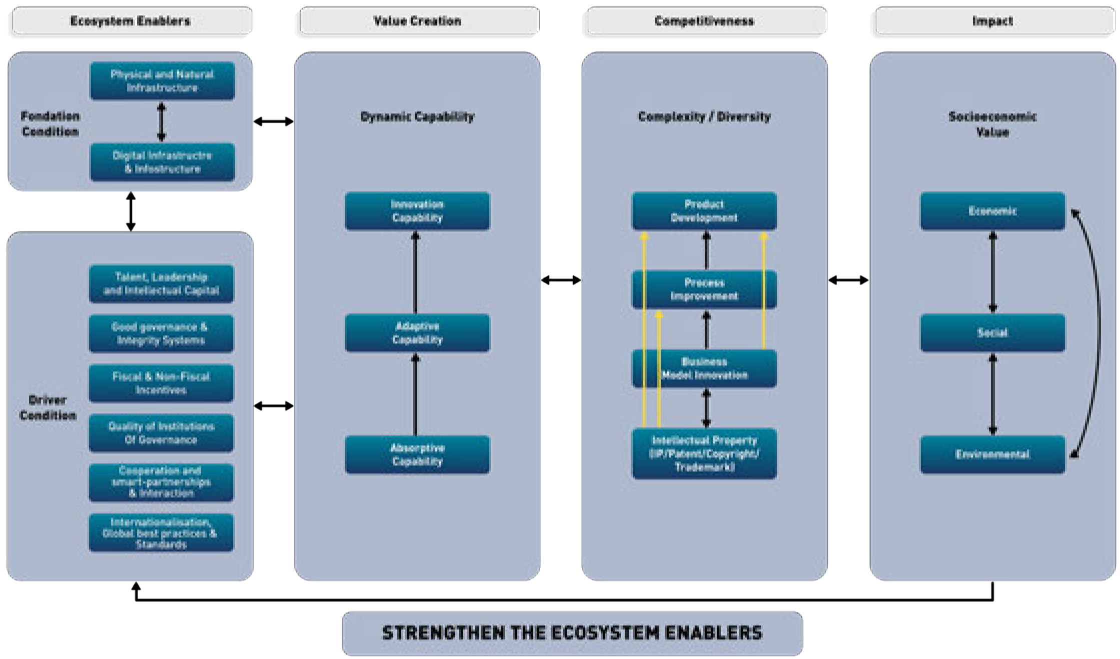
ROV (Return on Value) is the value an organization gains as a result of continuous improvement using new technology, systems, processes and new business models. The return on investment (ROI) is hence a function of ROV. In the context of STI, managing our resources effectively and efficiently will enhance the value proposition of the STI initiatives for all stakeholders, which in turn will increase its ability to raise the ROI.

Reference:
Nair, (2011)

policies that will deepen the impact of STI on sustainable socioeconomic development and environmental sustainability.

- *Smart Partnerships, Cooperation, Networking and Interaction* – quality and depth of cooperation, collaboration and knowledge sharing between all stakeholders to create network externalities and multiplier effect within the economy.
- *Internationalisation, Global Best Practices and Standards* – participation in the development, formulation and adherence to international laws, treaties, regulations and engagements that ensure sustainable management of the country's STI ecosystem. These include the depth and breadth of engagement with global knowledge networks, institutions of governance, and supply chains.

The above STI ecosystem is used to assess the impact on economic, social and environment of the nation. The STI ecosystem impact analysis is characterised by Figure 4. Here, we postulate that STI ecosystem will have a significant impact on the dynamic capabilities of firms, organisations and people in the economies. As these economic agents enhance their dynamic capabilities, they will increase their competitiveness, leading to the development of intellectual property, emergence of new business models (some can disrupt the entire value chain), increase process improvement and intensify new product development. Improvements in the competitiveness of the economic agents will increase economic, social and environmental value. All of which will contribute to the wealth of the country, community and firms.



References: Adapted from Nair (2011) and Wang and Ahmed (2007)

Figure 4: STI Ecosystem Framework

It is postulated in advanced STI ecosystems, there are strong linkages between the foundation and driver conditions – they reinforce one another. There are also strong inter-relationships between the three dynamic capabilities components – the flow is from absorptive to adaptive capabilities; and from adaptive to innovative capabilities. There are also complex linkages between intellectual property, business models, process improvements and product development. Similarly, it is postulated the advanced STI ecosystem will lead to strong endogenous relationships economic, social and environmental initiatives. While economic development will enable social transformation and better management of the environment; it is also envisaged social development also has the potential to contribute to economic development and more effective environmental outcomes. With effective ecosystem in place, sound environmental management practices is also expected to lead to greater economic value and spawn new eco-friendly industries. Sustainable development in this context is defined as countries, communities and firms reinvesting the wealth generated to strengthen the STI enablers, further reinforcing the impact of dynamic capabilities on competitiveness and socioeconomic development.

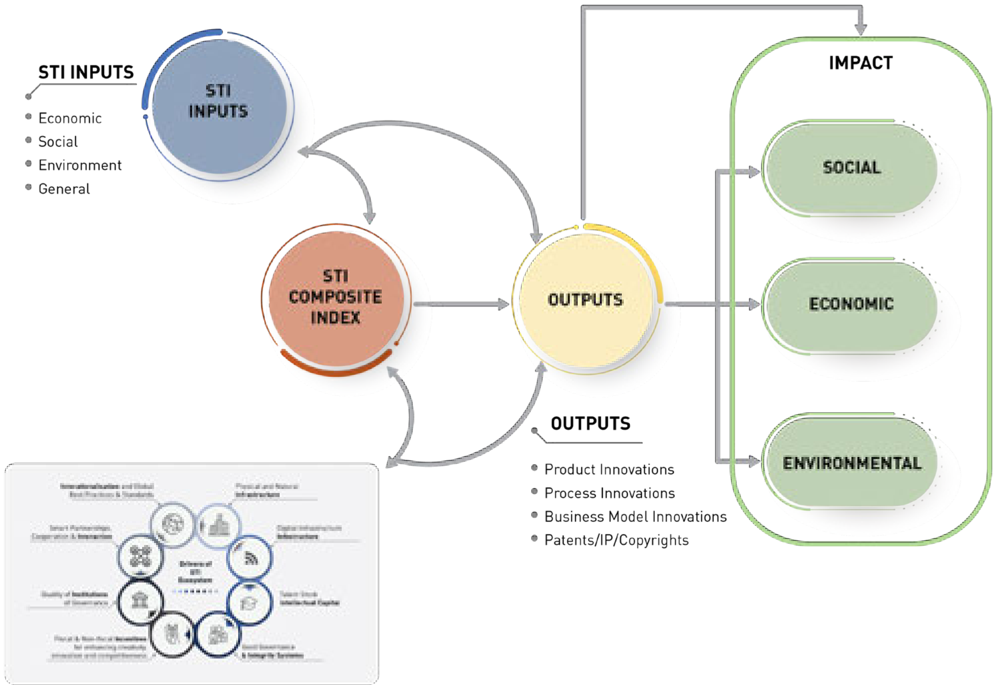


Figure 5: Macro-Level STI Ecosystem Composite Index

The STI composite index at the macro-level is characterised in Figure 5. The STI composite index consists of the STI inputs and the STI ecosystem enablers. The indicators for the STI composite index are provided in **Appendix 6.6** in **Chapter 6**. The STI composite index captures the state of development of the STI ecosystem. The correlation analysis between the STI composite index and STI outputs and impact on social, economic and environmental are undertaken in this study.

At the micro-level, the impact of the STI ecosystem on Dynamic Capability and Competitiveness of firms can be assessed. This model also allows the evaluation of the STI ecosystem on dynamic capabilities and socioeconomic development and the environment. The analysis was undertaken from firms and the public perspectives with the results for the macro and the micro level analyses detailed in **Chapter 6**.

The assessment in this report suggest that Malaysia has significant progress in terms of the three pillars-economic, social and environmental across multiple indicators. This has allowed Malaysia to become a successful industrial-based economy. However, as will be detailed in the report, Malaysia is hamstringed by a number of deficiencies in its ecosystem. Malaysia in its current stage of development lacks the necessary STI ecosystem to become a knowledge-intensive economy. If this condition persists then Malaysia will continue to fall short of the standards of performance required to become a developed country. For Malaysia to catch up and keep pace with its aspiration to be a developed economy it must put in place policies, programs and actions to uplift the Malaysian STI ecosystem, such that it allows the country to create the crucially necessary economic, societal and environmental transformations. The current predicament is in large part because Malaysia has not kept pace with the fast development of global economies and even risks being overtaken by emerging economies in the ASEAN region.

Prelude: Overview of the Past Science Outlook Reports Progress

Brief Overview Of
Past Science Outlook Reports

Science Outlook is one of Academy of Sciences Malaysia's (ASM) flagship studies that aims to present insights supported by relevant data on Malaysia's Science, Technology and Innovation (STI) landscape. Mainstreaming STI at all levels and sectors is recognised as the key driver to catalyse productivity, enhance competitiveness and promote inclusive growth. In order to realise Malaysia's aspiration of becoming one of the top innovation-led nations in the world, STI proficiency must be increased and the way STI is coordinated and propelled in Malaysia must be transformed.

This study was initiated in 2013 with its first report the *Science Outlook 2015* (SO2015) launched in 2015. This **evidence-based independent review** on key trends in science, technology and innovation (STI) in Malaysia was specifically introduced as a yardstick for Malaysia's performance. Recognising the need to place considerable emphasis on evaluating the nation's capacity where STI is concerned, to understand the current and possible future implications for national STI trends both at the national and global level, a biennial review was proposed. The second report, *Science Outlook 2017* (SO2017) was launched in April 2018.

To optimise our capacity to harness modern science and technology to achieve the above aspiration, the two previous published Science Outlook reports, the Science Outlook 2015 – Action towards Vision and the Science Outlook 2017 - Converging towards Progressive Malaysia 2050 alert the country of its progress in STI and were carried out with the philosophy depicted in Figure 1 below:

Figure 1: Philosophy Of Science Outlook Studies

The Science Outlook studies by ASM serves as a monitoring and evaluation exercise which has paved the path for several key platforms of engagement and drawn opportunities for collaboration with government ministries and agencies, industry players, researchers and civil society. The past two issues were conceptualised based on the six pillars of the National Policy on Science, Technology and Innovation (NPSTI) (2013-2020) as shown in Figure 2 below:

SO2015 AND SO2017

6 Chapters in the Science Outlook
aim to continue provide evidence-based insights
and new perspectives on the Malaysian STI landscape

Key focus areas
that contribute to a robust STI ecosystem

Figure 2: Pillars of Previous Science Outlook Studies

As we embark on the next phase towards producing the Science Outlook 2020, we present here the **progress that has been made in the recommendations of the previous two reports:**

11 out of 18 recommendations of **SO2015** have been fully implemented or partially taken-up till date:

1. National Science Council (2016) was formed in 2016

2. A Special Select Committee on Health, Science and Innovation has been established in 2020.

3. Initiative has been restarted in 2019 by MOSTI to revisit the earlier drafts of the Science Act.

4. Research Management Agency (RMA)* proposal was approved by the Cabinet in 2018,

5. In 2017 the NSC decided for the collaborative network model to be implemented to enable demand driven research and enhance innovation capacity.

6. In 2019 MESTECC launched an initiative to share researchers with industry through the Researcher-Industry Scientific Exchange (RISE) platform.

7. An index on STEM students had been conceptualised by MOE. In 2021, an STI Enculturation Index is being explored by MOSTI.

8. National STEM Centre under the purview of MOE has been set up by 2020.

9. National STEM Action Plan (2018-2025) has been formulated.

10. Increasing public engagement on STEM through initiatives by NGO's, industry government. A coordinated effort will show higher impact.

11. Continued efforts for early childhood exposure to STI as stipulated in the Waves of the Malaysia Education Blueprint (2013-2025).

10 out of 18 recommendations of **SO2017** have been fully implemented or partially taken-up till date:

1. Partial role of a dedicated centralised STI body to operationalise STI-related decisions at NSC is followed through by MOSTI's Foresight Division.

2. In 2018, MESTECC's announced that 50 per cent of research and development funds will be allocated to experimental research beginning 2019 onwards.

3. Establishment of RMA* has been approved by the Cabinet.

4. In 2020, the 10-10 *My*STIE framework with 30 National STIE Niche Areas was launched to harness STI to impact socio-economic growth, resilience and competitiveness.

5. Possible spin-off of Innovation clusters through i-Connect platforms upon full uptake of the 10-10 *My*STIE framework.

6. 2020: MOSTI has initiated preliminary meetings among its agencies to discuss the present remuneration scheme. In 2021 the Graduate Research Assistant (GRA) allowance rate under MOSTI's R&D Fund funding scheme according to academic qualifications was increased to RM3,200 for Doctor of Philosophy GRA and RM3,000 for Master's GRA.

7. In 2019 ASM has started the i-Connect initiative to create and nurture a conducive innovation ecosystem in Malaysia in the areas of Industry 4.0, Fintech in Islamic Finance, Health & Wellness, and Halal Supply Chain.

8. An improved Knowledge Resources For Science Technology Excellence (KRSTE.my) is in place.

9. In 2020 Malaysian Biotechnology Information Centre (MABIC) and The Petri Dish established the Science Media Centre Malaysia, an information resource centre aimed at promoting accurate and evidence-based reporting especially on complex or controversial science issues in the media.

10. a. Partial uptake – individual efforts by MDEC, MaGIC, SME Corp, MIDA & FMM to dissemination STI related knowledge. A virtual centralised STI knowledge repository and data centre is not in place.

    b. No formal STI platform between Federal and State Governments across Malaysia has been established. There was one such meeting Chaired by YB Madius Tangau (then Minister of MOSTI) in April 2017. No continuity of any such initiative seen till date.

*The RMA was renamed to Research Management Unit (RMU) during the tabling of the 12th Malaysia Plan on 27 September 2021.

SCIENCE OUTLOOK 2015 (SO2015)

STI GOVERNANCE

Strengthen STI Management Cycle:
Focus on continuous Monitoring and Evaluation, as well as Ideation, in keeping with global best practices.

Establish a Centralised STI Body:
Empowerment of a centralised STI coordination and monitoring body that transcend across all ministries needed to ensure harmonisation of efforts, collaboration of resources, exchange of information between various stakeholders, and a seamless progression across various stages of the STI Management Cycle.

Establish a Parliamentary Select Committee:
The establishment of a Parliamentary Select Committee on STI will build the necessary political will and create legislative consensus towards promoting STI agenda.

Enactment of a Science Act:
The proposed Science Act (of Malaysia) will be instrumental in setting up a robust institutional framework on science governance. The Act will serve as an overarching Master Plan for unified execution strategy.

SCIENCE OUTLOOK 2017 (SO2017)

Strengthen Science Planning and Coordination through a Centralised Dedicated Body:
Alignment of national STI actors through a rationalisation exercise is proposed to be carried out and a centralised STI body named as the Science Planning Unit (SPU) is proposed to be established under the purview of the Prime Minister's Department. SPU will be the enforcement arm of the National Science Council (NSC) with a mandate that transcend all ministries to enable greater stakeholder participation and synchronised planning, coordination and monitoring of STI decisions.

Establish a Formal STI Platform between Federal and States Governments in West Malaysia as well as Sabah and Sarawak:
Effective delivery and coordination of STI governance at federal and state level require concerted cooperation between the two. A formal structure with clearly delineated expectations, roles, and supporting network will benefit the development and implementation of STI policies in each state.

SCIENCE OUTLOOK 2015 (SO2015)

R,D&C

Empower Centralised Coordination Body:
Empowering the Science Planning Unit (SPU) to help oversee, manage and evaluate all R,D,C&I budgets for a seamless and smooth transition from the Pre-R&D stage to subsequent stages of R,D,C&I, Early Stage Commercialisation and Commercialisation. Additionally, it will be possible to evaluate beyond the ROI by integrating intellectual property (IP), industry set-up, role of solution-providers, interest of researchers and project managers for sustainable R,D,C&I, with socio- economic benefits.

Effective Use of GERD:
For better planning and targeted results, empowerment of existing organisation/s for centralised funding mechanism or management is crucial. An introduction of a special purpose Ideation Fund may help evidence-based decision making, when choosing the areas of R,D,C&I as well as towards efficient allocation of resources to achieve optimum capacity.

SCIENCE OUTLOOK 2017 (SO2017)

Emphasis on Experimental Development:
Increased funds for experimental development will encourage more collaboration between university and industry towards demand driven research which will consequently increase experimental development activities to produce more market ready products and/or services.

Expedite the Establishment of a Multifunctional Research Management Agency (RMA) and to Consider Establishing a Technology Commercialisation Accelerator (TCA):
Need to expedite the establishment of RMA to catalyse demand driven collaborative research with effective utilisation of funds and the TCA to complete the ready-to-market delivery cycle. This will assist in prioritisation of research and formation of symbiotic relationships with technology transfer offices and collaborative platforms.

Re-identify National RDC Priority Areas:
Re-identifying national RDC priority areas by aligning and streamlining to Malaysia's research and economic strengths and needs will result in optimisation of available resources.

Development of Regional Innovation Clusters:
Development of regional innovation clusters by enhancing collaboration between industry and knowledge institutions as the case in Malaysia's E&E sector must be considered.

STI TALENT

SCIENCE OUTLOOK 2015 (SO2015)

Systemic Planning & Development:
Need for strategic framework to guide human capital development in S&T services and delivery.

Bridge Gap between Policy & Reality:
Need for drastic intervention measures to be taken at each domain of the human capital value chain in order to reach the targeted number of 500,000 skilled S&T workforce.

Retain STI Talent:
Need to devise a 'sustainable' action plan for retaining STI Talent, especially to fuel the high-priority sectors of the economy. The plan should outline methodologies and criterion to identify the right talent, with the right skills and expertise, who can be incentivised with a career roadmap in the country, with opportunities created through public-private partnerships.

SCIENCE OUTLOOK 2017 (SO2017)

Attracting and Retaining STEM Talent through Improved Remuneration and Continuous Career Development:
Engaging and attracting young people to first enrol in STEM-related degree programs and then to pursue careers in STEM done through an improved remuneration scheme comparable to other nations and continuous career development is proposed to ensure sustainability and succession

Prioritisation of Numerically and Technically Competent Talent Development:
Numeracy skills are the foundation of most STEM courses at tertiary level and it is predicted to come in handy in most future jobs. Therefore, numerically competent talent development must be prioritised to develop technical competency.

Development of Biennial National STEM Talent and Skill Gap Assessment:
Development of a biennially nationwide STEM talent and skills gap assessment is proposed to gauge and identify the mismatch of our STEM talent - if there is either an oversupply or an under demand of, especially critical jobs.

SCIENCE OUTLOOK 2015 (SO2015)

ENERGISING INDUSTRIES

Formal and Regulated Linkages for Public-Private Partnerships:
An "STI Stakeholder Engagement Model" will not only define "critical stakeholder universe" essential for STI policy implementation success but will also define the nature and extent of collaborations between the industry and other STI proponents (including academia).

Disseminate STI Agenda amongst Industry Players:
An awareness and enculturation campaign for the industry using appropriate and innovative ICT channels will help enhance the level of understanding as well as involvement in promoting STI agenda. This is one by providing industry associations, with measurable KPIs, can educate and mobilise the industry towards creating a better STI ecosystem.

STI Data Centre:
A centralised knowledge repository will provide access to critical and credible Malaysian STI information. Such a centre can also help synergise and coordinate all STI funds, plans, policies and programmes across sectors, to avoid duplication of efforts and maximise output.

SCIENCE OUTLOOK 2017 (SO2017)

Establish Industry-Led Collaborative Networks to Enhance Demand Driven Research and Private Sector Participation:
An initiative to stimulate the uptake of R&D and innovation among industries should be facilitated by industry-led collaborative networks that shall guarantee the rise of knowledge clusters, leading to organically formed talent hubs (thus enhancing knowledge workers) and disruptive innovations.

Facilitate Dissemination and Monitoring of Industry Related Information through a Virtual Centralised Knowledge Repository and Data Centre:
Establishing a virtual centralised knowledge repository and data centre to make the full range of STI-based resources as well as market intelligence information known to all, is pertinent to energise the industries to enhance the development of STI-based SMEs and innovative start-ups, it is essential to provide sufficient industry related STI resources.

SCIENCE OUTLOOK 2015 (SO2015)

STI ENCULTURATION

Early Exposure to Science:
Formulating a strategic long-term STI Enculturation Plan centred around the global philosophy of "Science beyond Scientists" that is relevant for Malaysia as it helps to sensitise the society on various aspects of development, while the nation achieves its 2020 milestone of being a developed economy.

Players in Popularising Science:
The long-term plan should define the roles of multiple stakeholders such as the Government, scientists, prosumers, businesses, media, parents and youth, and the society at large, in promoting the cause of science for development.

Engage Public through Multiple Platforms:
The Plan should also clearly define the platforms for public engagements, including the frequency and the content to popularise science amongst non-science communities.

Develop Science Enculturation Index:
An STI Enculturation Index will help derive meaningful data, which can be used by critical influencers (such as schools, educationists, parents, industry leaders) to garner interest for STEM disciplines as well as scientific initiatives.

SCIENCE OUTLOOK 2017 (SO2017)

Public-Private Partnership to Update and Upgrade STI Enculturation Spaces:
Encourage Public-Private partnership to update and upgrade STI enculturation spaces to attract more visitors. STI places should also leverage on local scientists, scientific associations and social innovators such as content providers giving input on STI.

Virtual Science Media Centre to Strengthen STI Content in Various Media Platforms:
A virtual resource centre that focuses on communicating science in laymen *Bahasa Melayu* and English and encouraging translation and creation of STI content needs to be in place.

Prioritise Development of STI-based Creative Content:
To focus on entertainment-based programmes such as creative edutainment-based STI content in order to increase interest in STI.

SCIENCE OUTLOOK 2015 (SO2015)

STRATEGIC INTERNATIONAL ALLIANCE

Increase STI-Focused International Alliance:
STI-focused international alliances such as the following should be increased to gain better benefits:

i. Individual Country (Inter-Ministries):Partner with respective ministries from various countries and develop a comprehensive engagement plan.

ii. Intra ASEAN – MOSTI to MOSTI equivalent: Define development strategies for Intra-ASEAN collaborations.

iii. International (ASEAN-Rest of World): Develop ICT and mobile engagement platforms that will allow the ASEAN scientific community to engage with Malaysian STI stakeholders.

iv. Scientists as Torch Bearers: Establish multilateral linkages with global research institutions, technology houses, innovation hubs, STEM talent and experts.

Position Malaysia's STI Capabilities to Strategic Partners:
Formulate a plan that defines the roles of multiple stakeholders such as the Government, scientists, prosumers, businesses, media, parents and youth, and the society at large, in promoting the cause of science for development.

SCIENCE OUTLOOK 2017 (SO2017)

Leadership in Positioning Malaysia's Strategic STI International Alliances:
To further strengthen the strategic STI international alliances, the various international platforms where Malaysia is a member must be fully utilised by our STI key opinion leaders to add to global competitiveness and increase the visibility of Malaysia's STI capacity and capabilities.

Enhance Roles of Science Attaché in Malaysian Embassies:
The roles of Science Attaché in Malaysian embassies should be enhanced and expanded to include strategising, monitoring and evaluating STI-related issues pertinent to the nation's interest.

Strengthen Linkages Between Ministry of Foreign Affairs (MOFA) and Malaysian Scientific Community
The linkages between the Ministry of Foreign Affairs (MOFA) and Malaysian scientific community should be strengthened to include scientific evidences as an avenue for diplomatic decision makings.

Leverage Malaysia's Trade Platforms Globally to Facilitate Market Intelligence in STI-based Industries
Malaysia's should also leverage on its global trade platforms and trade missions for gathering STI-related intelligence to develop the right STI related strategies for the Nation.

EXECUTIVE SUMMARY

Malaysia has successfully diversified its economy into one of the most open economy in the world, underpinned by a robust manufacturing and service sectors. The growth was also made possible by the strengthening of the Science, Technology and Innovation (STI) ecosystem over the last three decades that reshaped the global landscape, opening borders and markets in unprecedented ways. Malaysia's readine readiness to take up STI advances contributed to the nation's rapid transformation during this period, building upon the stable growth laid by visionary policies to make Malaysia one of Southeast Asia's success stories.

The rigors of the modern economy demand the prioritisation of STI for everyone; from individual citizens to the Government machinery, including for-profit and non-profit entities. The mechanisms supporting the nation's STI capability are the linchpins of its STI strategies; the modality must have indicators for systematic measurement of STI performance and forecasting potential prospects using evidence-based feedback. The STI networks to advance Malaysia's STI capability demand dynamic talent, agile industries positioned for growth and innovation, sound financial institutions, as well as transparent and robust regulatory architecture.

Today, the progress of a nation is not only measured by gross domestic product (GDP) or national expenditure, but it is just as much about ensuring the overall quality of life and well-being of its citizens. A successful country also makes sure that the growth of today is not at the expense of the future generations. As Malaysia strives to become a developed nation that is united, prosperous, inclusive, and sustainable, it is important to reflect on the successes and failures of domestic STI policies that served as the nation building foundation on the economic, societal, and environmental pillars (Figure 1.1).

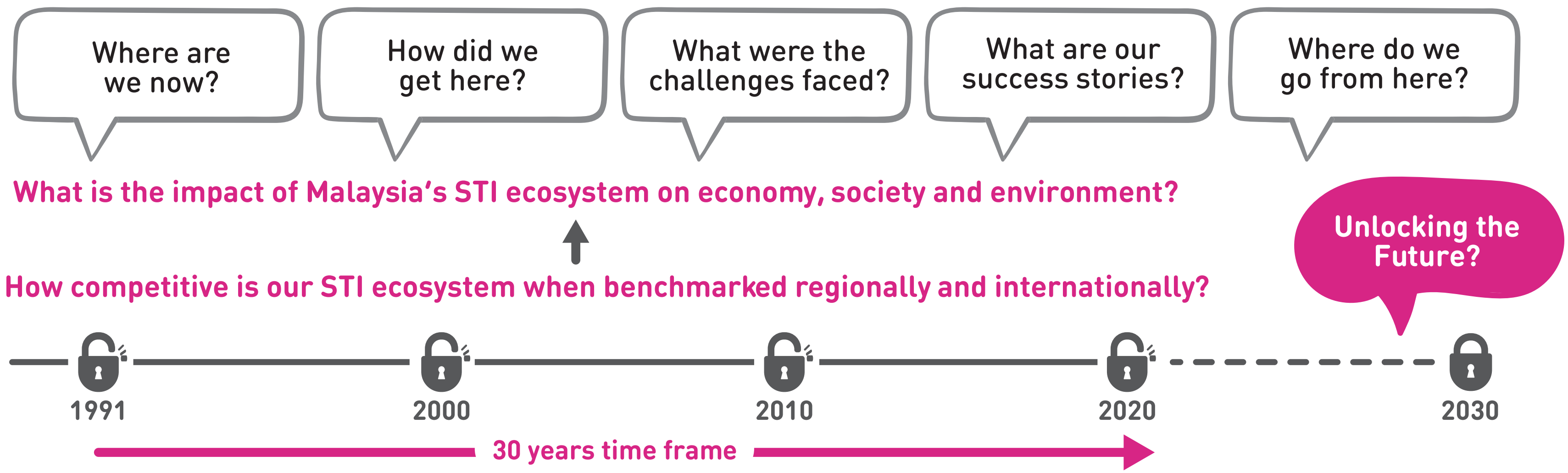


Figure 1.1: Three Decades of STI Evolution

About the Science Outlook

Science Outlook is one of Academy of Sciences Malaysia's (ASM) flagship studies. Its aim is to present insights based on relevant data on Malaysia's STI landscape – on how to increase the use and adoption of STI and to transform the coordination of STI policies as part of the efforts to mainstream STI at all levels in the country. These efforts are needed to catalyse the nation's productivity, enhance competitiveness, and promote inclusive growth to realise Malaysia's aspiration of becoming one of the top innovation-led nations in the world.

ASM's Science Outlook was initiated in 2013 with its first report the Science Outlook 2015 – Action towards Vision (SO2015) launched in 2015. This evidence-based independent review on key STI trends in Malaysia was specifically introduced as a yardstick for Malaysia's performance. Response to SO2015 indicated the necessity to keep a finger on the pulse of national STI trends at local, regional and global levels to assess possible future implications; hence a biennial review was proposed. The second report, Science Outlook 2017 – Converging towards Progressive Malaysia 2050 (SO2017) was launched in 2018. 18 recommendations were proposed in each edition, of which 11 and 10 were successfully considered and implemented either partially or fully in SO2015 and SO2017 respectively. The progressive outcomes of SO2015 and SO2017 are outlined in the pull-out section of the main report. Figure 1.2 illustrates the philosophy guiding the Science Outlook reports.

Science Outlook 2020 – Unlocking the Future (SO2020) explores STI progress in Malaysia since the declaration of Vision 2020. This report probes selected STI-related indicators and the impact of national-level programmes, frameworks, and initiatives from the year 1991 to 2020. This data is used to identify the strengths and shortfalls of the present STI ecosystem (see Chapter 6) and how the ecosystem can be stimulated to boost Malaysia's sustainable growth into a high-income nation.

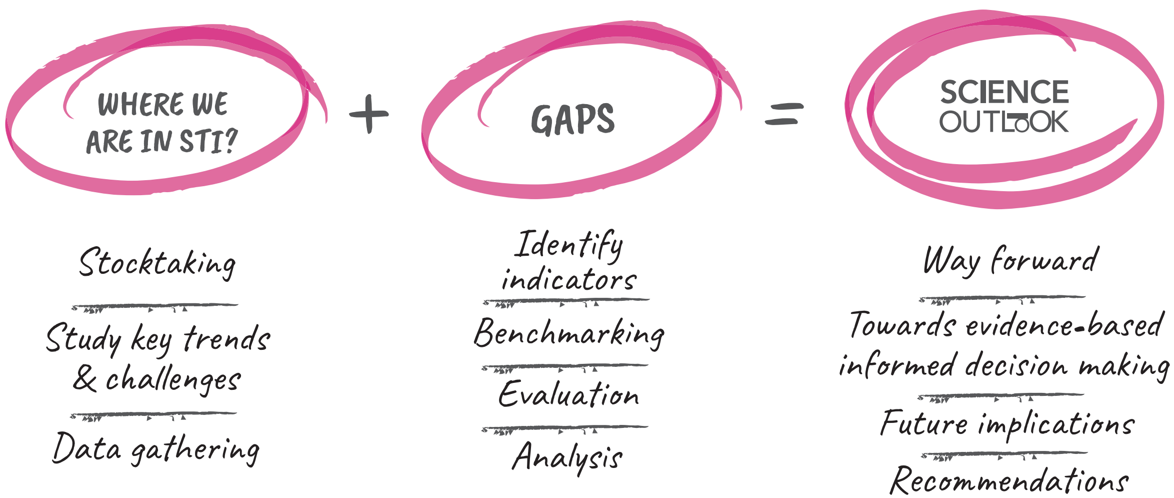


Figure 1.2: Philosophy of the Science Outlook

Objective

SO2020 examines the impact of STI on the economic, societal, and environmental outcomes for Malaysia since the inception of Vision 2020. The approach of this report is beyond auditing the current progress towards evaluating the steps and possible development trajectory to ensure that Malaysia is able to reach its goals and aspirations as defined in the Shared Prosperity Vision 2030 (SPV2030).

Scope and Conduct of the Report

SO2020 employed a mixed methods approach to assess the Malaysian STI ecosystem. The mixed methods research entails using qualitative and quantitative research approaches to draw a comprehensive understanding of the industry, public and the key stakeholders' perspectives. This data was used to forecast the nation's growth trajectory towards becoming a high-income nation by 2030, as encapsulated by the SPV2030.

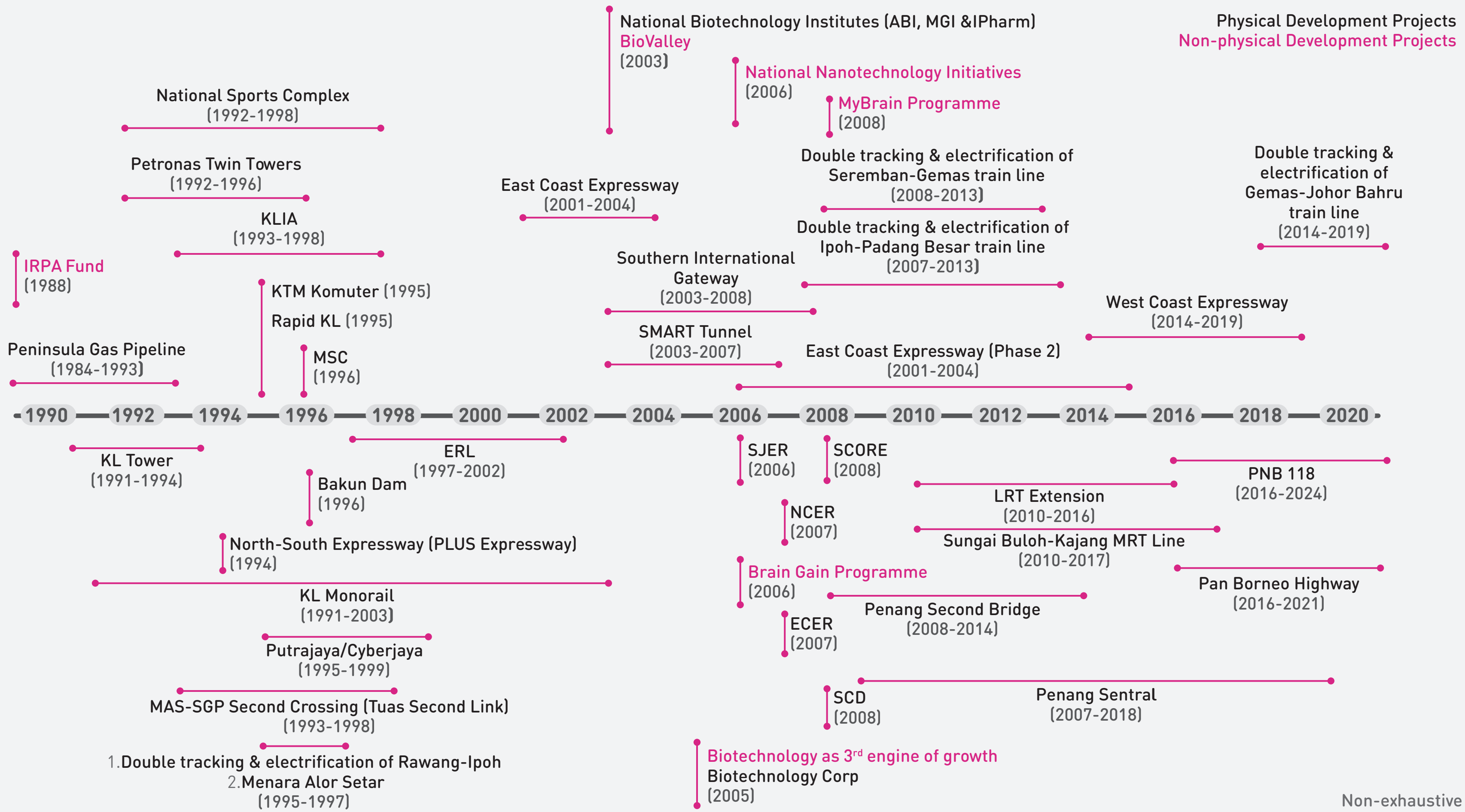


Figure 1.3: Three Decades of National Projects

STI Policies for Inclusive and Holistic Growth

Infrastructure development was determined to be the engine of growth and capacity building for Malaysia and this approach was ramped up since the 1980s. The new roads that opened up the country also helped make it safer against the Communist insurgency that was only laid to rest by the peace accord signed in 1989. The incidence of poverty dropped dramatically when the land-poor was given opportunities to participate in the palm oil boom; such development in remote areas was made possible with the expansion of access to utilities such as piped water, electricity, and telecommunication. This trend continued in the 1990s onwards with many national infrastructure developments (Figure 1.3) serving as the cornerstone of the country's economic expansion and preparing Malaysia to be globally competitive.

Focus on capacity building in research and development (R&D) began in earnest in the 1990s with the establishment of the Intensified Research Priority Area (IRPA) funding to foster research and development (R&D) in public universities and research institutions. It laid the groundworks for the Malaysian Research Universities (MRUs) in 2007 which helped intensify the country's R&D outputs. The Brain Gain Programme in 2006 was initiated to coax Malaysian STI talents who had established expertise abroad to return home and share their knowledge and skills. This was also supported by the MyBrain Programme two years later to increase the number of highly qualified and well-trained research personnel through education investment both locally and overseas. However, funding for both programmes had shrunk since their inception; other issues related to research personnel in the country are discussed at length in Chapter 2.

The Government's five-year Malaysia Plan (MP) provides a framework for national medium-term socio-economic policies while the long-term planning is mapped out by the Outline Perspective Plans (OPP) to optimise resource mobilisation. These policies had to be adjusted periodically in response to global and local events (Figure 1.4).

The first major adjustment was with the formulation of the New Economic Policy, an affirmative action programme to address the economic inequalities. The plan was to increase Bumiputera economic equity to 30% through social re-engineering and preferential access to education. It was then replaced by the National Development Policy, the National Vision Policy, the New Economic Model, and now, the SPV2030, all of which shared the same focus: i.e., restructuring the economy for a fair and equitable distribution of the nation's wealth across the population.

While there were a number of policies introduced, these policies were unable to systematically address the socio-economic gaps in the country. These gaps highlight those policies that target wealth inequalities and promote social mobility must be needs-based. Rapid transformation of the Malaysian economy will require continuous review and assessment of poverty indicators and other social well-being measures (see Chapters 3 and 4 for more details).

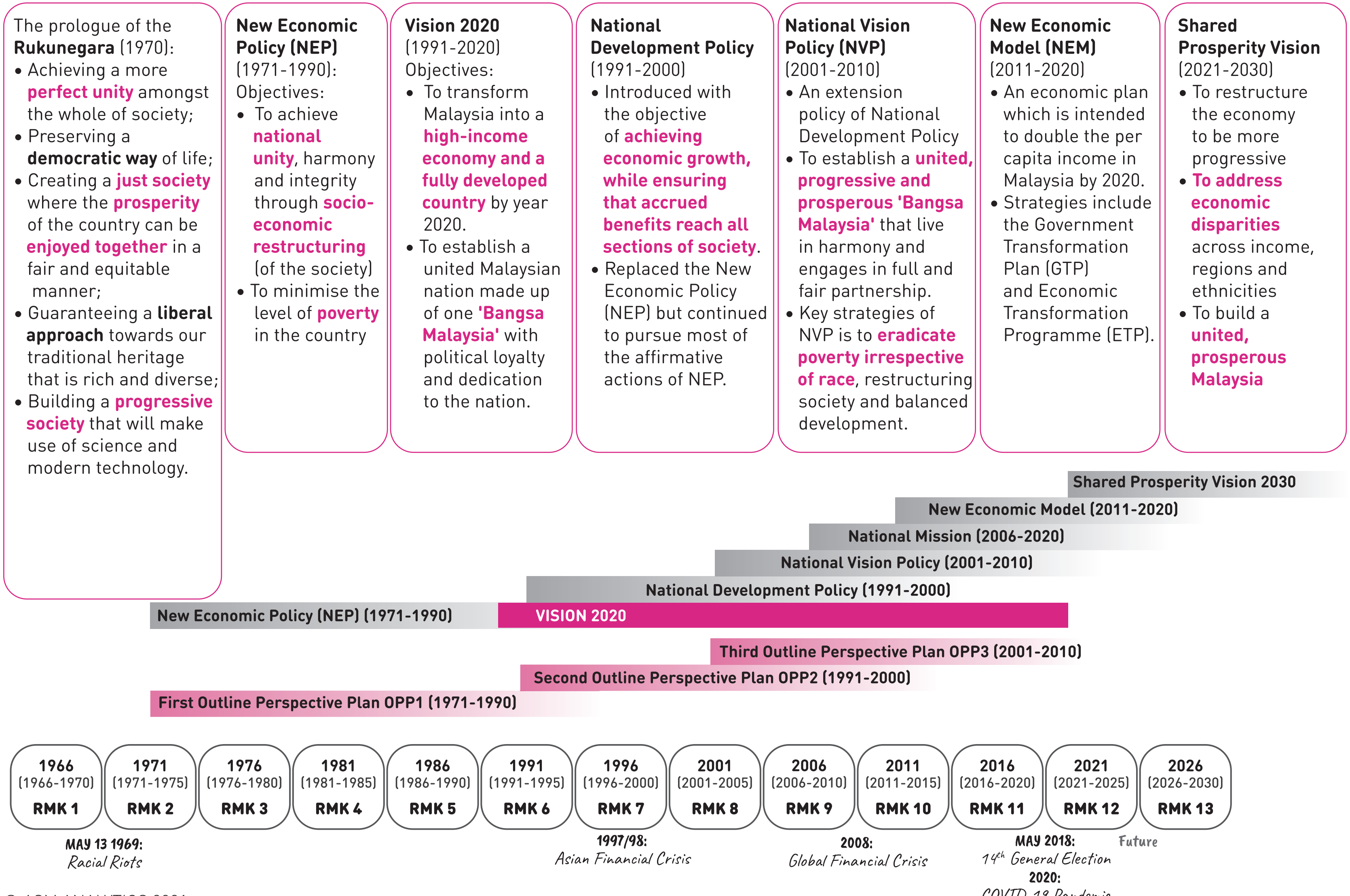


Figure 1.4: Key Development Policies and Plans

Vision 2020 defined Malaysia's aspirations to be a high-income developed economy across all economic, political, social, spiritual, psychological, and cultural dimensions by year 2020. The Vision expanded the idea of *'Bangsa Malaysia'* as the cornerstone of a united Malaysian nation and emphasised technological, social, and environmental advancement for Malaysia to ensure a balanced development.

The ideals of Vision 2020 had inspired not just Malaysians, but also admirers from abroad who saw Malaysia as a model for developing nations to progress in a holistic manner. Six out of the nine challenges centre around the humanistic aspect of nation building and societal progress. As seen in Figure 1.5, many aspects of the Vision such as unity, diversity and biodiversity were not realised due to inconsistencies between economic and social engineering policies. Analyses of the Malaysia's performance in the various Vision 2020 challenges are articulated in the pull-out section.

The conservation of the environment and maintenance of Malaysia's natural capital were not given adequate priority compared to other development initiatives. Weak enforcement, insufficient resources for protecting the environment, and unfettered industrial development has made the country vulnerable to risk arising from climate change and global warming. Chapter 5 of this report explores this theme more thoroughly.

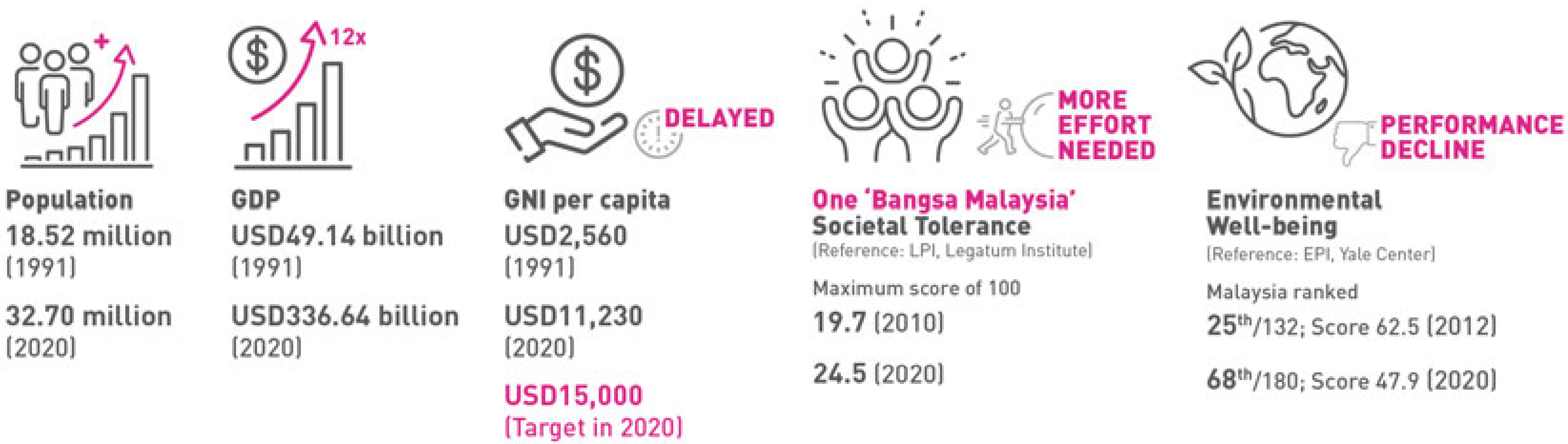


Figure 1.5: Envisioning Vision 2020

Key STI Indicators Performance

Over the years, Malaysia has shown commitment to developing and leveraging on STI to drive its trajectory towards becoming a developed and prosperous nation. Several key STI indicators have been selected to assess the country's STI performance, i.e., research expenditure, personnel, and productivity as well as the impact of the country's STI ecosystem on Malaysia's socio-economic development.

Malaysia's gross expenditure on R&D (GERD) expanded from 2006 until 2016 but fell sharply to an 8-year low of 1.04% GERD per GDP in 2018, after the watershed general election (Figure 1.6). This drop is expected to affect the other STI indicators which can hamper Malaysia's target to become a robust knowledge economy by 2020. Malaysia has done well in maintaining a healthy percentage of GERD per GDP compared to developing nations but performs poorly in this aspect when contrasted against developed countries like the Republic of Korea, Sweden, Japan, Germany, and Denmark which have surpassed 3% of GERD per GDP. The National Policy on Science, Technology & Innovation (NPSTI) 2021-2030 outlined a target of 2.5% GERD per GDP by 2025 and 3.5% GERD per GDP by 2030; however, this may be tough to accomplish given the present economic disruption caused by the COVID-19 pandemic.

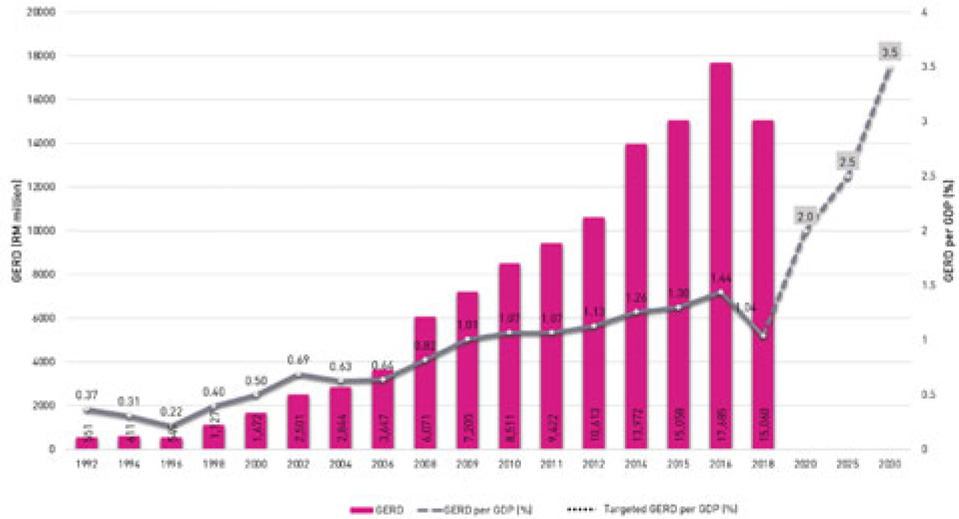


Figure 1.6 (a): Malaysia's Gross Expenditure on Research and Development (GERD)

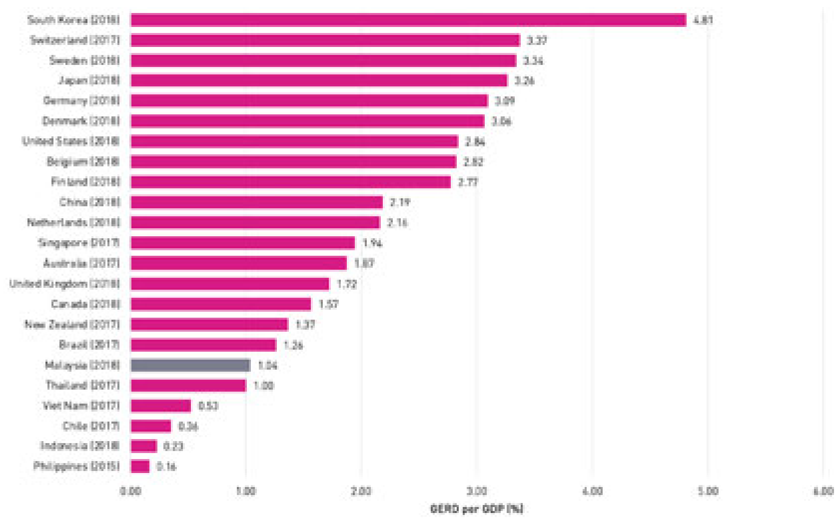


Figure 1.6 (b): Benchmarking on Gross Expenditure on Research and Development (GERD) in 2018

The number of research personnel in Malaysia has been increasing since the implementation of the My Brain Gain and MyBrain programmes as well as the MRUs in the mid-2000s. Malaysia's number of full-time equivalent researchers (FTE) per thousand labour force is 4.5 FTE/1000 labour force (Figure 1.7) which is ahead of other developing countries but still lags behind developed countries. The largest number of researchers are in public universities and government research institutions, unlike advanced economies where they have a higher proportion of researchers in the business sector (Figure 1.8). The hesitancy of Malaysia's business sector to invest in research, development, commercialisation, and innovation (RDC&I) is a major stumbling block of building the resilience and capacity needed for the country to move up the value chain as a knowledge economy.

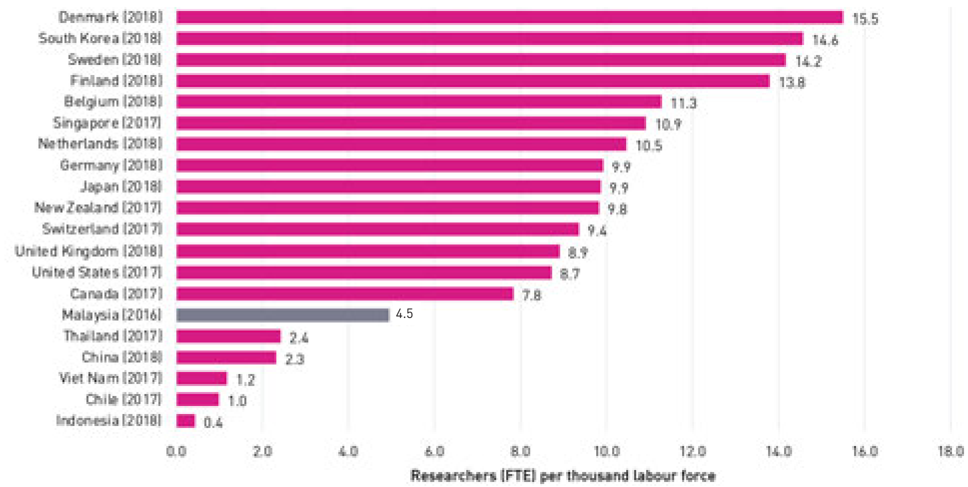


Figure 1.7: Global benchmarking of Researchers (FTE) per Thousand Labour Force in 2018

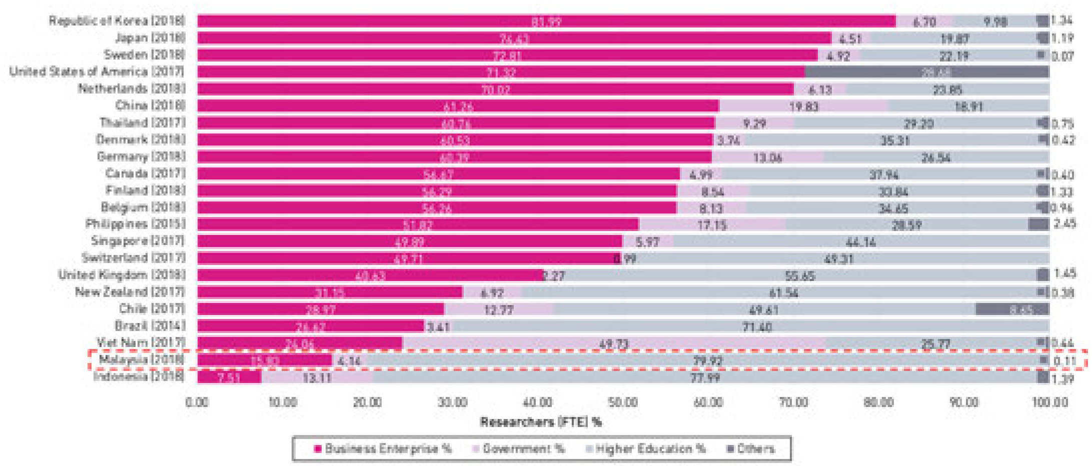


Figure 1.8: Global Benchmarking of Researchers (FTE) by Sectors in 2018

Figure 1.9 is a comparison of Malaysia's research productivity and outcomes against selected advanced economies; it appears that the nation's research productivity has been regressing from 1996 to 2016, despite producing greater publications by 2016. Many countries that experienced similar downward trend in the same period had shown rebound by 2016 are countries that are largely tech-driven with the largest number of researchers in the business sector.

In 1996, Malaysia had an enormous amount of research funding but insufficient number of appropriately qualified research personnel to make the most of the investment as evidenced by the poor research outputs. During this time period, the Government intensified investments in establishing and upgrading the RDCI infrastructure in public universities and research institutes.

In the next 10 years, the number of Malaysian researchers quadrupled which ramped up the number of publications in the country. The majority of the researchers were based in universities and government-linked research institutes where publications are considered a priority. In addition, most of the research funds were channelled towards basic and applied research, with little set aside for experimental projects or industrial scale-ups. The disconnect with the industry also means less focus on patentable or experimental discoveries for expanding economic growth. By 2016, the average GERD per researcher has shrunk, suggesting that the country has become more efficient in generating publications and patents. However, the quantum increase in publications is not accompanied by more granted patents due to mismatched priorities between the researchers and the national STI aspirations.

In short, Malaysia's relatively poor performance can be attributed to the fragmentation of the STI ecosystem with too many researchers in universities whose basic and applied science output have very little traction with industry as well as the lack of long-term R&D investment strategy across all stakeholders.

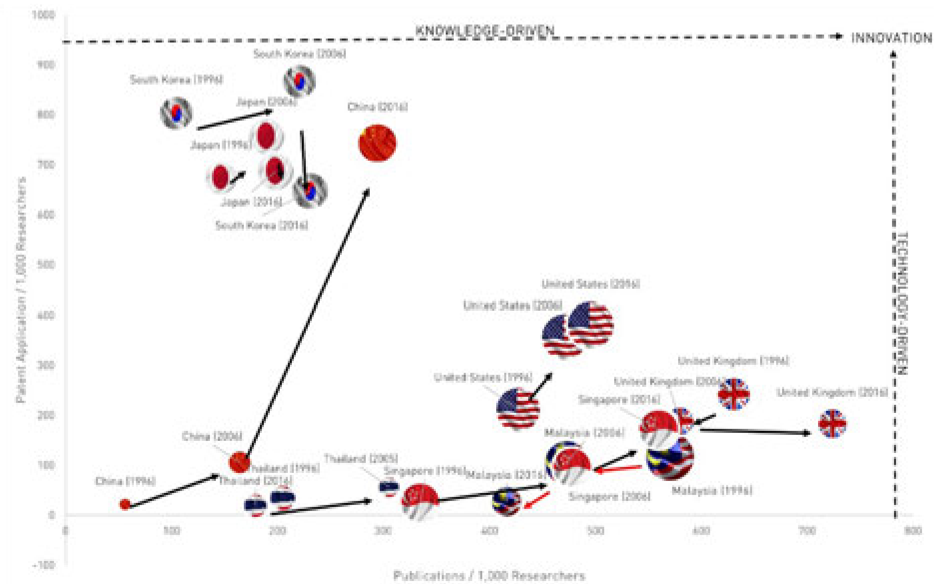


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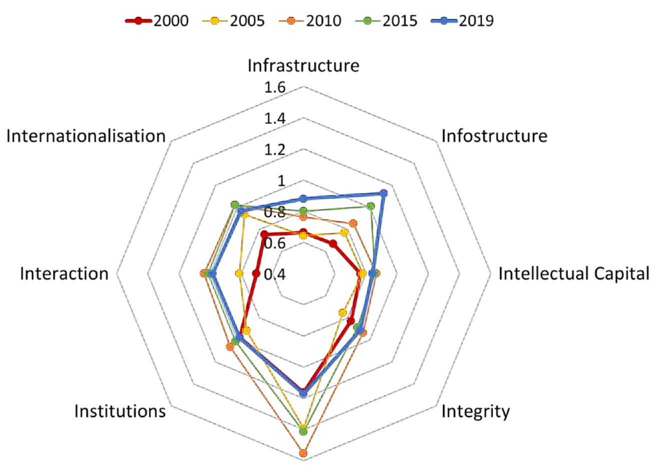
Figure 1.9: Correlation Between Publications, Patent Applications and Average GERD per Researcher (FTE) for 1996, 2006 and 2016

The country's STI ecosystem showed that except for infrastructure and infostructure, the other STI enablers have advanced very little or declined over the years (Figure 1.10). The incentives indicator showed a significant decline, leading to relatively lower industry investment in R&D and other STI-related activities. Reduction in internationalisation suggests that STI activities and networks in Malaysia are not being effectively utilised to penetrate global markets. The gradual weakening of institutions reflect that they are not keeping pace with the rapidly transforming global STI landscape. This indirectly affects the effectiveness of the integrity systems (regulatory architecture and incentive system) in ensuring a dynamic and strong STI ecosystem.

Figure 1.11 illustrates the overall STI indicators and their impact on the economic progress, societal development and environmental sustainability of Malaysia. After a successful transition of the Malaysian economy from an agrarian to an industrial economy, Malaysia's STI ecosystem remained stagnant from 2010 to 2019, and only the economic impact experienced significant growth over this period.

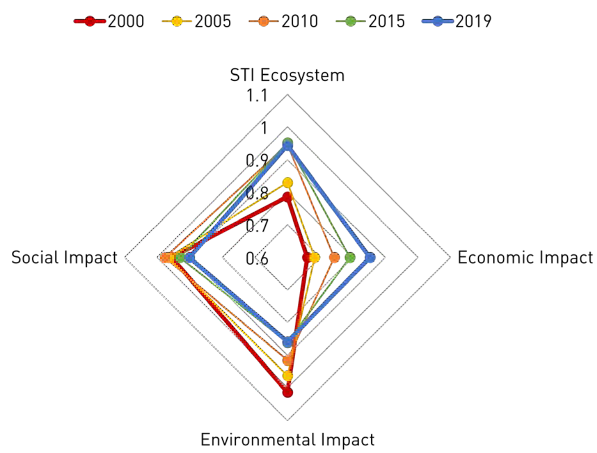
Social development and environmental sustainability declined over the years, with the environment suffering the most, indicating a lack of synchronicity between economic progress and these aspects of the country's growth.

Traditional developmental models enabled socio-economic progress at the expense of natural environmental resources. As Malaysia progresses towards a developed nation status, it must ensure that the nation's prosperity is built upon environmental considerations that are coupled with social equity and inclusion so that no one is left behind.



Analysed by Sunway University Research Team

Figure 1.10Malaysia's STI Ecosystem (using the 8i's model)



Analysed by Sunway University Research Team

Figure 1.11: Malaysia's STI Ecosystem and Its Economic, Societal and Environmental Impact

STI Governance in Malaysia

Numerous government institutions involved in the ideation, planning and implementation of STI-related policies and activities make up a large part of the STI ecosystem in Malaysia. Ministries and agencies carry out varying divergent policies, strategies, and frameworks which led to the fragmentation and inefficiencies in the use of resources. The ecosystem also suffers from duplication of efforts as many players share similar responsibilities, resulting in redundancies and lack of meaningful impact. This has been elucidated at length in the SO2015 and SO2017 reports.

Figure 1.12 illustrates the fluid nature of the highest authority that determines STI policies from 1973 to the present day. Without a central organising entity to coordinate the STI ecosystem effectively across all stakeholders, the economic priorities outlined in the various national development plans (Figure 1.13) failed to align with the RDC&I efforts. This led to wasted resources, duplicity of efforts, and diminished the potential impact of the various national development blueprints.

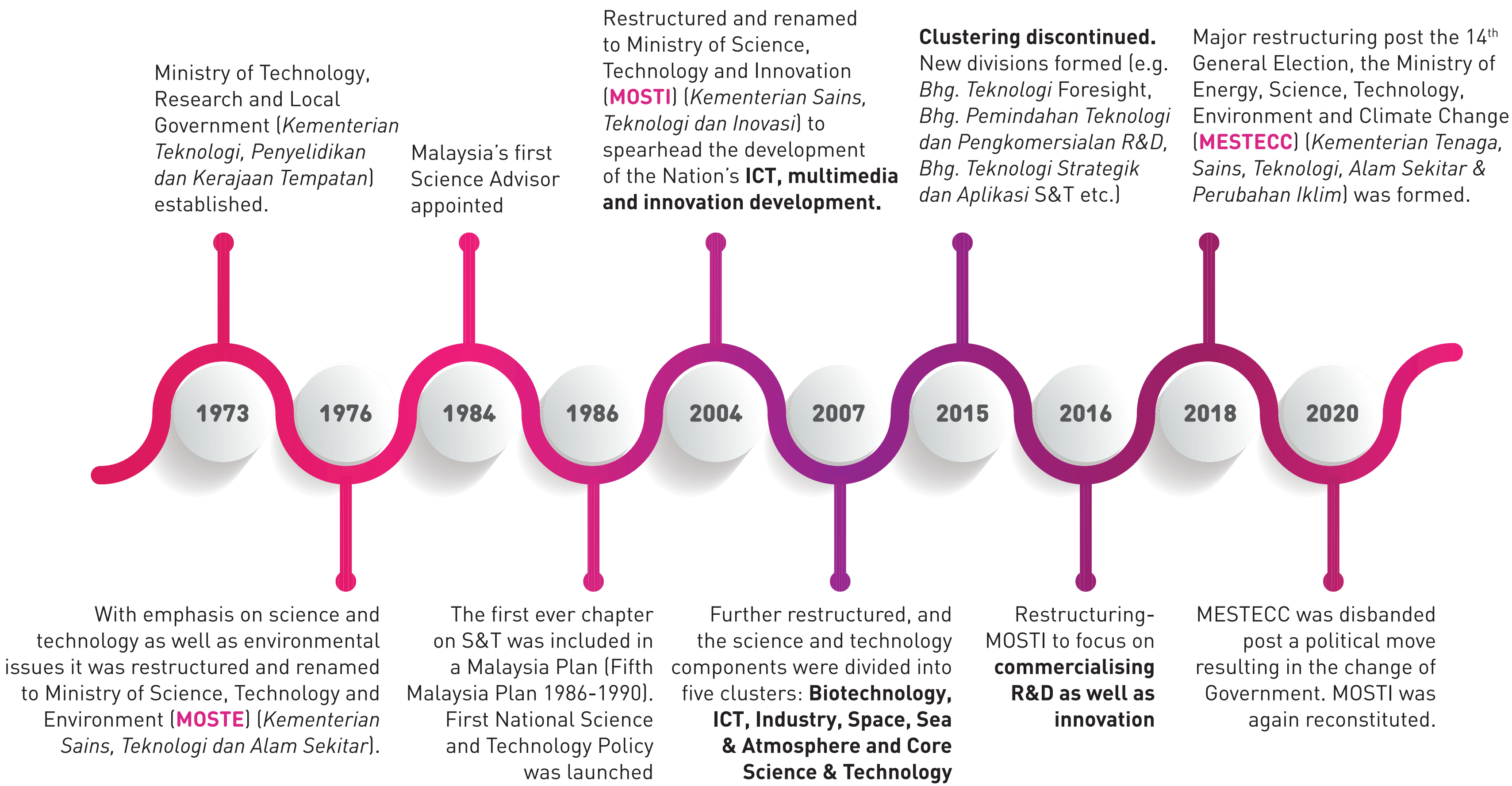


Figure 1.12: The Evolution of the Ministry with the STI portfolio in Malaysia

	1986 (1986-1990) **RMK 5**	**1991** (1991-1995) **RMK 6**	**1996** (1996-2000) **RMK 7**	**2001** (2001-2005) **RMK 8**	**2006** (2006-2010) **RMK 9**	**2011** (2011-2015) **RMK 10**	**2016** (2016-2020) **RMK 11**	**2021** (2021-2025) **RMK 12**	**2026** (2026-2030) **RMK 13**
Priorities in Malaysia Plan	• Agriculture • Industry • Medical • Selected strategic areas	• Agriculture • Industry • Medical • Selected strategic areas • Social	• Agro-industry • Construction • Energy • Environment • ICT • Manufacturing • Medical • Material & Geosciences • Science Engineering • Services • Socio-economic • Biotechnology • Photonics	• Manufacturing • Plant production & primary products • ICT • Health • Education & training • Optical technology • Speciality fine chemicals technology • Design • Software technology • Nanotechnology • Precision Engineering	• Biotechnology • Agriculture & agro-based • Manufacturing & related services • ICT • Financial services • Tourism • Human Capital • Health • Environment • Social	12 NKEA: • Oil and gas • Palm oil & related products • Financial services • Wholesale & retail • Tourism • ICT • Education • Electrical & electronics • Business services • Private healthcare • Agriculture • Greater KL	**Industry 3+2** • Electric & Electronics • Machinery & Equipments • Medical • Medical devices • Aerospace		
Science and Research Priorities	**1st National Science and Technology Policy (1986 - 1989)** • Advanced manufacturing • Advanced materials • Micro-electronics • Biotechnology • Information technology • Aerospace • Pharmacueticals	**Action Plan for Industrial Technology Development (1990 - 2001)** • Automated manufacturing • Advanced materials • Biotechnology • Electronics • Information technology		**2nd National Science and Technology Policy (2002 - 2010)** • Advanced manufacturing • Advanced materials • Micro-electronics • Biotechnology • Information & communication technology • Multimedia technology • Energy • Aerospace • Nanotechnology • Photonics • Pharmaceuticals		**National Science, Technology & Innovation Policy (2013 - 2020)** • Biodiversity • Cyber security • Energy security • Environment & climate change • Food security • Medical & healthcare • Plantation Crops & commodities • Transportation & urbanisation • Water security			

Figure 1.13: Priority Areas of the Various National Development Blueprints

Recognition of the value of STI priorities in planning for state development has led to an increasing number of STI-related portfolios in State Governments with nine states in the Peninsula now with STI-related Excos (Figure 1.14). Sabah has a dedicated ministry on STI which is the Ministry of Science, Technology and Innovation while Sarawak has a Ministry of Education, Science, and Technological Research.

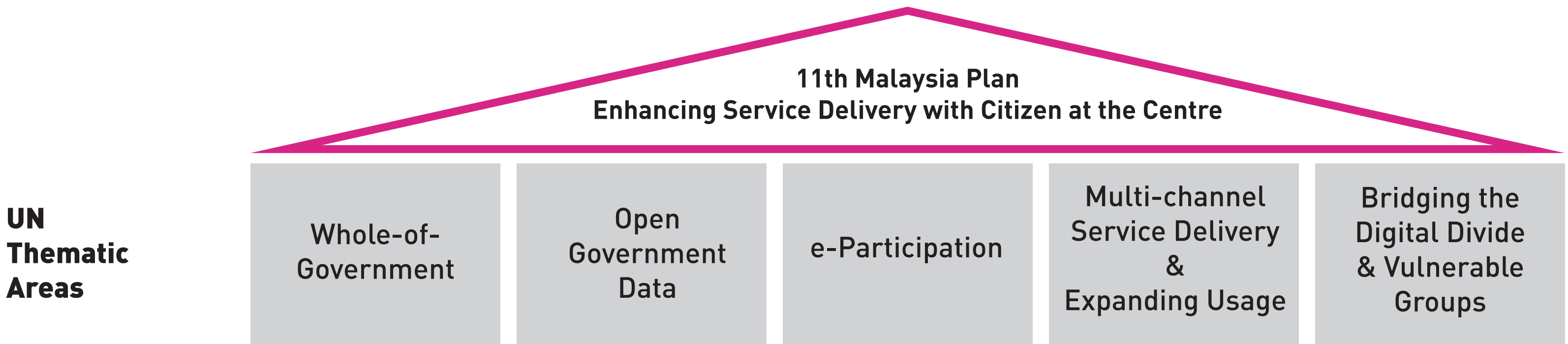
Coordination between federal and state authorities on STI matters is vital for Malaysia's STI ecosystem. The bulk of the resources lie with the federal agencies and ministries while on the ground STI-related activities are carried out by the state governments; hence, harmonisation of STI-policies by these major players would nurture the integration of business entities and other stakeholders in the STI ecosystem more effectively. At the moment, this lack of coherence in STI governance is a stumbling block in cultivating the STI ecosystem needed for successful knowledge economy to propel Malaysia to be an advanced economy by 2030.

As per SO2017	As of June 2021
Perlis Natural Resources and Environment; Science, Technology and Innovation; Information and Communication Technology Development (ICT), Corporate Communications Affairs & Public Complains; Special Duties	Education, Talent, Higher Education, Science, Technology and Innovation, Information and Communication Technology
Kedah Science, Innovation and Information Technology; Communication and High-Technology; Human Resources	Industry & Investment, **Science, Technology and Innovation**, Higher Education
Kelantan Agriculture, Biotechnology and Green Technology	Human Development, Education, Higher Education, **Science, Technology and Innovation**.
Penang State Economic Planning, Education & Human Resources, Science, Technology and Innovation	Human Capital Development, Education, **Science & Technology**
Perak Education; Science, Environment and Green Technology	Health, **Science**, Environment and Green Technology
Terengganu Exco Pendidikan, Sains, Teknologi dan Transformasi Kerajaan Negeri	No specific STI-related portfolio i)Tourism, Culture and **Digital Technology** ii) Infrastructure, Public Utilities and **Green Technology**
Pahang Health, Human Resources and State-related Special Tasks	**Science, Technology and Innovation**, Communication and Multimedia
Selangor Education; Human Capital Development; Science,Technology and Innovation	Enculturation of **Innovation** & Smart Selangor
Negeri Sembilan Education and Health	No specific STI-related portfolio
Melaka Education; Higher Education; Science and Technology; Green Technology and Innovation	Education, Higher Education, Technical & Vocational, and **Science and Innovation**
Johor Health and Environment; Education and Information	No specific STI-related portfolio
Sarawak Ministry of Education, Science and Technological Research	Ministry of Education, **Science and Technological Research**
Sabah Ministry of Resource Development and Information Technology Advancement * Science Advisor to Chief Minister of Sabah	Ministry of **Science, Technology and Innovation**

Figure 1.14: Expansion of STI Portfolios in State Governments

Is Malaysia on Track for Digital Transformation?
The speed at which knowledge is generated underscores the need to embrace knowledge and accelerate digital empowerment in order not to be left behind. This insight was the core of 9th Malaysia Plan (2006-2010) which highlighted knowledge intensive sectors, including information and communication technology (ICT), and biotechnology as new sources of wealth for the nation.

A digital-ready government is crucial to nurture knowledge economy, which is why the mid-term review of the 11th Malaysia Plan (2016-2020) had identified the various components needed to build a digital government operative model to better serve the people of Malaysia (Figure 1.15).



Reference: MAMPU (2017)

Figure 1.15: Malaysia's Digital Government Roadmap under the 11th Malaysia Plan

A digitally enabled government will provide integrated end-to-end online government services which are more efficient, effective and transparent. Malaysia in 2025 will advance to achieve the following targets for the *Rakyat*, businesses and the Government (EPU, 2021):

RAKYAT

- Creation of 500,000 new jobs
- 100% households with access to internet
- All students to have access to online learning

BUSINESS

- 30% uplift in productivity across all sectors by 2030
- 22.6% of digital economy to Malaysia's GDP
- 875,000 micro, small and medium enterprises (MSMEs) adopt eCommerce
- Attract 2 unicorns (home-grown or foreign)
- RM70 billion investment in digitalisation
- Increase the number of start-ups to 5,000

GOVERNMENT

- 100% civil servants to possess digital literacy
- 80% end-to-end online government services
- All ministries and agencies to provide cashless payment option in 2022
- 80% usage of cloud storage across the government in 2022

The country's performance in the E-government ranking has dropped 15 places from number 32 in 2010 to number 47 in 2020 (United Nations, 2021). Nonetheless, Malaysia is on track for the six dimensions of digital government framework outlined by the OECD, making significant progress in moving from an information-centred government to a data-driven public sector as well as proactive policy making and service delivery (OECD, 2018a).

Malaysia began mapping the national digital governance beginning with the inception of the Multimedia Super Corridor (MSC) in 1996. The desired end-state of the original MSC was to achieve exponential growth through state-of-the-art infrastructure in the Cyberjaya and MSC areas to attract world-class companies to collaborate with domestic companies to spur regional, if not global, champions that will take endogenous technology to the next level. However, none of the seven MSC flagship projects launched fully realised their potential due to fragmentation in the STI ecosystem (Figure 1.16).

MULTIMEDIA SUPER CORRIDOR

The Seven Flagships (1996)

1 ELECTRONIC GOVERNMENT — PARTIALLY ACHIEVED

Lead agency: **The Malaysian Administrative Modernisation and Management Planning Unit (MAMPU)**

To introduce multimedia technologies towards a **paperless administration.** Aim is to have a paperless Prime Minister's office by 2000. Eventually, most inter-departmental communications and interactions with the public will be conducted via electronic and multimedia channels, including card-based birth and marriage registration, and drivers licences.

Selected Ministries and departments will also be equipped with multimedia mobile offices, video-conferencing, digital archiving, shared databases, and digital signature facilities.

2 SMART SCHOOLS — NOT ACHIEVED

Lead agency: **Ministry of Education**

To ensure that **all of its schools have internet access within two years** as a way to rapidly enhance information technology (IT) literacy.

3 TELEMEDICINE — PARTIALLY ACHIEVED

Lead agency: **Ministry of Health**

The key elements of telemedicine planned include distance learning; remote consultation, diagnosis, and treatment; virtual patient records; and a national , **electronic medical network.**

The Selayang Hospital is the pilot hospital-uses Electronic Medical Records. MOH has requested for budget to test out at Hospital Seremban.

An R&D cluster of universities and companies focused on developing new applications to position Malaysia as a **centre of excellence in telemedicine has not materialised.**

4 R&D CLUSTER — PARTIALLY ACHIEVED

Lead agency: **Ministry of Science, Technology and Environment**

To be at the forefront of R&D next-generation multimedia technologies by developing **collaborative R&D centres between corporations and universities.** Multimedia University, to be the **catalyst in creating a research community** which will utilise MSC's unique environment to test new multimedia and IT applications.

5 NATIONAL MULTI-PURPOSE CARD — PARTIALLY ACHIEVED

Lead agency: **Bank Negara**

The MSC will be the testbed for a whole-first, **national multi-purpose card** that will be issued to all Malaysian citizens.

This smart card can serve as a national identity card, and "electronic purse" **a credit card, telephone card, club membership card, and will ultimately be used in all electronic transaction with the Government.**

6 BORDERLESS MARKETING CENTRE — PARTIALLY ACHIEVED — LOW VALUE-ADDED

Lead agency: **Multimedia Development Corporation (MDC, now Malaysia Digital Economy Corporation, MDEC)**

To serve as an excellent platform for companies' customer service operations, such as telemarketing, technical support, "backroom" data processing, and local customisation of marketing materials.

7 WORLDWIDE MANUFACTURING WEB — PARTIALLY ACHIEVED — LOW VALUE-ADDED

Lead agency: **Ministry of International Trade and Industry**

Companies to use the MSC to establish **regional hubs** for real-time control, monitoring, and delivery of operational support to their regional networks of design, manufacturing and distribution centres.

Using the MSC's low-cost, high-performance information and logistics networks, regional operations can be linked with operations across the globe 24 hours a day, 365 days a year.

Figure 1.16: Progression of the Seven Flagships of the MSC

The Global Connectivity Index (GCI) annually ranks 79 nations according to ICT investment, ICT maturity, and digital economic performance. Malaysia dropped by one spot between 2015 to 2020 while many other ASEAN countries have been improving.

As reflected in the fixed broadband average download in Figure 1.17, Malaysia must keep pace with advanced economies in ICT infrastructure to support its digital and knowledge economy aspirations.

Digital access in Malaysia has improved between 2013 to 2019, with the urban-rural gap narrowing significantly from 2017 onwards (Figure 1.18). The stability of the connection heavily favours the urban population, whilst the rural population has pockets with low to zero connectivity. This gap was magnified during the pandemic when all schooling was done online and a significant proportion of the workforce having to work from home. It is also a reflection of the income disparity with the more economically precarious household lacking not just connectivity but also the digital devices.

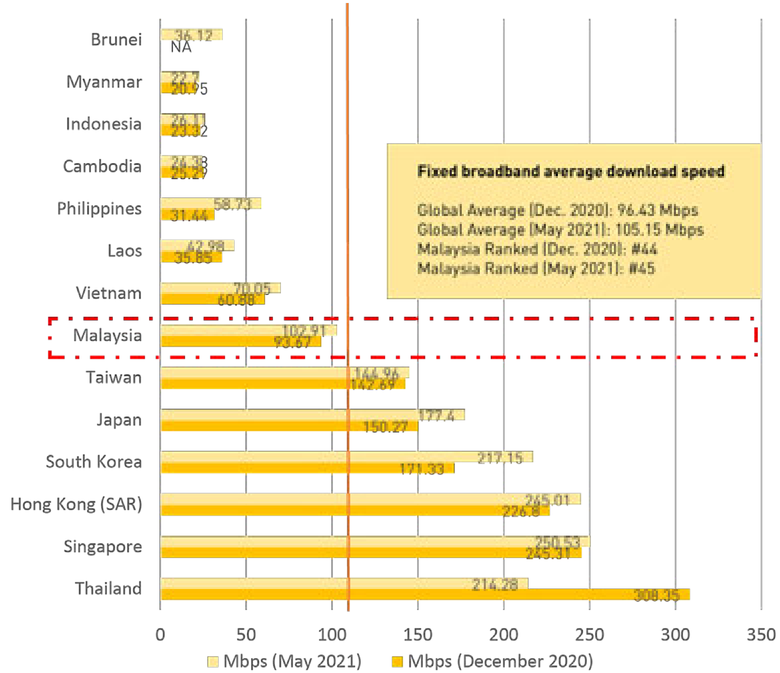


Figure 1.17: Fixed Broadband Average Download Speed of ASEAN and Selected Countries

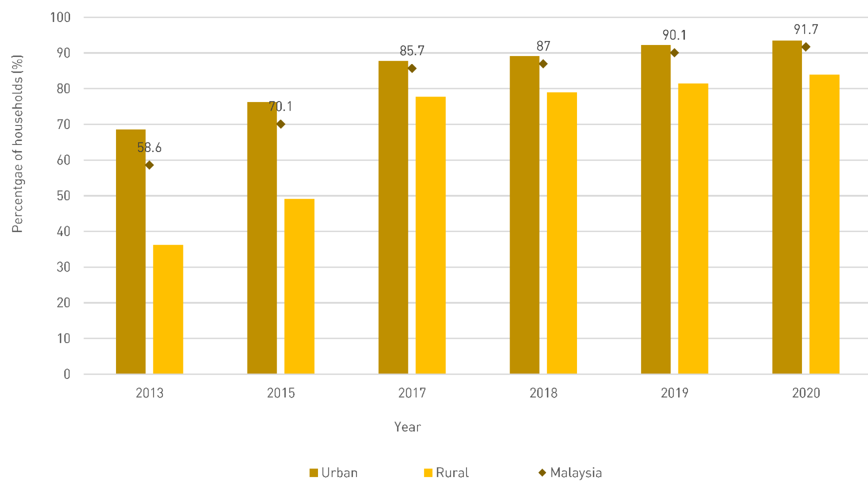


Figure 1.18: Percentage of Household Internet Access

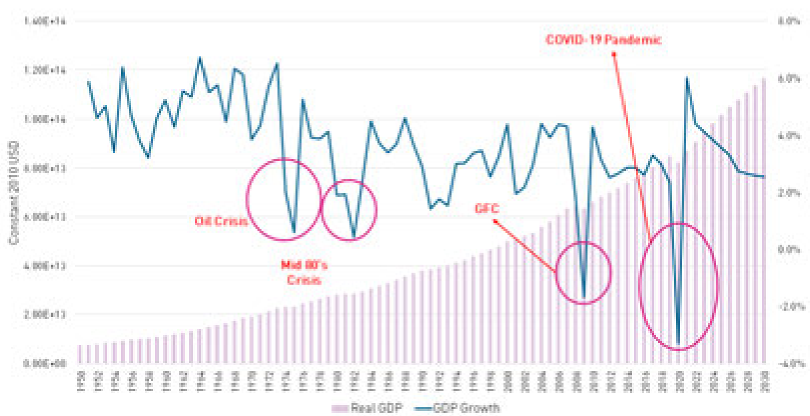
Building Resilience and Competitiveness

Malaysia, being part of the global economy, is susceptible to technological and financial shockwaves that strike the interconnected global economy. Historical and contemporary examples show the importance of cultivating a robust STI ecosystem with the dynamism to respond to these changes quickly and effectively. Beyond tech, globalisation means greater mobility of people, data, goods and services, and increase in trade across the globe. Such resilience can only arise from agile policies, plans and initiatives that support better growth trajectory.

As seen in Figure 1.19, the world economy has been growing steadily in the past 70 years. The volatility in global markets demonstrate that the impacts are no longer limited by the borders of a nation or a region; instead, the repercussions can be felt across the globe. Countries with lower economic resources tend to suffer more from these upheavals and take longer to recover from the damages to their economy. Moments of crises can open opportunities for countries that are prepared to explore and leverage different possibilities to ensure sustainable development, e.g., South Korea's economic progress after the Asian financial crisis in the late 1990s.

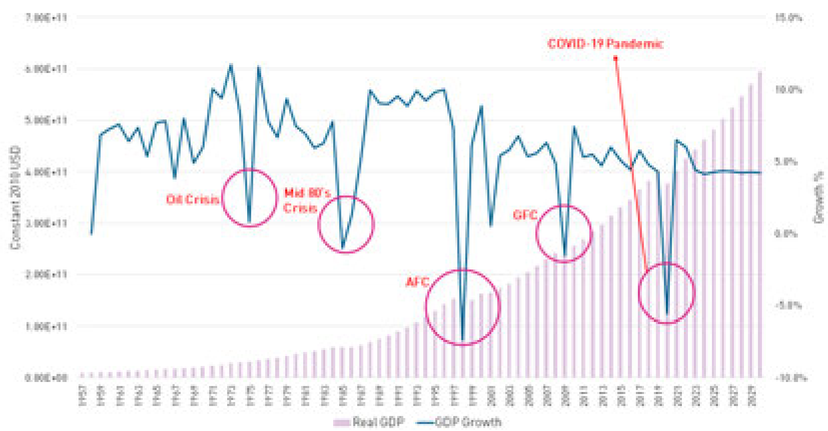
More recently, no continent has been spared of the COVID-19 pandemic which adversely impacted the global economic system, leading to contraction in growth across every region and countries. However, countries with more robust STI ecosystem were able to deal with the pandemic more effectively than countries with weak STI ecosystems.

Comparing Figure 1.20 with Figure 1.19, it is evident that Malaysia's economic growth patterns are similar to the rest of the world. This suggests that the Malaysian economy is inter-connected to the global markets.



Analysed by Sunway University Research Team

Figure 1.19: Trend in World's Real GDP against Economic Growth (1950 – 2030)

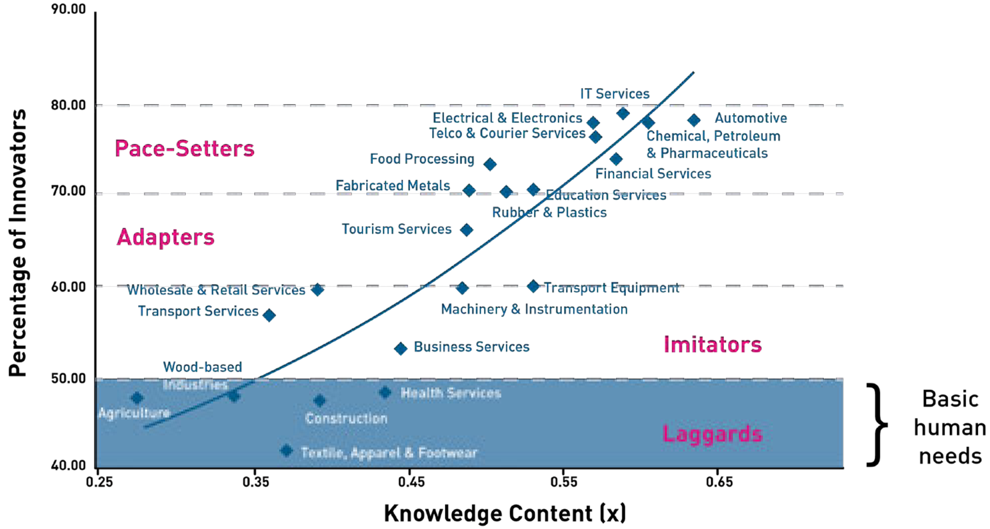


Analysed by Sunway University Research Team

Figure 1.20: Malaysia's GDP and Economic Growth (1957 – 2029)

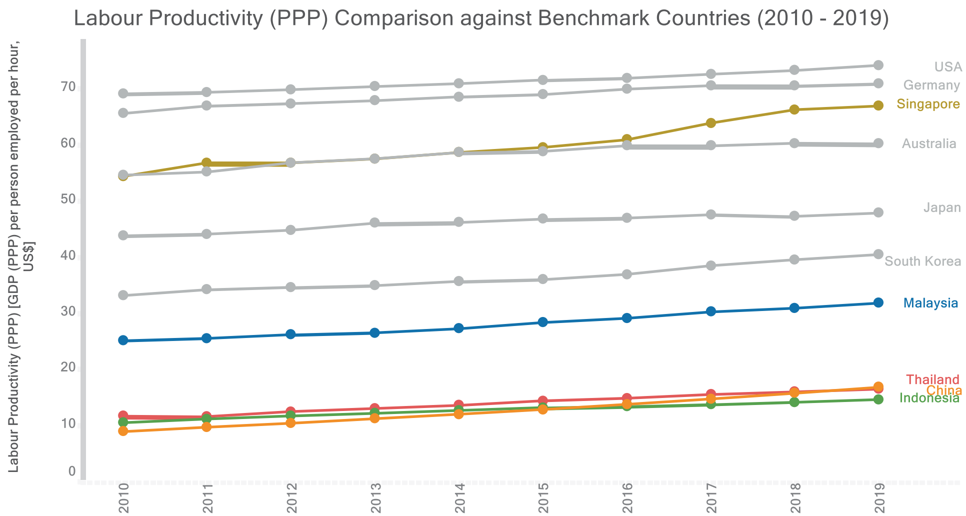
Figure 1.21 shows the state of Malaysia's industries based on knowledge content. Malaysia is a pace setter in certain industries such as IT services, electrical and electronic goods and petrochemicals.This shows that there are sectors where the STI ecosystem performs well. Unfortunately, the greater number of the nation's industries are adapters and imitators operating at a lower end of the global value chain. It is worrying how sectors related to basic human needs such as health services, construction, agriculture, and apparel remain laggards with little knowledge generation or innovation.

Looking at the overall productivity growth (Figure 1.22), Malaysia continues to lag advanced countries. The nation's inability to close the gap with other developed countries is a matter of concern, especially in upgrading their STI ecosystem. Most of Malaysian industries depend on low-skilled foreign workers and are content to remain as adapters or imitators in their sector. There is a need to transform the industry ecosystems to be more technology and innovation driven.



Reference: Adapted from EPU (2016)

Figure 1.21: Innovation-led Knowledge Content in Malaysia

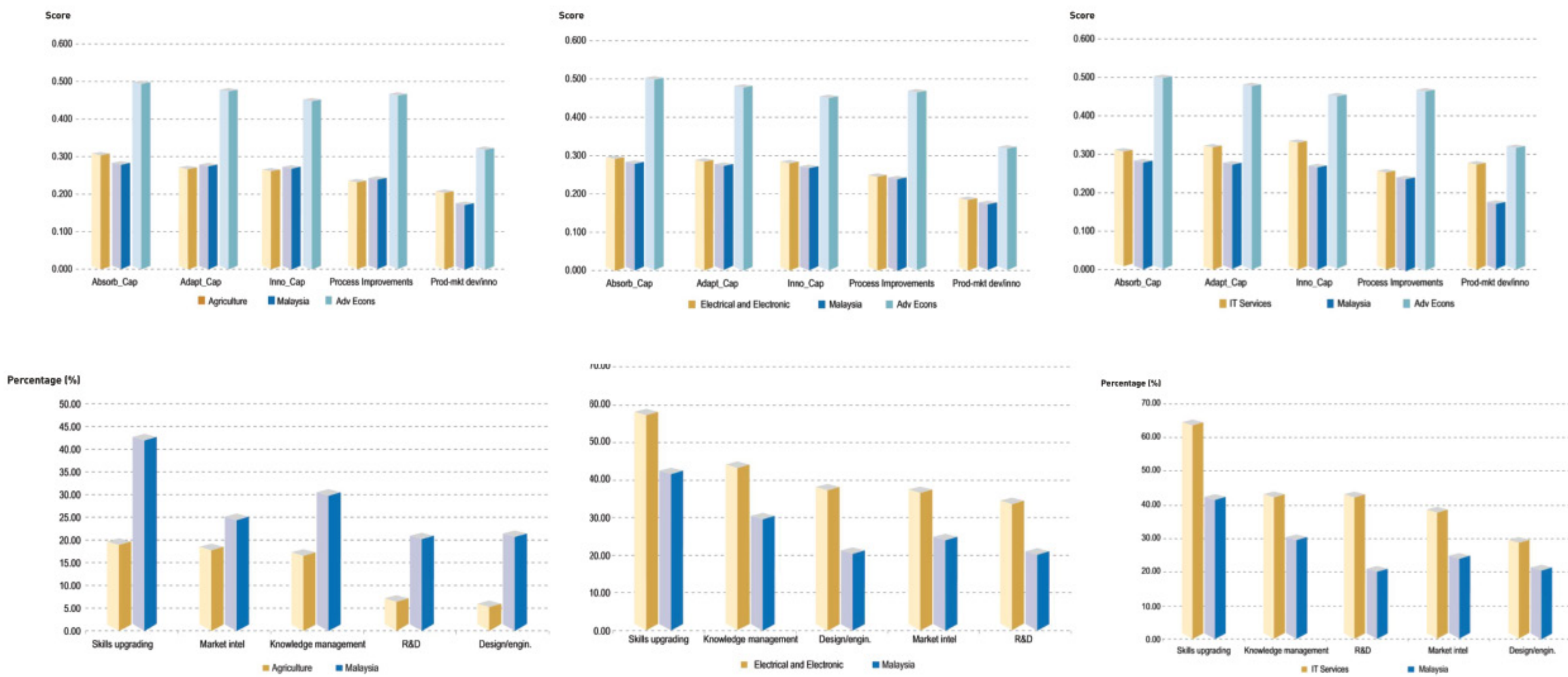


Analysed by Sunway University Research Team

Figure 1.22: Malaysia's Productivity Against Benchmark Countries (2010 – 2019)

Figure 1.23 shows how Malaysia has yet to catch up with advanced economies in terms of dynamic capability and knowledge intensive activities across three sectors. The agriculture industry is an example of the sector's inability to increase dynamic capabilities and knowledge intensity. Although the country did better in the electrical and electronics (E&E) as well as the information technology (IT) sector, more effort is needed to strengthen the STI ecosystem for these sectors in order for Malaysia to achieve the desired prosperity and sustainable growth outlined in SPV 2030.

There are three major gaps that led to the lack in dynamic capability and knowledge intensive activities across these industries, the first of which is the talent and skill gap. The agriculture industry is perceived as unattractive in terms of salary, career prospects, and societal perception of farming. In the E&E and IT sector, the skills gap arises from dynamic shifts taking place in the sector and the inability of the education and training institutions to keep pace with the changing needs of these industries as they transform.



Reference: EPU (2016a)

Figure 1.23: Dynamic Capability and Knowledge Intensive Activities of Three Key Sectors

The second gap is the competitiveness gap. Malaysian agriculture industry has been falling behind due to continued entrenchment of commodity products through traditional farming while the global agricultural industry has moved forward with strong levels of automation, adoption of emerging agricultural science, and digitalisation of farming to connect with global food supply chains. This is an example of competitiveness gap (or industry capability gap), which also affects the E&E and IT industries. The E&E sector has performed well in the low-value add back-end part of the E&E industry and has built the skills, capacity and capability in the back-end "packaging" part of the E&E over time. However, in the high-value front-end IT fabrication and design and development, the E&E sector are finding it difficult to stay competitive due to the level of investment needed and scale of operations needed due to the lack of technical skills and specialist scientific knowledge. The mismatch in the IT sector is a consequence of the rapidly evolving STI landscape that defines the IT industry's digital and emerging artificial intelligence (AI) evolution.

The third gap relates to market development and market positioning of local industries. For instance, the agriculture and ICT services industries are heavily dependent on the domestic market. Considering the small size of the domestic market, it is imperative for Malaysian firms to have robust access to and operate in international markets to avail themselves of the economies of scale and scope needed to build their competitive advantage. Despite strong progress, Malaysian industries have been unable to build strong global competitive advantage positions across the full spectrum of their industry operations; whatever global competitiveness has been attained to date happened in narrow niches.

The Government has made several attempts to catalyse industry using STI to spur growth. For instance, the Government's investment in biotechnology as an engine for growth through the BioValley in 2003, followed by Biotech Corporation in 2005 as well as the National Biotechnology Institutes to administer the implementation of the National Biotechnology Policy (Figure 1.24). Unfortunately, this initiative has been unable to achieve its full potential to contribute to the broader economy as compared to other countries that embarked on similar biotechnology initiatives. One of the problems was the lack of focus on niche areas where Malaysia has competitive and comparative advantage, and secondly the investments were thinly spread across many initiatives.

The evidence points to a national STI ecosystem which is more suited for a production-based economy rather than a knowledge-based economy. The challenges faced by the biotechnology sector in Malaysia (Figure 1.25) are also seen across other STI-related industries.

Malaysia has been losing its competitive edge to regional economies with relatively cheaper labour and larger markets. To move up the value chain, Malaysia needs to invest in its STI ecosystem to enhance dynamic capabilitiesand total productivity. As part of this plan, investments should be intensified to nurture homegrown technologies that spur innovation and transform Malaysia into a competitive knowledge-based economy.

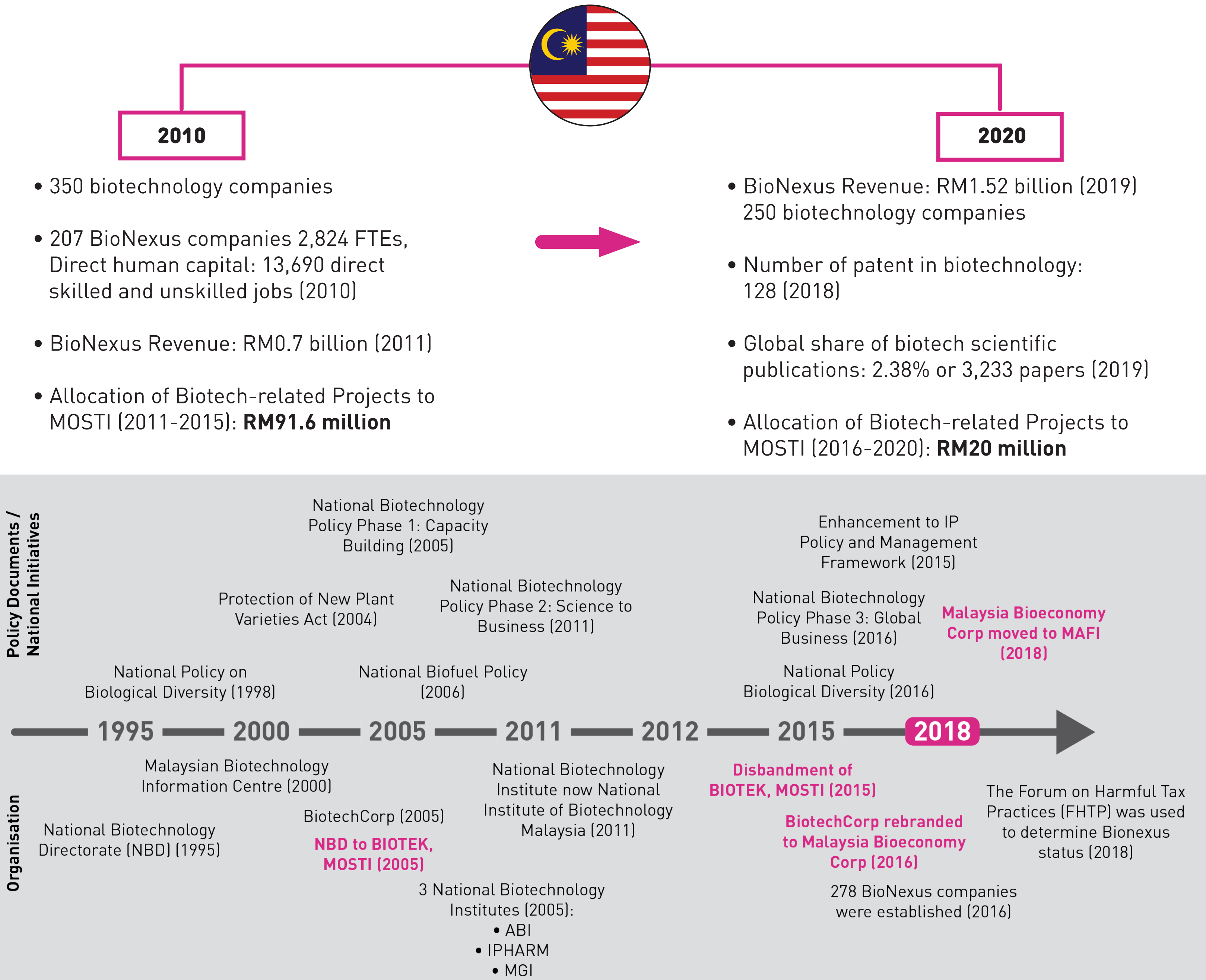


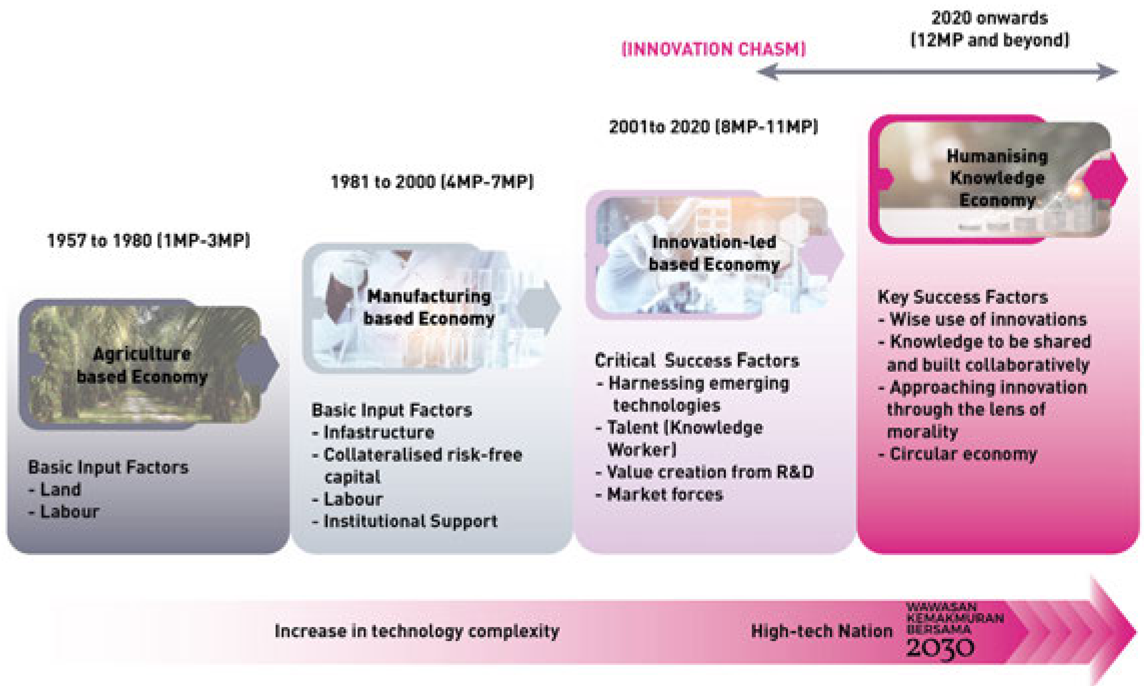
Figure 1.24: Biotechnology as an Industry in Malaysia

Humanising Growth for Sustainable Progress

History has shown that human progress is often built on knowledge creation and its application. This process has been accelerated over the past three centuries, culminating in the birth of information and communication technology (ICT) which has transformed every facet of human life. Increasing knowledge diffusion has a positive impact on socioeconomic development of societiesacross the globe, intensifying the pace of globalisation through the formation of global knowledge networks and supply chains. This has led to greater homogeneity in the economic and social systems across the globe.

The increasing convergence in STI elements has led to convergence in economic, social and environment and other global systems which poses challenges to many countries. Advanced countries with stronger STI ecosystems are in a better position to benefit from this convergence and set the tone for global developmental agenda. Countries that lag in the STI development are becoming increasing dependent on countries that are leading the agenda.

The national developmental policies were designed with adaptations for the evolving international economy and increasing technological complexity that spurs globalisation (Figure 1.25). Analyses of major development policies that emphasised on tangible economic gains demonstrated that such measures are not only unsustainable, but also adversely affect societal and environmental well-being which underscores the need for national policies to be people-centric rather than GDP-oriented alone.



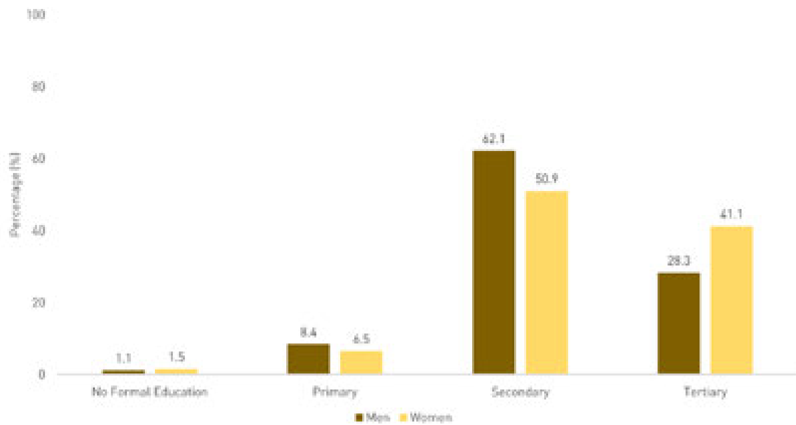
Reference: Adapted from ASM, (2017)

Figure 1.25: The Changing Global Economy and Malaysia

Humanising the knowledge economy is an attempt to reduce support for unfeasible economic activities through STI to balance socio-economic development and socio-environment sustainability. This requires talent capable of dealing with the knowledge paradigm catalysing globalisation (Figure 1.26) to strengthen Malaysia's resilience and capacity against cataclysms – such as the COVID-19 pandemic and world market instability – that threaten the nation's progress.

Figure 1.26: Knowledge Paradigms for the 21st Century Economy

Malaysia's education system has made tremendous progress in laying the foundation for the country's talent, based on the overall literacy rate improvement from 82.9% in 1991 to 94.9% in 2018 (World Bank, 2021). Most of the population attained at least secondary school qualification (Figure 1.27). Unlike many other countries, there are more women obtaining tertiary education than men in Malaysia, indicating fewer gender-based barriers for young girls and women in education. Unfortunately, women still face barriers in the workplace with many of these qualified talents leaving the workforce to raise their families. This is a significant loss to the productive capacity of the economy during prime reproductive age to raise
their family.



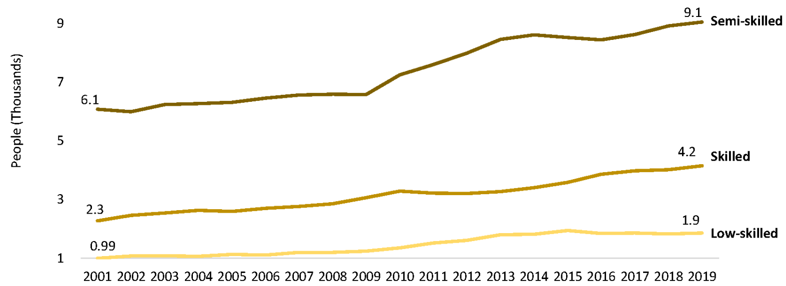


Figure 1.27: Employed Malaysian by Educational Attainment based on Gender, 2019

Figure 1.28: Employed Person by Occupation Sector (2001-2019)

Most of the nation's employment is in the semi-skilled category (Figure 1.29), suggesting that Malaysian industries are engaged in the mid to low end of the global value chain. This is impairing Malaysia's competitiveness and resulting in nation being caught in the middle-income trap.

Comparison of Malaysia's talent growth per the Global Innovation Index Report in 2016 and 2020 indicated that the nation is performing poorly in knowledge workers preparedness despite improvement in tertiary education attainment and knowledge absorption (Figure 1.29). This is also another indicator that the industry's capacity for innovating up the value chain is below par.

Malaysia is lagging behind other developed countries in translating knowledge into innovation and wealth due to the Malaysian industry's dependence on low-skilled foreign labour, mismatch in skill sets as well as education attainment levels. Most Malaysian firms have strong absorptive capabilities but lag advanced countries in adaptive and innovative capabilities (Figure 1.30). Inculcating an STI ecosystem that helps the industry to expand their dynamic capabilities, in particular building strong adaptive and innovative capability, including nurturing a knowledge sharing and risk-taking entrepreneurial culture are crucial aspects for Malaysia to become a developed high-income nation.

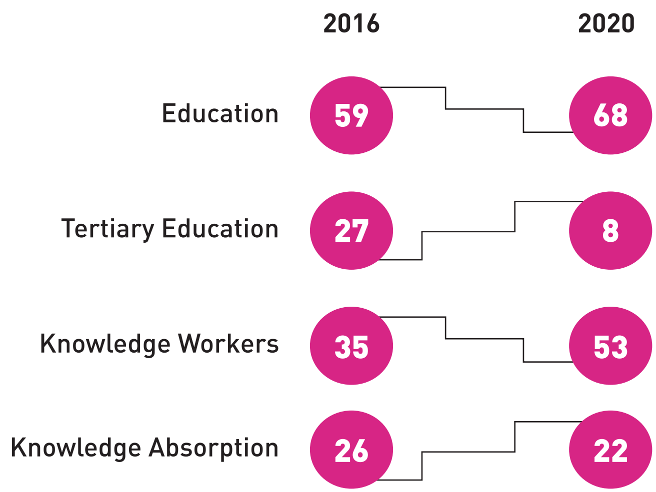
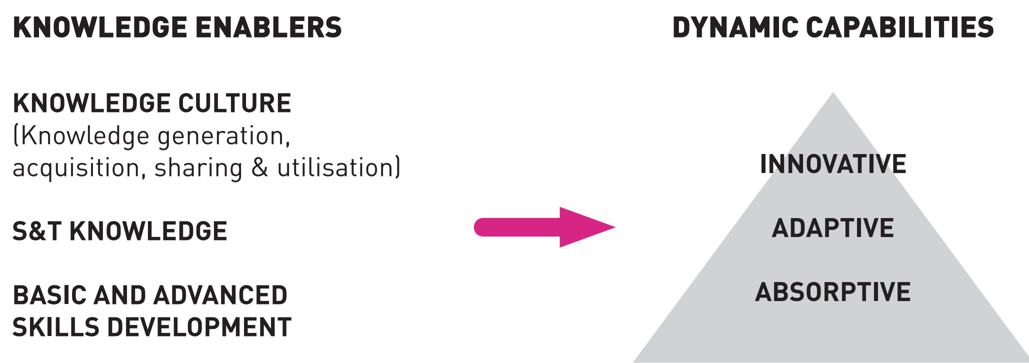


Figure 1.29: Malaysia's Talent Capital Progress in the Global Innovation Index Report



Reference: Adapted from EPU, (2016)

Figure 1.30: Dynamic Capabilities of Malaysian Industry

Malaysia has grown into an upper middle-income country with vastly improved human development indicators, attaining Gross National Income (GNI) per capita of USD11,230 in 2019. Malaysia is likely to transition from an upper-middle income economy to a high-income economy in the next few years if Malaysia is able to strengthen its STI ecosystem.

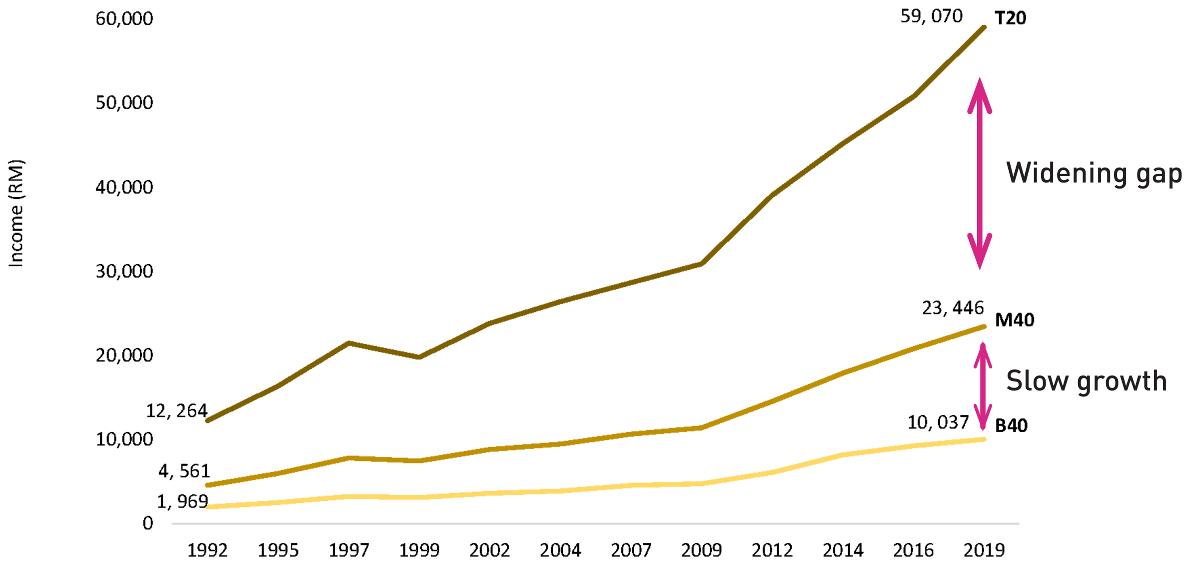


Figure 1.31: Mean Household Income based on Household Group

There have been many national development initiatives to close the income disparities in the country, and some of the initiatives have been successful in addressing the development challenges. However, rapid transformation of the Malaysian economy towards a more knowledge driven economic structure and slowness in many of the enablers of the STI ecosystem has increased the knowledge and income gaps among the different segments of the population in the country (Figure 1.31). The sluggish wage growth affects socio-economic mobility of those from the lower socio-economic tier; about half of Malaysian workers, or 4.4 million people are B40, who earn RM2,160 or less a month (BNM, 2019). The national mean poverty line income for households in Malaysia in 2019 is RM2,208 per month (with RM1,169 for food and RM1,038 for non-food items) (DOSM, 2020). When this was contrasted against the median house prices in Malaysia – which was four times the annual median household income in 2019 – house ownership is becoming out of reach for many sections of the society.

The B40s are plagued with physical and mental health issues, made worse by the pressure of surviving on stagnant wages while the cost of living continues to rise. The urban poor were further burdened during the COVID-19 pandemic with the movement control orders (MCOs) diminishing their precarious income with little to no social safety net.

1 in **2 adults** in Malaysia are overweight or obese (NHMS, 2019).

20.7%

of children under five are stunted

11.5%

suffer from wasting

(UNICEF, 2019a)

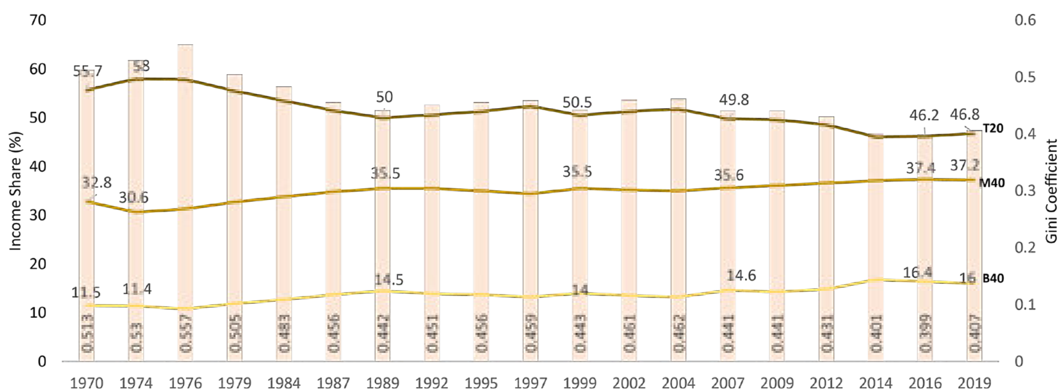
Access to vegetables and fruits among urban poor are decreasing on average. Malaysians' consumption of these food items has not reached the recommended minimum requirement of 200 to 250g per day.

1 in **4 Malaysians** turn to less nutritious food due to poverty.

1 in **5 Malaysian** households could not afford to feed their children a variety of foods (UNICEF, 2018; Ahmad et al., 2020).

The National Health and Morbidity Survey (NHMS) 2019 reported that one in three Malaysians experience mental health problems and roughly half a million adults suffer from depression in the country. Prevalence of mental health issues in Malaysia has tripled from 10.7% in 1996 to 29.2% or 4.2 million people in 2016. However, the stigma afflicting mental health issues as well as insufficient talent capital is making is harder to address this issue; the ratio of psychiatrist to 100,000 population is 1 (10 times less than the recommendation made by WHO of one psychiatrist per 10,000 population) and in 2018, only 15 clinical psychologists were employed in the public health service sector (Chua, 2020). As financial hardship arising from the pandemic drives more Malaysians to seek public healthcare service, the service delivery is expected to be adversely affected as insufficient resources are available in the face of greater demand.

The inequitable wealth distribution over the last few years shows a concerning trend in the country which is reflected in the increase in the Gini coefficient from 0.399 in 2016 to 0.407 in 2019. to (Figure 1.32). Under the mid-term review of the 11th Malaysia Plan, efforts were put forth to raise the B40 households into the middle-class community from 16.8% in 2014 to 20% by 2020. However, the numberof B40 households that transition to M40 declined from 16.4% in 2016 to 16% in 2019. This troubling trend was recently reported by DOSM and Ganeshwaran (2021) that 600,000 M40 households, or at least 8% of Malaysian households, have slipped into the B40 segment of the population due to the pandemic.



Reference: Adapted from DOSM, (2020)

Figure 1.32 : Gini Coefficient of Various Malaysian Households

The Human Capital Index (HCI) – which measures the amount of human capital that a child born today can expect to attain by age 18 – score for Malaysia is 0.611, indicating that the future earnings potential of children born today will be 61% of what they could have been with complete education and full health. This score is expected to be diminished by the impact of the global pandemic on the quality of children's education as well as other socio-economic stressors arising from it.

Malaysia's performance is relatively poor in comparison to advanced economies (Figure 1.33), which suggests the present national education and health policies are weak in building the HCI of Malaysian youths. Both sectors receive among the highest funding from the national budget, which may imply the need to review policy implementation to optimise expenditure and maximise outcome for the children.

The COVID-19 pandemic has given rise to many examples illustrating the unpreparedness of the STI ecosystem to deal with unanticipated shocks to the healthcare system, industrial structures and social well-being of society. The lack of a coordinated approach across multiple agencies and institutions worsened the spread of COVID-19 and prolonged enforcement of the MCOs. This imposed significant burden on the healthcare system and hampered economic recovery.

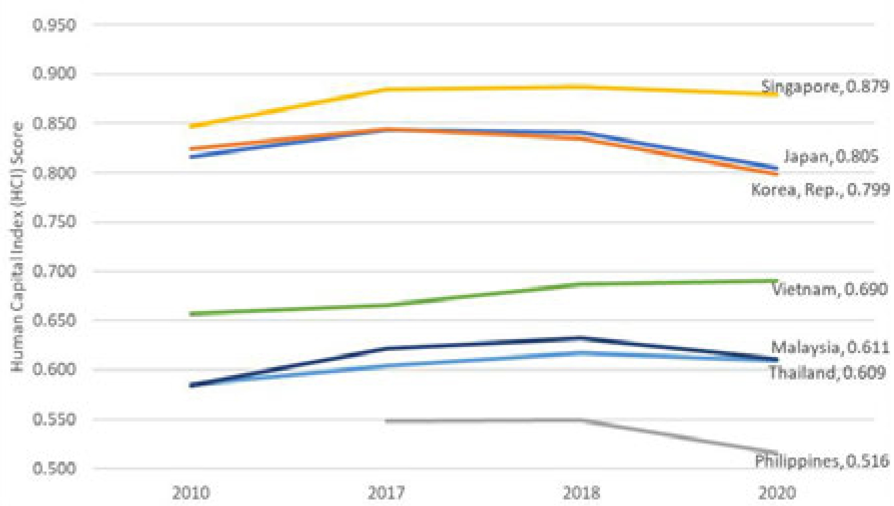


Figure 1.33: Human Capital Index Comparison Against Selected Countries

A vital strategy to ensure economic recovery and strengthenthe healthcare system to address COVID-19 and future pandemics will require the development of a dynamic, agile and responsive STI ecosystem. This would entail developing a comprehensive competency framework aligned to socio-economic sectors of the country. Conducting Foresighting exercise to match Malaysian global STI trends would be invaluable in linking talent with industry, corporate R&D labs, public administration, technology enterprises, spin-off companies, and academia. All these efforts would require periodic evaluation and impact monitoring to ensure optimal resource management for favourable outcomes.

Understanding the cause, effects, and best interventions to fix societal ailments requires long-term investment and planning. This is where a longitudinal study that links different social, economic, and environmental factors driving health outcomes to formulate long-term health policies comes in. Information from these analyses will help shift the healthcare system to preventive care rather than treatment and thereby lower the burden on the national healthcare system.

The study can feed into a comprehensive registry with end-to-end data collection and monitoring of health status through multifaceted policies using the Whole-of-Government (WOG) and Whole-of-Society (WOS) approach. The intersection of this exercise with socioeconomic disparity data can be used to develop cross-cutting measures to reduce inequities suffered by Malaysians to promote upward mobility through social cohesion and economic stability.

Holistic evaluation of the nation's progress is not just about the people and the economy, but also the natural capital of the country. Like many other countries, Malaysia's natural assets have bankrolled the socio-economic growth of the nation, at the expense of the natural resources and environment. Unfortunately, the STI advances that have fuelled the economic progress are not in step with environmental protection and conservation efforts (see Figure 1.11).

The nation's natural assets – from water catchment network, tropical rainforest, peat swamp forest, wetlands, mountains and hills of granite and limestone, to the rivers, lakes, and sea – have diminished as a consequence of supporting Malaysia's economic progress. The number of forested areas slowly declined from 1990 to 2018, particularly the peat swamp forest which halved within that period. The loss of carbon sinks from massive deforestation of tropical peat swamp forest worsens Malaysia's GHG emission, affects the nation's mega-biodiversity as well as impairs Malaysia's climate change adaptation.

Figure 1.34 shows the fluctuation of Malaysia's performance in the Environmental Performance Index (EPI) by the Yale Center for Environmental Law and Policy. The only significant progress was in the climate change index but the country's performance declined across other parameters, scoring below 50 in vital spheres such as pollution emissions, forestry, water, and fisheries. These are red flags that need to be addressed for the country to flourish in a sustainable manner and ensuring that the natural assets are conserved for future generations.

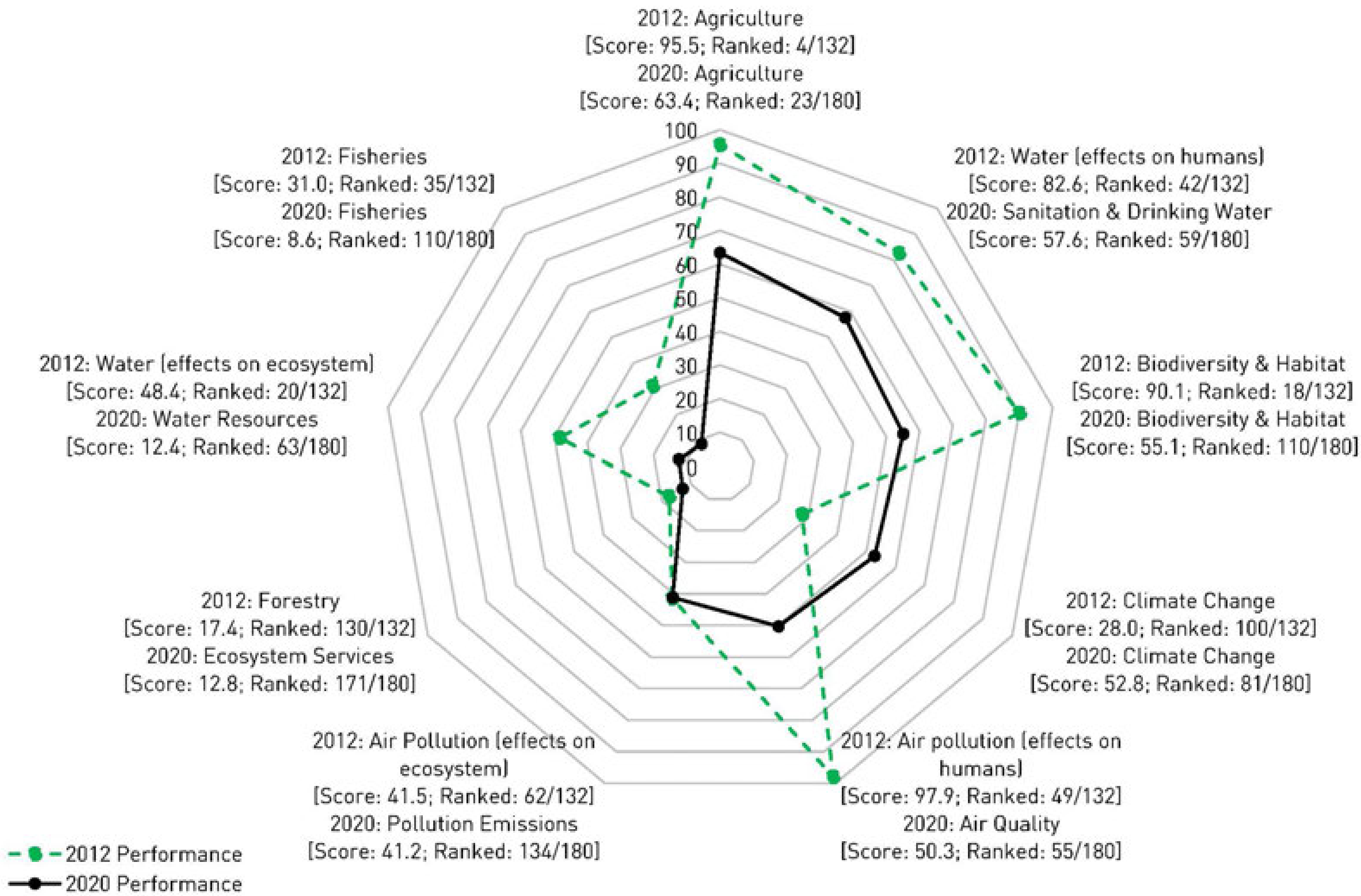


Figure 1.34: Malaysia's Performance in EPI 2012 and 2020

Urbanisation, population expansion, and intensification of economic activities place greater pressure on the need for sustainable water supply. The lackadaisical attitude towards water conservation by the public and private sector, as well as the general population contributed to Malaysia's poor result in the water index. The nation's water availability is threatened by damage to water catchment areas, diminishing peat swamp forests, river pollution, as well as poor sewage management.

Air pollution is very costly on many fronts from escalating health care cost, productivity loss, economic setbacks, diminishing natural capital, as well as increasing environmental stress. Malaysia's ambient air quality from 2000 to 2019 indicated pollution level above WHO's air quality guideline, added to the series of severe haze from uncontrolled fires from neighbouring countries as well as local peat fires. Concerted efforts to reduce greenhouse gas emissions have the benefit of improving air quality and should be made a national priority.

Malaysia has yet to fully embrace renewable energy on a scale needed to fulfil the international environment treaties that the Government has signed. The country's economic growth has been largely fuelled by its energy sector and electricity generation is still heavily reliant on fossil fuels, a huge contributor of Malaysia's greenhouse gasses (GHG) emission. The move towards renewable energy needs a comprehensive mechanism for assessing and improving electricity network connections, use, pricing, and renewable energy integration mechanisms. The Government needs to harmonise existing energy-related STI initiatives with the Green Technology Master Plan and improve energy governance in the country.

Integrated waste and resource management is vital to ensure the sustainability and equitability of Malaysia's transition into a high-income nation. The country's solidwaste has increased almost 98% over the past 17 years attributed to population increase, urbanisation, and massive industrialisation. Local solid waste management is still inefficient due to inadequate waste facilities and lack of funding and expert human capital, presenting a danger to Malaysia's natural asset through ground and water pollution as well as GHG emissions.

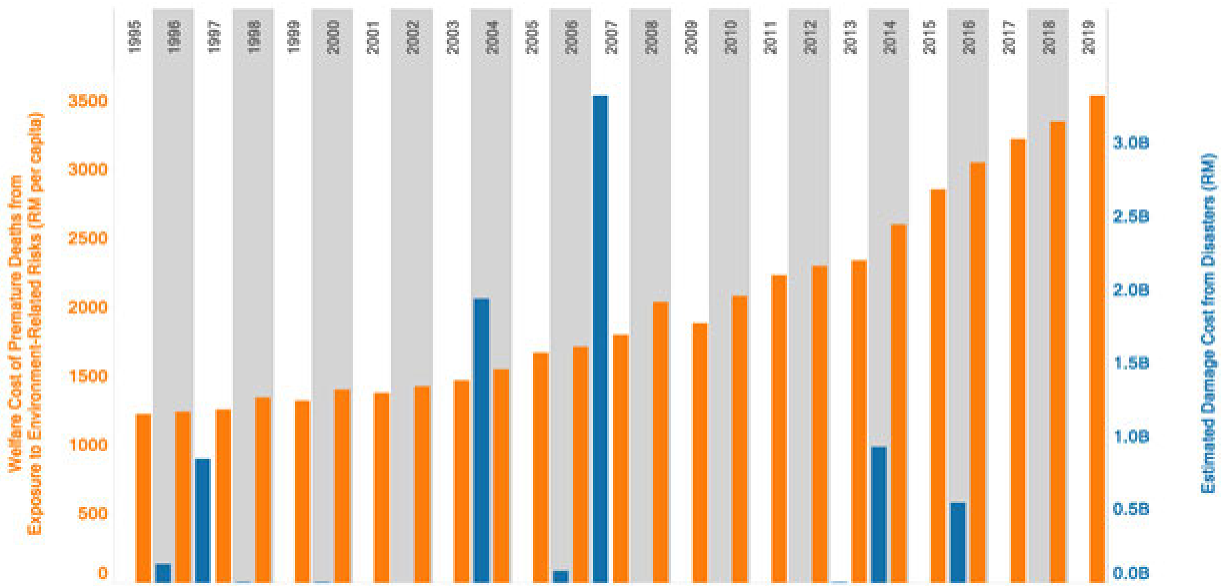
Resources can be utilised more effectively through refurbishment, remanufacturing, and recycling in a zero-waste circular economy (CE). CE technologies can generate energy, reduce GHG emission, and minimise the release of environmental toxins while also extracting nutrient from organic wastes to reduce dependency on artificial fertiliser. Sourcing of raw material for industry can also be reduced through material recovery and recycling, which is better for the environment as well as prolonging their lifecycle and stabilising the supply chain.

Ecosystem and biodiversity loss are a danger to the national food supply and not just to the sustainability of Malaysia's natural capital. Restoration of these losses should be prioritised as it not only affects the quality and sustainability of life for the *Rakyat*, but also can be a stumbling block in trade negotiations with countries that employ non-tariff barriers to their markets. The international market, particularly those from advanced economies, have begun denying the entry of products deemed to be from unsustainable sources. Increasing the renewable energy share in Malaysia's energy pie will not only help the country manage its resources better for future generations while conserving the environment, but it will also neutralise possible objection from economies with protectionist policies.

In short, any threat to the environment is a threat to the population. Figure 1.35 illustrates the escalating financial impact of environment-related issues on the *Rakyat*. Main disaster damage for Malaysia includes landslides, forest fires, tropical cyclones, floods and diseases such as cholera and dengue. About 75% of disaster damage in Malaysia results from flood-related disaster. For full list of disaster classifications, see Centre for Research on the Epidemiology of Disasters (CRED), 2009.

Over the last 24 years, Malaysia has cumulatively lost an estimated RM7.8 billion to environment-related disasters which does not include an estimated RM947.2 billion to welfare cost of environment-related premature deaths. That is an average loss of RM39.8 billion per year due to environment-related causes, which amounts to about 3% GDP loss in 2019 and 2020.

Climate change has intensified the rainfall and flooding threat in Malaysia, which also has a knock-on effect on water quality and availability. The average cost from annual flood damage was estimated to be around RM100 million in the 1980's, increasing almost ten-fold to RM915 million in the early 2000s. Urbanisation, extensive logging, deforestation of peat swamp forests as well as reclamation of mangroves are all contributing factors of the record-breaking floods in the past 30 years. Malaysia's cumulative sea level rise rate were almost double the global rate of 2-3mm per year, making the country vulnerable to the threat of rising sea-level driven by climate change.



Analysed by Sunway University Research Team

Figure 1.35: Estimated Cost of Environment-related Issues in Malaysia

The fragmentation of resources and authority over environmental protection and conservation is making it hard to ensure the sustainability of Malaysia's growth. Figure 1.36 shows the administration of environmental issues under the past six Malaysia Plans; the lack of a dedicated ministry for the environment led to a lack of political will to implement evidence-based policies that align nature's conservation with the country's progress.

Environmental protection and conservation need stronger institutional capacity and collaboration at Federal and State levels. For example, the proposed Malaysia Federal-State Commission for The Environment (MyFSCE) with the support of respective State River Basin Authorities (RBA) or Inter-State River Basin Authorities (I-SRBAs) and various state environment enforcement agencies to monitor and enforce environment protection.

Environmental credits for growth have been proposed to be a mechanism for mainstreaming natural assets management to increase terrestrial and marine protected areas up to 30% beyond the present; such measures need a cohesive Whole-of-Government and Whole-of-Society approach across Federal and State authorities as well as other private and non-profit partners. Compliance monitoring and enforcement across all the relevant agencies requires investment in monitoring technology as well as a robust data management and sharing framework in the form of a national digital ledger. Another advantage of setting up a national digital ledger in systematic and secure data gathering and sharing across all arms of the Government to strengthen policy administration for a better outcome for the people.

6th MP (1990 -1995)	7th MP (1996 - 2000)	8th MP (2001 - 2005)	9th MP (2006 - 2010)	10th MP (2011 - 2015)	11th MP (2016 - 2020)
Ministry of Science, Technology and Environment	Ministry of Science, Technology and Environment	Ministry of Science, Technology and Environment	Ministry of Science, Technology and Innovation	Ministry of Science, Technology and Innovation	Ministry of Science, Technology and Innovation
			Ministry of Natural Resources and Environment	Ministry of Natural Resources and Environment	Ministry of Environment and Water
Ministry of Energy, Telecommunications and Posts	Ministry of Energy, Communications and Multimedia	Ministry of Energy, Telecommunications and Posts	Ministry of Energy, Water and Communications	Ministry of Energy, Green Technology and Water	Ministry of Energy and Natural Resources

Figure 1.36: The Environment Portfolio Throughout Six Malaysia Plans (1990-2020)

Unlocking the Future

In the 1990s, Malaysia was known as a robust Asian Tiger economy underpinned by a strong manufacturing and service sectors. However, over the years, increasing competition from larger regional economies has eroded Malaysia's competitiveness. At the same time, the failure to protect the environment and biodiversity has adversely impacted the environment which has a knock-on effect on the quality of life of the Rakyat. This necessitates the decisive action at the highest levels to ensure the nation's progress towards equitable, inclusive and sustainable growth.

There are a number of gaps in Malaysia's STI ecosystem that prevents the fulfilment of the STI initiatives to move the nation to become an innovation- and knowledge-driven economy, one of which is the lack of alignment between the numerous STI initiatives with the socio-economic and environmental development of the country. Malaysia needs a focused approach in setting the STI priorities and direction across multiple agencies and economic sectors. The governance for STI and socio-economic development must be transparent with appropriate accountability and coordination between the Federal and State authorities.

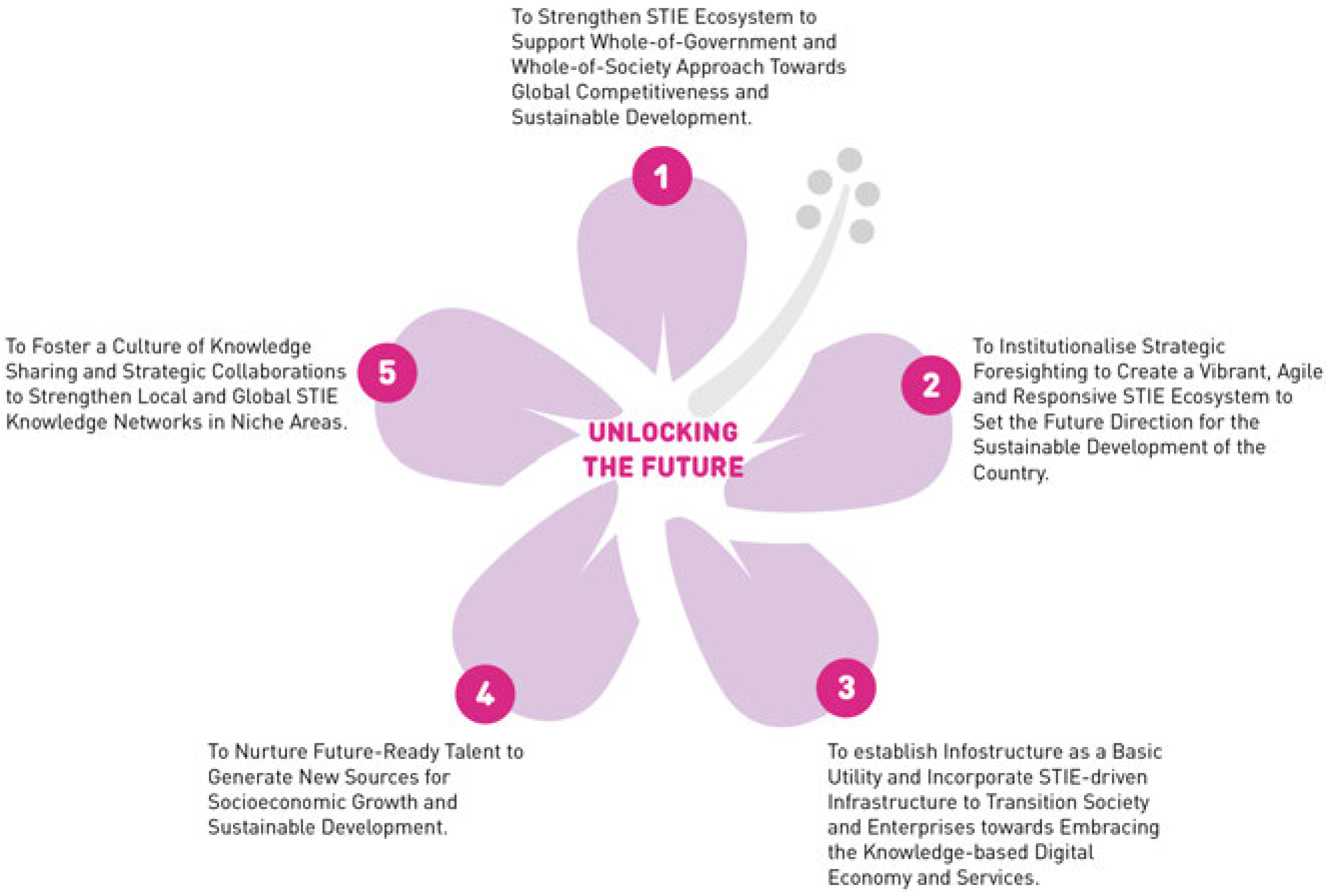


Figure 1.37: Recommendations for Science Outlook 2020

RECOMMENDATION 1

To Strengthen STIE Ecosystem to Support Whole-of-Government and Whole-of-Society Approach Towards Global Competitiveness and Sustainable Development.

There is no clear institutional champion to provide direction, monitor, evaluate, track impact, and put in place a continuousimprovement cycle to the national STIE ecosystem. The absence of a champion results in fragmented policy directives leading to ineffective and time-consuming implementation of strategies, programmes and initiatives. Currently, there are too many institutions with overlapping roles and responsibilities, resulting in ineffective utilisation of limited resources. Additionally, unfocussed fiscal and non-fiscal incentives fail to target core sectors of the economy due to constant policy changes, coupled with inconsistent funding for large scale and long-term STI initiatives.

The STIE ecosystem management should be strengthened, streamlined and transformed through a WOG and WOS approach to ensure formulation and implementation of evidence based STIE policies. This will require the Government to implement seamless planning, coordination, and monitoring of STIE-related issues by nurturing a high level of transparency and integration of interdependency across ministries and agencies with different portfolios and jurisdictions. Collaboration with civil society organisation, by including them at the decision-making level of STIEwould enhance the process of engagement and buy-in from community and industry-based groups who are conduits to the final users of the products and services.

Actionable Strategies

1

Create a robust STIE management and monitoring system for impact tracking and e-governance through establishment of a national digital governance ledger.

2

Create specific national digital registries for healthcare, environmental and natural assets (physical & non-physical) and intellectual capital to name a few, for better management, monitoring, analyses and decision making.

RECOMMENDATION 2

To Institutionalise Strategic Foresighting to Create a Vibrant, Agile and Responsive STIE Ecosystem to Set the Future Direction for the Sustainable Development of the Country.

The nation lacks integrated and coordinated national foresighting planning to ensure sustainable socioeconomic development across the country despite the various nationalplans and visions such as the National Economic Policy and Vision 2020. To ensure Malaysia remain competitive and adaptive to future challenges, foresight capacity needs to be institutionalised within the Government using a cross-cutting platform that can harmonise the strategic planning of all ministries.

Actionable Strategy

1

Formation of an independent "Foresight entity" to develop Malaysia's overall STIE ecosystem to be agile, adaptive and responsive to address global challenges and provide global leadership in key strategic areas of importance, especially from the perspective of the four Ministerial clusters namely, Infrastructure, Defence, Education and Economy.

RECOMMENDATION 3

To establish Infostructure as a Basic Utility and Incorporate STIE-driven Infrastructure to Transition Society and Enterprises towards Embracing the Knowledge-based Digital Economy and Services

The global economy has been transformed by the information revolution and this is changing every facet of the nation.However, Internet connectivity and quality in many parts of the country remain weak, particularly in areas where the poor and marginalised communities live despite the availability of sufficient capacity to supply these communities. Expanding access and other digital infrastructural support is a powerful catalyst to empower everyone the opportunity to participate in the global digital economy in the spirit of the SPV2030.

Actionable Strategies

1

To include fixed broadband infostructure services as a basic utility, from deployment, management and maintenance of high-quality services in all future mid- to low-level real estate development projects. The process should involve democratisation of infostructure services by breaking up extant monopolies held by any single party to a system that involves an open market in the supply and maintenance of infrastructures and infostructure services.

2

To ensure the physical and natural ecosystems adopt advanced digital technologies to pre-empt, manage and mitigate man-made and natural disasters and risks. Ensuring that our valuable natural resources continue to yield to the needs of our national development in a sustainable manner requires that protection, preservation and enhancement of natural infrastructure is accorded high priority since the wellbeing of society and the planet is at stake.

RECOMMENDATION 4

To Nurture Future-Ready Talent to Generate New Sources for Socioeconomic Growth and Sustainable Development.

Knowledge and intellectual capital growth are not keeping up with the needs of the industry and the nation in critical areas. Talent in Malaysia possess high general skills but lacks multidisciplinary and specialised skills, as well as leadership and entrepreneurial acumen. Industries in Malaysia rely heavily on foreign technology and know-how to upgrade their operations. The level of technology and knowledge transfer in many sectors among local and foreign firms are relatively low and opportunities to acquire and upgrade appropriate skills are scarce, especially for marginalised communities. The talent of the future must be equipped with depth of knowledge and specialist industry competencies, resilient and multi-versed to be able to communicate and work across disciplinary areas and be ready to constantly upgrade and re-skill over their lifetime. They also need to be well- schooled in societal values such as ethics and morality to tackle today's problems in ways that ensure they do not deplete and sacrifice the physical and natural endowments needed by future generations.

Actionable Strategies

1

To formulate and institutionalise a Talent Masterplan based on the 10-10 *My*STIE Framework and develop a clear competency framework that is co-developed by government, academia, industry players, and civil society groups for future-ready talent.

2

To establish an occupation tracking mechanism to monitor technical school leavers and graduates as they enter the workforce and monitor their career trajectories over time. This system would identify and project STIE-related jobs, the needed supply and skills of the future for Malaysia and adjust training and learning to meet the evolving needs of the economic, social and environmental sectors.

3

To enhance the curriculum of local training institutes for policy and diplomacy (i.e. Institute of Diplomacy and Foreign Relations (IDFR) and National Institute of Public Administration (INTAN)) to incorporate STIE-knowledge as part of existing curriculum and provide training to nurture civil servants who will then graduate as multi-versatile citizens, capable of responding to market intelligence with appropriate knowledge of global standards and best practices for advocating sustainable development. There is a need to acculturate civil servants to be good advocates and ambassadors of our rich biodiversity, natural ecosystem, and environmentally friendly industries and keep abreast with key emerging issues of interest to Malaysia.

RECOMMENDATION 5

To Foster a Culture of Knowledge Sharing and Strategic Collaborations to Strengthen Local and Global STIE Knowledge Networks in Niche Areas.

The quadruple helix of government-universities-industry-public is weak in knowledge sharing, collaboration, and actionable coordination for sustainable development of communities and enterprises. An STIE ecosystem with a strong knowledge sharing culture will enable marginalised communities to access information, knowledge, technology,innovation and other resources to improve their quality of life. This vibrant STIE ecosystem will enable micro- and SMEs to build strong dynamic capabilities through technology and knowledge transfer to support a strong global supply chain.

Actionable Strategy

1

Strengthen regional innovation centres in the localities across the country to drive multi-stakeholders' collaboration between regional Corridors, Science/Technology Parks, technology incubators, universities, institutions of learning/training research institutes, industry and community organisations to strengthen and enable technology-based start-ups, communities and, micro and SMEs to develop the local economy with a global outlook while ensuring the sustainability of the physical environment and natural resources.

In summary, strategic planning of the STIE ecosystem is critical to ensure a balance between economic development, social progress and environmental sustainability. The nexus between all three pillars is imperative for a holistic and sustainable progress that can be accessed by everyone today and future generations aligned to the SPV2030.

Vision 2020 Spread

Assessment of Vision 2020

The Malaysian Vision 2020 was unveiled by then 4th Prime Minister of Malaysia, Tun Dr Mahathir bin Mohamad, on 28th February 1991, in his presentation on "The Way Forward" at the inaugural meeting of the Malaysian Business Council (Fleming and Soborg, 2019). The aspirations outlined in the speech caught the country's imagination. The Malaysian Cabinet approved the Vision unanimously and mandated for an immediate national conference to map its agenda in December 1991.

The essence of the vision was to transform Malaysia into a high-income economy by year 2020. The goal was to build a nation with a dynamic middle-class and provide opportunities for all, especially to help the vulnerable segments of society to transition out of poverty.

Box S1: **Vision 2020**

Vision 2020 defined the goals for Malaysia to be a high-income economy with that is fully developed across all economic, political, social, spiritual, psychological, and cultural dimensions. The ultimate objectives of the vision:

- Malaysia to be a fully developed country by the year 2020 bolstered by a competitive, dynamic, robust, and resilient economy,
- Establishing a united Malaysian nation made up of one *'Bangsa Malaysia'* with political loyalty and dedication to the nation,
- The citizens are infused with strong moral and ethical values in a society that is democratic, liberal, caring,
- A just, and equitable, progressive,and prosperous economy, and
- Uplifting disadvantaged population to abolish any ethnic-related economic marginalisation.

Reference: Mahathir (1991)

The aim of Vision 2020 was to create an equitable Malaysia within a 30-year period. The Vision also emphasised technological, social, and environmental advancement for Malaysia to ensure a balanced development. While Malaysia has made significant progress in economic development, much of the Vision was difficult to realise due to the lack of clear metrics to gauge progress across many of the dimensions such as unity, diversity, biodiversity etc. in the Vision. This study will provide an overview of the progress along the dimensions of Vision 2020.

Challenge

01

Establishing a United Malaysian Nation (*'Bangsa Malaysia'*)

Challenge

02

Creating a Psychologically Liberated, Secure and Developed Malaysian Society

Challenge

03

Fostering and Developing a Mature Democratic Society

Challenge

04

Establishing a Fully Moral and Ethical Society

Challenge

05

Establishing a Matured, Liberal, and Tolerant Society

Challenge

06

Establishing a Scientific and Progressive Society

Challenge

07

Establishing a Fully Caring Society

Challenge

08

Ensuring an Economically Just Society, in Which There is a Fair and Equitable Distribution of the Wealth of the Nation

Challenge

09

Establishing a Prosperous Society with an Economy that is Fully Competitive, Dynamic, Robust and Resilient

Challenge 1
Establishing a United Malaysian Nation (*'Bangsa Malaysia'*)

Social Capital comprise of five elements namely personal and family relatioships, social networks, interpersonal trust, institutional trust and civic and social participations. It measures how cohesive a society is in terms of people trusting, respecting and helping one another, and the institutional structures they interact with. A person's wellbeing is best provided for in a society where people trust one another and have the support of their friends and family. Societies with lower levels of trust tend to experience lower levels of economic growth and social wellbeing. Thus, the word "capital" in "social capital" highlights the contribution of social networks as an asset that produces economic returns and improves well-being (Legatum Institute, 2020).

The graph below shows a comparison in terms of social capital between Malaysia and three OECD countries (USA, Australia, and Japan) and an ASEAN country, Indonesia for year 2010 and 2020. As reflected in the chart, the improvement is dominated by developing countries, Indonesia and Malaysia, while all three developed OECD countries facing a decline.

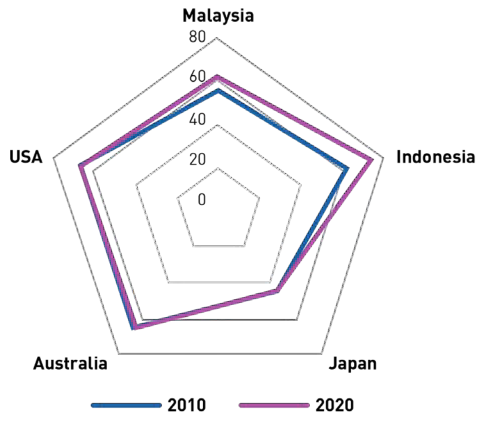


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Figure S1.1: Comparison of Social Capital between Malaysia and Selected Countries

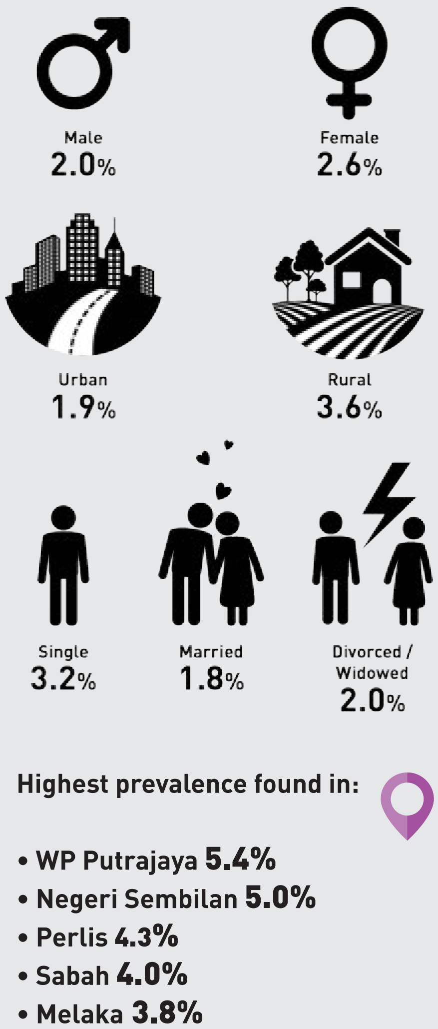
The improvement of social capital is contributed by a stronger social network, greater trust in others and institutions, and increased participation and engagement in society. The community that can function as a cohesive unit is the one that could increase the attachment among the member of the society. This is precisely the case of Malaysia, where the multicultural population developed a social diversity that has been a great asset for the country to grow upon and develop (Hamid et al., 2016).

Challenge 2
Creating a Psychologically Liberated, Secure and Developed Malaysian Society

A psychologically healthy Malaysian population is critical for the development of a vibrant and globally competitive Malaysian society. The increasing complexities of modern living and socio-economic uncertainties are challenging the psychological state and mental health of the population.

The National Health and Morbidity Survey (NHMS) in 2019 (Institute for Public Health, 2020) shows around 2.3% or 500,000 of the adult population suffered from depression; this is a marked improvement compared to the statistics compiled in 2015 (Institute for Public Health, 2015). Depression is a common but serious mood disorder that can severely affect how you feel, think, and handle daily activities (e.g. sleeping, eating, or working too much or too little).

By sociodemographic groups



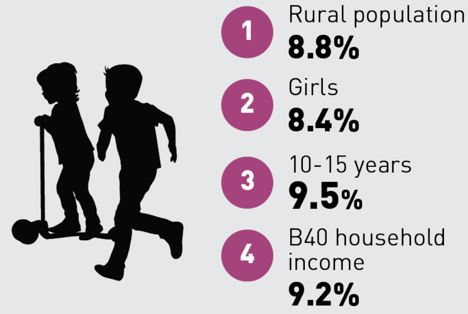
Reference: Adapted from Institute for Public Health, 2020

Figure S1.2: Prevalence of Depression among Adult Malaysians in 2019 by State and Sociodemographic Group

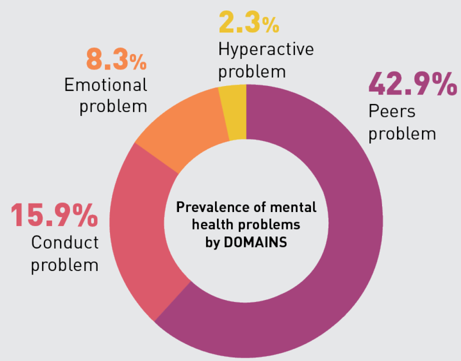
Statistics in Figure S1.2 indicate that women are more affected by depression. This is very likely due to the societal demands on their role at home and gender-linked pressure they face at work. The incidence for depression is almost double in the rural compared to the urban areas. The survey also showed that married people are less affected by depression compared to those who are widowed / divorced or single.

The 2019 National Health and Morbidity Survey found that almost 8.0% of the under-18 population (424,000 children) are affected with mental health problems. The highest prevalence of mental health problems was in Perak (19.0%), followed by Perlis (14.9%), and Sarawak (14.1%). Children from rural areas had higher prevalence of mental health problems as compared to those from urban areas at (8.8% vs 7.5%). This is also true in terms of household income, where children from families of lower income (<RM2,000) showed higher prevalence of mental health problems (22.0%). Those in the B40 income group showed highest prevalence of mental health problems (8.8%); this is worrisome as they tend to have less mental health resources available.Children between the age of 10-15 years show higher prevalence of mental health problems, which may be attributed to the stresses of puberty as well as the pressures faced by teenagers.

Which children have more problems?

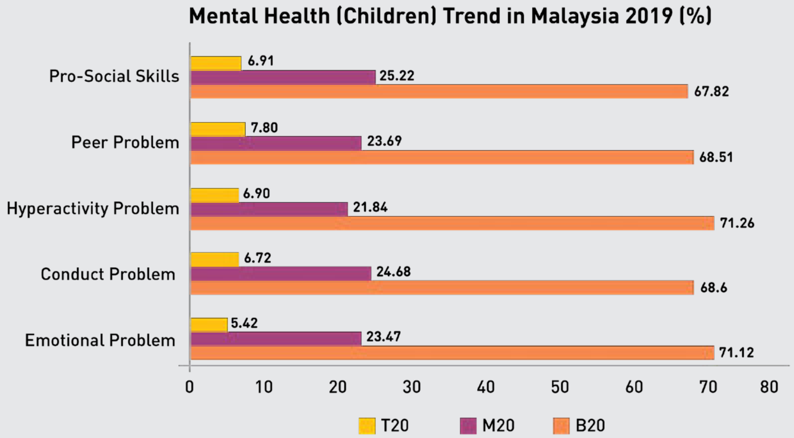


What contributes to the mental health problem?



Reference: Adapted from Institute for Public Health, 2020

Figure S1.3: Prevalence of Mental Health Problems among Malaysian Children



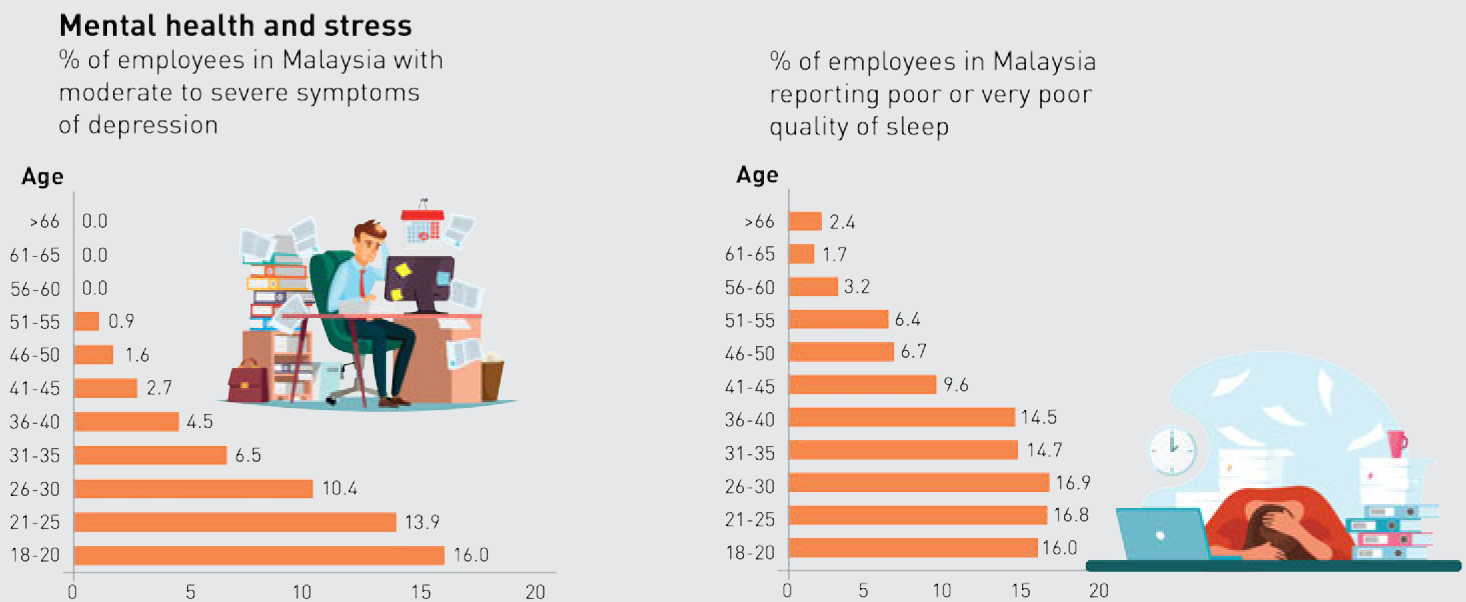
Reference: Adapted from Institute for Public Health, 2020

Figure S1.4: Causes of Mental Health Problems among Malaysian Children by Family Income Group

	2015	2019
Mental Health	**12.1**	**7.9**
Emotional Health	15.7	8.3
Conduct Problem	16.7	15.9
Hyperactivity Problem	4.6	2.3
Peer Problem	32.5	42.9
Pro-Social Skills	11.2	27.7

Reference: Adapted from Institute for Public Health, 2020

Figure S1.5: Causes of Mental Health Problems among Malaysian Children in 2015 vs 2019



Reference: Adapted from The Edge Markets, 2020

Figure S1.6: Causes of Mental Health Problems among Malaysian Children by Family Income Group

Peer problems, pro-social skills, and conduct problems had the highest prevalence at 42.9%, 27.7%, and 15.9% respectively, in 2019. This indicates that more children are having behavioural and socialisation issues, which could affect their academic performance as well render them vulnerable to juvenile delinquency that can have a long-term adverse impact on their lives.A study by AIA Vitality in 2019 (17,595 employees polled) showed that more than half of the Malaysian workforce suffered from work-related stress, 53% get less than the requisite seven hours of sleep, and about one out of 10 Malaysian employees is either anxious or depressed. The most affected are those born between 1981 and 1996.

The well-being of Malaysians, as measured under the Malaysian Well-Being Index (MyWI) has increased by 0.6% in 2019 to 121.0 points as compared to 120.3 points in 2018. MyWI measures the well-being of Malaysians from an economic and social perspective and comprises of five economic components and nine social components. The increase was driven by the growth in economic well-being which is 2.3%. The components that experienced the highest growth are working life (4.4%), followed by transport (3.9%) and education (2.8%). However, social well-being sub-composite index showed decline of 0.6%.

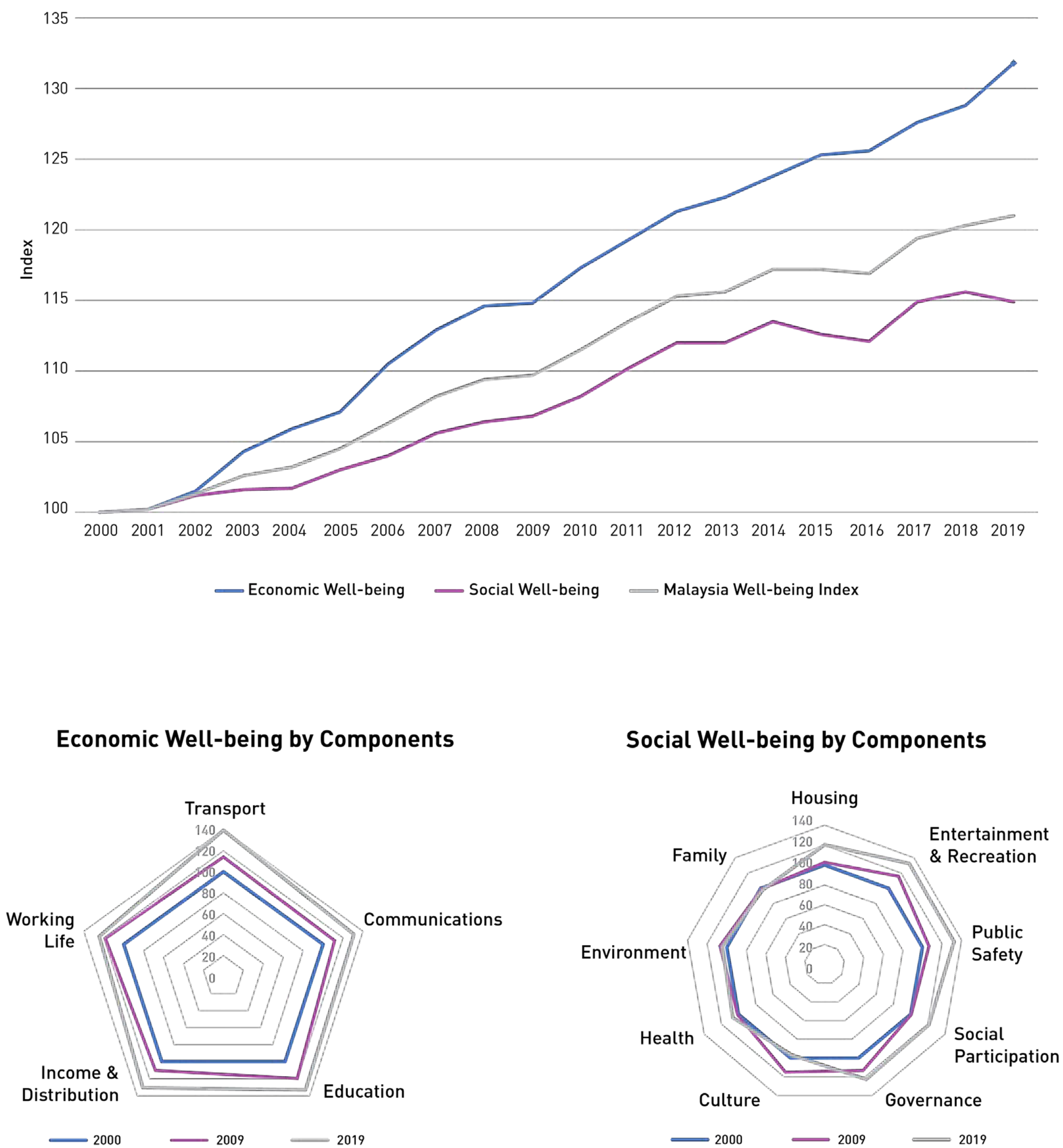
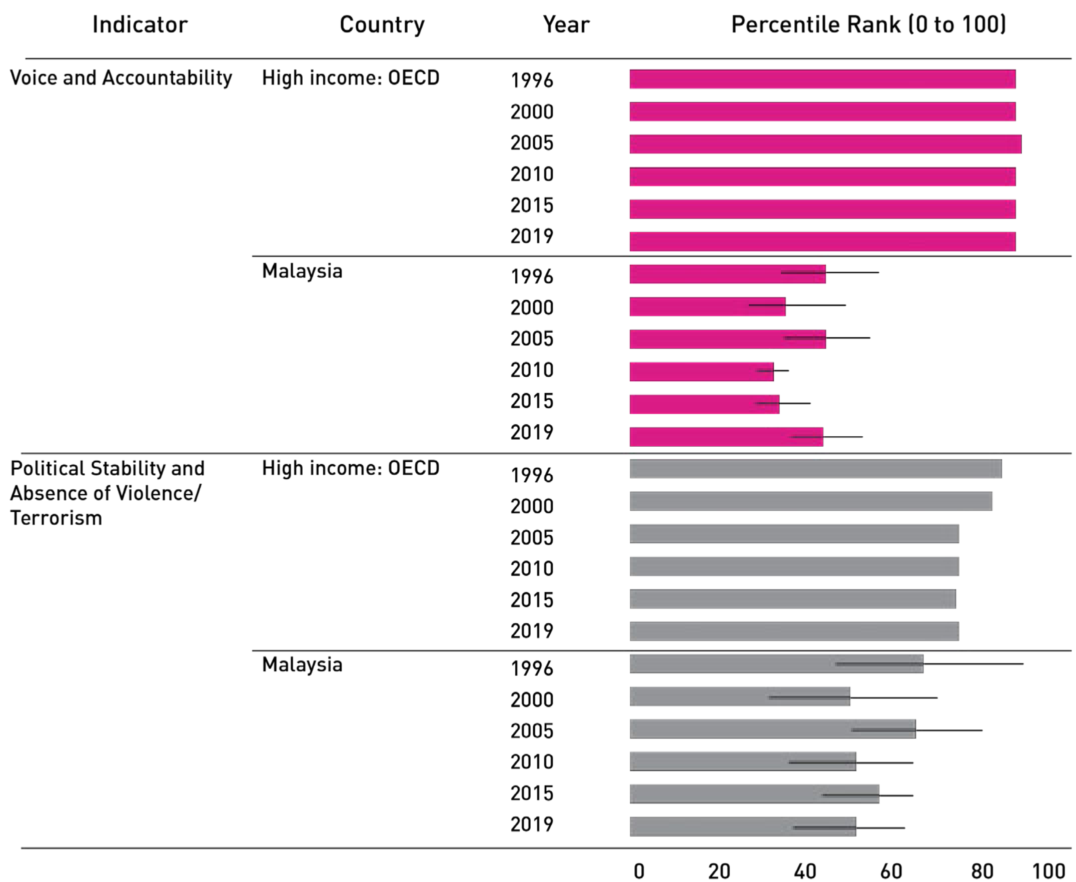


Figure S1.7: Trend of the Malaysian Well-Being Index (MyWI), Economic Well-Being and Social Well-Being Component Index from 2000-2019

Challenge 3
Fostering and Developing a Mature Democratic Society

A mature democratic society entails the ability of society to participate in the political process, freedom of expression and independent media and judiciary.

The World Bank uses proxy measures such as "Voice and Accountability" and "Political Stability and Absence of Violence/Terrorism" indicators to characterise a mature and democratic society. Both the measures for Malaysiawere found to be lower than that of OECD countries, suggesting that democratic reforms to instil greater voice & accountability and political stability in the country are lagging behind the OECD countries.

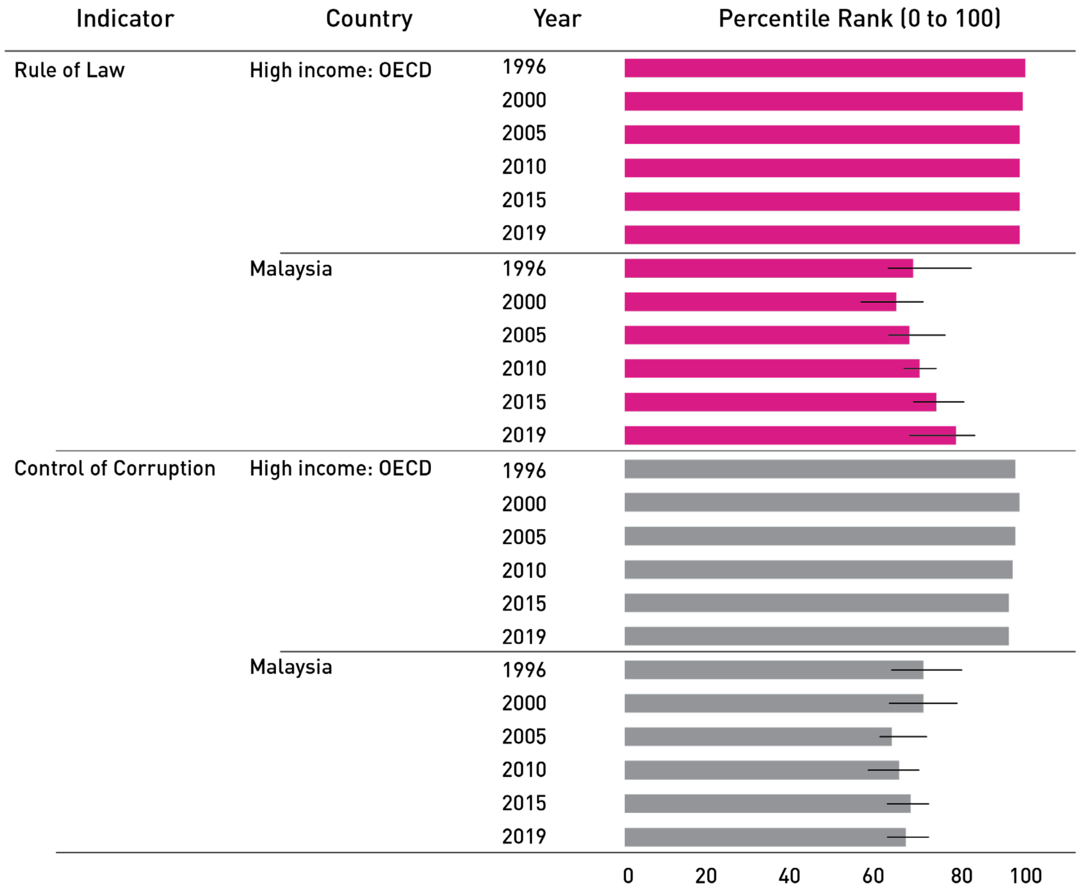


Reference: Adapted from World Bank, 2020

Figure S1.8: The World Bank Indicators for Voice and Accountability and the Political Stability & Absence of Violence/Terrorism from 1996 to 2019

Challenge 4
Establishing a Fully Moral and Ethical Society

For this challenge, the following indicators from World Bank were used to assess the level of moral and ethical society: rule of law and control of corruption level. There has been improvement in the rule of law from 2000 to 2019. However, the indicators are significantly lower than that of OECD countries. In the case of control of corruption, there was a decline from 2000 to 2015; but there was a slight decline in 2019. Overall, the control of corruption of Malaysia was significantly lower than that of OECD countries. These results suggest that level of moral and ethical standards lag behind the OECD countries.



Reference: Adapted from World Bank, 2020

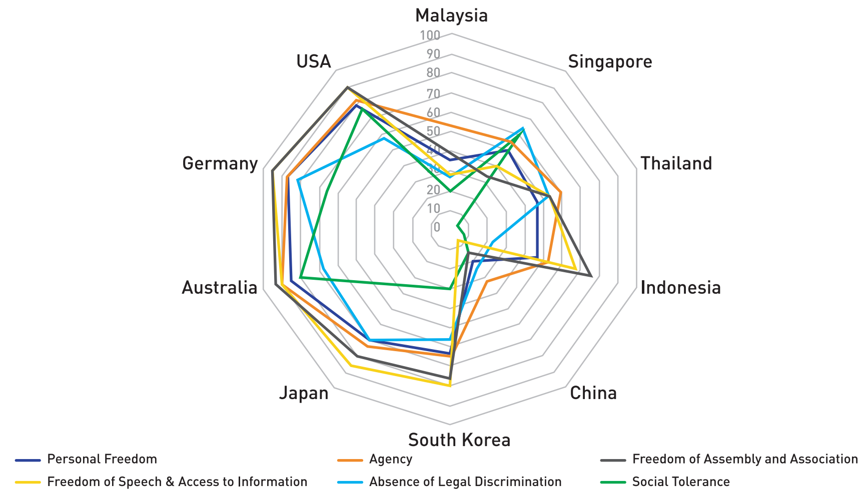
Figure S1.9: The World Bank Indicators for Rule of Law and Control of Corruption from 1996-2019

Challenge 5
Establishing a Matured, Liberal, and Tolerant Society

The indicators under the Legatum Prosperity Index's Personal Freedom Pillar can be used to assess the level of a "matured, liberal and tolerant society" as ascribed under Challenge 5. The Personal Freedom Pillar measures progress towards providing basic legal rights, individual liberties, and social tolerance of any society as well as captures the extent to which the population of a country is free to determine the course of their lives without undue restrictions. Central to this is the level of agency an individual experiences, and their their freedom from discrimination. This also includes freedom from coercion and restrictions on movement, speech and assembly.

Across all the elements under the Personal Freedom Pillar, Malaysia has seen improvements in affording basic rights and civil liberties to all members of the population. However, the performance of these indicators is below that of most developed nations. The Legatum Prosperity Index 2020 notes that 87 countries in the Asia-Pacific, including Malaysia, have a lowscore in Personal Freedom (a score of lower than 70) even though these countries have seen massive improvements in terms of economic growth and health and well-being.

Legatum Prosperity Index: Comparison of Performance in Personal Freedom Pillar between Malaysia & Selected Countries in 2010



Legatum Prosperity Index: Comparison of Performance in Personal Freedom Pillar between Malaysia & Selected Countries in 2020

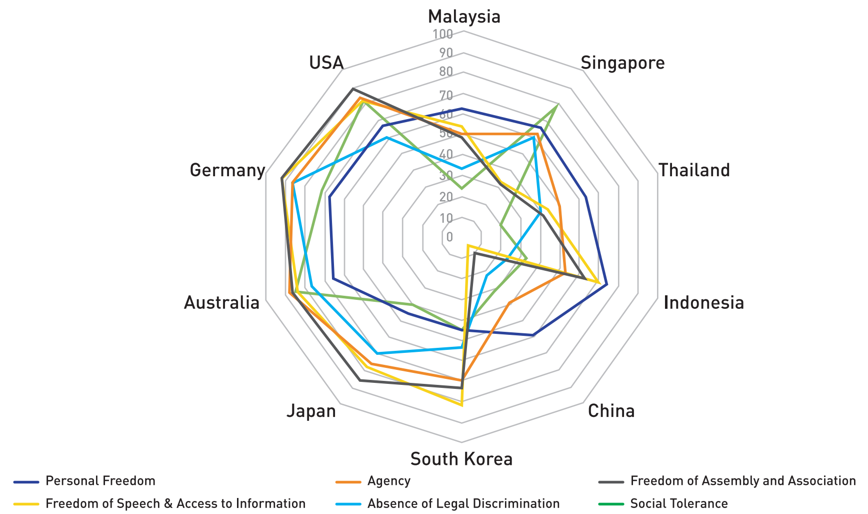


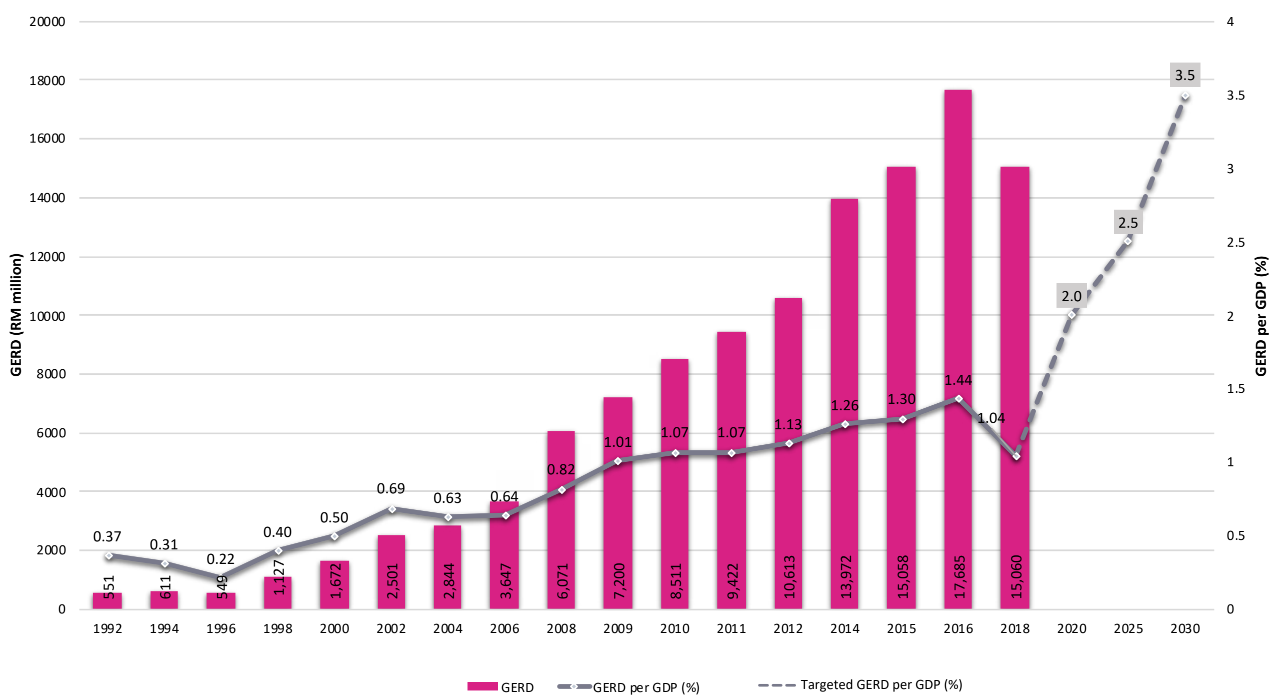
Figure S1.10: Legatum Prosperity Index Comparison of Performance in Personal Freedom Pillar of Malaysia against Benchmark Countries in 2010 and 2020

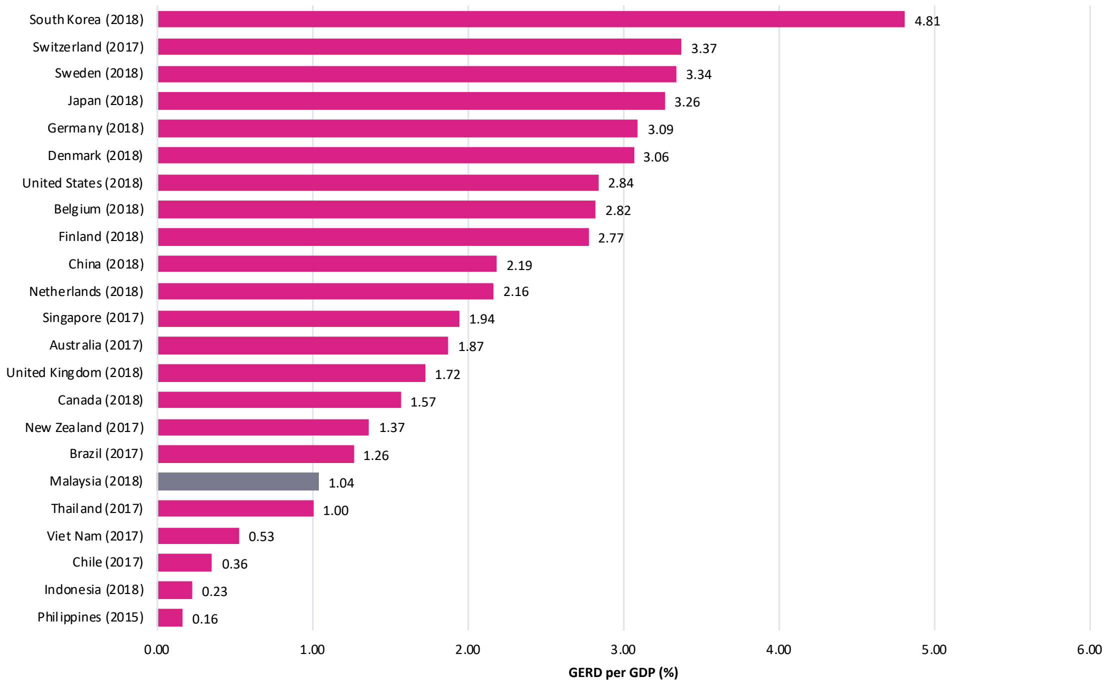
Challenge 6
Establishing a Scientific and Progressive Society

The STI indicators show that Malaysia has made progress over the years to increase its scientific intensity (refer to Figure S1.11).However, the rate of investment in STI and STI outcomes have not kept pace with many of the developed countries and regional economies. The problem is further exacerbated with high proportion of research personnel in universities as compared to many of the advanced economies. The percentage of experimental R&D was relatively low compared to these advanced economies. Hence, the potential of home-growth scientific endeavours contributing to industrial development and a progressive society are relatively low, as to compared to that of developed economies. As such, Malaysia is highly dependent on foreign technology and 'know-how' to move up the value chain to create a progressive society and a competitive economy. Relatively low scientific intensity vis-à-vis other advanced countries in a highly competitive global economy have led to Malaysia being caught in the "middle-income country trap".

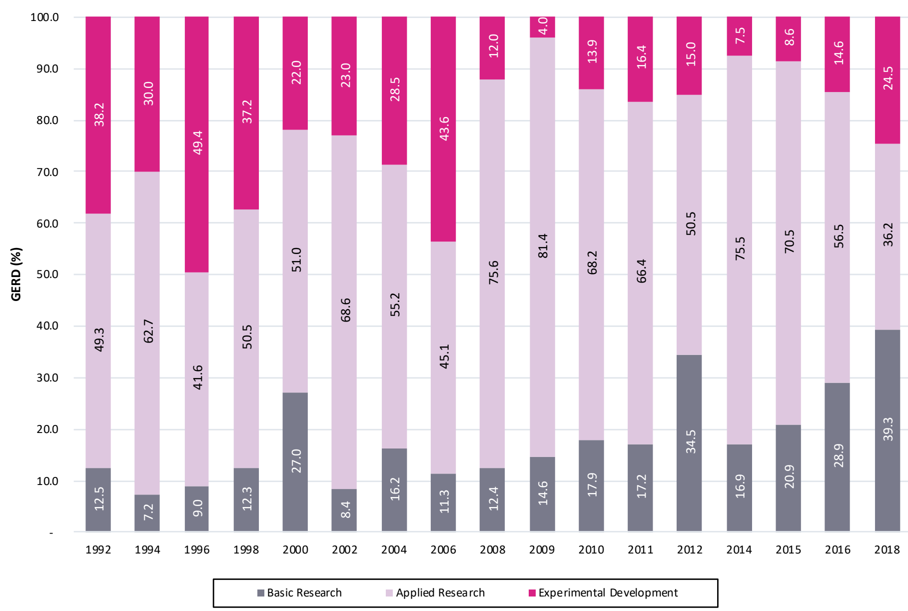
In terms of investments in R&D as measured by GERD per GDP, Malaysia is below the average expenditure of innovative countries; even falling short of the target that was set by the National Policy on STI 2013-2020, which was 2.0% by 2020.

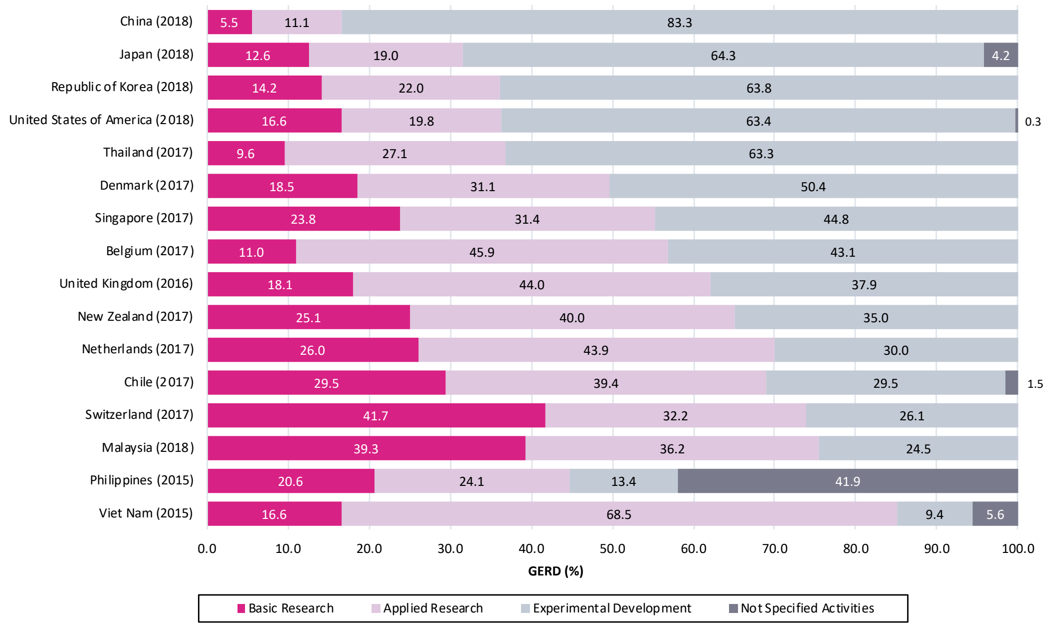
1 Expenditure on R&D per GDP



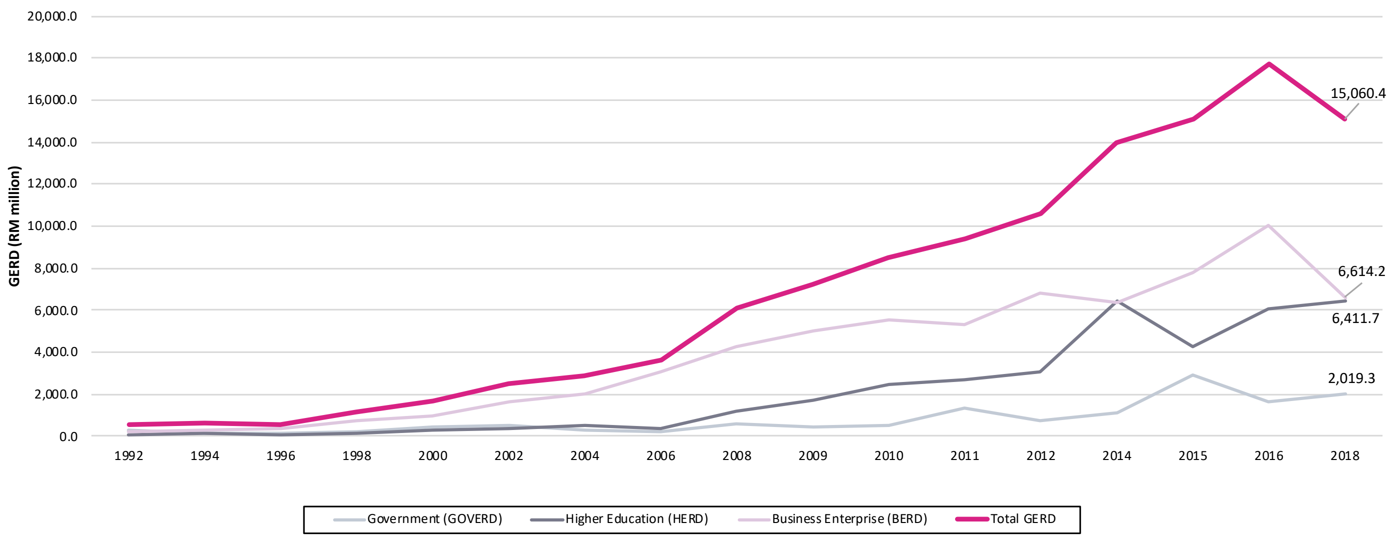


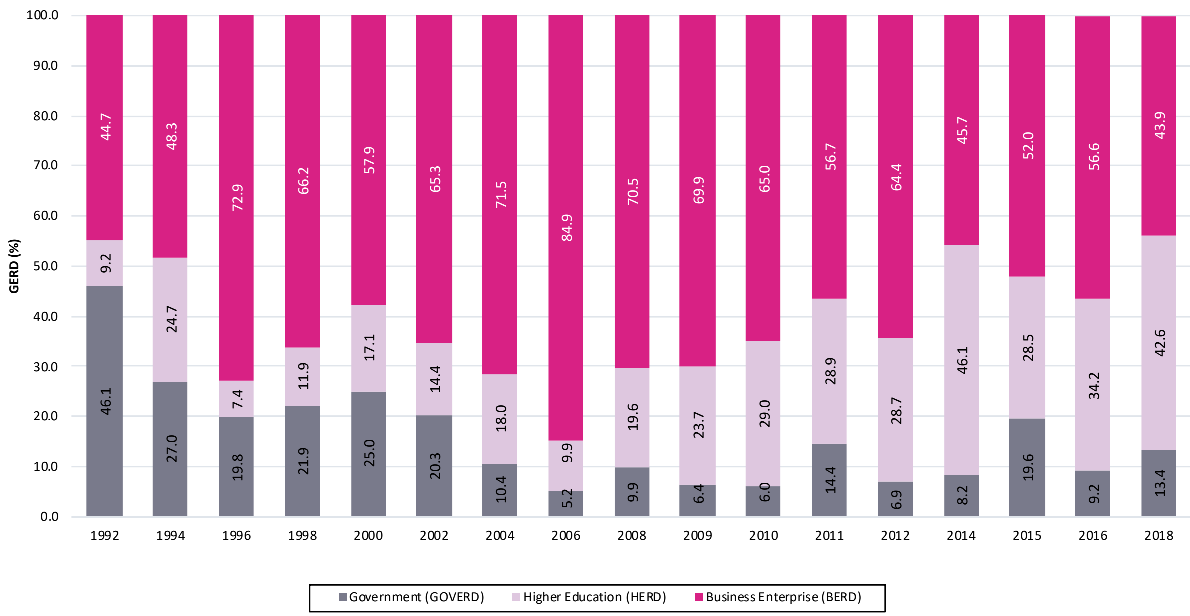
2 GERD by R&D Activities

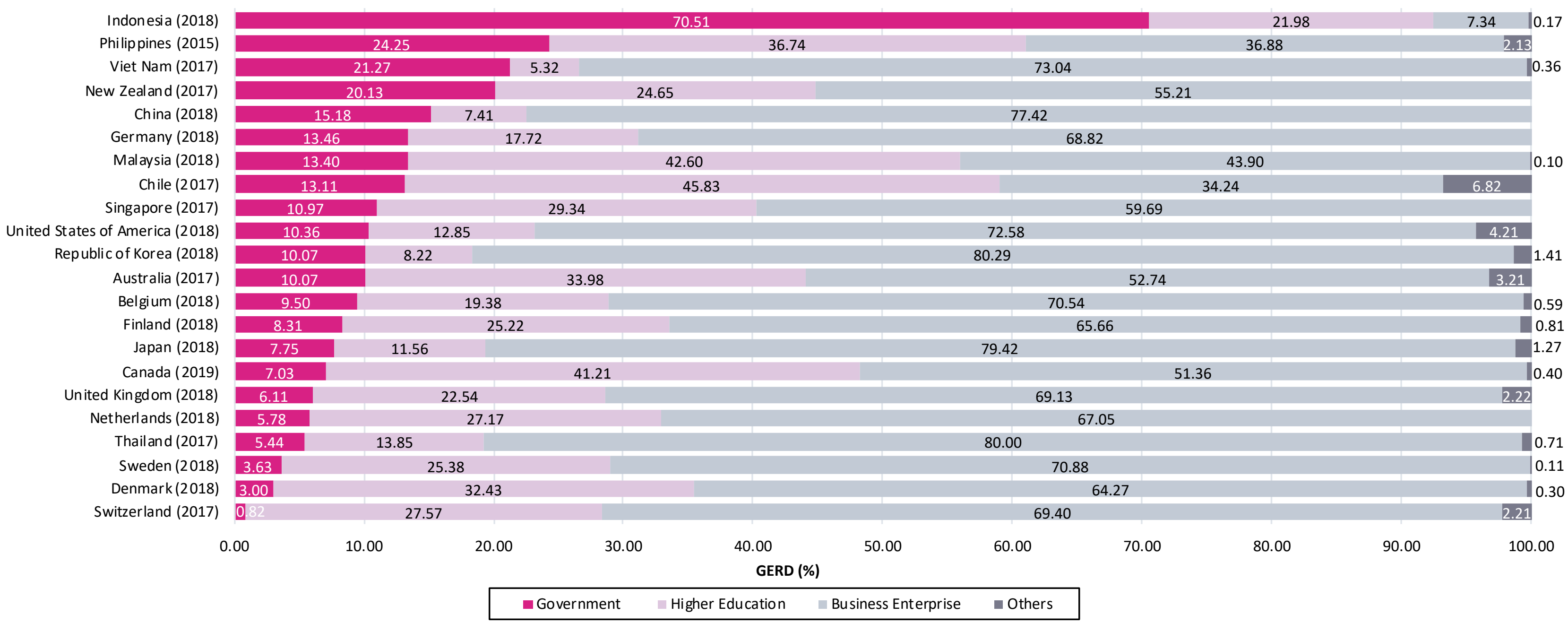




3 GERD by Sectors




GERD (%)
Government (GOVERD)
Higher Education (HERD)
Business Enterprise (BERD)


Indonesia (2018)
Philippines (2015)
Viet Nam (2017)
New Zealand (2017)
China (2018)
Germany (2018)
Malaysia (2018)
Chile (2017)
Singapore (2017)
United States of America (2018)
Republic of Korea (2018)
Australia (2017)
Belgium (2018)
Finland (2018)
Japan (2018)
Canada (2019)
United Kingdom (2018)
Netherlands (2018)
Thailand (2017)
Sweden (2018)
Denmark (2018)
Switzerland (2017)
GERD (%)
Government
Higher Education
Business Enterprise
Others

4 Researchers per Thousand Labour Force

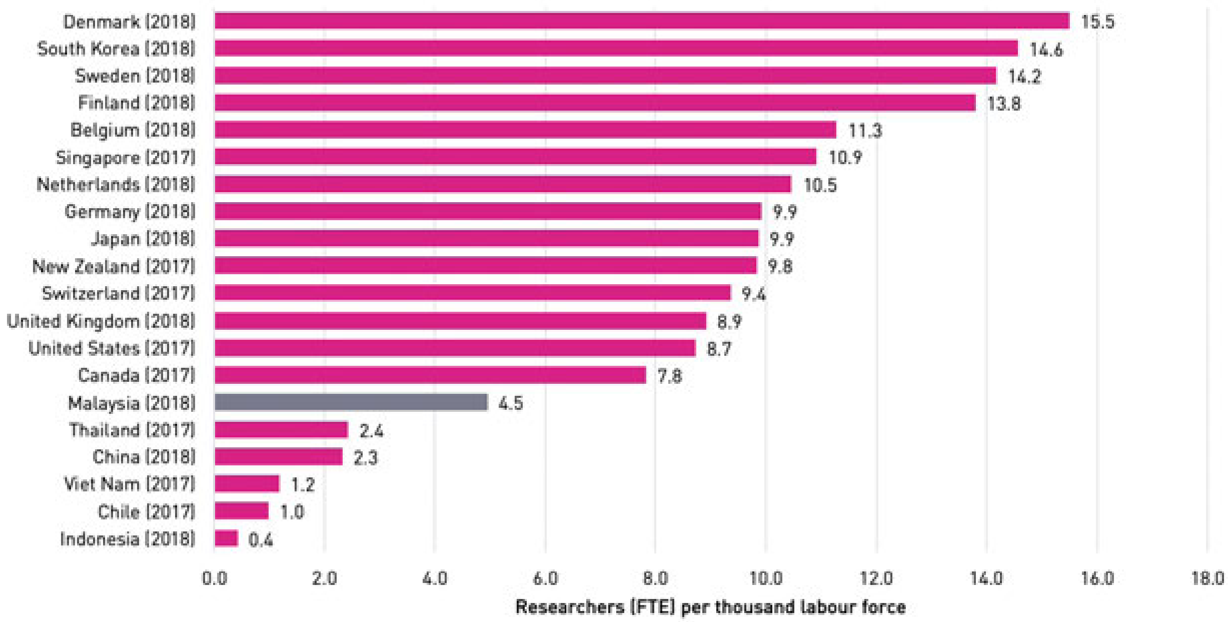


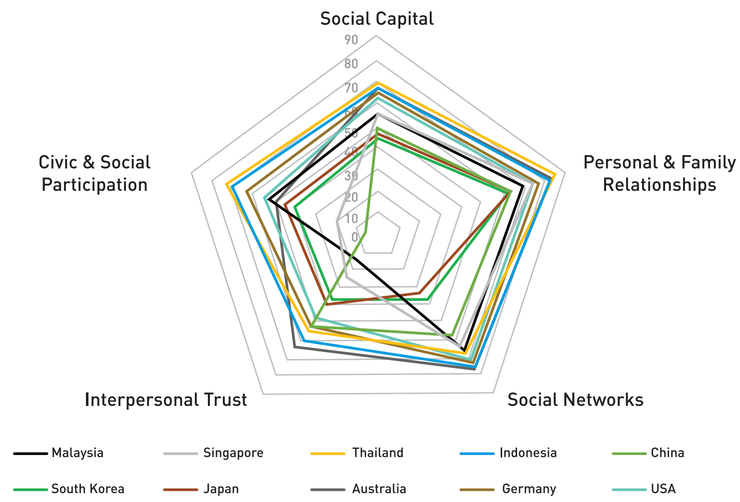
Figure S1.11: Trend in Malaysia's GERD, Distribution of GERD by Type of R&D and Researcher per 1000 Personnel Labour Full-time Equivalent and Comparison with Innovative Countries

Challenge 7
Establishing a Fully Caring Society

A "fully caring society" can be measured through the Legatum Prosperity Index's Social Capital Pillar. Social Capital measures how cohesive a society is in terms of people trusting, respecting and helping one another, and the institutional structures they interact with (i.e. family relationships, social networks, cohesion with society). A person's wellbeing is best provided for in a society where people trust one another and have the support of their friends and family. Societies with lower levels of trust tend to experience lower levels of economic growth. Thus, the word "capital" in "social capital" highlights the contribution of social networks as an asset that produces ROV to all stakeholders.

All four elements measuring social capital show improvement from 2010 to 2020 for Malaysia with its best performance in building and maintaining ties with other individuals. In contrast to Japan, South Korea and USA that showed decline, Malaysia showed positive development in terms of trusting people outside their social sphere and helping a stranger.

Legatum Prosperity Index: Comparison of Performance in Social Capital Pillar between Malaysia & Selected Countries in 2010



Legatum Prosperity Index: Comparison of Performance in Social Capital Pillar between Malaysia & Selected Countries in 2010

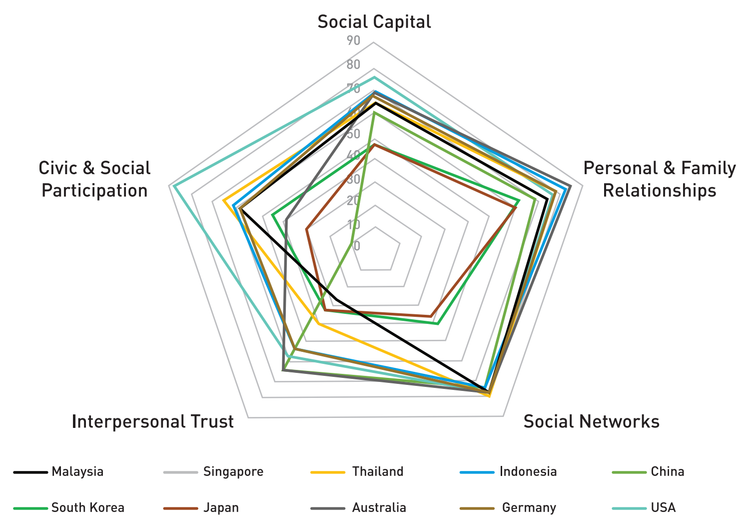
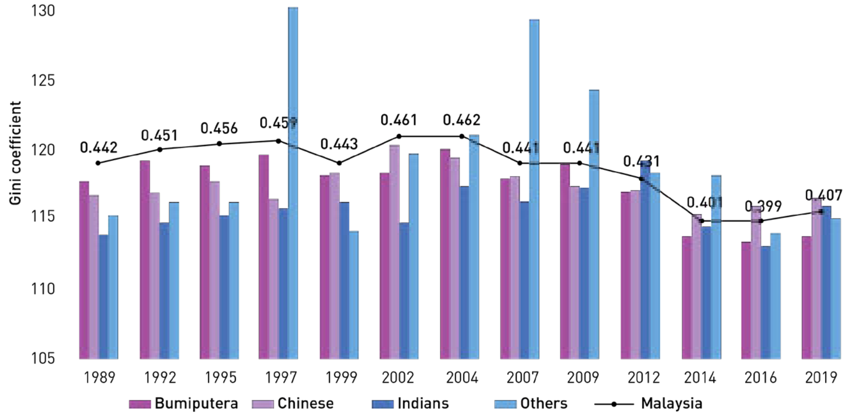


Figure S1.12: Legatum Prosperity Index Comparison of Performance in Social Capital Pillar between Malaysia and Selected Countries in 2010 and 2020

Challenge 8
Ensuring an Economically Just Society, in Which There is a Fair and Equitable Distribution of the Wealth of the Nation

Challenge 8 describes the goal of the "eradication of absolute poverty regardless of race and geographical location" and providing full opportunities for bottom third to move out of relative poverty. 'High-income households' earn 6.7 times more than 'low-income households' in 2019. Over the last 30 years, across ethnic groups and strata, the level of inequality has declined but has since seen an increase from 0.399 in 2016 to 0.407 in 2019. While the relative income gap has decreased, the absolute gap has increased, which could lead to the perception that income inequality has not improved over the last few decades.

Malaysia has made significant progress in reducing absolute poverty from 16.5% in 1988 to 0.2% in 2018. However, Malaysia revised the absolute poverty line based onthe recommendations from the United Nations Special Rapporteur on Extreme Poverty and Human Rights report in 2019. The revised national poverty line income (PLI) shows that absolute poverty line has decreased from 7.61% in 2016 to 5.6% in 2018. Based on the new definition, households with income of RM2,208 are considered part of the B40 group. This translates to approximately 1.8 million population living below the poverty line.



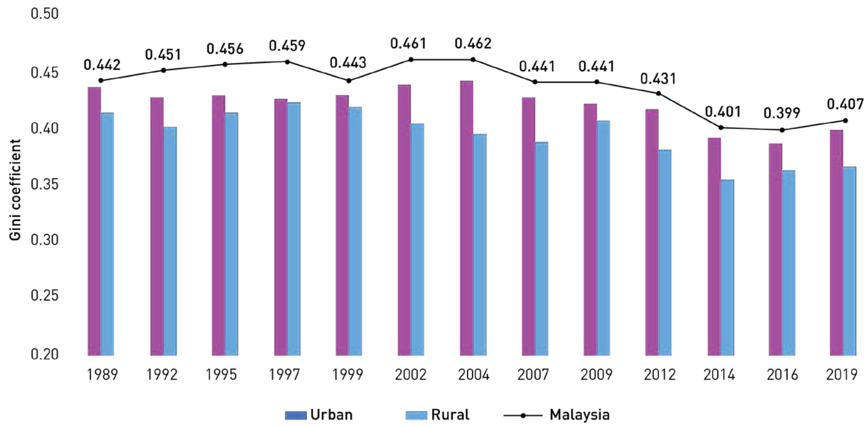
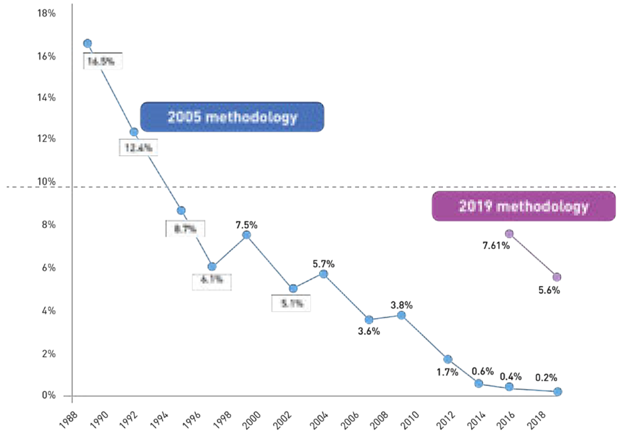


Figure S1.13: Gini Coefficient by Ethnic Group and Strata from 1989-2019

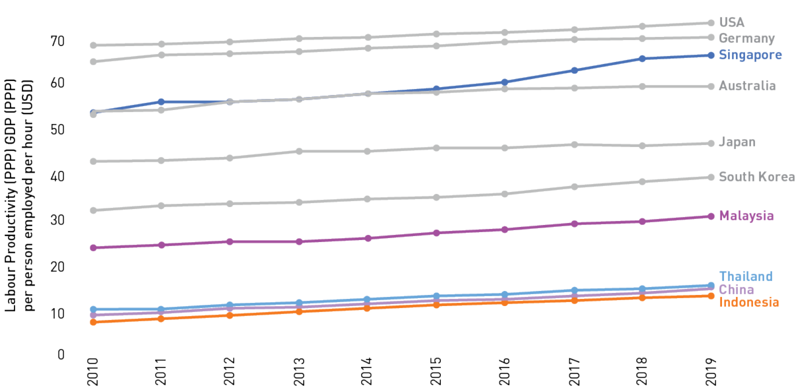


Reference: Adapted from Ida Lim, 2020

Figure S1.14: Absolute Poverty in Malaysia, 1989-2020

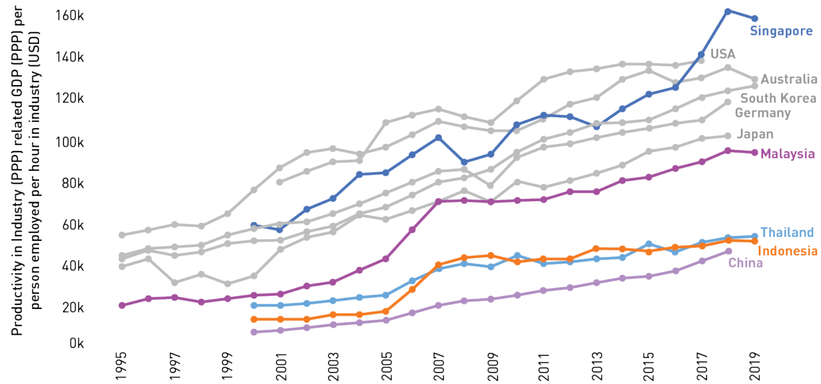
Challenge 9
Establishing a Prosperous Society with an Economy that is Fully Competitive, Dynamic, Robust and Resilient

A prosperous and competitive economy would require the country's labour, industry and economic sectors to continuously improve its productivity. Malaysia has improved its labour, industry, service and overall productivity over the years (refer to Figure S1.15 to Figure S1.18). However, the productivity levels are significantly lower than many developed countries. The concerning trend is that the gap between Malaysia and some developed countries is widening.



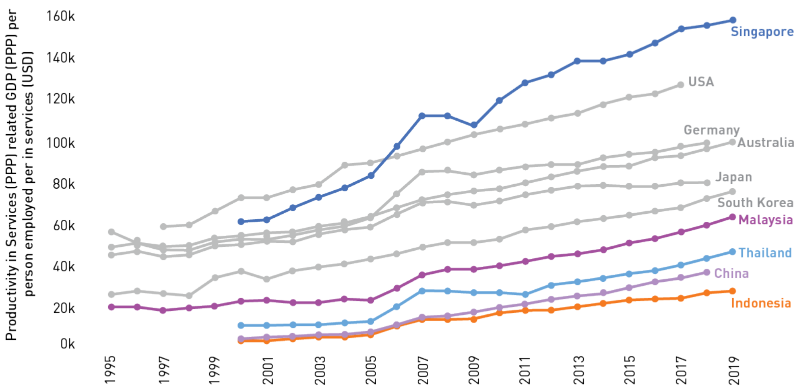
Analysed by Sunway University Research Team

Figure S1.15: Labour Productivity for Malaysia and Selected Developed and Developing Countries



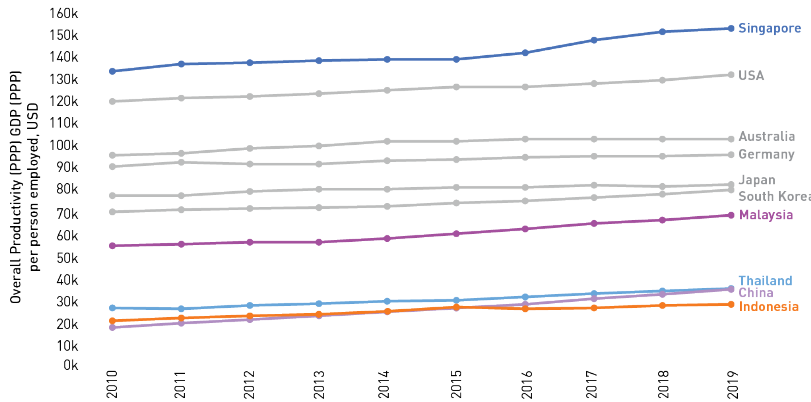
Analysed by Sunway University Research Team

Figure S1.16: Industrial Productivity for Malaysia and Selected Developed and Developing Countries



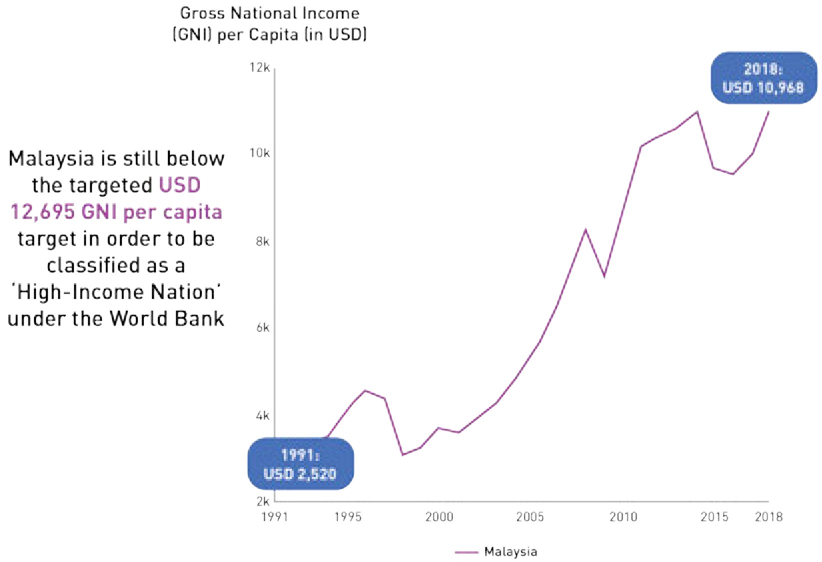
Analysed by Sunway University Research Team

Figure S1.17: Service Sector Productivity for Malaysia and Selected Developed and Developing Countries



Analysed by Sunway University Research Team

Figure S1.18: Overall Productivity for Malaysia and Selected Developed and Developing Countries



Reference: Knoema, N.D.

Figure S1.19: Gross National Income per Capita, 2000-2019

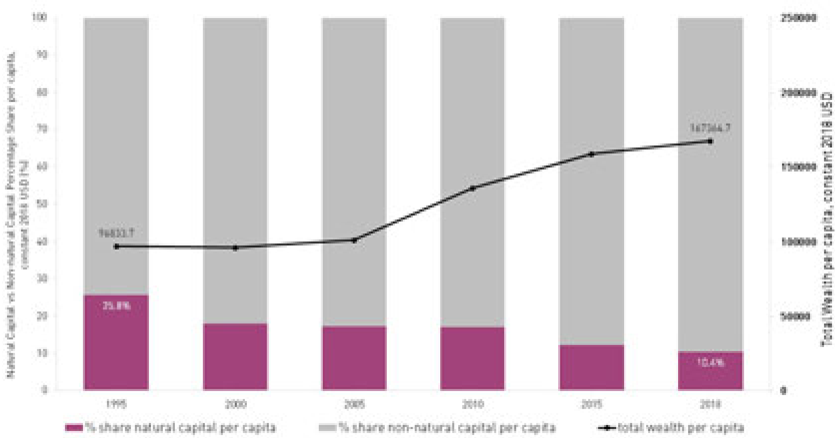


Figure S1.20: Malaysia's Share of Natural Capital and Total Wealth, 1995-2018

Figure S1.19 show that GNI has increased significantly since 1991, Malaysia is still below the threshold of a 'high-income nation' (>USD12,695).

The pursuit of economic and social progress has unfortunately come at the expense of depleting natural capital (refer to Figure S1.20).

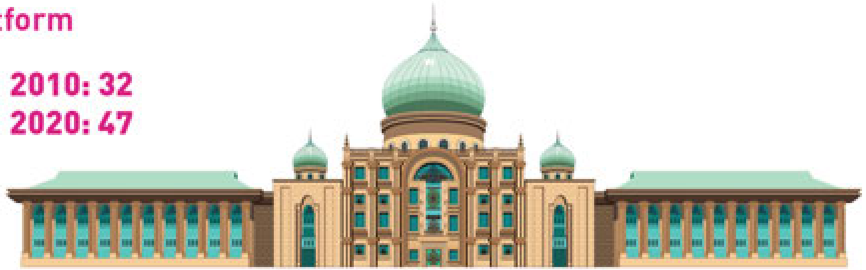
02

Three Decades of STI Evolution

Government as a Platform

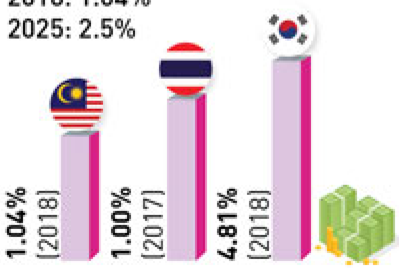
Malaysia Performance in E-Government ranking

2010: 32
2020: 47

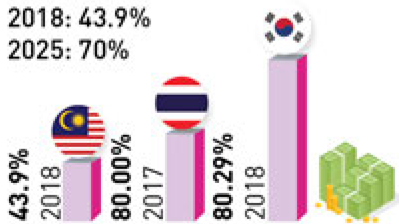


Research Expenditure

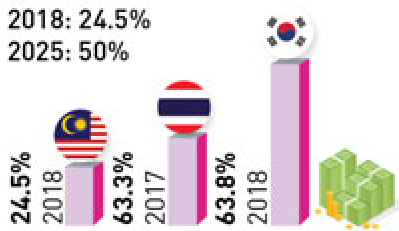
GERD/GDP
2012: 1.13%
2018: 1.04%
2025: 2.5%



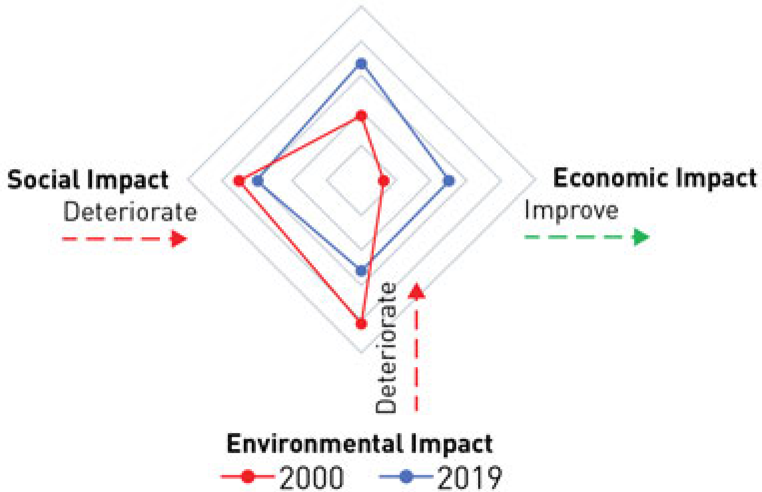
BERD
2012: 64.4%
2018: 43.9%
2025: 70%



Experimental Research
2012: 15.0%
2018: 24.5%
2025: 50%

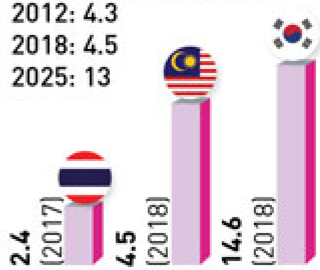


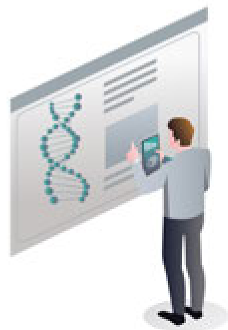
Malaysia's State of Development of STI Ecosystem



Research Personnel

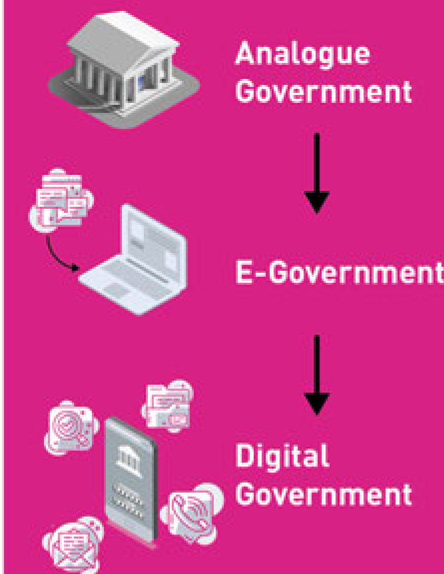
Researcher per 1,000 Personnel Labour Full-Time Equivalent
2012: 4.3
2018: 4.5
2025: 13





THREE DECADES OF STI EVOLUTION

Progression Towards Digital Transformation



The progress of Science, Technology and Innovation (STI) in any country does not happen in isolation; its growth is built on substantial policy framework and participatory forms of governance to help regulate its development. A solid understanding of the country's STI agents' capabilities and their interactions as well as the incentives and obstacles they face is important to formulate, implement, and monitor effective STI policymaking. Beyond that, STI policies also must consider how to best nurture home-grown innovation as an engine of growth while technology continue to evolve at breakneck speed.

Technical or scientific knowledge is not sufficient to maximise STI benefits for Malaysia. All stakeholders – be they public or private – must be able to position specific STI goals against the nation's strategic interest, working with inclusive public policies and effective governance. This approach requires accurate information gathering as well as monitoring and evaluation capacity to assess the effectiveness of the STI policy implementation against relevant global STI benchmarks, thus gaining a clearer understanding of the long-term evolution and governance of STI structures.

POLICIES & KEY EVENTS THAT SHAPED MALAYSIA'S STI LANDSCAPE

Malaysia's five-year development plans (Malaysia Plan) have been a tool for shaping the Government's medium-term policy frameworks since the early 1950s. Besides optimising resource mobilisation for socio-economic growth, these mid-term plans also implement structural and institutional adjustments of the Government's planning and operation mechanisms.

The Malaysia Plans are embedded within the long-term *First Outline Perspective Plan* (OPP1, 1971-1990), *Second Outline Perspective Plan* (OPP2, 1991-2000), and *Third Outline Perspective Plan* (OPP3, 2001-2010) which were anchored by key policies, e.g., Vision 2020 that spanned 30 years was launched during OPP2. The focus of these plans has changed throughout the years; some were driven by domestic needs while others were influenced by external developments (Figure 2.1).

These development policies are designed not only to expand the nation's economic wealth, but also building a cohesive and resilient populace for sustainable development. Numerous social policies encompassing a wide spectrum of human well-being factors were implemented to establish the foundation for inclusive development and shared prosperity however we observed the research priority areas were not common or aligned; STI was not linked to key economy areas (Figure 2.1).

Social policies in Malaysia play an important role to reduce inequality while promoting equity and societal well-being. The dimensions of individual and social well-being also change with better economic positioning as well as global socio-economic growth, e.g., elementary education is no longer enough for socio-economic sufficiency, mobile phone is an essential resource, etc. Policies and plans to address the welfare for all Malaysians are included in the First up to the Eleventh Malaysia Plan. These include strategies to increase the well-being of the people living rural areas, bridging the urban-rural as well as urban-urban divide, upgrading the national healthcare systems, and creating an inclusive, quality education system. Supporting these plans are infrastructure developments ranging from electric power, roads, transportation, and infostructure to empower progress for all.

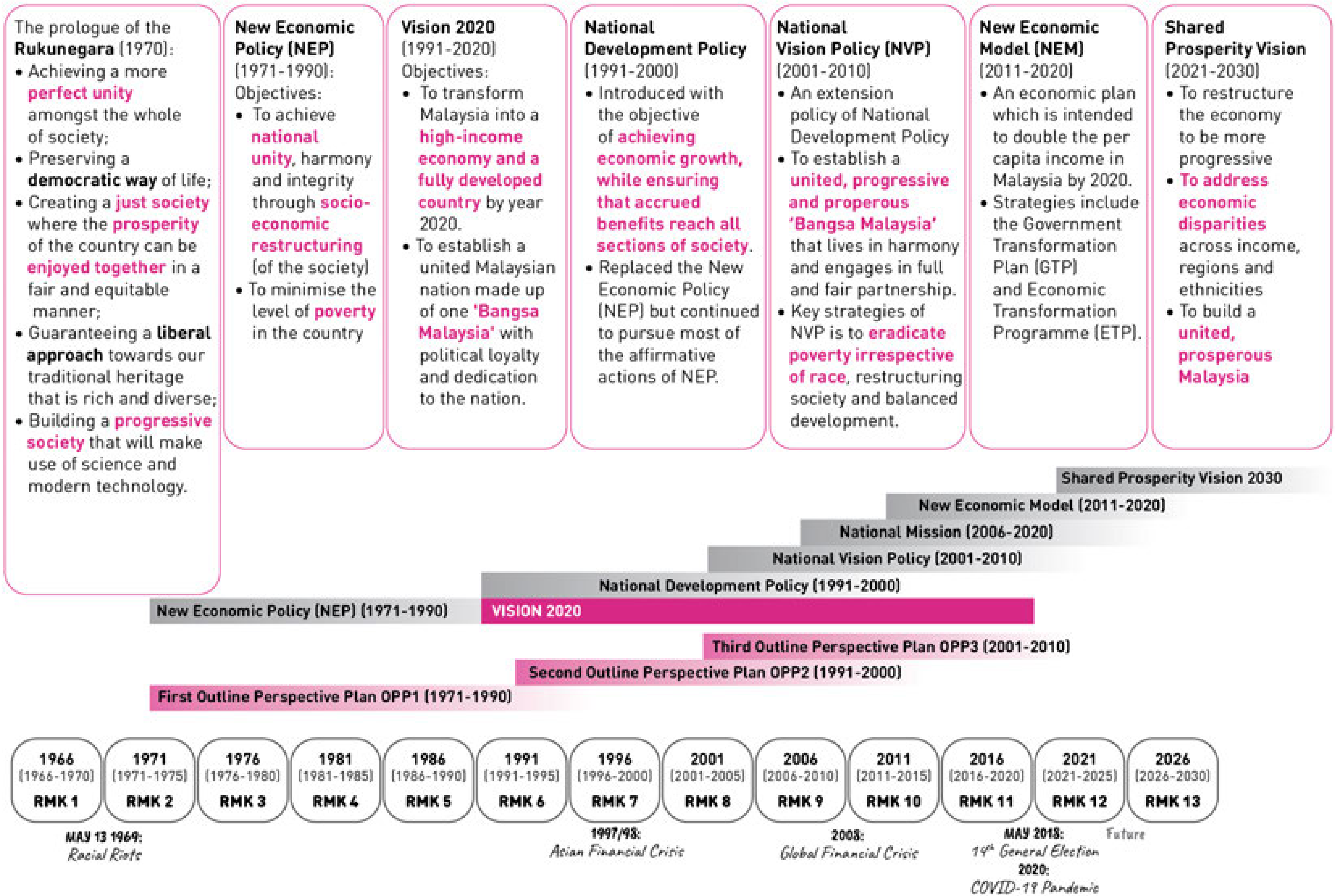


Figure 2.1: Choronology of Malaysia's Development Aspiration

Unfortunately, prevailing socio-economic gaps persists in Malaysia's push to become a leading economy in the region. Many programmes and projects directed towards socio-economic reform was launched to spread the prosperity for greater growth inclusivity; mostly focussing on infrastructure development rather than structural issues afflicting the population. For example, several policies related to modernising economic sectors through infrastructural development became the prime focus of effort after Vision 2020 was announced. This is reflected by, among others, the National Telecommunication Policy and the establishment of Construction Industry Development Board in 1994 and Prasarana Malaysia Berhad in 1998 for public transport systems and services.

Tun Abdullah Ahmad Badawi, the 5th Prime Minister, reframed Malaysia's social progress through a set of noble values to guide the nation's development. He introduced the National Social Policy in 2003 with the objective of ensuring that the basic needs of individuals, families, and communities are fulfilled. Among the strategies outlined in this plan was creating opportunities to gain and achieve equitable education through flexible and innovative modes across all ages and walks of life. This policy encouraged active community participation in various rehabilitation services for target groups such as drug users and people with special needs. The National Social Policy also stressed the provision of affordable legal guidance and services to help communities in need exercise their rights and responsibilities, enhancing the Rakyat's participation in governmental processes.

Emphasis on women and their role in developing the economy began with the National Economic Policy (1971-1990) and the National Development Policy (1991-2000) (ADB, 1998). The National Policy on Women was introduced in 2009 to integrate women in all sectors of development while ensuring equitable sharing of resources and opportunities. However, Malaysia's reports on the Convention on the Elimination of all Forms of Discrimination Against Women (CEDAW), a United Nation's mechanism to monitor women's rights in its member states, show that more work is needed for Malaysian women in terms of participation in politics and decision making, conferment of nationality, marital and family rights, as well as special protection measures (NCWO, 2019).

The National Youth Development Policy was introduced in 1997 to strategise self-development opportunities in social and economic functions for the younger generation. This plan of action includes STI-specific elements that stressed on providing the infrastructure and mechanisms necessary to direct youth activities towards fundamental and applied research. Strategies include knowledge, vocational, and entrepreneurial development through youth involvement in activities that were in-line with the demands of national building. The Malaysian Youth Policy which was introduced in 2015 expanded efforts in youth inclusion in governing and social participation as part of multilevel collaboration initiatives.

The goal of these policies was to empower the Rakyat from various backgrounds to create a balanced and just society. However, not all these well-drawn policies translated into their intended outcomes, which highlights the importance of practical implementation for the efficacy and sustainability of policies on their target.

Environmental sustainability is integrated into Malaysia's national development planning; various national policies are guiding the nation's transition into the green economy. Once a dynamic and robust STI ecosystem is in place and the strategic interventions are rolled out, the reforms are expected to enable effective coordination of climate change actions needed to align Malaysia's growth with the sustainable development goals (SDGs).

Environmental policies are supported by a host of important laws, e.g., Land Conservation Act 1960, Protection of Wildlife Act 1972, Environmental Quality Act 1974, National Parks Act 1980, National Forestry Act 1984, Fisheries Act 1985, Mineral Development Act 1994, and more. These legislations aimed to manage the numerous environmental problems such as air pollution, water pollution, and exploitation of natural resources.

The regulatory requirements of these legal instruments stress upon the importance of environmental planning tools such as environmental impact assessment (EIA), strategic environmental assessment (SEA), cost-benefit analysis, market-based instruments, environmental auditing, and others. Adoption of a systematic planning approach and associated tools was core in the effort to evaluate and mitigate environmental impacts of development activities. Nonetheless, a crucial shortcoming of these laws is the absence of a coordination mechanism to foster cooperation among the stakeholders for addressing environmental concerns in a holistic and practical manner.

National megaprojects and pivotal policies were vital factors in creating an enabling STI ecosystem in Malaysia for the past 30 years (Figure 2.2). Mapping these megaprojects and policies against STI enablers from 1990 to 2020 showed how the Government intensified efforts across these enablers by stressing specific enablers within different policies at different points in time.

Close inspection of these numerous megaprojects and science policies showed contrasting areas of prioritisation. Lack of alignment and incongruence in the socio-economic priorities sketched in the Malaysia Plans created inconsistencies in the national priority research, ultimately weakening the ability to create any long-term impact. This inconsistency in priorities over time has reinforced the idea that science and technology are mere checkboxes in driving the country's development rather than a crucial underpinning of its growth. Among reason is a poor follow hindered when portfolio and focus of relevant Ministries are changed due to restructuring or after a new Cabinet is formed.

Box 2.1: Evolution of the Ministry of Science and Technology

1973: The Ministry of Technology, Research, and Local Government *(Kementerian Teknologi, Penyelidikan, dan Kerajaan Tempatan)* was established.

1976: The ministry was restructured and renamed as Ministry of Science, Technology and Environment (MOSTE) *(Kementerian Sains, Teknologi dan Alam Sekitar)* to expand emphasis on science and technology as well as environmental issues.

2004: MOSTE was restructured and renamed as Ministry of Science, Technology and Innovation (MOSTI) *(Kementerian Sains, Teknologi, dan Inovasi)* to spearhead the development of the nation's ICT, multimedia, and innovation development.

2007: Additional MOSTI restructure to divide the science and technology components into five clusters: Biotechnology, ICT, Industry, Space, Sea & Atmosphere, and Core Science and Technology

2015: Clustering was discontinued and new divisions such as *Bahagian Teknologi Foresight*, *Bahagian Pemindahan Teknologi dan Pengkomersialan R&D*, *Bahagian Pembangunan Bakat STI*, *Bahagian Teknologi Strategik dan Aplikasi S&T* and *Bahagian Perkhidmatan, Pembangunan dan Pembudayaan STI* were formed at MOSTI.

2016: Restructuring of MOSTI to focus on commercialising R&D as well as innovation.

2018: Major restructuring post the 14th General Election. The Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) *(Kementerian Tenaga, Sains, Teknologi, Alam Sekitar & Perubahan Iklim)* was formed.

2020: MESTECC was disbanded as a result of the change of the Government coalition, the ministry reverted to MOSTI.

The restructuring illustrates the possibility of lack of continuity or follow-through in MOSTI's governance leading to- inconsistencies in priorities over the years.

Reference:
Ministry of Science, Technology and Innovation (MOSTI) (2018)

Malaysia's Key Development Policies, Programmes and Iniatives Related to STI

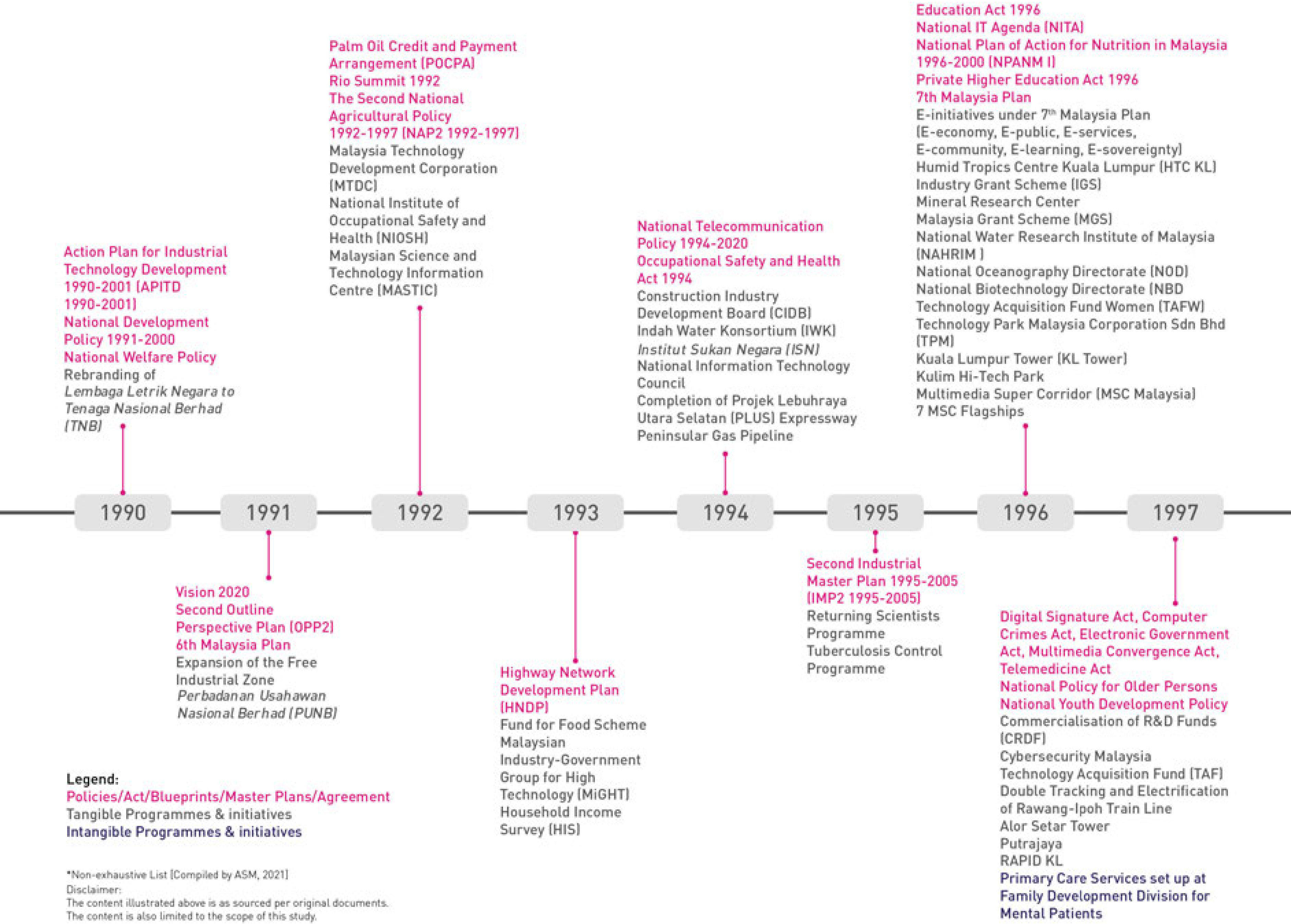


Figure 2.2: Snapshot of Malaysia's Key Development Policies, Programmes and Initiatives Related to STI from 1990 to 2021

1998

Communications and Multimedia Act
Intellectual Property Protection Act
National Biodiversity Policy 1998
National Economic Recovery Plan
National Mental Health Policy
Third National Agricultural Policy 1998-2010 (NAP3 1998-2010)
Malaysian Rubber Board
National Economic Action Council (NEAC)
Prasarana Malaysia Berhad (Prasarana)
Kompleks Sukan Negara (KSN)
Kuala Lumpur International Airport (KLIA)
Malaysia-Singapore Second Link (Linkedua)
KTMB Electric Commuter
Demonstrator Application Grant Scheme (DAGs)
Taman Kekal Pengeluaran Makanan (TKPM)
Integration of Mental Healthcare into Primary Practice

1999

National Property
Petronas Twin Towers
Universiti Telekom renamed to Multimedia University (MMU)

2000

ICT Fund
Institute for Clinical Research Malaysia (ICR)
Malaysian Palm Oil Board (MPOB)

2001

National Vision Policy 2001-2010
8th Malaysia Plan
Malaysia Venture Capital Management Berhad (MAVCAP)
The Malaysian Information Communication & Multimedia Services: Cellular Telephony, Internet & Broadcasting
Returning Malaysian Experts Programme
Stockholm Convention on Persistent Organic Pollutants
Communication for Behaviourial Impact (COMBI) Programme

2002

National Policy on Science, Technology and Innovation (NPSTI 2002-2010)
Knowledge-based Economy Master Plan
Housing Development Act (Control and Licensing)
National Environment Policy
Malaysian Organic Certification Scheme (myORGANIC)
BioGen Project
Energy Commission Malaysia (Suruhanjaya Tenaga)
Inno Biologics Sdn Bhd
Konsortium Perikanan Nasional Bhd (KPNB)
Malaysia Debt Ventures Sdn Bhd
Institut Perubatan Forensik Negara (IPFN)
Technology Depository Agency Berhad
Express Rail Link (ERL)

2003

Cartagena Protocol on Biosafety
National Nutrition Policy
National Social Policy
Third Outline Perspective Plan (OPP3)
Cradle's Funding Programme
Malaysian Intellectual Property Organisation (MyIPO)
Kuala Lumpur Sentral Station (KL Sentral)
Rural Internet Centre
KL Monorail
Program Latihan Khidmat Negara (PLKN)

2004

Environmental Quality Control (Control of Emissions from Motorcycles) Regulation 2003
National Broadband Plan
National ICT Policy
Protection of New Plant Varieties Act
Construction Research Institute of Malaysia (CREAM)
Feed-in-Tariff (FiT) Scheme
Malaysian International Tuna Port Sdn Bhd
FAMAXchange, Agribazaar Portal, Ikan Online, Sistem Rangkaian Informasi Perikanan (SIRIP), Padi Net
Completion of East Coast Expressway Phase I
Government-linked Company (GLC) Transformation Programme
National Agricultural Skills Training Programme

2005

Fair Trade Practices Policy
Kyoto Protocol
National Biotechnology Policy
National Physical Plan (NPP) Malaysia (2005-2020)
Bioeconomy Corporation
Small Medium Enterprise (SME) Bank
Malaysia Genome Institute (MGI)
Malaysia Building Integrated Photovoltaic (MBIPV) Project

2006

Biosafety Act
National Biofuel Policy
National Mission 2006-2020
9th Malaysia Plan
National Plan of Action for Nutrition II 2006-2015 (NPANM II)
National Strategic Plan on HIV/AIDS 2006-2010
National Wireless Communications Technology Roadmap
National Solid Waste Management Policy
National Urbanisation Policy
Malaysian Information, Communications and Multimedia Services 886 (MyICMS886)
Agro-Biotechnology Institute Malaysia (ABI)
Malaysian Institute of Pharmaceuticals and Nutraceuticals (Ipharm)
BioNexus Status Companies
Biotechnology Acquisition Grant
Biotechnology Commercialisation Fund
Fibre and Biocomposite Development Centre (FIDEC)
Halal Development Corporation Berhad (HDC)
Innovation Fund (InnoFund)
Malaysian Life Sciences Capital Fund
Malaysia Agriculture, Horticulture and Agro-tourism Show (MAHA 2006)
Malaysia Agro Exposition Park Serdang (MAEPS)
Malaysian Technical University Network (MTUN)
Suruhanjaya Perkhidmatan Air Negara (SPAN)
Sustainable Energy Development Authority Malaysia (SEDA)
Techno Fund
Technopreneur Development – MSC Pre Seed Fund
Water Asset Management Company (WAMCO)
Brain Gain Malaysia Programme (BGMP)
Agro Biotek R&D Initiatives
Genomics & Molecular Biology R&D Initiatives
Pharmaceutical & Nutraceutical R&D Initiatives
National Nanotechnology Initiatives of Malaysia

2007

National Intellectual Property Policy 2007-2020
National Cyber Security Policy 2007
National Policy for Persons with Disabilities 2007-2012
East Coast Economic Region (ECER)
Malaysian Institute of Road Safety Research (MIROS)
Malaysian Pepper Board (MPB)
Malaysia Research University Network (MRUN)
Terminal Agribisnes Negara (TEMAN)
Gopeng
Northern Corridor Economic Region (NCER)
Pasukan Petugas Khas
Pemudahcara Perniagaan (PEMUDAH)
Health Informatics Centre
Stormwater Management and Road Tunnel (SMART Tunnel)

2008

National Action Plan for Elderly Health Service 2008-2020
Iskandar Malaysia
Terminal Agribisnes Negara (TEMAN)
Kota Bharu
Sabah Development Corridor (SDC)
Sarawak Corridor of Renewable Energy (SCORE)
Southern Integrated Gateway
MyBrain 15 Programme

2009

Intellectual Property Commercialisation Policy 2009
National Green Technology Policy
National Slope Master Plan 2009-2023
National Timber Industry Policy
New Economic Model
United Nations Framework Convention on Climate Change (UNFCCC COP15) - Copenhagen Accord
Malaysian Quarantine and Inspection Services (MAQIS)
Green Building Index
Malaysia's Performance Management And Delivery Unit (PEMANDU)
Abandoned Land Development Project (ACDA)

2010

Biosafety Bill and the Access and benefit-sharing (ABS) Bill
Education Development Plan 2001-2010
Mental Health Act and Regulations
National Climate Change Policy
National Renewal Energy Policy
National Transformation Policy
Occupational Safety & Health Master Plan for Malaysia 2010-2015
Second National Policy for the Elderly
National Strategic Plan for Non-communicable Disease 2010-2014
Accounting Research Institute (ARI)
Centre for Drug Research (CDR)
Green Technology Financing Scheme (GTFS)
UKM Medical Molecular Biology Institute (UMBI)
Institute for Research in Molecular Medicine (INFORMM)
Institute of Bioscience (IBS)
UM Power Energy Dedicated Advanced Centre (UMPEDAC)
Program Susu 1Malaysia (PS1M)
Expansion of HALMAS (Halal Malaysia) Industrial Parks
Malaysian Green Technology Corporation (MGTC)
National Broadband Initiative (NBI)
Program Saringan Literasi dan Numerasi (LINUS)

2011

1 Student 1 Sport
Blueprint of Enculturation of Lifelong Learning for Malaysia 2011-2020
National Agro-food Policy 2011-2020
10th Malaysia Plan
New Economic Model 2011-2020
National Higher Education Action Plan 2011-2015
Agensi Inovasi Malaysia (AIM)
Community Mental Health Centre (MENTARI)
Malaysia Institute for Supply Chain Innovation (MISI)
Mass Rapid Transit Corporation (MRT Corp)
Low Carbon Cities Framework (LCCF)
Malaysian Health Data Warehouse (MyHDW)
Bakun Dam
MyBrainSc Programme
Residence Pass-Talent (RP-T)
Skim Latihan 1Malaysia (SL1M)

2012

Greater KL/Klang Valley Land Public Transport Master Plan
National Commodity Policy
National Land Public Transport Master Plan 2012-2020 (NLPTMP)
Review of National Mental Health Policy
National Space Policy
National Water Resources Policy
Perumahan Rakyat 1Malaysia Act (PR1MA) 2012
Collaborative Research in Engineering, Science and Technology Centre (CREST)
Domestic Investment Strategic Fund (DISF)
Institut Oseanografi dan Sekitaran (INOS)
MyHIJAU Mark & Directory
Agroprenuer Integrated Farming & Practical Training Centre
National Institutes of Biotechnology Malaysia (NIBM)
Construction of Pengerang Integrated Petroleum Complex (PIPC)
High Impact Project 6 Programme (HIP 6)
Program Pengukuhan Bekalan Ladang Kontrak ke Pasar Tani (KUKUH)

2013

National Policy on Science, Technology and Innovation (NPSTI 2013-2020)
Look East Policy 2.0 (2013-2020)
Perbadanan PR1MA Malaysia
1BestariNet
PlaTCOM Ventures Sdn Bhd
Malaysian Good Agricultural Practices Scheme (MyGAP)
Completion of East Coast Expressway Phase II
Double Tracking and Electrification of Seremban-Gemas Train Line
Double Tracking and Electrification of Ipoh-Padang Besar Train Line

2014

National Internet of Things (IoT) Strategic Roadmap 2014-2020
National Graphene Plan 2014-2020 (NGAP)
National Automotive Policy 2014-2020
Food and Agro Council for Export (FACE)
Malaysian Business Angel Network (MBAN)
Malaysian Global Innovation and Creativity Centre (MaGIC)
Photonics Research Centre (PRC)
River Engineering & Urban Drainage Research Center (REDAC)
Wireless Communication Centre (WCC)
Institute of Microengineering and Nanoelectronics (IMEN)
Centre for Intelligent Signal & Imaging Research (CISIR)
Institute of Ocean and Earth Sciences (IOES)
Completion of Penang Second Bridge
Construction of Merdeka 118
Industrial collaboration programme (ICP)

2015

Logistics Trade Facilitation Master Plan 2015-2020
Malaysia Education Blueprint (Higher Education) 2015-2025
Malaysian Youth Policy
Rural Power Master Plan
United Nations Framework Convention on Climate Change (UNFCCC COP 21) – Paris Agreement
Digital Free Trade Zone (DFTZ)
Inaugurate of One Auto Hub @Batu Kawan Construction
Malaysia Board of Technologists (MBOT)
Rural Electrification Scheme
Inaugurate of Pan Borneo Highway Project
SMEs Go Global Programme

2016

11th Malaysia Plan
National Action plan for Orang Kurang Upaya (OKU) 2016-2022
National Biodiversity Policy 2016-2025
National Plan of Action for Nutrition III 2016-2025 (NPANM III)
National Strategic Plan for Tuberculosis Control 2016-2020
Talent Roadmap 2016-2020
Teacher Professionalism Development Master Plan
Institute of Noise & Vibration (IKG)
Advanced Membrane Technology Research Centre (AMTEC)
Green Technology Park (GTP) Pahang
Program Pembaikan Sekolah Daif
Completion of Royal Belum Jetty
Completion of Kelana Jaya Line Extension
Penang Sentral
Dual Language Programme (DLP)

2017

Access to Biological Resources and Benefit Sharing Act
Green Technology Master Plan Malaysia (2017-2030)
Construction of East Coast Rail Link (ECRL)
Full service of Sungai Buloh-Kajang (SBK Line)
Teleprimary Care- Oral Health Clinical Information System (TPC-OHCIS)
Institute of Bioproduct Development (IBD)
Institute of Tropical Forestry and Forest Products (INTROP)
Institute of Tropical Agriculture & Food Security (ITAFoS)

2018

Industry4WRD Policy
Industry 4.0 Capital Allowance
Double Tracking and Electrification of Gemas-Johor Bahru Train Line
Rural Economy Funding Scheme (SPED) NANO
Zero Student Dropout Program
International Collaboration Fund (ICF)

2019

Nagoya Protocol
National Fiberisation and Connectivity Plan (2019-2023)
Supply Agreement of Renewable Energy (SARE)
Centre of Biofuel and Biochemical Research (CBBR)
Malaysian Space Agency (MYSA)
Net Energy Metering Scheme (NEM 2.0)
Open for Service - West Coast Expressway
The Tropical Infectious Diseases Research & Education Centre (TIDREC)
Tun Razak Exchange (TRX)
CyberSecurity Malaysia Collaboration Programme (CCP)
Program Pembangunan Usahawan Produk Getah secara Inkubator

2020

Shared Prosperity Vision 2030 (SPV2030)
National Automotive Policy 2020
10-10 *My*STIE Framework
National Policy on Science, Technology and Innovation (NPSTI 2021-2030)
Pilot Test of Electronic Medical Record (EMR) System
Institute of Tropical Aquaculture Hatchery UMT (AKUATROP)

2021

National 4IR Policy
National Nutrition Policy 2.0
Malaysia Digital Economy Blueprint (MyDIGITAL)
Net Energy Metering 3.0 Program (NEM 3.0)

National and State STI Governance

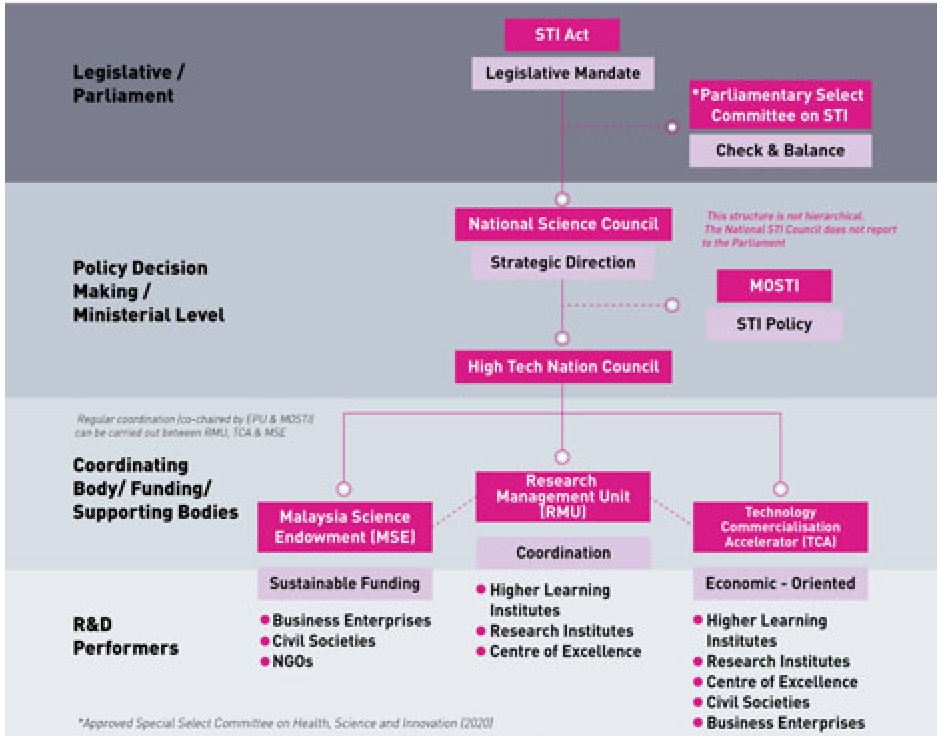
National: Science Outlook 2017 described Malaysia's STI ecosystem as a multitude of government institutions involved in the ideation, planning and implementation of STI-related policies and activities. Ministries and agencies implement varying divergent policies, strategies, and frameworks which led to the fragmentation and watering down of resources. The ecosystem also suffers from duplication of efforts as many players share similar responsibilities, resulting in redundancies and lack of meaningful impact. To address these challenges and create a vibrant STI ecosystem, the National Policy on Science, Technology and Innovation (NPSTI) 2021-2030 mapped the formation of entities to streamline all STI-related planning and activities across the Government, complementing the role of the Research Management Unit (RMU) (Figure 2.3).

The following components are framed to establish a vibrant STI ecosystem in Malaysia:

I. RMU as the key planner and manager to follow through on the direction and decisions made by the apex council. It will also plan, manage, and monitor research-related activities and strategic initiatives. The RMU will facilitate public-private collaboration, international co-operations, and talent development for researchers, while monitoring and reviewing R&D performance.

II. TCA to serve as the commercialisation arm of the RMU. It will identify the necessary mechanism of intervention and facilitation (finance, design, incubation, advisory services, etc.) for products to achieve commercial readiness.

Institutionalising STI Governance



Reference: Adapted from Academy of Science Malaysia (ASM) (2019)

Figure 2.3: Institutionalising STI Governance

III. MSE is responsible for sourcing alternative funds from various avenues and strategising the disbursement as well as monitoring the outcomes of STI-related R&D activities for reporting.

Malaysia's environmental governance provide a clear example of how fragmentation in governance weakens the execution of legislation authority, i.e., the management and implementation of the federal Environmental Quality Act (EQA) 1974 and 1985 falls under the jurisdiction of the State Government – land and associated natural assets are under State power – which may be constrained in terms of expertise and funds. Apart from that, most of the legislations are largely sectoral, i.e., focussing on specific activity areas under the jurisdiction of a number of other government agencies besides the Department of Environment (DOE) with no integrated policy implementation approach. Although environmental policy implementation involves various government agencies, only the DOE and local authorities and district offices are equipped with enforcement officers which may be insufficient in numbers or have inadequate resources. This fragmentation limits the roles of federal and state agencies as well as discourage effective participation by the indigenous community and other stakeholders which further undermines environmental governance.

State: Although most of the national STI-related planning falls under the purview of MOSTI and federal ministries such as MOHE, MOA, MITI, and MOH, there are also STI actors at State Government level. Science Outlook 2017 showed that out of eleven states in Peninsula Malaysia, only three states do not have a state executive councillor (Exco) that looks into STI development. An updated stocktake (Figure 2.4) found that nine states in the Peninsula now have Excos holding STI-related portfolio. Sabah has a dedicated ministry on STI which is the Ministry of Science, Technology and Innovation while Sarawak has a Ministry of Education, Science, and Technological Research.

State	STI-related State Exco/Ministry
Perlis	Science, Technology and Innovation Information and Communication Technology (ICT) Biotechnology & Green Technology Education, Human Resources, Higher Education
Kedah	Science, Technology and Innovation Industry & Investment Higher Education
Kelantan	Human Development, Education, Higher Education, Science and Technology Agriculture, Agro-based Industry, Biotechnology, Green Technology and Environment
Pulau Pinang	Human Development, Education, Science and Technology Agrotechnology & Food Security, Rural Development and Health
Perak	Health, Science, Environment and Green Technology
Terengganu	Infrastructure, Public Facilities, Utilities and Green Technology Tourism, Culture and Digital Technology
Pahang	Science, Technology, Innovation, Communication and Multimedia Agriculture, Agro -Based Industries and Biotechnology
Selangor	Finance, Economy, Land Development, Natural Resources, Strategic Communication, Education, Enculturation of Innovation, Smart Selangor and Disaster Management Tourism, Environment, Green Technology, Indigenous Affairs and The Special Committee on Buddhism, Christianity, Hindu, Sikh and Tao of The State of Selangor (LIMAS)
Negeri Sembilan	No specific STI related portfolio
Melaka	Education, Higher education, Technical & Vocational, Science and Innovation District, Rural, Flood Management and Green Technology Economics, Finance, Land Development, Coasts & Rivers, Water Management, Religious Affairs, Industry, Investment, Technology, Communications, Multimedia and Government Linked Agencies (GLCs)
Johor	No specific STI related portfolio
Sarawak	Ministry of Education, Science and Technological Research
Sabah	Ministry of Science, Technology and Innovation

Reference: Respective websites of State Governments

Figure 2.4: STI-related state Excos in Malaysia

Box 2.2: Indigenous Communities and Knowledge in Policy

As of 2017, the indigenous population in Malaysia were estimated to account for roughly 13.8% of the 31.7 million population. They are collectively known as Orang Asal in Sabah and Sarawak, and Orang Asli in the Peninsula. The population of native people in Sarawak is about 1,932,600 people or 70.5% of the population, while Sabah has about 2,233,100 Orang Asal or 58.6% of the population. Orang Asli comprises of 19 tribes while there are 64 indigenous groups in Sabah and Sarawak; each a distinct community with unique culture, language and social norms.

Native people in Sabah and Sarawak still practice some of their indigenous system in agriculture, river management and resource management. The Murut scatters the pounded sour fruit of the tree called liposu in their fields to prevent pest and disease infestation. The practice of meminting refers to sustainable hunting activity that focusses on capturing only mature animals to protect the animal population. Telinting is the method of frightening away bird pests by using a can tied with a long rope strung across the paddy field or garden. A well-known practice of river management among indigenous people is managal, a system of collective responsibility to ensure the sustainability of fish resource in the river.

Tagal System *@ Sistem Bombon* is a local practice by the Kadazan-Dusun tribe in Sabah to preserve their fishery resources from unsustainable fishing activity through closure of administered river to restrict any fishing activity. In Sarawak, it is called the 'Tagal System' and its practice has been adopted by the Sarawak Agriculture Department. The Tagal system literally means "fishing in rivers is prohibited by the concerned communities for a certain pre-agreed period of time" aims to restore depleted fisheries, keep the rivers free from pollution, and generate income for the communities. The State Fisheries Department of Sabah (DOF) also adopted the system; in 2000, the system was formally administered by the community with a strict formal penalty (e.g., jailed for two years) instead of the traditional payment of buffalo sacrifice.

DOF also enhanced the system by introducing eco-tourism activity within the prohibited river which increased the local community economy. The implementation of the Tagal System is promoted for empowering the local communities based on Section 58 of the Sabah Native Courts Rules of 1995 (Native Customary Law) and Section 36 of the Sabah Inland Fisheries and Aquaculture Enactment (2003). Under the Tagal System however, concerned communities are still allowed to harvest fish from the rivers but in a sustainable manner.

Tagal management system are divided into three zones, i.e., red, yellow and green zones. The Green Zone is an "open fishing zone" where fishing is allowed all year round for all Tagal members under strict Tagal regulations, e.g., using regulated fishing methods (no gillnet fishing allowed, only cast netting and angling). The Yellow Zone is open once or twice a year, particularly during community celebrations or festivals. Encircling gillnets could be used in this zone and the catch is shared by the Tagal members after appropriate deduction for the Tagal committee's administrative costs. The Red Zone is exclusively for the conservation of the Tagal fishery resources and is opened for sports fishing after paying a reasonable entrance fee. The cost of sport fishing is RM50/day from 8 a.m. to 4 p.m. plus the cost of local guides at RM50/two guests. The Tagal system gives the communities the power to protect their respective fish stocks from poachers, overfishing, illegal fishing, and any other activities that could pollute the rivers and water bodies and destroy the fish habitats.

References:

Borneo Today (2016), Halim, et al. (2012), IWGIA (2020), Jacinta and Asmiaty (2020) Jephrin, et al. (2009), Minah (2013)

Government as a Platform

The government acts as an intermediary (Government as a Platform, GaaP) through various platforms to facilitate collaboration, connecting the public to essential government services such as training programmes and knowledge transfer services (O'Reilly, T., 2010; D. Lathrop, and L. Ruma, eds. 2010). These platforms generally provide basic government services ranging from immigration to taxation as well as information access for the public through physical institutions, e.g., one-stop centres and knowledge sharing centres – and digital platforms, such as databases to public facilities.

There are also platforms that promote knowledge transfer and catalyse collaborative R&D in the form of "innovation intermediaries" which are mechanisms or institutions that form networks with different organisations for services such as technology transfer, innovation funding, and expert consultation (ASM, 2018). Innovation intermediaries link local firms, particularly SMEs, with organisations with the STI know-how (i.e., industry leaders, members of academia etc.) to collaborate in demand-driven R&D.

The Urban Transformation Centres (UTC) and Rural Community Centres or *Pusat Komuniti Desa* (PKD), are platforms where a range of public amenities as well as key government and private sector services are provided to rural and urban communities in a single location. Both initiatives were implemented as part of the National Blue Ocean Strategy (NBOS), which aimed to enhance service quality by forming strategic alliances between government and private sector entities (Shahriar et al., 2014).

UTCs and PKDs are governed by the National Strategic Unit of Ministry of Finance (MoF) and the Rural Community Division of Ministry of Rural Development respectively. The centres offer health services; security services; education, training, and employment services; financial services; business and entrepreneurial growth services; utility services; youth development services; welfare and community development services; and non-governmental organisation (NGO) services. Nationwide, there are 23 UTCs and 191 PKDs. Visitors to UTCs had doubled from 2013 to 2017 while PKDs recorded 9.7 million visitors (Figure 2.5 (b)). This reflects the impact of these platforms to enhance the quality of life of people in urban and rural areas by increasing income, lowering the cost of living, and improving access to government services.

State	UTC	PKD
Perlis	1	3
Kedah	2	30
Kelantan	1	15
Pulau Pinang	1	2
Perak	1	13
Terengganu	1	31
Pahang	1	20
Selangor	1	9
Kuala Lumpur	3	-
Negeri Sembilan	1	10
Melaka	1	13
Johor	2	24
Sarawak	3	6
Sabah	4	15
Total (As of March 2021)	**23**	**191**

Figure 2.5 (a): Nationwide Breakdown of UTCs and PKDs by State

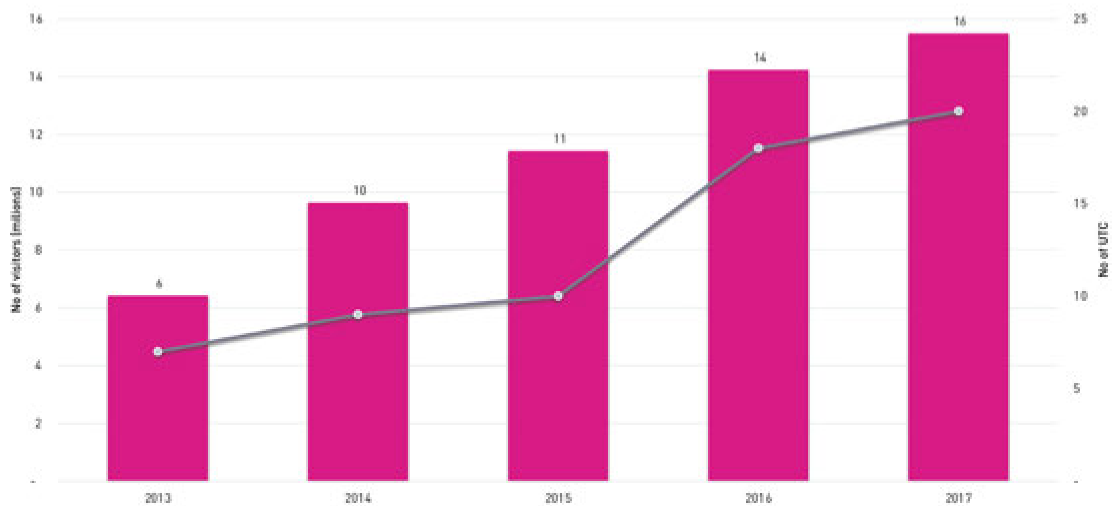


Figure 2.5 (b): Number of UTCs Visitors from 2013 to 2017

In recent years, attempts towards digital transformation was undertaken to increase the Rakyat's access to government services while simplifying administrative processes to better respond to the needs of the people. Efforts such as MAMPU's MyGovernment portal, a portal that lists Government agencies working together across borders to share the organization's portfolio of actions to resolve specific issues and, MOSTI's krste. my, the biggest reservoir of information on anything and everything to do with Research, Development & Commercialisation in the area of STI are examples of some digital platforms across ministries and the services provided. Refer Appendix 2.1 for more such efforts, the list is non-exhaustive.

However, such pockets of digital transformations are not sufficient to meet the fast pace global demands of public delivery services, businesses and everyday activities. The Ninth Malaysia Plan (2006-2010) highlighted the importance of new sources of wealth in knowledge intensive sectors, including information and communication technology (ICT), and biotechnology while digital transformation was emphasised in the Eleventh Malaysia Plan to enhance service delivery for the Rakyat. This report referred to the six dimensions of the Digital Government Framework (OECD, 2018a), as shown below to gauge where Malaysia is and there is work to be done in all dimensions with some progress seen in dimensions (2) and (5):

1. *From the digitisation of existing processes to digital by design*

2. *From an information-centred government to a data-driven public sector*

3. *From closed processes and data to open by default*

4. *From a government-led to a user-driven administration, that is, one that is focused on user needs and citizens' expectations*

5. *From government as a service provider to government as a platform for public value co-creation*

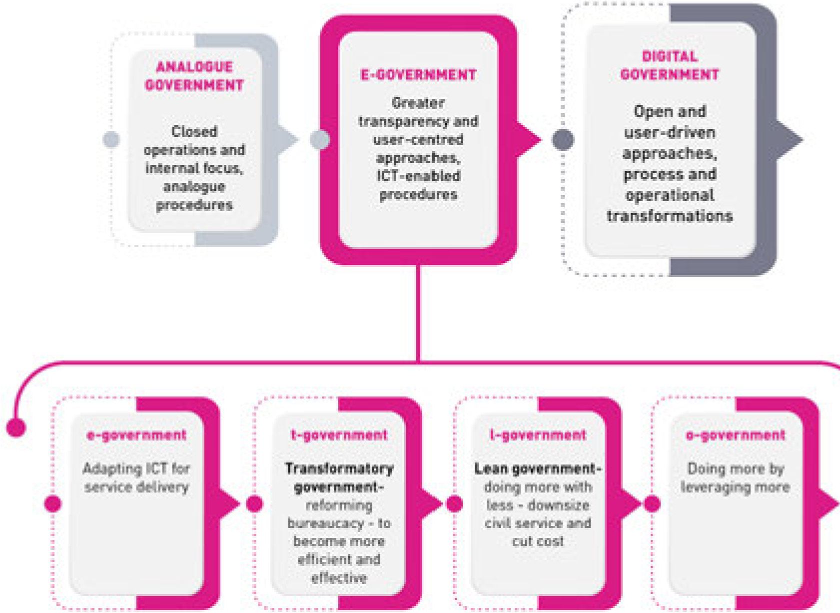
6. *From reactive to proactive policy making and service delivery*

Despite e-Government being one of the flagships of Malaysia's Multimedia Super Corridor (MSC) (please refer for details in the case study on MSC in the next chapter) announced in 1997, Malaysia ranks 47 in year 2020 (Figure 2.6) in the UN's E-Government Survey (UN, 2021).

	E-Government Rank		
	2010	**2020**	
Denmark	7	1	↑
Republic Of Korea	1	2	↓
Estoria	20	3	↑
Finland	19	4	↑
Australia	8	5	↑
Sweden	12	6	↑
United Kingdom	4	7	↓
New Zealand	14	8	↑
United states of America	2	9	↓
Netherlands	5	10	↓
Singapore	11	11	↔
Malaysia	32	47	↓

Figure 2.6: Malaysia's Performance in the E-Government Ranking Against Top 10 Economies

The OECD (2019) also outlines the progression from analogue- and e-government towards the digital governments, while another reference (Ojo, A. and Millard, J., 2017) further defines the four waves of evolution of e-government (Figure 2.7). Based on this and with the present progress, Malaysia is very much an analogue government moving towards the first wave of the e-government despite early efforts to do since 1997.



Reference: Adapted from OECD (2019), Ojo, A. and Millard, J. (2017)

Figure 2.7: The Progression Towards Digital Transformation and the Four Waves of E-Government Evolution

Box 2.3: Estonia's Digital Ledger in Government Services

Digital ledger or blockchain for governance has been used in countries such as Estonia where it is integrated in their justice and legislative system. Created in 2007, Keyless Signature Infrastructure (KSI) blockchain is a distributed public ledger designed in Estonia and used globally to ensure government-related networks, systems, and data are safe from being compromised while retaining 100% data privacy. Estonia deployed KSI blockchain across its government networks to safeguard the authenticity of electronic public data to stay transparent and cannot be manipulated by those inside and outside of government (i.e., hackers, government systems administrators). At present, the digital public ledger is used in:

- e-Law: An online system database for the Estonian Ministry of Justice that allows the public to read every draft law submitted, its current status, changes made to it as it passes through the parliamentary process and connects to the final passed law.
- e-Justice: A fully automated court processes and electronic communication tools which provides an overview of the different phases of criminal, misdemeanour, civil and administrative procedures, court adjudications, and procedural acts to all the parties involved; allows information exchange between different parties' information systems (i.e. police, prosecution offices, courts, prisons); enables the registration of court cases, hearings and judgments, automatic allocation of cases to judges, creation of summons, publication of judgments on the official website and collection of metadata.
- e-Police: Provides a fully rugged tablet with a docking station in each patrol car and a web-based modular software for police personnel field communication. This has led to the elimination of the need to radio for information while moving on foot and the positioning system tells location and status of each patrol officer in real-time.

Reference:
e-estonia (2021)

Planning has always been among the core activity of a government, and all the plans, policies, programmes, and initiatives over the last three decades are noteworthy. However, the outcomes have yet to propel Malaysia to be among the developed economies, both in terms of the desired GNI per capita and the social cohesion as envisioned in the Vision 2020.

In a world where changes are both rapid yet unpredictable, Malaysia must be future-ready to cope with the problems of the 21st century. The uncertainties and massive impact arising from global volatility demands the Government to invest in strategic foresight. National plans, policies and strategies must take multiple future possibilities into account and the government must be agile to respond to these exponential unprecedented global developments.

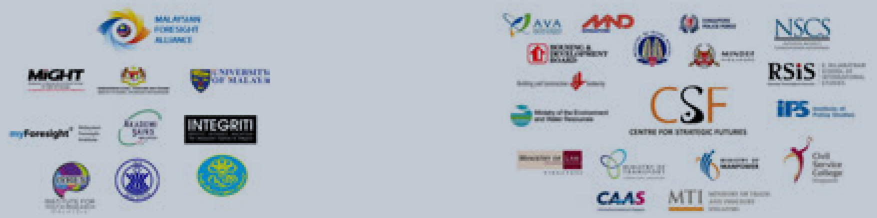
Innovative countries such as Finland and Singapore established institutions that focus on strategic foresight with built-in networks across ministries, the legislative body, and research institutions. In Finland, such networks extend to the regional and state municipality level. These networks enable the Government to set the long-term agenda by considering possible scenarios and the best measures to overcome them (SOIF, 2021). However, Malaysia does not have any formal platforms or long-term funding for foresight-related activities that connect all relevant partners in the Government for better anticipation, policy innovation and future proofing.

Box 2.4: Foresighting Landscape

Singapore has a well-established foresighting ecosystem at the heart of the government, which provides the necessary infrastructure and investments in creating a foresight-literate civil service. The Strategic Planning Office (SPO) was setup in the Prime Minister's Office to develop scenarios from a whole-of-government perspective and to strengthened links between foresight work and strategy formulation. In 2009, the Centre for Strategic Futures (CSF) was established think tank for strategic foresight, under the SPO, with the focus in developing foresighting tools for the use of government ministries and agencies as well expand "futures thinking" across the civil services (SOIF, 2021). It is a formal, cross-cutting platform for strategic foresight activities that enables better impact tracking and harmonises strategic planning of all ministries. Singapore had expended. Building on the existing bodies related to foresight, the Singapore government formed the Strategy Group which brings together the SPO, CFS, Population and Talent Division (NPTD) and National Climate Change Secretariat (NCCS). This network of agencies would provide strategic foresight capabilities across ministries as well as coordinate the planning with all "Futures Unit" in these ministries.

An entity with a similar role to that of Singapore's CSF would build system capability and capacity in strategic foresight across the Government. At present, Malaysia does not have a formalised platform embedded to provide foresighting input directly to all ministries. To create a foresight ecosystem, Malaysia would need to create a formal network to develop tools, provide capacity training and create awareness on foresighting in domestic and international policy planning. This formal network would need to connect all the different national councils to provide foresighting capabilities for each sectoral governance structure. The Malaysian Foresight Alliance is formed by independent parties.

Comparison of Foresighting Landscape of Malaysia and Singapore



Strategic foresight: an organisational foresight capacity that informs the development of strategy, the development of which happens when there is a critical mass of foresight-aware individuals in organisations.

Reference:
SOIF (2021)

KEY INTERVENTIONS

1. **Transformation towards digital governance must be the main aim of the Government for greater transparency, tracking, monitoring and seamless delivery of public service in-line with being a High-tech Nation.**

2. **Institutionalising strategic foresight. All upcoming national plans, policies and strategies must be future-ready and as much as possible be future proof.**

STATE OF PLAY OF THE MALAYSIAN STI ECOSYSTEM

The previous section highlighted key STI policies implemented over the last three decades while this section presents the key performance of Malaysia's STI ecosystem and their outcomes, e.g., research inputs (research expenditure and research personnel), outcomes (publications and patents), state of STI ecosystem development, and its impact on economic, social and environmental outcomes.

Research Expenditure

Malaysia's gross expenditure on R&D (GERD) grew steadily from 2006 until 2016. The growth in percentage of GERD per GDP started around the same period as the establishment of the Malaysian Research Universities (MRUs) in 2007 but fell sharply to an 8-year low of 1.04% GERD per GDP in 2018, during the change of the government. The National Policy on Science, Technology & Innovation (NPSTI) 2021-2030 outlined a target of 2.5% GERD per GDP by 2025 and 3.5% GERD per GDP by 2030; however, this may be tough to accomplish given the current rate of near continuous economic disruption caused by the COVID-19 pandemic.

Compared to other developing countries, Malaysia has done well in maintaining a healthy percentage of GERD per GDP in line with Challenge 6 of the Vision 2020 to establish a scientific and progressive society. However, this comparison fell short when contrasted against developed countries like the Republic of Korea, Sweden, Japan, Germany, and Denmark which have surpassed 3% of GERD per GDP (Figure 2.8 (b)). Even Thailand (1% GERD per GDP) could overtake Malaysia in the near future if the R&D activities in the country do not intensify.

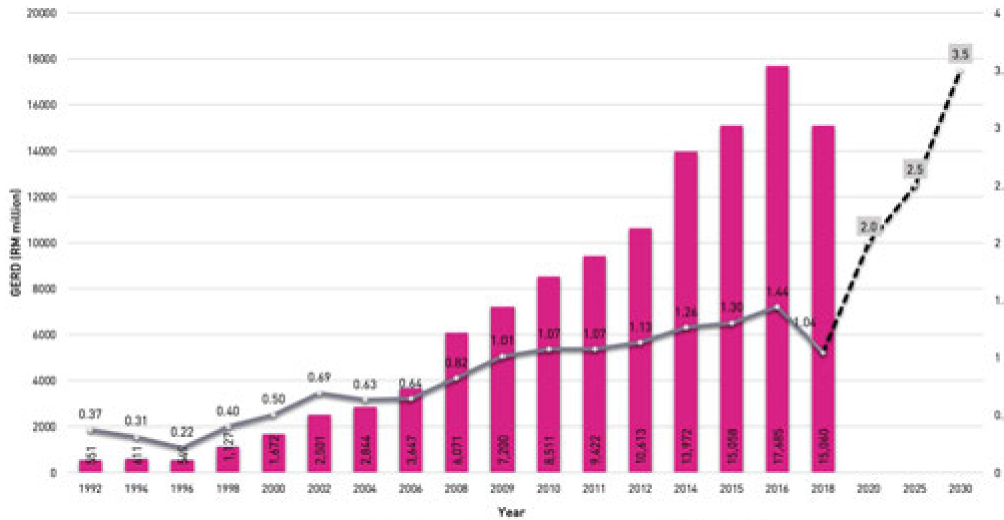


Figure 2.8 (a): Malaysia's Gross Expenditure on Research and Development (GERD)

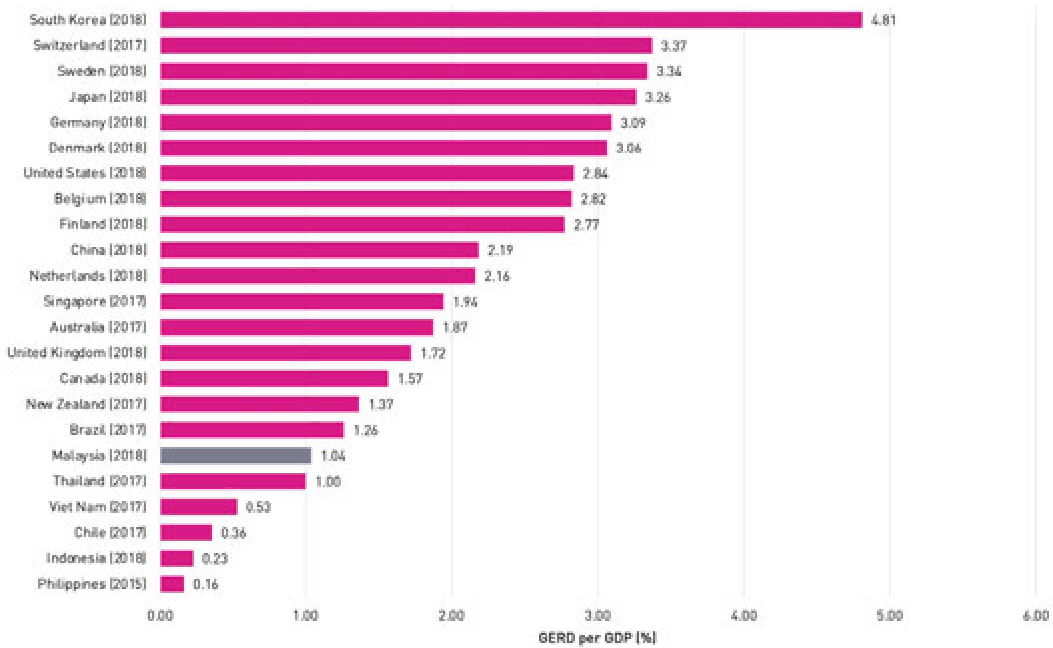


Figure 2.8 (b): Benchmarking on Gross Expenditure on Research and Development (GERD) in 2018

The breakdown of the GERD based on research expenditure by government agencies, academic institutions, industry, and other organisations is shown in Figure 2.9 (a). Overall, the GERD in Malaysia has been increasing since 1992, with the majority of R&D expenditure originating from business enterprises. However, from 2016 to 2018, business enterprise expenditure on R&D (BERD) declined due to global economic uncertainties (e.g., trade war between China and USA) and political instability in Malaysia. Additionally, R&D expenditure by higher education (HERD) saw an increase from 2008 onwards which could be a direct result from the establishment of the MRUs; however, this percentage begun to decline in 2018 and has not risen since.

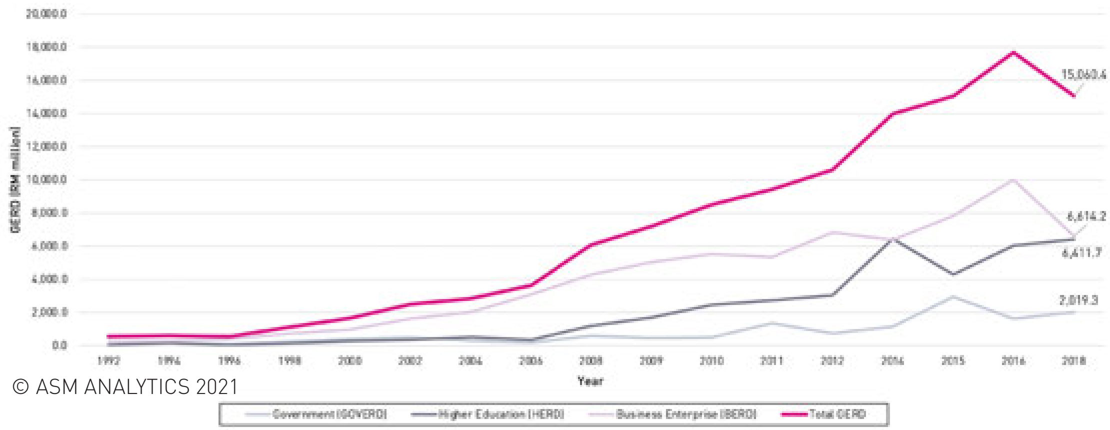


Figure 2.9 (a): Malaysia's Breakdown on Research Expenditure by Government, Higher Education and Business Enterprise

Most of the developed countries tend to have a 60% to 80% of their GERD from business enterprises (Figure 2.9 (b)). In 2018, Malaysia's BERD sat at 43.9% which is behind Thailand (80%) and Viet Nam (73%). The National Policy on Science, Technology & Innovation 2021-2030 targets to increase Malaysia's BERD to 70% by 2025, which suggest significant investment are needed if the target is to be met. However, the present climate over the business sector does not indicate that Malaysia's BERD is likely to shift higher in the new future, given the industry's continued hesitancy to invest in local R&D.

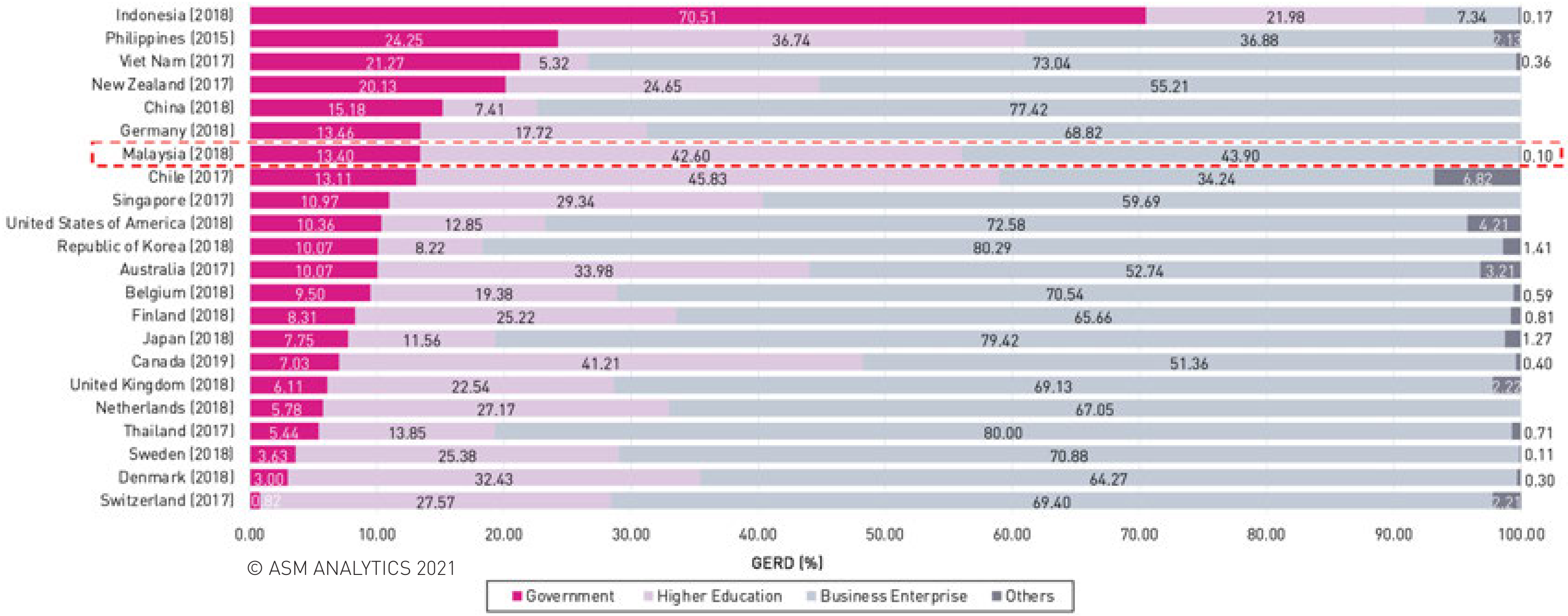


Figure 2.9 (b): Benchmarking on the Research Expenditure by Government, Higher Education and Business Enterprise in 2018

Experimental development is a crucial step in translating R&D into commercially viable products/services which is why developed countries often pace their percentage of experimental development between 40% to 60%. However, between 2008 to 2016, Malaysia's experimental development expenditure has dipped below 20% while the majority of the country's GERD was spent on basic and applied research. This changed in 2018 when the national's experimental development percentage increased to 24.5%, 10% more than in 2016 (Figure 2.10 (a)). NPSTI 2021-2030 aims to increase investments into this area to catch up and even surpass experimental research spending in Singapore and Thailand which are significantly higher.

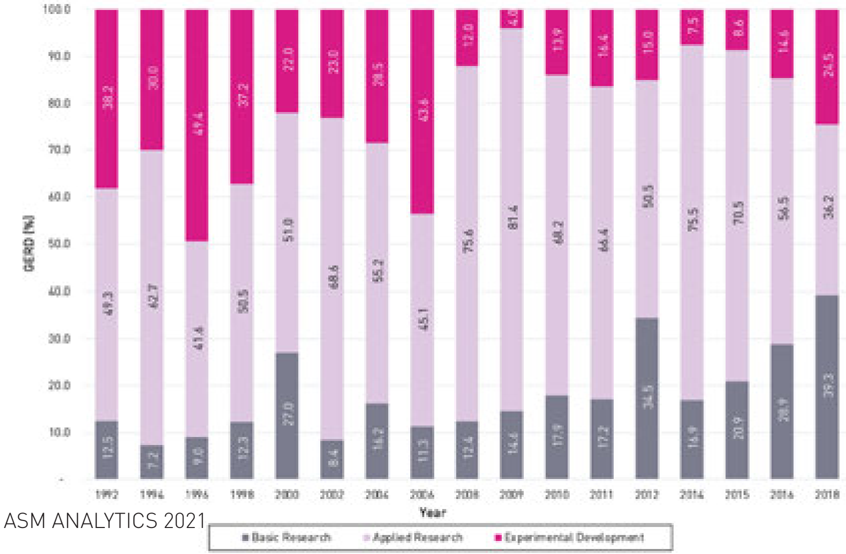


Figure 2.10 (a): Malaysia's Research Expenditure based on R&D Activities

Figure 2.10 (b): Benchmarking on the Research Expenditure based on R&D Activities in 2018

Research Personnel

STI cannot progress without adequately trained talent in sufficient numbers. Malaysia's number of full-time equivalent researchers (FTE) per thousand labour force is ahead of other developing countries but still lags behind developed countries (per Figure 2.11). The establishment of MRUs and the MyBrain15 (under the Tenth and Eleventh Malaysia Plan) contributed to driving up the numbers of researchers through encouraging postgraduate education which saw 56,910 students registered in graduate programmes (Sivanandam, et al., 2020).

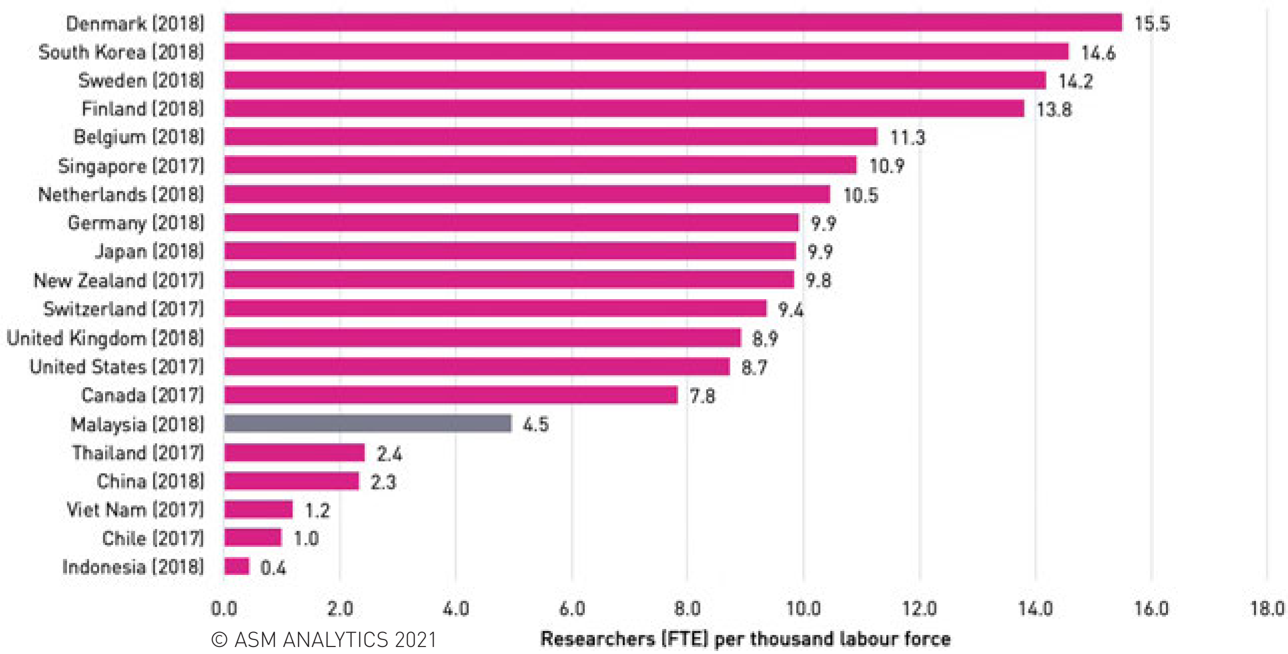


Figure 2.11: Global Benchmarking of Researchers (FTE) Per Thousand Labour Force in 2018

Almost 50% of FTE researchers were located in higher learning institution (HLI) from 2000 to 2006 and this figure jumped up to 70% to 83% after MRUs were established in 2007. The FTE researchers in industry was higher before the year 2000 with an all-time high in 1998 at 58.5% (very close to the proportion in advanced nations) and has since drastically dropped to 15.8% in 2018 (Figure 2.12 (a)). This drop may be due to the Asian Financial Crisis in the late 1990s which saw many business ventures failing, including those that invested heavily in STI. This is unfortunate as industrial R&D often focus on experimental development, which is crucial for commercialisation and scale up, unlike research in HLI which tend to centre more around basic and applied research.

The present researchers (FTE) proportion in Malaysia is not conducive towards establishing a knowledge economy needed to propel the country to become a high-income nation and needs to be addressed comprehensively in both the public and private sector. The Government introduced the Researcher Industry Scientific Exchange (RISE), an initiative where researchers from universities are sent to work with the industry to increase commercial enterprises' appetite for research. This initiative is hoped to increase translational and experimental R&D that leads to viable commercial outcomes and encourage industry to continue to invest in STI development in Malaysia.

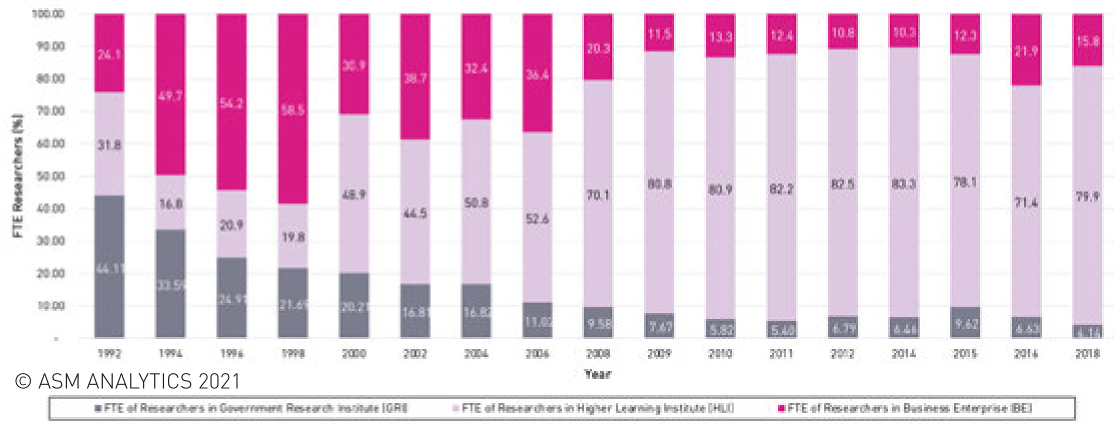


Figure 2.12 (a): Where Researchers are Employed in Malaysia

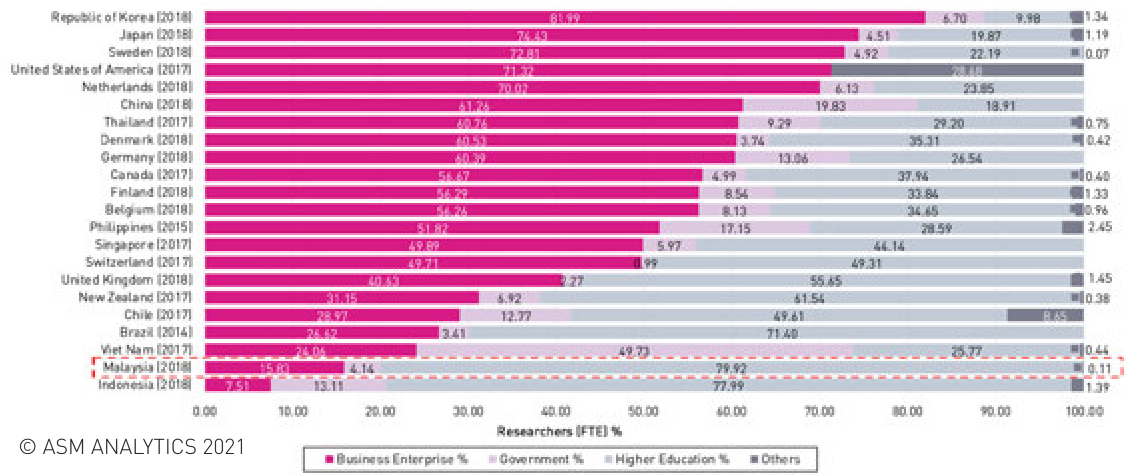


Figure 2.12 (b): Global Benchmarking of Researchers (FTE) by Sectors in 2018

Research Outcomes

Publication is an important measure for research intensity. Among the ASEAN member states, Malaysia's publications observed significant growth since the establishment of MRUs, surpassing Thailand in 2009 and Singapore in 2011. However, Indonesia overtook Malaysia in the number of journal articles in 2019, indicating the heightened research pace in the neighbouring country (Figure 2.13).

While Malaysia appears to be productive in terms of publications, the quality of the publications is relatively poor compared to Singapore and OECD countries (Figure 2.14); Singapore is the only ASEAN nation with publication quality on par with other OECD countries. Publishing in high quality academic treatises is a measure of research output quality, level of international collaboration, and return on investment (ROI) as well as potential for expansion into translational and experimental research for commercialisation.

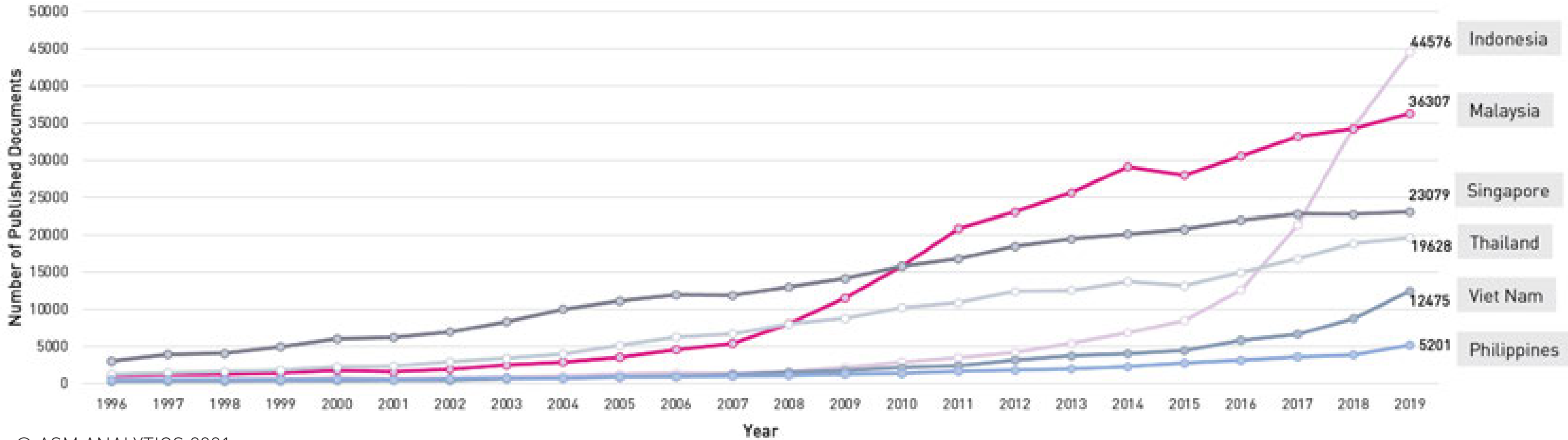


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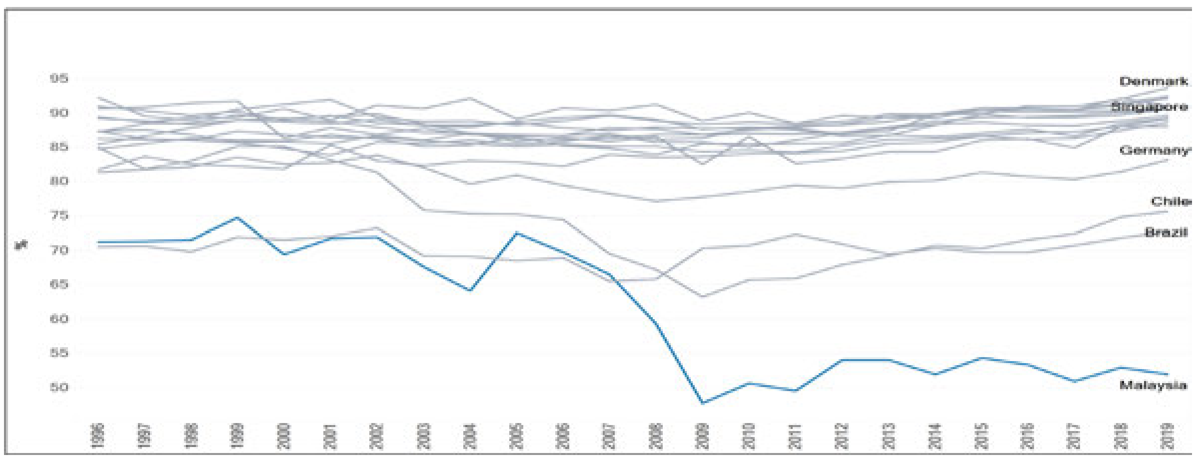
Figure 2.13: Publications in Malaysia and selected ASEAN Countries, 1996 - 2019



Analysed by Sunway University Research Team

Figure 2.14: Percentage of publications in Malaysia and pace-setter countries

Note: Publications in Q1 and Q2 Journal Quartile by Scientific Journal Rankings

The bulk of Malaysian research personnel are employed in Higher Education (Figure 2.12), and they face huge pressure to produce scientific publications that are indexed in SCOPUS or Web of Science as a mark of quality and performance (i.e., citation rate). Macháĉek and Srholec (2021) placed Malaysia at number four of the top twenty countries reported to publish in predatory journals that exploit the open access model by receiving payment from authors to make the articles freely available without the usual peer review process that normally safeguards the scientific merit of the work. The pressure to publish combined with modest research findings due to inadequate research funding may be a factor for Malaysian researchers to publish in low prestige and quality journals.

Another measure of STI ecosystem effectiveness is the number of patents filed and granted. Figure 2.15 shows that the number of patents filed picked up in 2000, but granted patents only began an upward trend from 2005 onwards, coinciding with the establishment of MRUs. One possible explanation for the surge in patents filed may be because the Ministry of Higher Education (MOHE) started to acknowledge patent grants and applications as a key performance indicator (KPI) for HLI at around this time. Although the number of patent applications rose significantly to hover around just over 1000 points, the number of granted patents has yet to break the 600-point. This suggests that a considerable number of applications were not up to par for a patent to be granted, with a good number being frivolous applications in response to KPI targets.

As seen in Figure 2.16, public HLI continue to lead in local products and technology development at 39.3%, followed by government research institutes (GRI) at 27.9%, and companies limited by guarantee (CLG) at

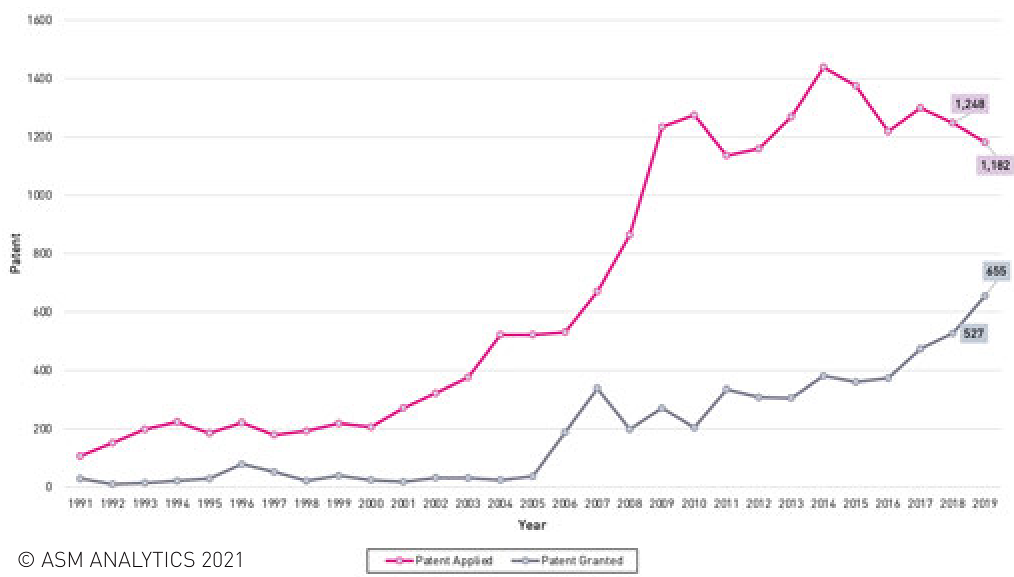
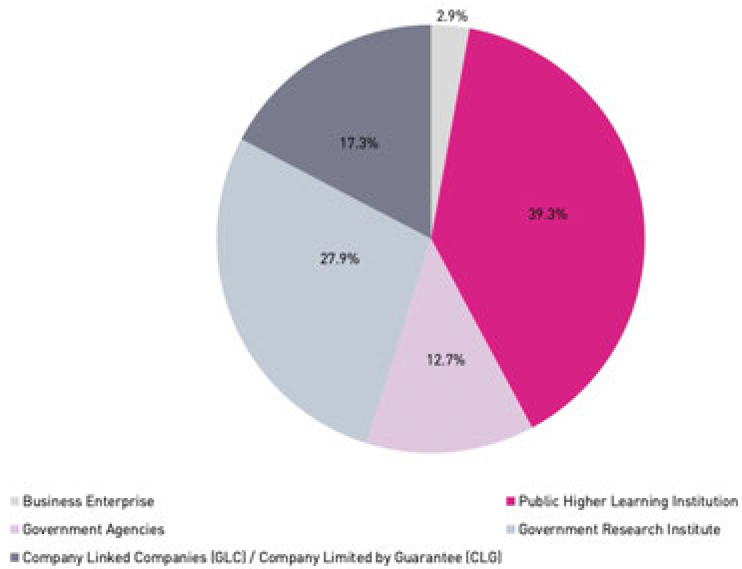


Figure 2.15: Number of Patent Application from 1991 to 2018



Reference: Adapted from Knowledge Resources for Science Technology Excellence Malaysia (KRSTEMY) (2021)

Figure 2.16: Percentage of Product & Technology Development by Type of Organisation from Ninth Malaysia Plan to Eleventh Malaysia Plan

17.3%. Though business enterprise remains the sector with the highest contribution to GERD, product and technology development in Malaysia still largely concentrated within higher learning institutions. Commercial enterprises should push their business up the value chain by capitalising on the STI resources of HLI either through public-private partnerships, grants for specific projects, staff secondment, etc. to come up with innovative products and services for their market.

Figure 2.17 depicts the correlation analysis between average GERD per researcher (FTE), patent applications and publications for Malaysia and other countries. In 1996, Malaysia had the highest average GERD per researcher (FTE) in the world due to the large amount of research funds and small number of researchers in the country. Although the amount of research fund was abundant at the time, Malaysia failed to produce a reasonable level of R&D output (publications and patent applications) due to insufficient high-quality research personnel. By 2006, Malaysia had four times more researchers than in 1996 which helped to increase the R&D output (publications outweighing patent applications). Over this period, Malaysia surged ahead of the Philippines, Indonesia and Vietnam, but lagged behind Singapore and Thailand. On the other hand, the Republic of Korea, which achieved developed country status in 1995, and China were moving at a faster pace in both publication and patent applications.

By 2016, Malaysia managed to overtake several developed countries like Singapore, Finland, Denmark and New Zealand in the number of publications, but not for patents, especially granted patents. Over time, the reduction in the average GERD per researcher for Malaysia suggests that the country has become more efficient in generating publications and patents. Unfortunately, as indicated earlier, Malaysia's quantum increase in publications can mainly be attributed to low quality publications and hence it is not too surprising that it is not accompanied by higher level of granted patents.

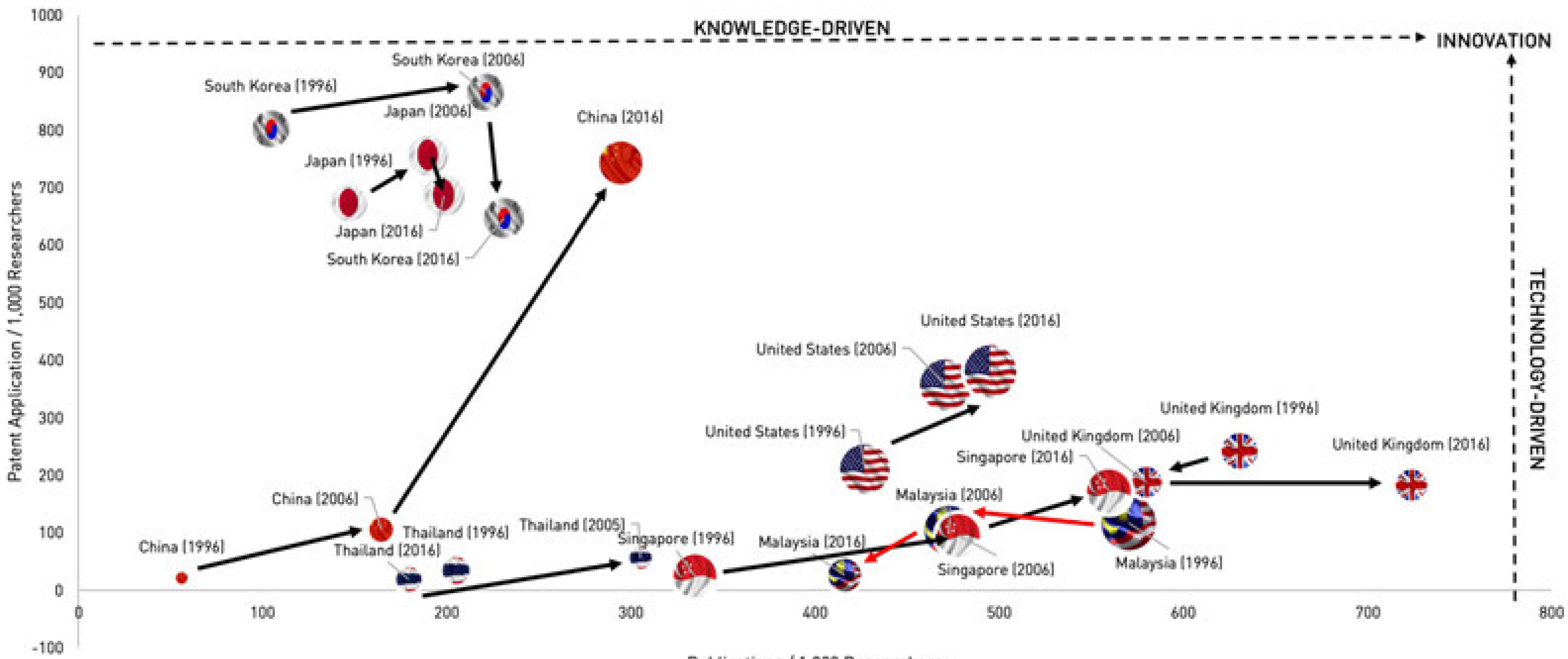


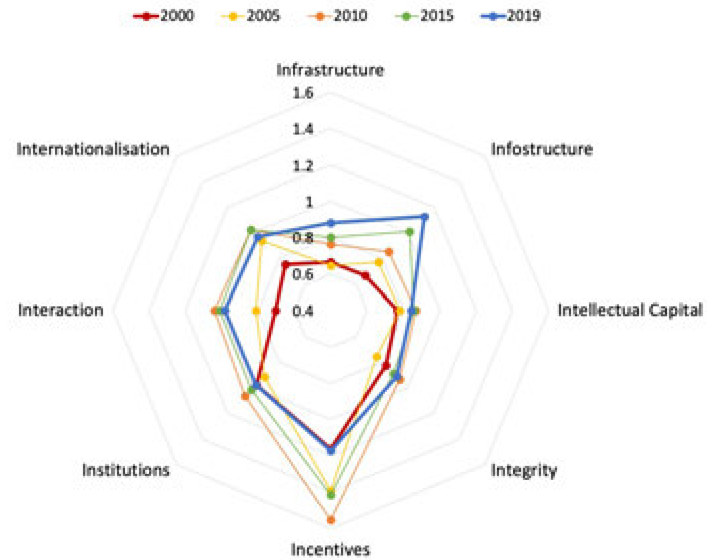
Figure 2.17: Correlation Between Publications, Patent Applications and Average GERD per Researcher (FTE) for 1996, 2006 and 2016

Note: Size of the bubble indicates the average GERD per researcher (FTE) of the year

State of Development of STI Ecosystem

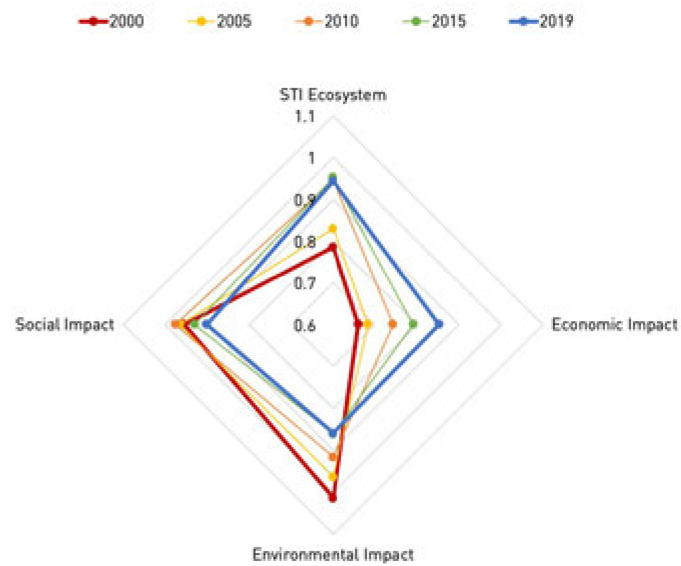
The state of development of STI enablers for Malaysia between 2000 to 2019 is presented in Figure 2.18 with a series of indicators to assess the performance of Malaysia STI ecosystem. It shows that with the exception of infrastructure and infostructure, the other STI enablers have advanced very little or have declined over the years. The incentives indicator showed a significant decline, leading to relatively lower industry investment in R&D and other STI-related activities. Reduction in internationalisation suggests that STI activities and networks in Malaysia are not being effectively utilised to penetrate global markets. The gradual weakening of institutions reflect that they are not keeping pace with the rapidly transforming global STI landscape. This has a knock-on effect on the effectiveness of the integrity systems (regulatory architecture and incentive systems) to ensure a dynamic and strong STI ecosystem.

Figure 2.19 illustrates overall STI indicators and its impact on the economy, social development and environmental sustainability of Malaysia. After a successful transition of the Malaysian economy from an agrarian to an industrial economy, Malaysia's STI ecosystem remained stagnant from 2010 to 2019, and only the economic impact experienced significant growth over this period. Societal development and environmental sustainability declined over the years, with the environment suffering the most. indicating a lack of synchronicity between economic progress and these aspects of the country's growth. Traditional developmental models drive socio-economic progress at the expense of natural environmental resources. As Malaysia progresses towards a developed nation status, it must ensure that the nation's prosperity is built upon environmental considerations that are coupled with social equity and inclusion so that no one is left behind.



Analysed by Sunway University Research Team

Figure 2.18: Malaysia's State of Development of the STI Enablers, 2000-2019



Analysed by Sunway University Research Team

Figure 2.19: Malaysia's State of Development of the STI Ecosystem and Economic, Social and Environmental Impact, 2000-2019

Box 2.5: Composite Index

The past two editions of the Science Outlook highlighted several weak links in the country's STI management cycle; SO2017 reported poor monitoring and evaluation as a major inhibitor of Malaysia's STI ecosystem. The lack of a stable index to peg the performance of the nation's STI ecosystem makes it hard to gauge the effectiveness and return on value of Malaysia's STI policies.

In general, composite indexes are used in investment analyses to aggregate economic trends or to predict market movement; these indexes also serve as useful benchmarks to assess the performance of the parameters of interest. The STI composite index is a statistical depiction of various indicators to provide an overall representation of the economic, societal, and environmental impact brought upon by STI. For statistical accuracy, the indicators in the STI composite index are standardised and combined for data points to be illustrated visually in a simplified manner.

The narrative of the composite index proposed in this report attempts to look at some of the indicators in a streamlined manner to serve as a benchmark for the economic, societal, and environmental aspects and the methodology is described in the **Appendix 6.6** in **Chapter 6.**

KEY INTERVENTIONS

1. **Advances in science and technology are enabled by research and development. Malaysia must reconsider the proportion and consistency of its GERD. The emphasis must be balanced for research and development (basic and applied) as well as experimental development.**

2. **Businesses must be encouraged to invest in R&D to developed endogenous technologies. This can happen through carefully orchestrated collaborations such as i-Connect, with the government, academia, economic corridors and civil society organisations at enterprise or grassroots level. This will also spread the talent across various institutions rather than being concentrated at HLI and increase possibilities of higher value of innovations and patents.**

KNOWLEDGE PARADIGM AND HUMANISING KNOWLEDGE-DRIVEN ECONOMY

Human development is often built on knowledge creation and use; be it more efficient food production that drives population growth, weapons and transport for conquest, or even space exploration and medical breakthroughs. Technological trajectories are path dependent, and the location of innovation hotspots is associated with economic development and prosperity. Advancements in STI create innovation hotspots characterized by innovation ecosystems (Dosi et al., 1988). The nexus between knowledge creation, diffusion, and discoveries arising from the knowledge propelled civilisations' progress. Information and communication technology (ICT) has granted people across the globe instant access to information and knowledge; changing the dynamics of socio-economic development by allowing quick participation in the global network economy, reach for vital resources, market intelligence, products, and services to almost anyone with an Internet connection.

The Four Industrial Revolutions

Societal development over the past three hundred years was powered by major STI discoveries in steam engine (1st industrial revolution), electricity (2nd industrial revolution), computers (3rd industrial revolution) and cyber-physical systems (4th industrial revolution). A review of the industrial revolutions that shaped human history over the past three hundred years can be found in Stern.

Reference:
Stern, P.N. (2020) and Schwab, K. (2016)

The spread of new technology and innovation is a measure of the strength of relationship between the knowledge creation process, diffusion, and novel discoveries; the speed of which has intensified over the last three hundred years (refer side bar). Increasing knowledge diffusion has a positive impact on socioeconomic development of societies across the globe, intensifying the pace of globalisation through the formation of global knowledge networks and supply chains which led to greater homogeneity in the economic and social structures of many countries worldwide.

The rapid pace of globalisation also increased competition among countries for scarce resources and markets which led to two major negative outcomes (Porter, 1991). First, increased competition and unfettered industrialisation powered by modern technologies over the last three centuries has led to unsustainable economic activities[1] which contributed to environmental degradation and climate change, habitat loss and the extinction of many species, jeopardising and compromising the quality of life of many communities, especially the vulnerable indigenous populace[2]. There is increasing scientific evidence on how biodiversity loss increases the risk of humans coming in closer contact with zoonotic pathogens with the potential to trigger catastrophic pandemics such as COVID-19 (Keesing and Ostfeld, 2021; Ellwanger and Chies, 2021).

Second, intensive speed of STI development has led to asymmetric access to information and knowledge among developed and under-developed countries; it also has a destabilising impact on firms and other economic agents, especially those who are slow in adopting new STIs and knowledge systems. Joseph Schumpeter, an Austrian economist in 1942 coined the term "creative destruction" to explain this phenomenon (see side bar). The Schumpeterian creative destruction is magnified for firms, communities, and economies that are unable to pre-empt and respond quickly to the structural changes and forces shaping the global landscape. Asymmetric access to information and knowledge fuel the socioeconomic inequalities among the 'haves' and 'have-nots' within countries and across the globe.

The effect of unrestricted globalisation that fuelled Malaysia's development in the last 20 years are encapsulated in Figures 2.18 and 2.19. The nation's prosperity has not been enjoyed in an equitable manner by the people, indicating some deficiencies in the Government's socioeconomic policies institutional delivery. This worsens the wealth disparities in the country which the Government has been trying to address holistically since 1969; it limits the opportunities for social mobility, which then creates discontent and impairs the Rakyat's quality of life. This is discussed in greater detail later in **Chapter 4** of this report.

Creative Distruction

Schumpeter described the creative destruction process as the introduction of new innovations that increase efficiency and productivity in the economic system and initiate the "process of industrial mutation that incessantly revolutionises the economic structure from within, incessantly destroying the old one, incessantly creating a new one".

Reference:
Schumpeter, J. (1942)

The irrevocable damage on the environment and depletion of the natural capital that has been the backbone of Malaysia's wealth is more than just diminishing the nation's natural assets (Alamgir et al., 2020). It compromises water quality, which is the most basic need of all forms of life. Environmental degradation makes the country vulnerable to climate change driven destruction of property and life. It harms the livelihood of the population who depends on environmental resources, especially the marginalised indigenous people whose way of life are threatened by unsustainable expenditure of the natural capital. **Chapter 5** outlines this issue at length.

[1]The United Nation's Sustainable Development Goal 12 clearly articulates that unsustainable production and consumption patterns have major destabilising impact on the environment. The UN SDG-12 highlights that sustainable socioeconomic development can only be achieved if greater attention is given to ensure good environmental economic practices and adoption of circular economic models that adopts the philosophy of reused, remanufactured, recycled and recovered. Refer to UN Environmental Programme (2021), 'GOAL 12: Sustainable consumption and production', Sustainable Development Goals.

[2]The Club of Rome has warned on a number of occasions the downside of unregulated and unmonitored technology led development in their various reports. The first report "The Limits of Growth" set the scene for careful consideration in the approach adopted to development, and the need to pay attention to not only positive aspects but the negative aspects associated with development. The warning was followed in the latter two reports: "Mankind at the Turning Point" and "The First Global Revolution". Refer to King, A. & Schneider, B. (1991). Meadows, D.H., Meadows, D.L., Randers, J. & Behrans, W.W. (1972), The Limits to Growth, Universe Books, N.Y.; Mesarovic, M.D. & Pestel, E. (1975), Mankind at the Turning Point: The Second Report to the Club of Rome, Hutchinson, London; and The First Global Revolution, Simon and Schuster, London. Land clearing methods that disrupt the natural ecosystem in Southeast Asia poses major health hazard for the population. Refer to the study by Myers, S.S., Gaffikinc, L., Golden, C.D., Ostfeldd, R.S., Redford, K.H., Ricketts, T.H., Turner, W.R., and Osofsky, S.A. (2013), "Human health impacts of ecosystem alternation", Proceedings of the National Academic of Sciences of the United States of America (PNAS), November, Vol 110, no. 47, 18753-18760.

Malaysia can accentuate the positive spill-over benefits from a knowledge-intensive economy and mitigate risks associated to the adverse impact of STIs on society by developing sound, dynamic, agile, and responsive STI ecosystems to harness better return on value (ROV) and return on investment (ROI) from their natural resources, physical and financial assets as well as talent capital. The Government and other stakeholders are now recognising the importance of humanising socioeconomic development and environmental sustainability; prioritising the need to curate effective STI foundation for the country's progression.

Globalisation-powered rapid diffusion of STIs has increased the complexity of the global landscape. A major paradigm shift in mindset where all public policy plans and implementation are centred around collaborative STI and knowledge networks are needed to manage the forces shaping the global environment. These collaborative national and global platforms are becoming powerful forces that create multiplier effects on socioeconomic well-being of the planet and communities. The rapid transformation across globe demands the prioritisation of STI in nation building for everyone and require effort from individual citizens to the Government machinery, as well as industry, community organisations, civil society, and the youth of country.

A Whole-of-Government and Whole-of-Society approach must be the new norm and form the cornerstone of consideration when formulating national STI strategies and public policies. The new paradigm shift calls for transformative leadership to foster collective responsibilities by example, humanising the current and future national STI and knowledge-driven economic systems, creating better return on value and improve the *Rakyat's* quality of life for the present and future generations.

The new ecosystems require key indicators to systemically measure current and potential STI performances and its impact on society. Evidence-based feedback mechanisms are critical to ensure continuous development and refinement of policies and strategies to navigate the country on a sustainable development trajectory. Without such mechanisms, the design and implementation of STI policies will not attain the full potential needed to advance Malaysia's sustainable socioeconomic development agenda. In the push to enhance Malaysia's socioeconomic development and global economic competitiveness, conservation of the environment and Malaysia's rich biodiversity must be accorded as a key priority. The impact of STI-driven socioeconomic policies on the quality of life for the ordinary citizens must also be examined to ensure that Malaysia's progress is holistic and elevates all members of society in an equitable manner, as outlined by the Shared Prosperity Vision 2030.

The Science Outlook 2020 explores the progress and development of STI in Malaysia since the declaration of Vision 2020, taking the cue from the nine challenges of the Vision 2020 to examine selected STI-related indicators and the impact of national-level programmes, frameworks, and initiatives from 1991 to 2020. The gaps and lessons learnt towards transforming Malaysia into a developed, progressive, inclusive, and harmonious nation by 2030 are identified and recommendations to address them concludes this report.

KEY INTERVENTION

1. **Making Whole-of-Government and Whole-of-Society approach as the new norm to form the cornerstone of consideration when formulating national STI strategies and public policies.**

Recommendations

1. To institutionalise foresighting in decision making

An independent entity which would work alongside ministries to provide foresight capacity and insights should be institutionalise. The entity would formalise a platform to connect all players by creating a unified sense of purpose through a careful curation of strategic foresighting and support the existing apex councils in STI (National Science Council) and economic development (Economic Action Council). The entity would be tasked with coordinating the different stakeholders and players to bring greater depth of understanding and coordination to tackle emergent threats and take advantage of opportunities on the local and global horizon. The entity would also advise on the use of technologies and emerging technologies to increase Malaysia's competitiveness. Besides that, a proper foresighting will ensure the resources are aptly distributed and investments made in strategic niches. This would expand on Malaysia's global STIE footprint by leveraging on trade platforms and conventions globally to capture market intelligence across relevant STI-based industries to play a proactive role in strengthening the branding and market positioning of local enterprises as a mechanism to move up the global innovation value chain.

2. To establish a national digital governance ledger

The establishment of a national digital governance ledger would need to be integrated across ministries and agencies with different STIE portfolios and jurisdictions for effective assessment of impact across sustainable development dimensions (economy, society and environment) aligned to the SPV2030. For example, the aim of the E-government initiative, which was one of the seven flagships of MSC, when adopting paperless administration and the integration of government services has not been fully realised. Overall, the present digital governance system and inconsistency in policy direction appear to operate in functional silos and lack a single-point strategy to comprehensively implement, track, and measure the impacts of the various initiatives taking place under the rubric of different policies, plans, and programmes. The lack of integration between government entities toward a unified encompassing goals creates voids in which rent-seeking and moral hazard behaviour can emerge. Unfortunately, this prevails across many sectors of the economy which prevents the government from reaping optimal ROV. An institutional champion must be identified to set the direction and management of a vibrant, agile and responsive STIE ecosystem. The regulatory architecture and legislation must also be strengthened to ensure that the nation's resources and wealth are used effectively for sustainable development. This includes that we get better return of value and other resources of our country.

The envisioned Digital Governance Ledger

- The transparency and accountability would include monitoring and collection of comprehensive STIE-related meta-data. It would also enable open access for policy making and impact measurement.

- This digital governance ledger would also act as a real-time governance system to articulate targets, milestones as well as practices and outcomes across sustainable development dimensions. It would be a surveillance system that monitors all STIE-related policies and their associated initiatives by covering the full range of sectors and localities, and which would now be continuously tracked and reported to all stakeholders.

- The digital governance ledger would act as a platform for multiple stakeholders (i.e., industry, Industry associations, community leaders, NGOs, etc.) to deposit data on policy implementation for authorities to act on (Figure 2.20).

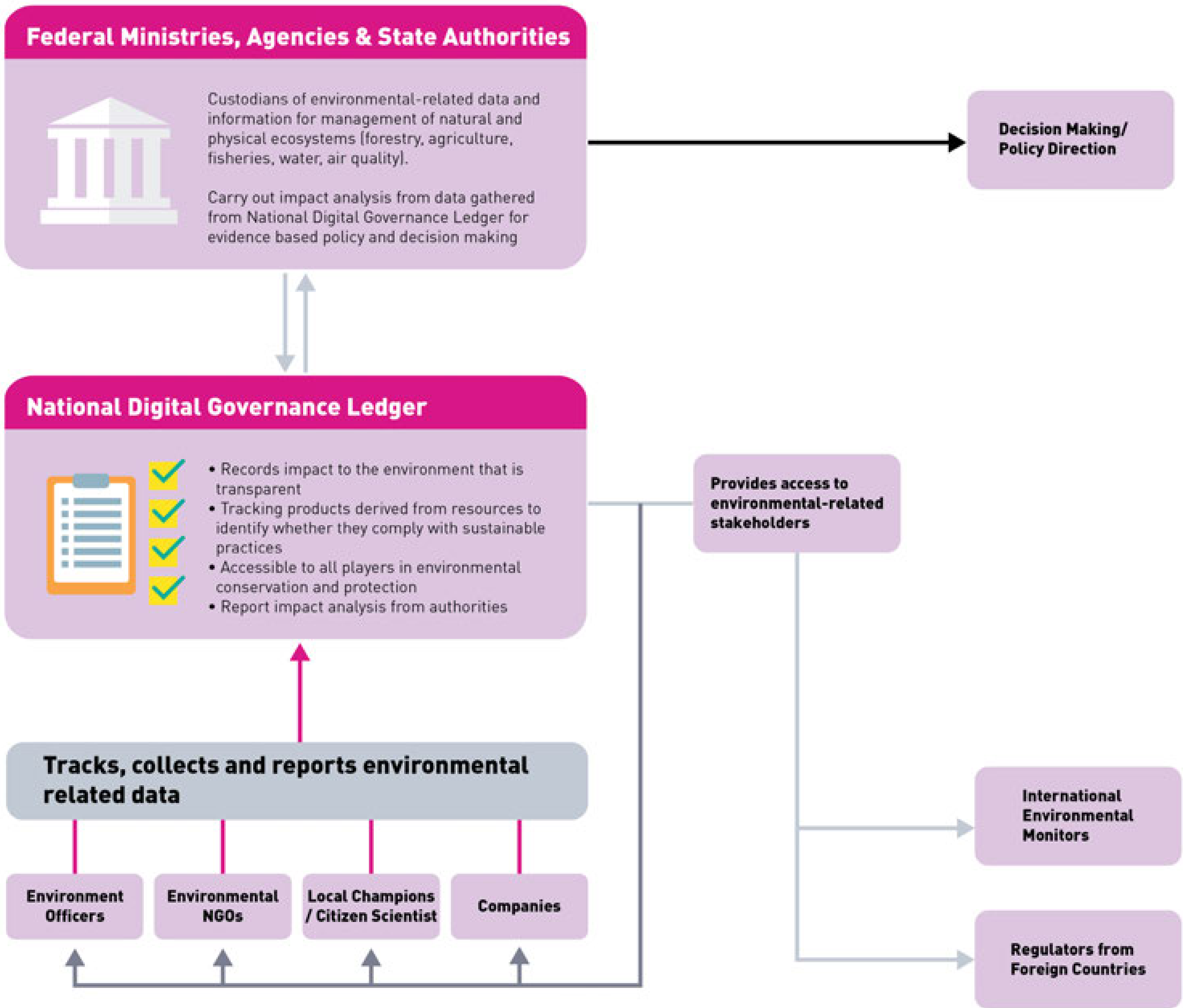


Figure 2.20: An Illustration of a Process Flow of a Digital Governance Ledger for Environmental Management

Note: This proposed illustration by ASM is for ease of understanding for readers and is subject to change if need arise.

Appendix 2.1: List of Digital Platforms Across Ministries and Agencies

Ministry / Agency	Digital platform	Function
MOSTI	Knowledge Resource for Science and Technology Excellence, Malaysia (KRSTE)	The biggest reservoir of information on anything and everything to do with Research, Development & Commercialisation in the area of Science, Technology and Innovation. KRSTE has six module and four of them are MyHRSTI, NSFE, R&D Project and Technology Market (TECHMart). **Module 1: MyHRSTI** MyHRSTI contains information on STI human resources such as researchers and experts in government departments/agencies, public and private research institutes, higher learning institutions, non-governmental organisations (NGOs) and private companies conducting R&D activities and other STI services in Malaysia. Each profile has detailed information such as name, organisation, current position, contact information, status and areas of expertise, educational background, awards, publications, and research project information. **Module 2: National Scientific Facilities & Equipment (NSFE)** The National Scientific Facilities & Equipment (NSFE) aims to encourage facilities and scientific equipment sharing among the STI community and enhance research and development (R&D) cooperation. The initiative also encourages the industrial and public sector to collaborate in R&D activities. **Module 3: R&D Project Bank** R&D Project Bank is a platform that contains information on R,D&C STI projects under the 8th Malaysia Plan onwards. This platform also maps out the R,D&C fund achievement information related to STI projects for monitoring and evaluation. **Module 4: Technology Market (TECHMart)** TECHMART provides a platform for promoting the application of local technology and technology transfer to build the country's STI capabilities. This database also provides an opportunity for industry players to obtain information on local products and technology. Reference: Knowledge Resources for Science Technology Excellence Malaysia (KRSTEMY) (2021)
Royal Cu-stoms De-partment Malaysia	Malaysia National Trade Repository (MNTR)	A single platform to access ASEAN Member States (AMSs) trade-related information. The MNTR contains the trade and customs laws and procedures of all AMSs and trade-related information such as: (i) tariff nomenclature; (ii) MFN tariffs, preferential tariffs offered under this Agreement and other Agreements of ASEAN with its Dialogue Partners; (iii) rules of origin; (iv) non-tariff measures; (v) national trade and customs laws and rules; (vi) procedures and documentary requirements; (vii) administrative rulings; (viii) best practices in trade facilitation applied by each Member State; and (ix) list of authorised traders of AMSs. ** Most Favoured Nations (MFN) tariffs are specific tariff concessions and other commitments negotiated and agreed upon by each ASEAN Member State within the framework of the WTO. These commitments are transposed into domestic legislation.* Reference: 1. Malaysia National Trade Repository (2021) 2. ASEAN Trade Repository (nd)

Ministry / Agency	Digital platform	Function
MDEC	Go-eCommerce	An online platform that provides a comprehensive guide for interested micro-entrepreneurs and SMEs who want to further expand their business through digital means. There are three main programmes namely, eUsahawan, eCommerce and Export via eCommerce. eUsahawan can be divided into three programmes: **1.eUsahawan** **eUsahawan:** Digital marketing training courses aimed at helping businesses enhance their digital presence. **eUsahawan Scale-Up:** Advanced eUsahawan courses on strengthening sales strategies and business processes.Application is only open to selected participants based on their business performance and reporting. eUsahawan Level-Up: An intensive 6-month program with personal mentoring and coaching, targeted at preparing for e-commerce and cross-border e-commerce (export). Application is only open to selected participants based on their business performance and reporting. **2.eCommerce** **eCommerce Marketplace Onboarding:** Onboarding program to match businesses with suitable marketplace partners that can help bring their product/service to a wider audience. **3.Export via eCommerce** **Digital Free Trade Zone (DFTZ):** Aimed at driving local businesses towards regional and global export. **eTRADE Programme:** A programme implemented by MATRADE to promote the adoption of eCommerce among Malaysian companies to accelerate exports through participation of leading international eMarketplaces **eMarketplaces:** Discover a wide range of online marketplaces where entrepreneurs can get their product/service listed. Reference: Malaysia Digital Economy Corporation (MDEC) (2021a)
MDEC	eRezeki (under myGIG Servis programme)	An initiative of MCMC and KBS implemented by MDEC that enables citizens, especially from low-income groups, generate additional income by doing digital assignments via online crowdsourcing platform. The eRezeki participants will be matched with digital work in line with their respective skills. There are three main job scopes provided which are digital micro task which refers to simple task, digital works which needs specialised skills, and digitally enabled task which do not require digital ICT skills. There are more than 400 eRezeki centres nationwide. Reference: Malaysia Digital Economy Corporation (MDEC) (2021b)

Ministry / Agency	Digital platform	Function
MDEC	Global Online Workforce - GLOW PENJANA (under myGIG Digital Freelance programme)	An intensive training and mentoring programme managed by MDEC in collaboration with MCMC and KBS, for qualified Malaysians to become competitive digital freelancers, winning international job and project contracts on global freelance platforms and earning sustainable income. This platform focused on five workstream for training which are website, IT and software; writing, content, SEO, and translation; data entry, admin, and virtual assistant; sales, marketing, and social media; and design, media, and architecture. Reference: Malaysia Digital Economy Corporation (MDEC) (2021c)
MOH	DoctorOnCall	A digital healthcare platform with collaboration between DoctorOnCall and Ministry of Health (MOH), bringing easier and more affordable access to medicines and treatment. Patients can book online consultations and walk in appointment through this website and online clinics allows you to connect with a general practitioner, an online hospital lets you speak to a registered specialist. They also allow patients to connect with doctors directly via video consultation from anywhere and can buy their medicine through online pharmacy. Reference: DoctorOnCall (2021)
MOH	COVIDNOW	The official Malaysia government website for daily data and insights on COVID-19. Reference: Ministry of Health (MOH) (2021)
MITI	MARii MARiiKerja	A platform for those looking to find specific jobs in various industries, especially in the manufacturing sector and manufacturing-related services. This digital platform offers job guarantee in manufacturing sectors, aimed at Sijil Pelajaran Malaysia (SPM) leavers and graduates of skill-based institutes through the Industry-led Professional Certificate (IPC) Programme. IPC Programme is one of the initiatives by MARii to produce skilled operator and technician through specific module and practical in workplace with collaboration from various industries. This program is focusing more on labour practice for various skills with adoption of technologies. Reference: 1. MARii (2021a) 2. MARii (2021b)
MATRADE	MyExport	An online service for Malaysian exporters registered with MATRADE. It provides access to key trade information and market intelligence compiled by MATRADE's worldwide offices. The example of information provided in the system are market alerts, product and market studies, trade leads, Malaysia's trade performance, international tender notices, and presentation materials. Reference: Malaysia External Trade Development Corporation (MATRADE) (2021)

Ministry / Agency	Digital platform	Function
INTAN	E-Pembelajaran Sektor Awam (EPSA)	An initiative under the purview of INTAN to promote the use of ICT to civil servants for continuous and lifelong learning through an online platform. According to the entry of the Public Sector Training Council Meeting, Public Service Department (PSD) on August 18, 2008, EPSA was recorded as one of the Training Program Category, which is Independent Learning. However, it depends on the policy of the department or agency respectively to achieve the seven day courses a year requirement. Among the courses provided are Advanced Leadership and Management Programme (ALMP) - Crisis Management, Awareness on Value Management for Public Projects, Outcome-Based Education: Basic for Enhanced Teacher Education, Pemahaman Tatacara Jenayah Mahkamah Syariah: Pasca Bicara and others. Reference: National Institute of Public Administration (INTAN) (2021)
HRDF	e-LATiH	An initiative funded by the HRDF as part of the economic recovery strategy by the Government to assist Malaysians whose employment has been impacted by the COVID-19 pandemic. It has been developed to provide Malaysians more than 300 free online courses that are in high demand of various industries worldwide. The courses provided cover topics on project management, leadership, digitization, marketing and innovation, programming, languages, health and wellbeing, personal development, financial skills, industry specific, customer service and also safety. The minister of MOHR stated that they will also add other features including linking the e-LATiH platform to the job website and the UpskillMalaysia site coordinated by them Reference: 1. Human Resource Development Corporation (HRD Corp) (2021) 2. The Sentral.my (2021)
KeTSA	Malaysia Biodiversity Information System (MyBIS)	MyBIS is a one-stop repository for biodiversity information in Malaysia and information exchange platform for the Convention on Biological Diversity (CBD). Created in accordance with Article 18(3), it has evolved into a global network of websites with the CBD website (www.cbd.int) as its central node, and MyBIS as the national node of the network. Biodiversity information deposited in this website are abstracted from published books, journals, expert checklists and specimen databases. Reference: Kementerian Tenaga dan Sumber Asli (KeTSA) (2020)
MAMPU	Whole of Government	A portal that lists Government agencies working together across borders to share the organization's portfolio of actions to resolve specific issues. The Malaysian government has developed a range of policies, standards and guidelines in reference to government agencies in implementing the Whole of Government. Reference: Malaysian Administrative Modernisation and Management Planning Unit (MAMPU) (2021)

03

Economic Impact Pillar

ECONOMIC IMPACT PILLAR

GDP Contribution by Sectors (at current prices)

Insignificant technological transformation in the agriculture sector

Construction	Mining	Manufacturing	Services	Agriculture
2020 : RM57,537 mil	2020 : RM95,328 mil	2020 : RM315,608mil	2020 : RM816,293 mil	2020 : RM816,293 mil
1990 : RM4,649 mil	1990 : RM14,111 mil	1990 : RM28,847 mil	1990 : RM55,268 mil	1990 : RM18,120 mil

Researchers (FTE) in industries vs GERD performed by industries

Propotion of R&D funding and number of researchers in the industries is relatively low compared to other countries

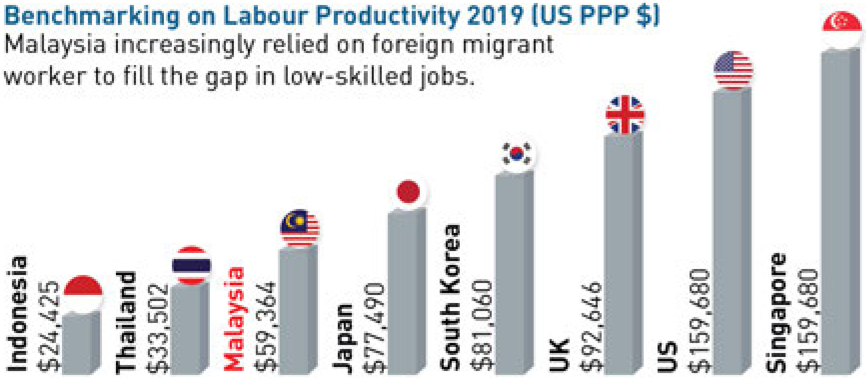
7.5%	15.8%	49.9%	60.8%	40.6%	82%
Indonesia	Malaysia	Singapore	Thailand	UK	South Korea
$472,048	$8,207,128	$8,985,964	$10,057,918	$27,691,682	$85,691,682
(2018)	(2018)	(2017)	(2017)	(2018)	(2018)

4.2% Average monthly household income
2019 RM7,901
2016 RM6,958

3.9% Median monthly household income
2019 RM5,873
2016 RM5,228

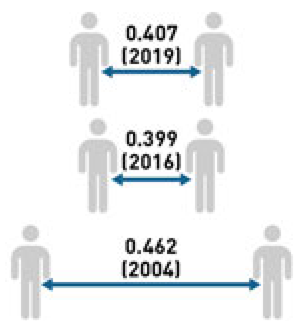
Benchmarking on Labour Productivity 2019 (US PPP $)

Malaysia increasingly relied on foreign migrant worker to fill the gap in low-skilled jobs.



Income inequality (Gini Coefficient)

Income inequality in Malaysia widened even while median household income rose to RM5,873 in 2019



Benchmarking on GDP (at current prices US$)

Singapore
2020: $339.1 billion
1990: $6.14 billion

Malaysia
2020: $336.64 billion
1990: $44.02 billion

South Korea
2020: $1.63 trillion
1990: $283.36 billion

Thailand
2020: $501 billion
1990: $85.34 billion

Benchmarking on GDP per capita (current international $)

Singapore
2020: $98,525
1990: $23,835

South Korea
2020: $43,124
1990: $8,352

Malaysia
2020: $27,886
1990: $6,818

Thailand
2020: $18,236
1990: $4,311

Malaysia is an open economy and is impacted by structural changes taking place globally. The nation's economic development is dependent on the state of development of the science, technology, and innovation (STI) ecosystem in responding to uncertainties and turbulence. This chapter characterises the changes in the global economic landscape and the measures taken by Malaysia to address the challenges.

STRUCTURAL CHANGES IN THE GLOBAL ECONOMY

Over the last 300 years, the global economy has undergone structural transformations powered by STI. Economists agree that the global economy has gone through three major structural revolutions and is currently undergoing the Fourth Revolution. The steam engine propelled the first revolution from 1784 to 1840 (Schwab, K., 2016), followed by the Second Revolution powered by electricity from the late 19th to early 20th century. The third structural change was brought about by electronics, computers, and the internet from 1960 to 1990s. The Fourth Revolution is on-going, enabled by developments in cyber-physical technologies that integrate computation, networking, and the physical systems that disrupt and transform the global economy (Schwab, K., 2016).

Embedded systems of the Fourth Industrial Revolution have birthed technologies, such as the Internet of Things (IoT), artificial intelligence (AI), smart devices, robotics, autonomous vehicles and machines, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing, with a wide range of applications cutting across a range of economic sectors. Some experts suggest the rise of the Fifth Industrial Revolution is already taking place in response to the dehumanising nature of the Fourth Industrial Revolution, and its inability to resolve the grand challenges of society (Gauri, P. & Eerden, J.V., 2019). It is likely that rapid developments in AI systems over the next decade will see the emergence of Technological Singularity – a period of exponential development involving the integration of biological and machine intelligence leading to convergence in virtual and physical realities to create transformative impact on all aspects of human existence.

> There is much disagreement and debate on the definition of Technological Singularity and the notion that machines are replacing human intelligence and creativity. In this report we adopted the notion that Technological Singularity involves convergence of human decision processes and artificial intelligence that model biological systems.
>
> References:
> Potapov, A. (2018), Last, C. (2018), and Eden, A.H., et al. (2012).

The transformation of the economy powered by the drivers mentioned above has led to major shifts in organisations and industries. In the early days of industrialisation, many organisations and firms operated in silos. Electricity and mass production led firms to achieve economies of scales by pooling their resources together, cutting down operational costs, and increasing revenues through mergers and acquisitions. In the process, larger firms acquired smaller companies in the same sector and consolidated them into larger entities. To reduce operational costs further and ensure steady supply of input resources, supply chains were established. As the world demanded higher manufacturing velocity, supply chains were soon converged horizontally and vertically.

The electronics and information technology age allowed the formation of supply chains spanning the globe. As a result, firms were able to benefit from cheaper resources worldwide and reduce their risks against uncertainties and disruptions in their supply chains. The increasing convergence of technologies made it possible for the emergence of common production and technology platforms which enabled a larger mix and variety of products and services. This facilitated firms to pursue greater economies of scale, economies of scope, and improve service quality. The technological advancements, hyper-connectivity, and rapid growth of computing power has moved us closer to technological singularity (Figure 3.1).

Intensification of technological singularity is leading to the formation of autonomous entities that are interconnected to other firms and systems to create greater ROV for the entity itself and the stakeholders' network (Gauri, P. & Eerden, J.V., 2019). These new developments are resulting in the emergence of new business models - some of the early examples are Uber, Airbnb, and other similar service sharing platforms. These new platforms are not only increasing the reach of products and services, but also provide a much richer and wider selection of services.

Since the First Industrial Revolution, STI development has led to major structural changes in the global economy and this trajectory has intensified exponentially. Increasing inter-connectedness of the global economy has led to positive spill-over impacts, which include greater diffusion of information, knowledge, mobility of goods and services and trade. They have also led to negative spill-over impacts – such that any volatility in one market will reverberate to other markets very quickly; faster transmission of health pandemics across the globe is the most recent example.

Figure 3.2 shows that since the 1950s, the global economy has undergone major growth. The growth trajectory can be attributed to several factors. The first is technology, which since the 1950s has seen an intensification of technology-induced developments. This led to the information and computer technology (ICT) revolution that paved the way for a digital economy, enabling an internetworked world. Significant R&D investments in science, engineering and other related areas played a key role in spawning new frontiers. Some led to the development of autonomous advanced intelligence systems that feature so prominently in the Fourth Industrial Revolution.

Second, improvements in technology allowed greater mobility of people, data, goods, and services which led to a positive spill-over effect across multiple sectors allowing them to achieve greater economies of scale and scope. On the downside, greater interconnectivity and mobility have increased the risk of the contagion effect, cybercrime, and transmission of digital and biological viruses.

Third is the increase in trade across the globe due to bilateral and multilateral trade agreements among countries. Trade further intensified due to the emergence of the digital economy via e-commerce and other commercial platforms.

The above factors highlight that the global economy is transforming at a rapid pace and several countries are increasing their investments to build agile STI ecosystems that respond to and shape the global economic landscape. A sound STI ecosystem is seen by advanced nations as a key driver for enhancing the dynamic capabilities of industries to continuously improve and innovate.

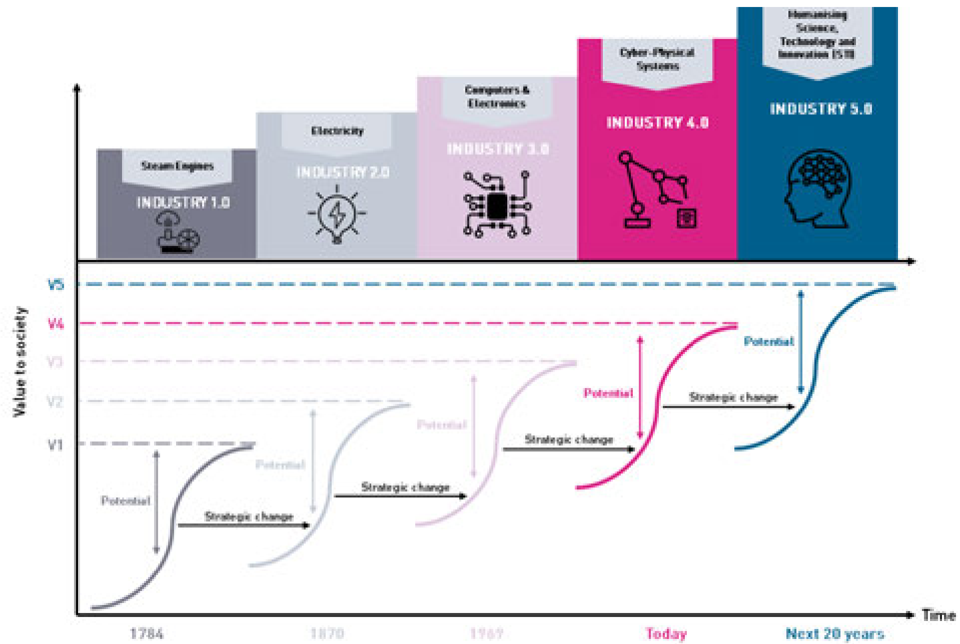
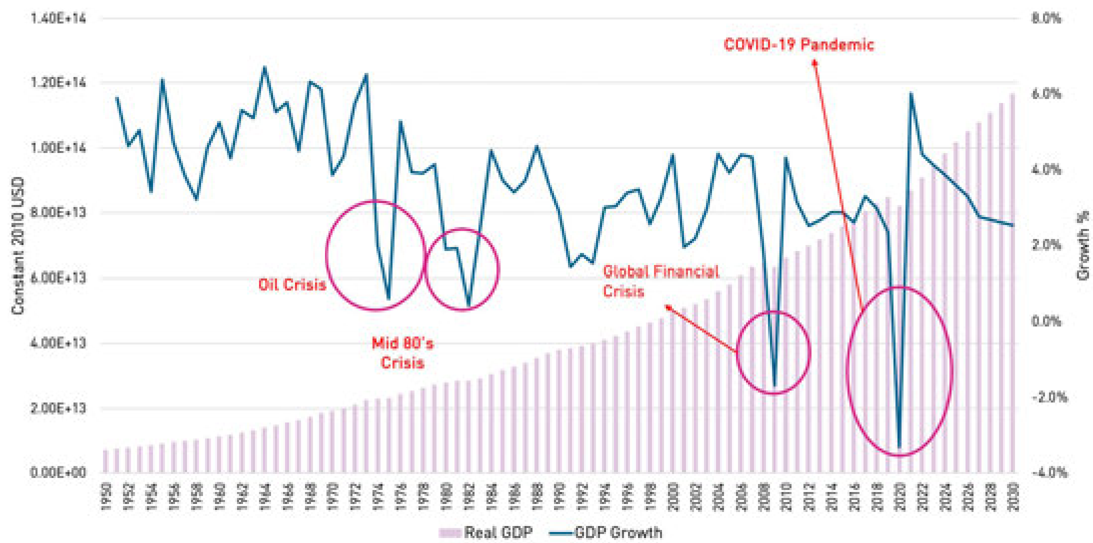


Figure 3.1: Structural Changes in the Global Landscape from 1700 to Present



Analysed by Sunway University Research Team

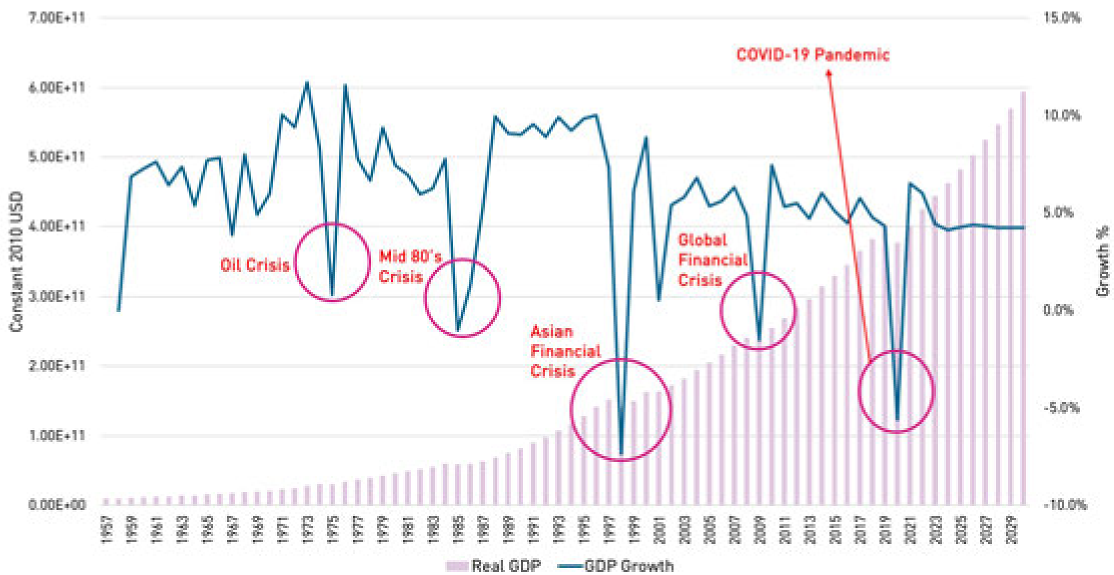
Figure 3.2: World Real GDP and Economic Growth, 1950 – 2030

KEY INTERVENTION

1. **To use state-of-the art technology in ensuring the regulatory architecture keeps pace with the STI developments to continue strengthening the STI and economic nexus.**

MACROECONOMIC TRANSFORMATION OF THE MALAYSIAN ECONOMY

The above discussion shows that the global economy has undergone structural changes over the past seven decades that are adversely impacting developing countries, including Malaysia. Figure 3.3 shows an upward trend in GDP and volatile GDP growth rates for Malaysia, which exhibits similar patterns to the world. To achieve sustained economic growth, Malaysia implemented a range of policies and strategies to nurture the nation's STI ecosystem to respond in an agile manner to these dynamic changes. This has allowed Malaysia to diversify its economic portfolio and create alternate streams of growth. On the downside, a more interconnected economy exposes Malaysia to the volatilities and uncertainties of global markets. This is evident in Figure 3.3 which shows significant volatility in the GDP growth rate due to shocks to the economy. Whilst the STI initiatives were envisioned to enable Malaysia to create a responsive STI ecosystem mentioned earlier (refer to Chapter 2), empirical evidence shows Malaysia is struggling to manage external shocks to the economy.



Analysed by Sunway University Research Team

Figure 3.3: Malaysian GDP and Economic Growth, 1950 – 2030

Malaysia's STI initiatives have helped the country to diversify its economy from an agrarian to manufacturing and service-based economy. Malaysia is a leading exporter of electrical appliances, electronic parts and components. It is also building strong competitiveness in several service sectors such as finance, education and IT. Over time, the expansion of the nation's GDP is increasingly being enabled by growth of the services and manufacturing sector, in areas that are heavily dependent on STI inputs (Figure 3.4).

Sustained economic growth and diversification, over the last three decades, has been powered by the STI ecosystem, the effectiveness of which is fostered through inter-linkages in key components of the different industrial sectors. This was facilitated through a focused industry cluster strategy, elucidated in the three Industrial Master Plans (IMP1-IMP3).

The cluster strategy was to foster knowledge and technology transfer within and across various industrial sectors to enable the manufacturing sector to move up the value chain. In the IMP2, this is referred to as "Manufacturing Plus Plus". These initiatives were also complemented by the Look East Policy to foster strong cooperation and collaboration, particularly with industries from Japan and South Korea in the manufacturing, automotive and other high-tech industries. The Look East Policy led to an increase in foreign direct investment flows in the early 1990s, building strong absorptive capabilities within the manufacturing sector and the development of nation's industrial supply chains. These initiatives raised the competitiveness of the manufacturing sector by enhancing higher value-added activities and raising the productivity of the entire value chain (Figure 3.5).

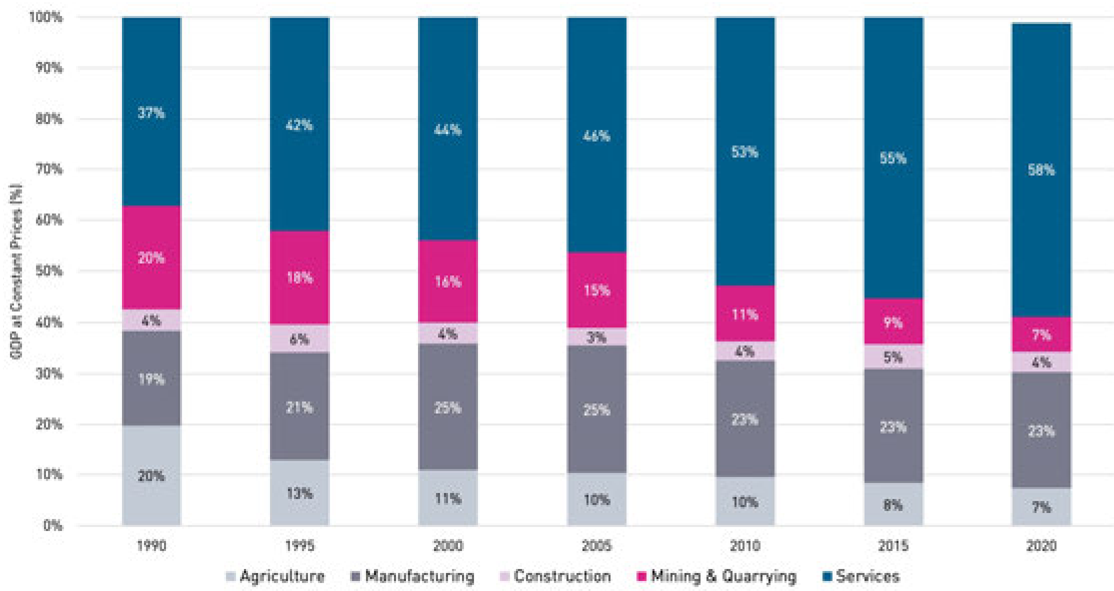


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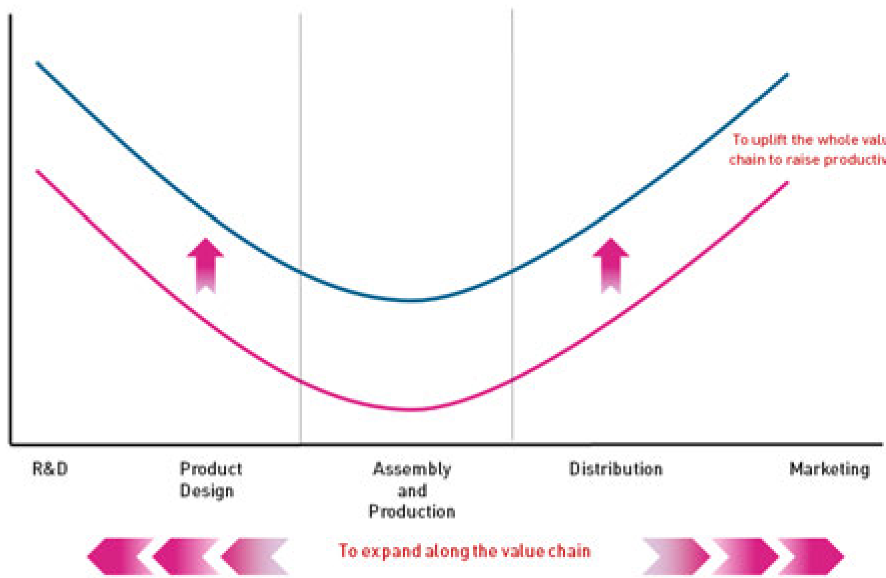
Figure 3.4: Malaysia's Economic Structure Over Three Decades



Reference: Adapted from National Graduate Institute for Policy Studies (GRIPS) (2006)

Figure 3.5: "Manufacturing Plus Plus" Adapted from IMP2 (1996 - 2005)

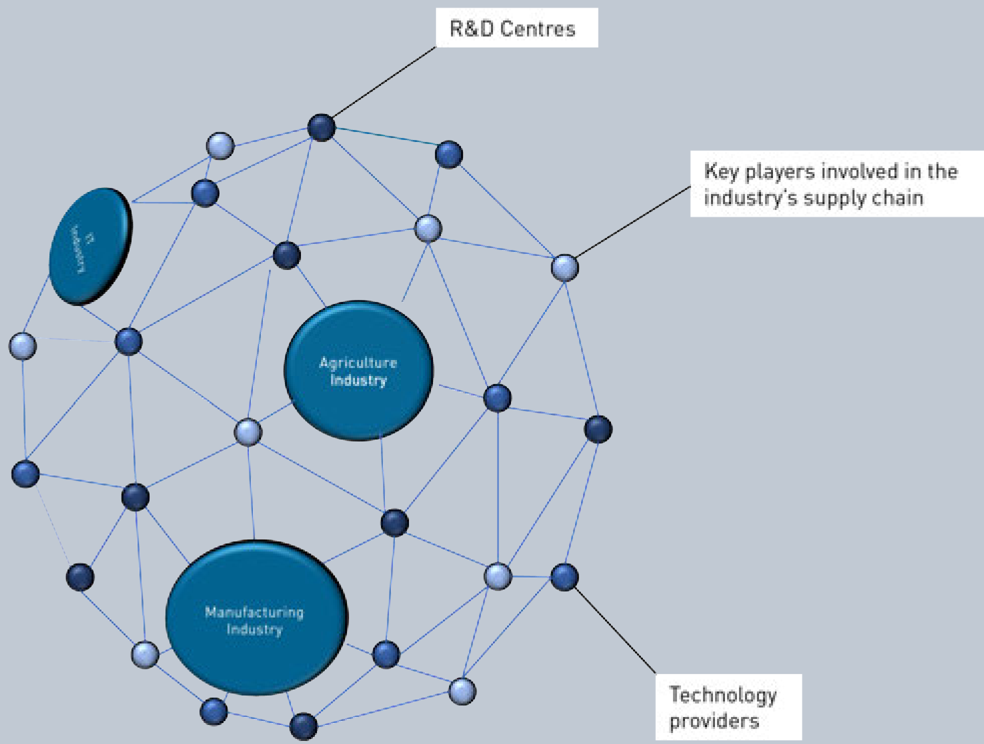
A critical part of the cluster strategy under IMP2 was to foster knowledge sharing and intensifying R&D among cluster members. This was further deepened in IMP3, where the objective was to strengthen intra- and inter-cluster linkages. In the intra-cluster strategy, support was provided for strengthening the sub-clusters within the electrical and electronics sector, such as nanotechnology, photonics and microelectronic mechanisms. This also included support for the biotechnology and pharmaceuticals sectors. As part of the inter-cluster strategy, support was provided to foster greater collaboration across the different clusters. In this context, strong emphasis was given to attract international players to use these clusters as testbeds for design, development and innovation. The international linkages were to encourage knowledge and technology transfer to build endogenous local technology-driven companies.

Industrial strategies and the investments under the various IMPs fostered knowledge transfer in some economic sectors of Malaysia. These initiatives nurtured pace-setter industries, such as IT Services; Business Services; Education Services; Financial Services; Transportation Services; Electrical and Electronics; Machinery and Instrumentation; and Chemical, Petroleum and Pharmaceutical. At the beginning, knowledge creation and knowledge use in these sectors was led by foreign multinational companies. Unfortunately, knowledge and innovation spill-overs from the pace setter industries were not realised in many traditional sectors of the economy, such as agriculture and wood-based industries. Consequently, many sectors progressed very slowly and remained at best imitator or adapter industries and continued to be highly dependent on foreign technology and know-how (EPU, 2016a and 2016b).

Characteristics of a Cluster

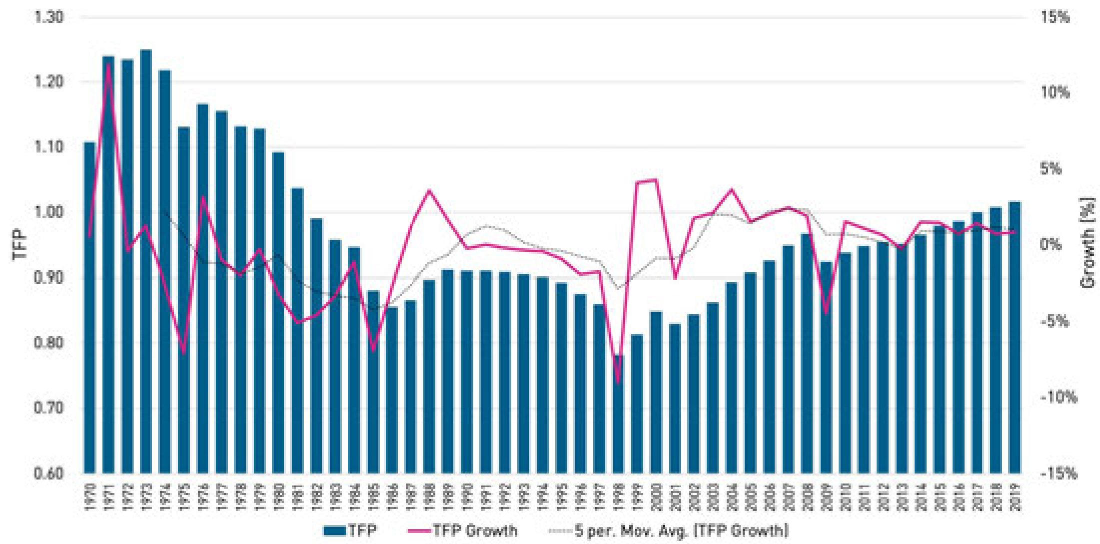
A cluster is characterised as an agglomeration of inter-linked or related activities comprising industries, suppliers, critical supporting business services, requisite infrastructure and institutions (IMP2). IMP2 had identified eight clusters: E&E, textiles and apparel, chemicals, resource-based industries, food processing, transportation equipment, materials, and machinery and equipment.

Reference:
Ahmed, P. and Shepherd, C.D. (2010)



The knowledge and innovation intensity of industries has direct impact on total factor productivity (TFP) growth of the country. Figure 3.6 also show that from mid-1980s to the early 1990s, the TFP growth increased steadily, as Malaysia transitioned from an agrarian to a manufacturing-based economy. Subsequently, there was a period of decline in the TFP until the 1997/1998 Asian Financial Crisis, which registered a sharp dip. The restructuring plan put in place post- 1997/1998 Asian Financial Crisis led to an upturn in the TFP. The restructuring plan is supported by a fixed exchange rate at RM3.80 to the US dollar, cheaper labour cost, intensification of the digitalisation of the Malaysian economy and attractive incentives for multinational companies to use Malaysia as a test-bed for innovative technology helped increase the TFP until early 2000 (Harris, R., 2021).

The increase in TFP growth was reinforced by an increase in the proportion of skilled workforce in the country relative to the unskilled workforce as shown in Figure 3.7. The higher skilled workforce can be attributed to an increasing number of public and private tertiary institutions in Malaysia in the 1990s, producing students with higher qualifications for the workforce (Lee, M.N.N., 2004).



Analysed by Sunway University Research Team

Figure 3.6: Total Factor Productivity (TFP) for Malaysia, 1917 – 2019

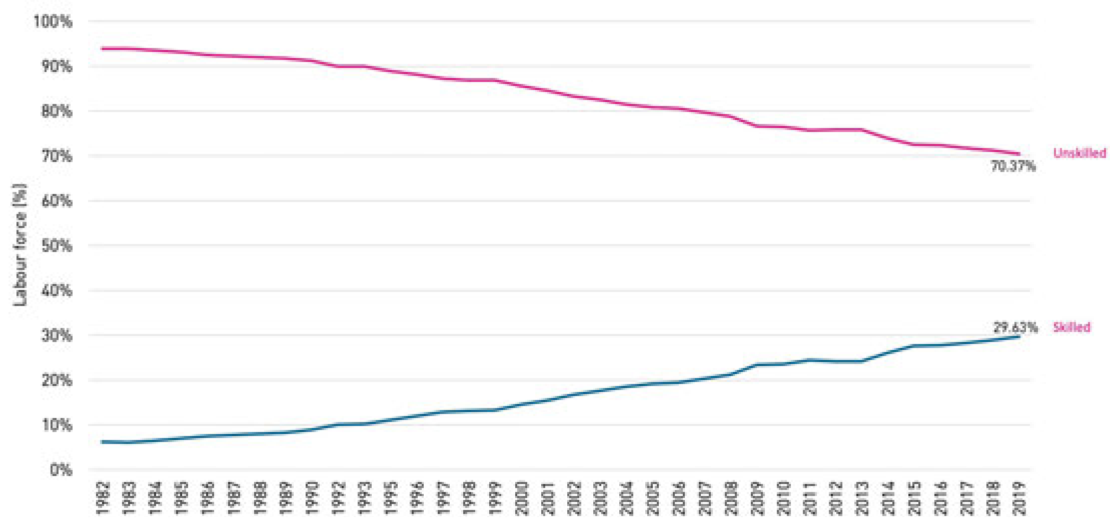


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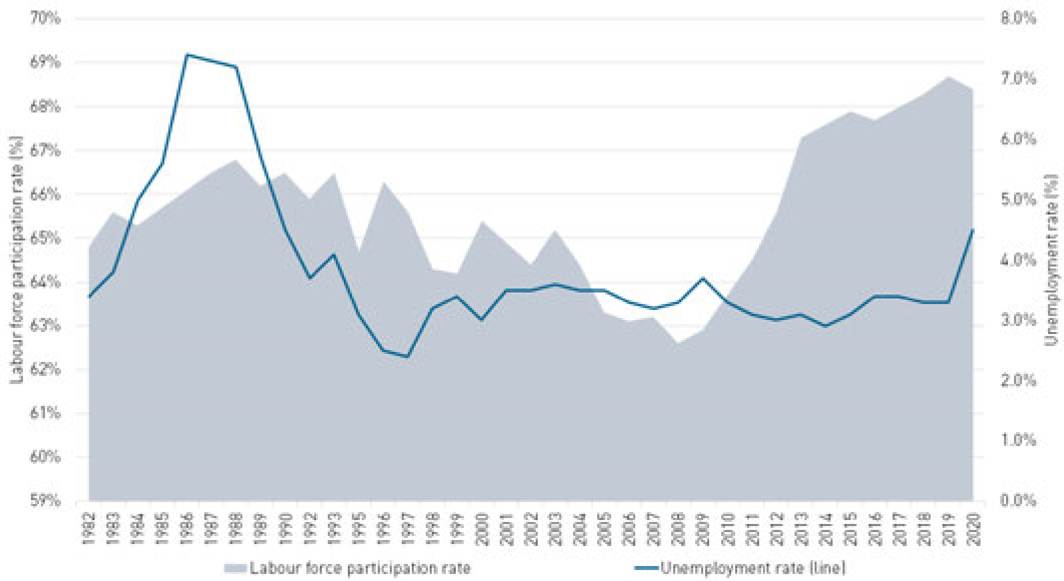
Figure 3.7: Labour Force Profile, 1981 – 2019

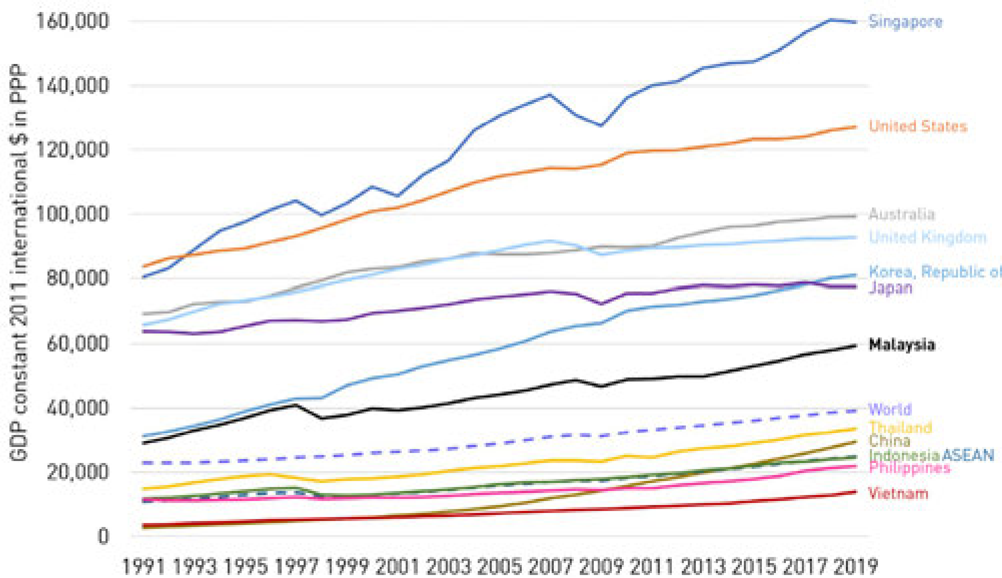
The labour market witnessed significant transformation due to the industrialisation process which commenced in the mid-1980s. As the Malaysia's workforce attained higher education levels and took on higher value-added jobs, the nation increasingly relied on foreign migrant worker to fill the gap in low-skilled jobs. Malaysia's labour force sits at 16.08 million (DOSM, 2021) and it is estimated that 20% of that is constituted by foreign migrant workers, giving close to 2.96 million to 3.26 million migrant workers (ILO, 2020). Figure 3.8 shows that labour force participation from 1982 to middle of 2000s was on a downward trend, and then began to increase until 2020. The unemployment rate has been relatively stable between 3% to 4% since the 1997/1998 Asian Financial Crisis. The stability in the unemployment rate is due to the large foreign workforce that insulated the local workforce from any economic slowdown and retrenchments. However, the unemployment level increased above 4% in 2020 due to the COVID-19 health pandemic.

Labour productivity is an important economic indicator and Figure 3.9 shows Malaysia's labour productivity performance in comparison to other countries in the region and selected developed countries. Comparatively Malaysia's labour productivity growth is above the ASEAN and world average but below advanced countries, such as Singapore, South Korea, and Japan.



Analysed by Sunway University Research Team

Figure 3.8: Labour Force Participation and Unemployment Rate, 1982 - 2020



Analysed by Sunway University Research Team

Figure 3.9: Labour Productivity, 1991 - 2019

In general, the STI and economic initiatives put in place over the last three decades have enabled Malaysia to maintain continuous economic development and growth underpinned by strong absorptive capability and adaptive capabilities in key STI areas, particularly in select manufacturing and service sectors considered to be priority areas by the Government.

While Malaysia had an adequate base of absorptive and innovative capabilities in some sectors of the economy (e.g., manufacturing and services sector), it was slow in building strong adaptive and innovative capabilities across the full range of its sectors. These sectors were major contributors to economic growth and employment. The cross-cluster linkages, technology and knowledge transfer between the pace-setter industries and the other industries were low, resulting in low adaptive and innovative capabilities across many of the major economic sectors (EPU, 2016a and 2016b). The slowness in building strong adaptive and innovative capabilities contributed to the downward trend in TFP. This can be attributed to six important reasons, which are discussed below.

First, Malaysia's STI and economic plans over the last three decades, lack integration and, effective implementation and tracking of performance mechanisms. The working in silo and ad-hoc approach in planning and implementation is due to a weak institutional framework. This led to duplication of resources, increase in bureaucracy and turf-wars among the various agencies managing the STI and economic development. There is also considerable misalignment of STI initiatives and economic development needs of the country (ASM, 2018). Figure 3.10 shows that Malaysia's STI ecosystem trails many regional and developed economies, such as South Korea and Singapore resulting in poor TFP.

Second, lack of cohesive strategic plans in identifying long-term R&D priority areas for the country and dove-tailing these plans with long-term sustained funding have resulted in Malaysia lagging other regional and developed economies in building a strong STI ecosystem that is able to power the economy (EPU, 2016b). Constant ad hoc changes in research direction and priority areas discourage the private sector from investing in long-term 'blue-sky' research programs needed to lay a strong foundation for the nation's future development (ASM, 2018). Many of the R&D initiatives and technology transfers undertaken in Malaysia by local and foreign firms are incremental innovations at the lower end of process improvement and product development. This hinders local industries to break into the global innovation value chain. Many of the multinational companies operating in Malaysia continue to undertake high-end R&D and design & development in their home countries or in countries that have a stronger STI ecosystem.

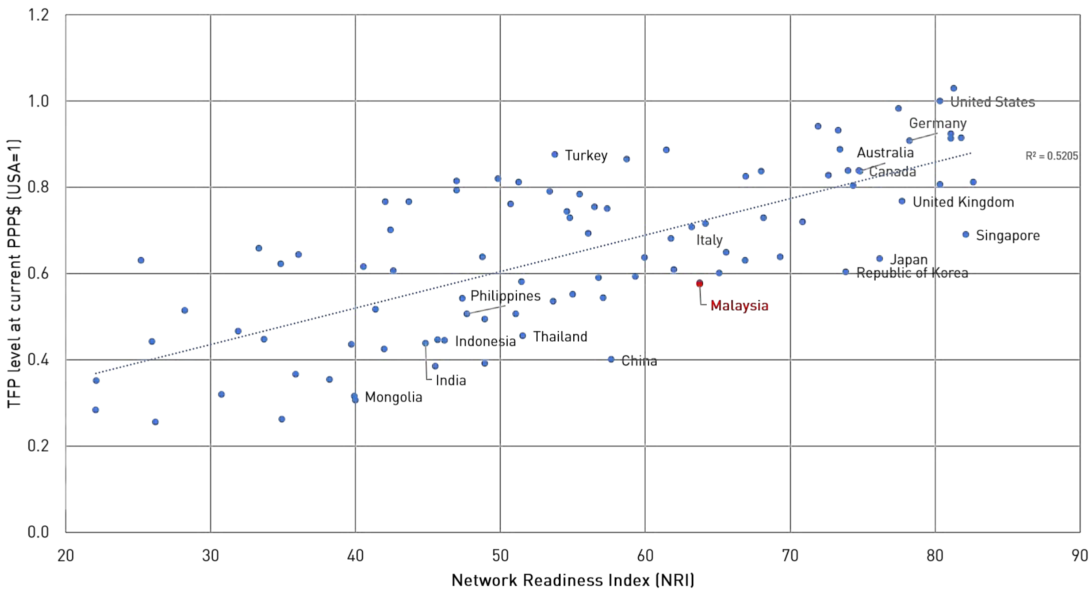


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Figure 3.10: Network Readiness Index and Total Factor Productivity, 2019

Note: Network Readiness Index (NRI) framework assesses the factors, policies, and institutions that enable a country to fully leverage information and communication technologies (ICTs) for inclusive, sustainable growth, competitiveness, and well-being. The four main pillars are Technology, People, Governance and Impact.

Third, moving up the innovation value chain will require considerable investment in R&D. Malaysia's contribution as a percentage of GDP is relatively low compared to many of the regional and developed economies, such as China and Singapore (refer to Figure 2.5). Many of these countries compete with Malaysia in the same economic sector, particularly within the manufacturing and service sectors. Hence, without significant investment in strategic research areas, Malaysia will struggle to build competitiveness in key sectors of the economy.

Fourth, much of the R&D investments and R&D workers in Malaysia are in public universities and public research institutions. Further, the proportion of R&D funding and number of researchers in the private sector is relatively low compared to regional and developed economies (see Figure 3.11). Low R&D investment by the private sector and inadequate effective mechanisms to foster strong industry-university research collaboration is compounding weaknesses in the STI ecosystem (EPU, 2016 and Invest Selangor, 2015). Weak cooperation and collaboration between institutions of higher learning and the industry have also resulted in mismatch and shortfall in talent needed for the fast-evolving needs of industry as well as limited amount of translational research outcomes. These weaknesses will continue to stifle industry from building strong absorptive, adaptive and innovative capabilities. Evidence of the net effect of these shortcomings shows Malaysia lags other regional and developed economies, such as China and Singapore in R&D expenditure and patents granted (Figure 3.12).

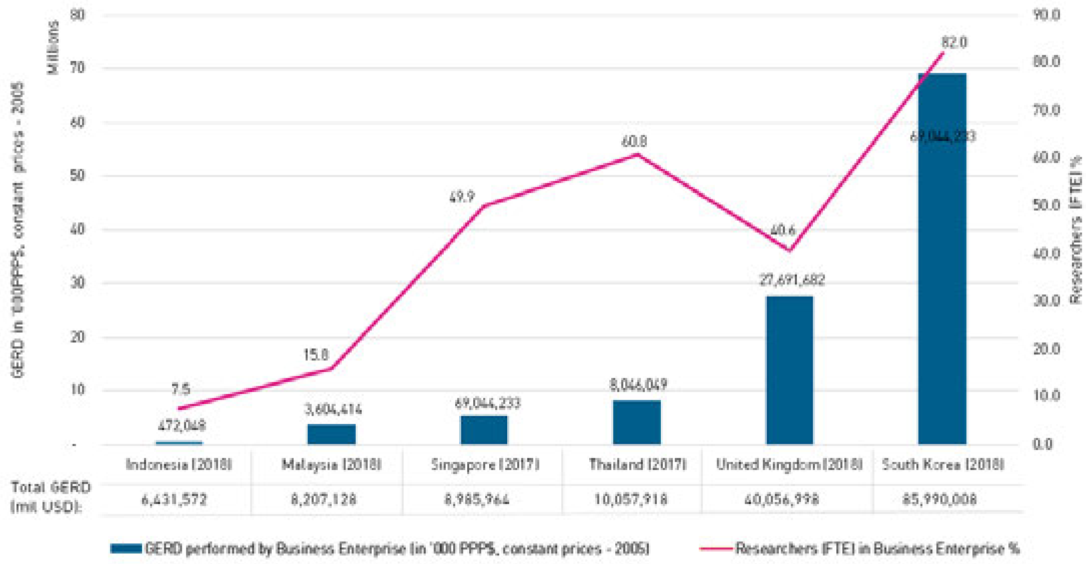

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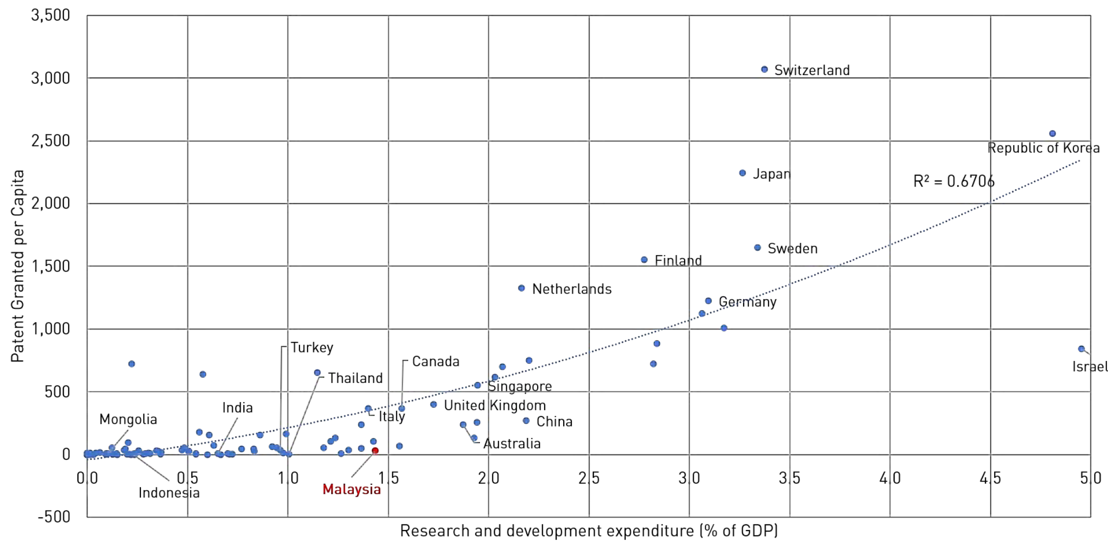
Figure 3.11: R&D Expenditure and Number of Researchers (FTE) in the Private Sector



Analysed by Sunway University Research Team

Figure 3.12: Research and Development Expenditure and Patents Granted, 2018

Fifth, is the challenge faced by Malaysian firms. The number of graduates with the necessary skills and affordable training programs in a fast-changing technology-driven economy are inadequate to build Industry 4.0 capabilities among their workforces. Due to the high demand for tech-savvy workers, industry leaders are of the view that universities need to work closely with industry to curate education and training programs to meet the needs of industry (refer Box Article 3.1).

Sixth, Malaysia's economic sectors are primarily driven by unskilled workforce. The Malaysia's labour force highlights that in 2019, close to 70% of the workforce are unskilled workers (see Figure 3.7). Due to a smaller workforce and domestic market, Malaysia's competitiveness is being eroded by ASEAN countries and regional economies. Most of these economies are also directly competing with Malaysia within specific parts of the manufacturing and services sectors. A small labour pool, a small domestic market and slow progress in adoption of technology has had major adverse impacts on the TFP growth and economic growth of the country.

> A recent World Bank study show that Malaysia recorded lower introduction of new products and services to Cambodia, Mongolia, China, Philippines, Thailand and Vietnam. In terms of process improvements, Malaysia lags behind China, Philippines and Vietnam; in terms of marketing innovation, Mongolia, Philippines and Vietnam; for organization innovation, it is Mongolia and Philippines.
>
> Reference:
> Ciera, X., et al. (2021)

Box Article 3.1: Preparing Talent of the Future

The upskilling in emerging areas will help resolve the graduate unemployment problem. The top three key capabilities for the knowledge economy are graduates with strong technical (ICT skills) and soft skills (critical thinking and personal confidence).

Role of Universities in Building the Economic Ecosystem, 2017 - 2020

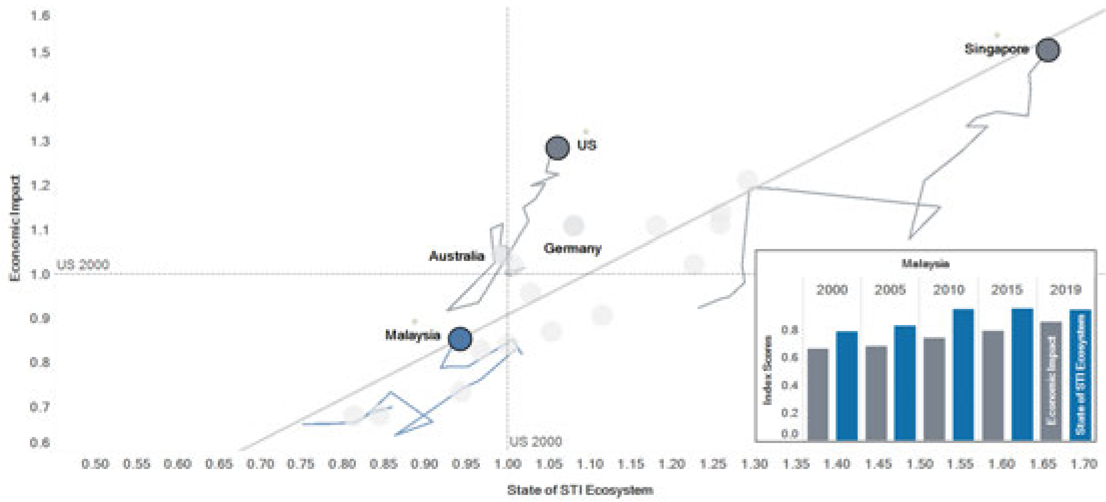
Skills Required by Industries, 2018 - 2020

Reference:
Nair et al. (2020)

Countries that have invested in building vibrant and strong STI ecosystems helm economic competitiveness and societal development. Malaysia made significant progress in building absorptive capabilities which are adequate only for a production-based economy. The national innovation and economic ecosystems of many sectors were slow in adopting emerging STI advances and making the necessary adjustments in the industry ecosystems to move Malaysia towards a knowledge-based economy. One of the primary reasons for the slow level of progress is the weaknesses in institutional governance of STI policies and fragmented and uncoordinated initiatives. These shortfalls in approach have meant that Malaysia has not been able to keep pace with the competitive transformations taking place in competitor nations, who are now exerting intense competitive pressures through the development of a larger pool of highly skilled workforce and skills in the use of sophisticated technologies that have been fine-tuned within their larger domestic markets.

Malaysia has made significant progress in STI development from 2000 to 2019 with an accompanying improvement in economic impact (Figure 3.13). However, Malaysia still trails many developed countries in STI development and economic impact. Over time, Singapore has been strengthening its STI ecosystem which has allowed the nation to achieve significant progress in the level of its economic impact.

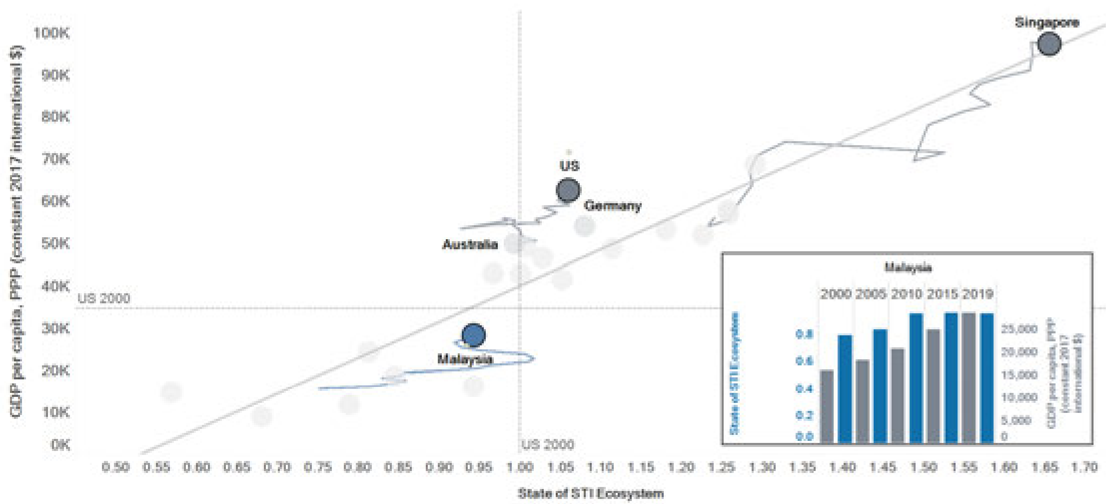
The STI ecosystem development and economic wealth (measured as per-capita GDP) shows similar patterns as in Figure 3.13, where there is a strong correlation between STI ecosystem and GDP per-capita increase, for the sample period (Figure 3.14). Here too, Malaysia lags in both STI ecosystem development and economic wealth.



Analysed by Sunway University Research Team

Figure 3.13: STI Ecosystem Development and Economic Impact, 2000 - 2019

Note: The circles on the chart represent data of the respective country in 2019 while the trails from the circle show the movement of the country from 2000 to 2019.



Analysed by Sunway University Research Team

Figure 3.14: STI Ecosystem Development and GDP per-capita, 2000 - 2019

Note: The circles on the chart represent data of the respective country in 2019 while the trails from the circle show the movement of the country from 2000 to 2019.

In summary, the global macroeconomic environment has changed dramatically over the last three decades due to the forces of globalisation, greater opening of markets and rapid pace of development in the STI landscape. It is well acknowledged that STI contributes to economic development through multiple channels. This includes improvement in productivity, innovation and nurturing high value-added industries. The evidence suggests that the Malaysia's STI ecosystem has been slow in adapting to the changes in the external environment and this has had an adverse impact on the speed of transformation of the Malaysia's economy.

KEY INTERVENTIONS

1. **To continue the cluster strategy by expanding into areas that have been identified under the 10-10 *My*STIE Framework**

    a. **for better facilitation of diffusion of technologies across sectors**

    b. **for intensified and focused translational R&D**

2. **To strengthen collaboration between regional Corridors, Science/Technology Parks and local universities Centres of Excellence**

    a. **to foster open innovation and to nurture home-grown technology companies and endogenous technologies**

    b. **to attract MNCs to establish R&D centres in Malaysia**

    c. **to nurture next generation of talent, who has the technology know-how and specialist skills to contextualise emerging technologies**

3. **To put in place a clear implementation framework to ensure seamless integration of the various national and state levels STI plans, with clearly specified KPIs and timelines; and these plans are regularly monitored and reported to all stakeholders.**

STI AND ECONOMIC DEVELOPMENT OF INDUSTRIES

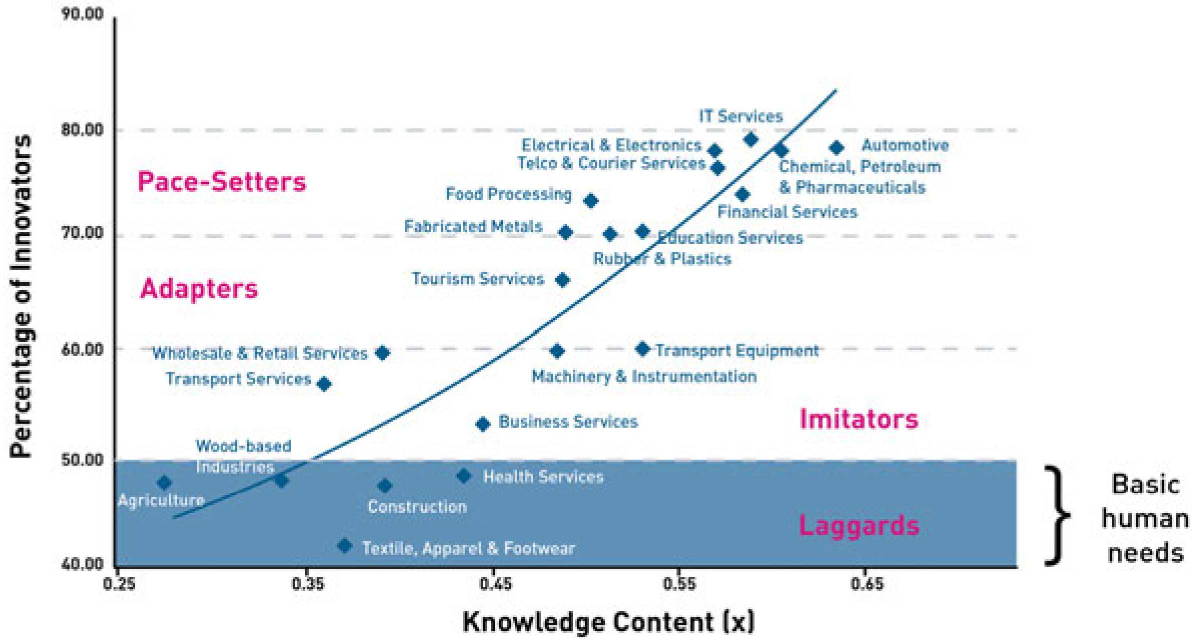
Over the last four decades, Malaysia has transitioned from an agrarian economy to an industrial economy, and more recently to a services-based economy. These transitions have been underpinned by policies and programs that have leveraged on STI advancements. The MyKE III (EPU, 2016a) study details knowledge transfer taking place in twenty-one industry sectors in Malaysia. The study suggests two important findings. First, intra-industry sector knowledge transfer takes place within the twenty-one industrial sectors. Second, there is an emergence of industrial sectors that act as knowledge enablers for other sectors. These include the following sectors: IT Services; Business Services; Education Services; Financial Services; Transportation Services; Electrical and Electronics; Machinery and Instrumentation; and Chemical, Petroleum and Pharmaceutical. The enabling industries act as nodal points for developing interlinkages and knowledge sharing.

Figure 3.15 shows the knowledge flow between source and recipient industries. STI initiatives have led to the emergence of pace-setter industries, which possess high knowledge content and innovation capability. Figure 3.16 shows industries classified as pace-setters, adapters, imitators and laggards based on the level of knowledge content and percentage of innovators in the industry (EPU, 2016a). The top three pace-setter industries are in high-technology industries: automotive, chemicals, petroleum & pharmaceutical and IT services. On the other hand, the three main laggard industries are agriculture, wood-based industries and textile, apparel & footwear. This surfaces an interesting insight that the local industries needed to meet the basic needs of the Rakyat, namely food, shelter, clothing and healthcare services are all operating at the lower spectrum of the value chain. It is evident that while the economy gravitates towards a high-tech nation, there needs to be greater focus on knowledge spill-over to key sectors that are classified as laggards to ensure equitable distribution of prosperity to meet the needs of the *Rakyat*.

	Source																				
Acquirer	Agriculture	Food Processing	Chemicals, Petroleum, Pharmaceuticals	Rubber and Plastic Products	Wood-Based Products	Fabricated Metals	Automotive	Transport Equipment	Textile, Apparel and Footwear	Electrical and Electronic	Machinery and Instruments	Education Services	Transportation Services	Finance Services	Tourism Services	Telecommunications and Courier Services	Health Services	IT Services	Business Services	Wholesale or Retail Trade	Construction
Agriculture	28.4	8.0	2.3	1.1	0.0	0.0	0.0	1.1	0.0	0.0	2.3	0.0	5.7	0.0	0.0	1.1	1.1	0.0	8.0	9.1	0.0
Food Processing	16.6	26.8	0.6	1.3	0.0	1.9	0.0	1.9	0.0	1.3	11.5	1.9	0.0	1.9	0.0	0.0	2.5	3.8	8.3	7.0	0.0
Chemicals, Petroleum, Pharmaceuticals	5.0	4.0	35.0	9.0	3.0	0.0	0.0	0.0	0.0	1.0	11.0	4.0	3.0	4.0	0.0	0.0	2.0	4.0	7.0	2.0	2.0
Rubber and Plastic Products	2.7	0.0	4.7	34.5	0.7	3.4	6.8	2.0	1.4	6.1	12.2	0.7	3.4	3.4	0.7	1.4	0.7	0.7	9.5	2.7	2.0
Wood-Based Products	1.0	0.0	1.0	2.0	22.5	2.0	0.0	2.9	0.0	1.0	7.8	1.0	4.9	1.0	0.0	0.0	0.0	1.0	5.9	1.0	5.9
Fabricated Metals	0.7	2.2	4.3	0.7	1.4	25.2	2.9	1.4	0.0	4.3	10.1	0.7	0.7	0.7	0.7	0.0	0.0	3.6	6.5	0.7	11.5
Automotive	0.0	0.0	0.0	4.3	0.0	8.7	42.0	8.7	1.4	4.3	26.1	2.9	2.9	5.8	0.0	1.4	0.0	2.9	7.2	0.0	1.4
Transport Equipment	2.5	0.0	2.5	0.0	0.0	10.0	5.0	25.0	0.0	5.0	17.5	5.0	2.5	2.5	0.0	0.0	2.5	0.0	10.0	0.0	5.0
Textile, Apparel and Footwear	1.3	1.3	1.3	0.0	1.3	0.0	0.0	1.3	18.4	1.3	3.9	0.0	3.9	2.6	1.3	0.0	1.3	2.6	5.3	0.0	0.0
Electrical and Electronic	0.0	0.8	4.0	3.2	0.0	4.0	6.4	0.0	0.0	35.2	18.4	2.4	3.2	2.4	0.0	2.4	0.0	7.2	11.2	0.8	3.2
Machinery and Instruments	1.9	0.0	1.9	0.0	0.0	1.9	1.9	3.8	0.0	7.7	23.1	5.8	3.8	1.9	1.9	0.0	0.0	0.0	7.7	0.0	3.8
Education Services	1.7	0.0	1.7	0.0	0.0	1.7	5.2	1.7	0.0	1.7	3.4	41.4	3.4	8.6	3.4	3.4	3.4	20.7	13.8	3.4	0.0
Transportation Services	0.0	0.0	2.6	0.5	0.5	0.5	2.1	8.9	0.5	1.6	3.1	1.6	19.8	3.1	2.6	3.1	0.5	3.6	4.2	1.0	0.5
Finance Services	8.7	13.0	4.3	8.7	4.3	0.0	4.3	0.0	0.0	4.3	4.3	0.0	0.0	17.4	4.3	0.0	0.0	4.3	4.3	4.3	0.0
Tourism Services	0.6	5.5	1.2	0.0	0.0	0.0	0.0	1.2	0.6	1.8	0.6	3.6	5.5	5.5	39.4	3.6	4.2	13.3	11.5	3.0	0.0
Telecommunications and Courier Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	3.3	0.0	3.3	13.3	6.7	0.0	30.0	0.0	6.7	16.7	10.0	0.0
Health Services	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.5	6.6	0.8	3.3	6.6	0.0	34.4	13.1	9.8	0.0	0.8
IT Services	1.5	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	6.1	1.5	3.0	3.0	9.1	0.0	13.6	0.0	45.5	18.2	3.0	0.0

Reference: Economic Planning Unit (EPU) (2016a)

Figure 3.15: Industry Knowledge Content and Innovation Mapping



Reference: Adapted from Economic Planning Unit (EPU) (2016[a])

Figure 3.16: Industry Knowledge Content and Innovation Mapping

We present three illustrative case industries, representative of each of the three stages of transition. The agriculture industry is representative of first stage, the agrarian economy, the electrical and electronics is typical industry of the second stage, the industrial economy, and the ICT industry case illustrates the shift to the third stage, the services-based economy in the subsequent section.

Agriculture Industry

Malaysia's agriculture industry was the early engine of the nation's economic growth and development. Over time, agriculture's contribution to the nation's GDP and exports has declined in relative terms, though it remains a significant contributor. The agriculture sector contributed 7.1% (RM101,549 million) to the Gross Domestic Product (GDP) in 2019 (Figure 3.17) with exports of agriculture sector in 2019 amounted to RM115,522 million and the imports at RM93,510 million (Figure 3.18).

Irrespective of the relative level of contribution to overall GDP, having a robust agriculture industry is key in safeguarding the country's food security. Despite its important role within the nation, the industry continues to remain labour intensive. Its employment profile is also characterised by reliance on foreign low skilled labour, and agriculture provides subsistence level of employment (Figure 3.19).

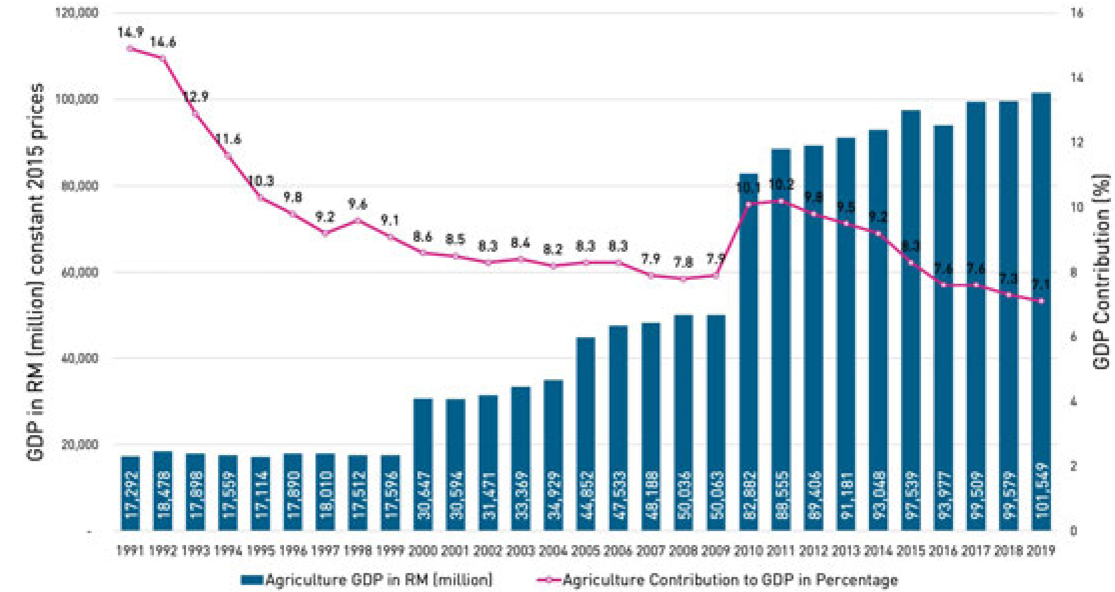


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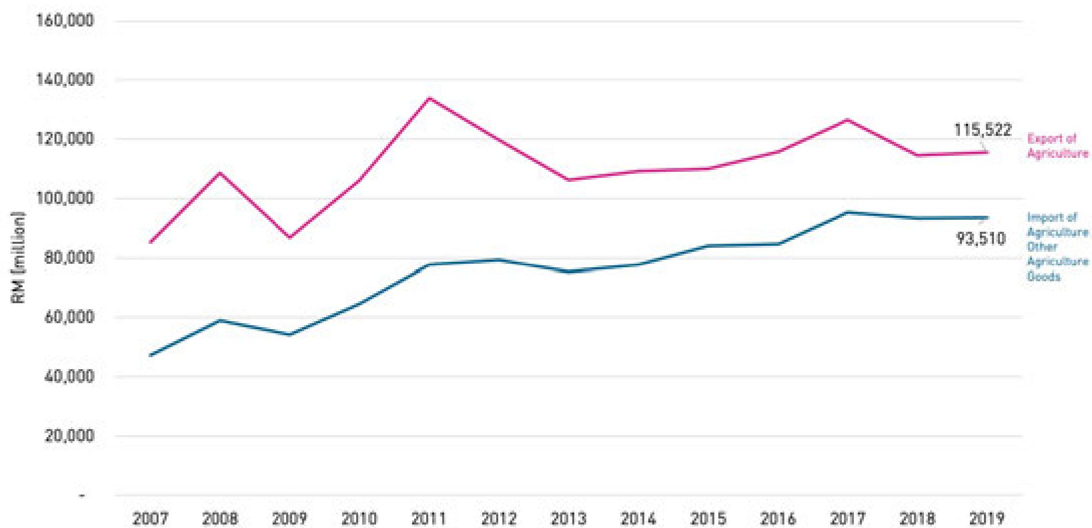
Figure 3.17: Malaysia's Agriculture Industry: GDP and GDP Contribution



Analysed by Sunway University Research Team

Figure 3.18: Malaysia's Agriculture Industry: Exports and Imports

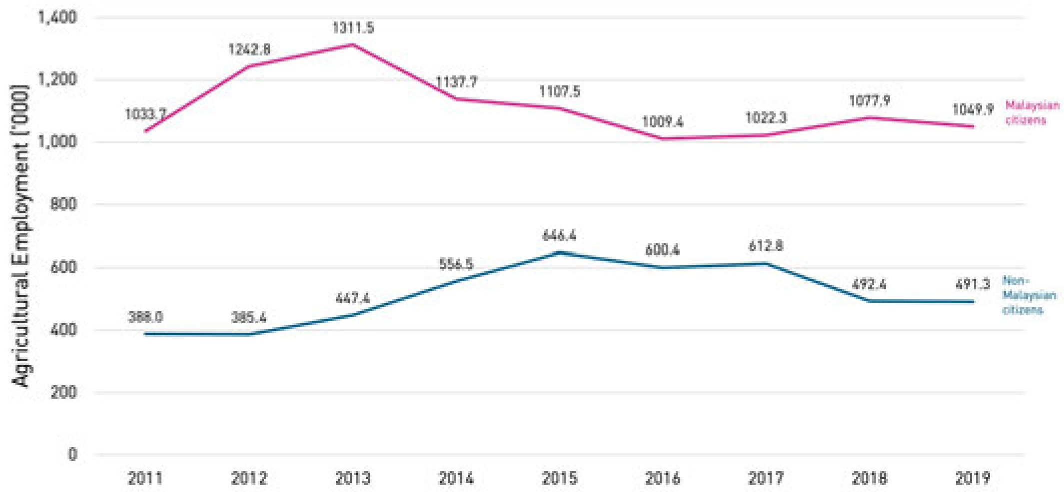
Malaysia's agriculture industry has not kept pace with advancements taking place in the STI ecosystems of international agricultural nations and remains highly production focused using traditional labour-intensive farming. Commodity products continue to predominate its market operations with minor level of activity in higher value products or high-value end of the food supply chain. Scrutiny of the agriculture industry shows low knowledge generation. The agriculture industry shows a weak overall development of its knowledge resource foundations, on which firms rely to generate dynamic capabilities.

Dynamic capabilities

Dynamic capabilities of an industry are a good reflection of the sector's ability to keep pace of change through innovation and appropriate adoption and leverage of emerging science and technologies.

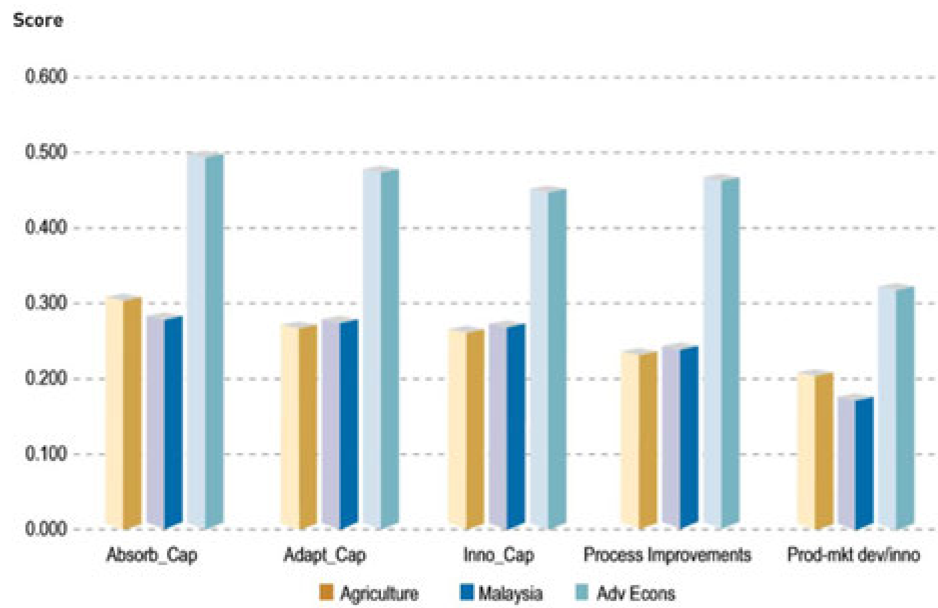
Dynamic capabilities reflect the ability to adapt to external change and turn them into opportunities for higher competitiveness. Absorptive, adaptive and innovative capabilities are the three main component of dynamic capabilities.

Among the three dynamic capabilities, the agriculture industry performs well in its absorptive capability, highlighting the agriculture sector's reliance on scanning the market and adopting insights and innovations that others, especially international players have developed (Figure 3.20). Given this reliance on external parties, it is unsurprising to note that the sector does not perform well in terms of its adaptive and innovative capability.



Analysed by Sunway University Research Team

Figure 3.19: Agriculture Industry: Employment Profile



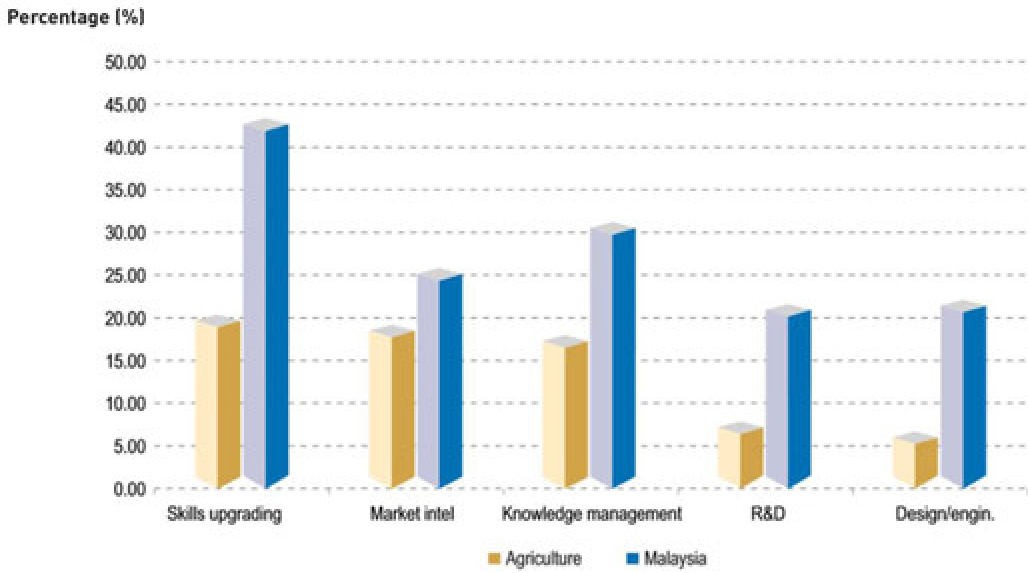
Reference: Economic Planning Unit (EPU) (2016[a])

Figure 3.20: Dynamic Capability Profile of the Agriculture Industry

Note: For all figures and charts featuring a comparison with advanced nations' dynamic capability, the dynamic capabilities for advanced countries are an aggregate rather than a sector specific measure.

Indeed, many of Malaysia's farming techniques and equipment are sourced from developed countries or regionally, such as Taiwan and even Thailand. Most significantly, Malaysian firms rely on foreign breeders for seeds and new breeds of crops. This is often the crucial 'technology' component in agriculture industries and suggests clear weaknesses in the agricultural STI ecosystem.

The weakness in the STI ecosystem indicated by the dynamic capability profile are further supported by Figure 3.21, which suggests that the agriculture industry is engaged in very low level of higher order value and innovation capability building activities. Firms in the industry score well below the national aggregate in skills upgrading, developing market intelligence, knowledge management, R&D and design improvements.



Reference: Economic Planning Unit (EPU) (2016[a])

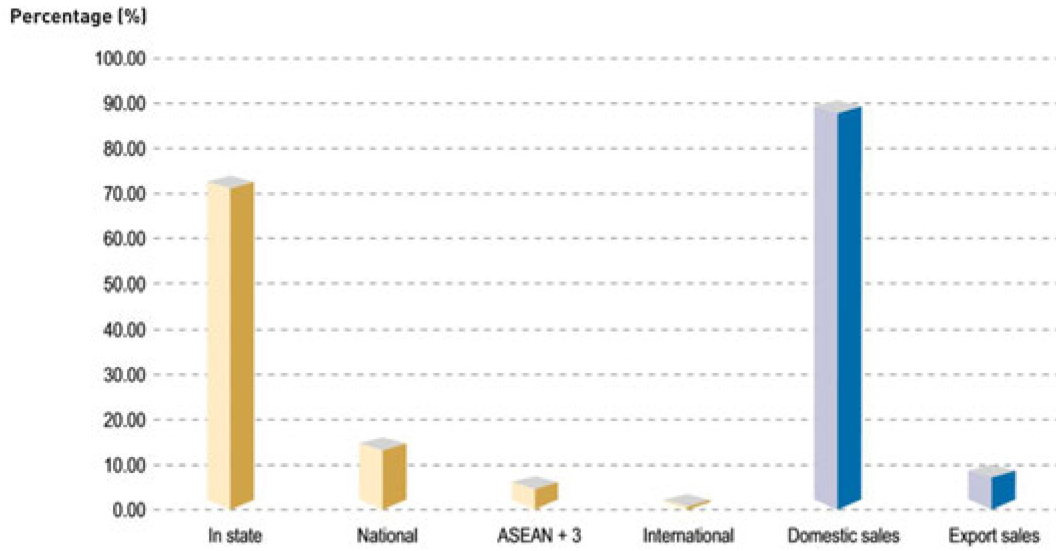
Figure 3.21: Knowledge Intensive Activities in the Agriculture Industry

A major export from the agriculture industry is palm oil. Malaysia's palm oil sector is the second largest global exported behind Indonesia; and it accounts for 28% of the world production and 33% global exports (Department of Commerce USA, 2020a). The non-primary commodity-based sectors (excluding palm oil and rubber) are primarily geared towards meeting the needs of the domestic market (Figure 3.22). The success in palm oil and rubber crops as strong export market has failed to 'trickle down' to other agricultural crops. The lack of development in the non-primary commodities part of the agriculture sector is mainly due to the following reasons: small farms, who do not have economies of scale and scope, land ownership issues; lack of R&D and suitable infrastructure to enhance productivity and new product development; weak institutional support and entrepreneurial acumen among the cooperatives, associations that represent farmers to develop strong positions for bargaining (World Bank, 2019).

Although the agriculture industry is involved in exports, the sector is primarily geared to meet the needs of the domestic market, from which it harvests around 90% of its revenue. Additionally, production and sales are geographically concentrated with the majority of these activities taking place within a single state. Export operations and exports are largely confined to regional markets (ASEAN plus Japan, China and South Korea) which account for approximately 7% of total revenue, with the remaining 2-3% coming from global markets (Figure 3.22).

Due to current state of the agriculture ecosystem, Malaysia produces close to 70% of the nation's food supply, while the remaining 30% are sourced from other countries (Dardak, R.A., 2020). The import value of food has increased over the years, for example the import value of food in 2012 was RM36.09 billion and this increased to RM51.46 billion in 2019 (Statista, 2021). In other words, despite improvements in food production, Malaysia continues to be a net importer of food and this food trade imbalance has persisted over the years.

Exploring the strategic profile of the agriculture industry (Figure 3.23), indicates that the sector is dominated by Defender (54.5%) and Reactor (21.6%) type firms. These two groups are indicative of highly inward-looking firms, who are slow to respond to changes in the environment. Analysers (12.5%) and Prospectors (11.36) are forward looking, proactive firms but exist in low numbers. Relative to the national aggregate, the agriculture industry appears to be dominated by defensive firms, rather than entrepreneurial risk taking and forward-looking firms. More than half of the firms in the industry are Defenders, suggesting it to be an industry that is focused on protecting existing products and commodity offerings, rather than developing new and novel lines of agricultural produce through innovation. Analyser and especially Prospector firms are both forward-looking



Reference: Economic Planning Unit (EPU) (2016a)

Figure 3.22: Market Presence of the Agriculture Industry

Strategic Posture of Firms

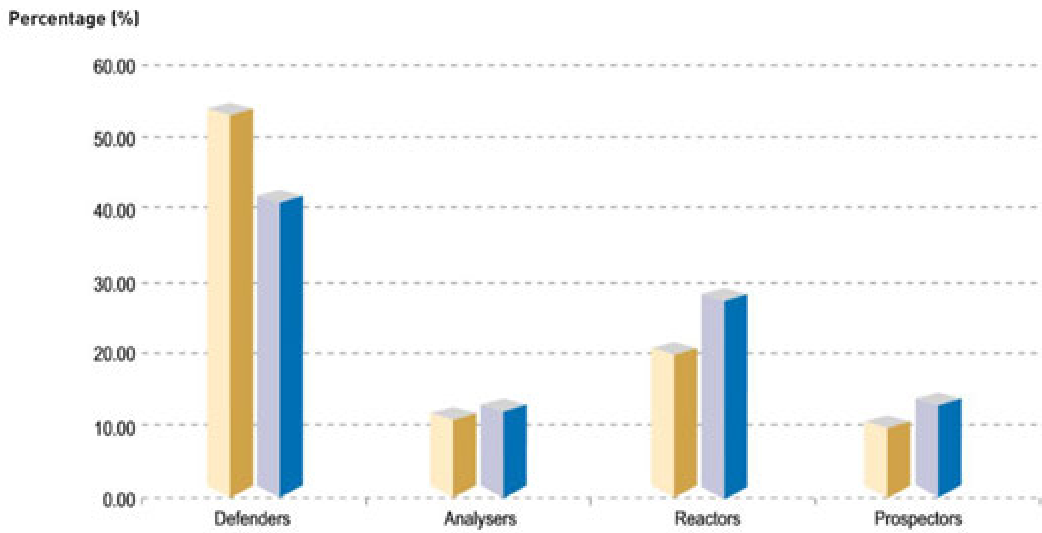
Defender firms are those that attempt for high quality provision in their selected market by focusing on operational efficiency instead of innovation.

Prospector firms, on the other hand are highly innovative and are prepared to take risks in seeking out new markets and opportunities in unchartered territories.

Reactor firms tend to only respond and adapt to changes in the marketplace when their existence is threatened.

Analysers are cautious and risk averse firms, who make transitions to new ways of doing things only after the flux in the environment has faded.

Reference:
EPU (2016[a])



Reference: Economic Planning Unit (EPU) (2016a)

Figure 3.23: Strategic Profile of Firms in the Agriculture Industry

but exist in the smallest number within the agricultural industry. Taken together these signal an innovatively inhibited industry and a poorly functioning STI ecosystem.

In summary, adoption of STI is not pervasive and the key challenges that persists in the agriculture sector are:

- continuing poverty among farmers (particularly rural small-holder farms);
- persistence of labour-intensive farming with heavy reliance on foreign workers;
- failure of firms to keep pace with science and technological adoption that is taking place within the international sphere of the agriculture industry;
- failure to break out of the commodities market, and move into high-value parts of the food chain, leading to low returns on investment; and,
- predominant focus on small sized domestic market and failure to significantly break into international food supply chains and markets to reap significant economies of scale.

KEY INTERVENTION

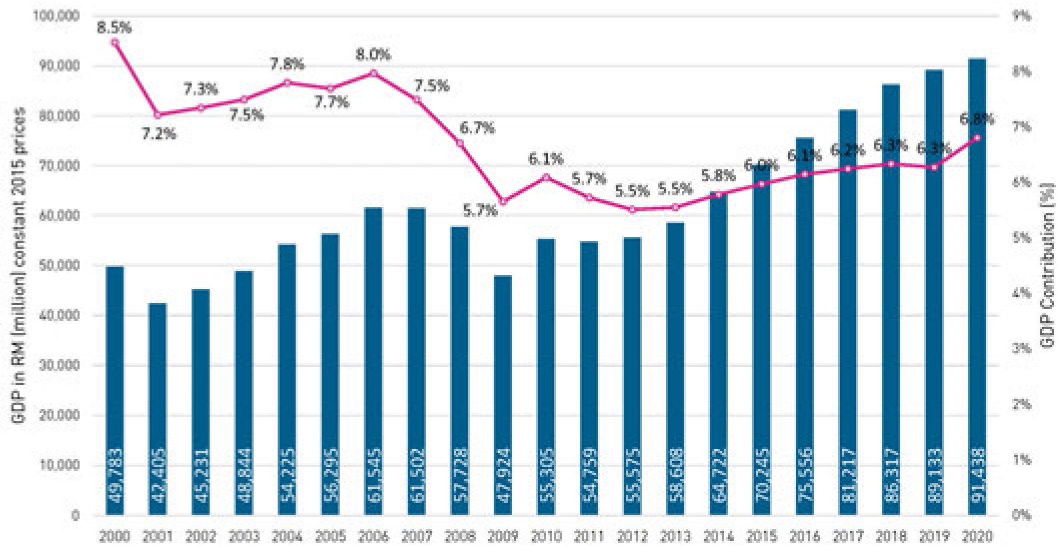
1. **There is a need for the agriculture sector to develop and adopt emerging agricultural STIs to increase the quality and quantity of the agricultural and food produce while optimising on human labour to ensure food security and sustainability. The use of the 10-10 STIE framework will better connect Malaysia's agriculture sector with global food supply chains.**

Electrical and Electronic (E&E) Industry

Having started in the 1970s with just eight productions companies, Malaysia's Electrical and Electronics (E&E) sector is in its fifth decade of operation. Over time, the sector has diversified from its start as a back-end labour intensive semiconductor assembly to front-end fabrication as well as design and development, especially of integrated circuits and embedded system designs.

From the 1980s onwards, the E&E industry has been a key driver of economic growth for the country and remains one of the most important contributors to national wealth. Indeed, the E&E industry has consistently exhibited strong performance, contributing significantly to GDP growth, employment and export-led economy. According to Ministry of International Trade and Industry (MITI), the E&E sector continues to be the primary driver of industrial development. By 2020, Malaysia's E&E industry employed over 575,000 people and contributed 6.8% to Malaysia's GDP, making it the leader in the manufacturing sector (see Figure 3.24).

In 2020, the E&E sector contributed to exports valued at RM386,110 million, constituting 39.4% of total exports (Figure 3.25). Export products with buoyant demand include integrated circuits, apparatus for voice, image and data transmission, as well as parts for integrated circuits to support the COVID-19 induced work from home phenomena. Key export destinations include China, US, Singapore, South Korea, Hong Kong and Japan.



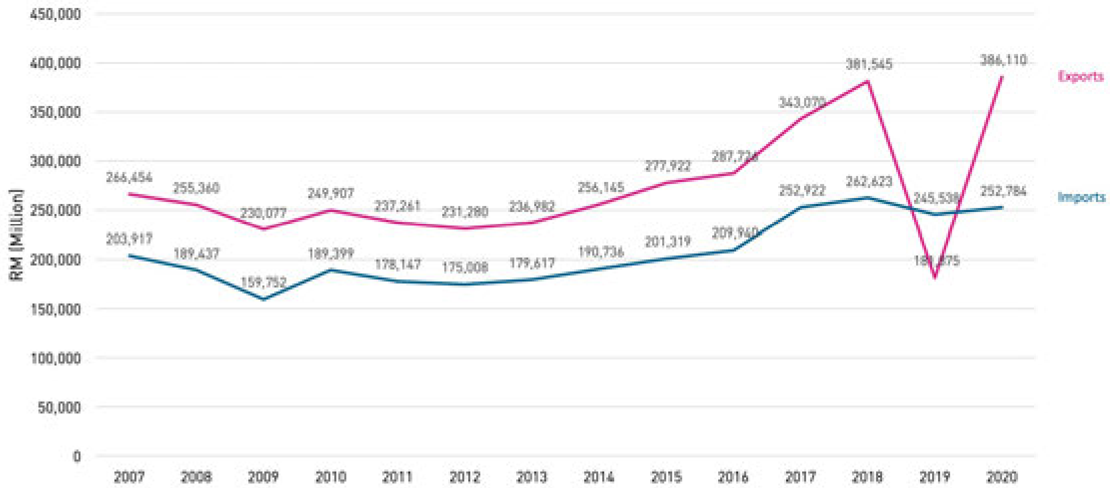
Analysed by Sunway University Research Team

Figure 3.24: Malaysia's E&E Industry: GDP and GDP contribution

Malaysia is also a substantial importer of E&E intermediate inputs, which creates an interesting overall picture. Taking the difference between exports and imports and expressing it as a percentage of exports shows that the local value-add to persistently languish around 25% to 35% mark. Why has this persisted over the decades, and the value-add not increased? Possible explanations lie in the weaknesses of E&E industry structure and STI ecosystem. Structurally, Malaysia has a strong back-end (involved in "packaging, which is low value-adding" activity) but a weak front end (involved in integrated circuit (IC) fabrication involving high-end science). Fabrication facilities require not only huge multi-billion investments but also require the right type of human resources and ecosystem to enable them. Notwithstanding the huge investment required, the E&E industry has struggled to attract the quantity and quality of specialist talent required to conduct high-value science and innovative activity. This problem has been accentuated by issues of structural fragmentation within the E&E ecosystem (EPU, 2016[b]).

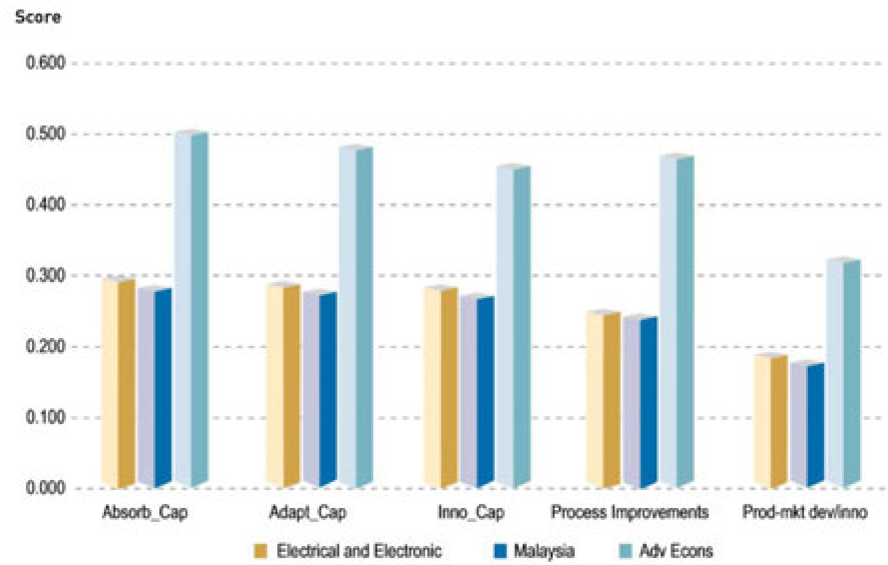
Examination of the E&E industry's ecosystem suggests that the E&E industry in terms of knowledge acquisition, development and application in local firms has made good progress in catching up with international counterparts in a number of areas. This indicates the initiatives implemented under the various government plans have managed to bear fruit and led to strengthening in capability of local E&E firms.

Knowledge generation, which is a crucial indicator of strength, in the E&E industry has been improving significantly over the decades. It is therefore not surprising to observe E&E industry emerging as a major driver of



Analysed by Sunway University Research Team

Figure 3.25: E&E: Exports and Imports



Reference: Economic Planning Unit (EPU) (2016a)

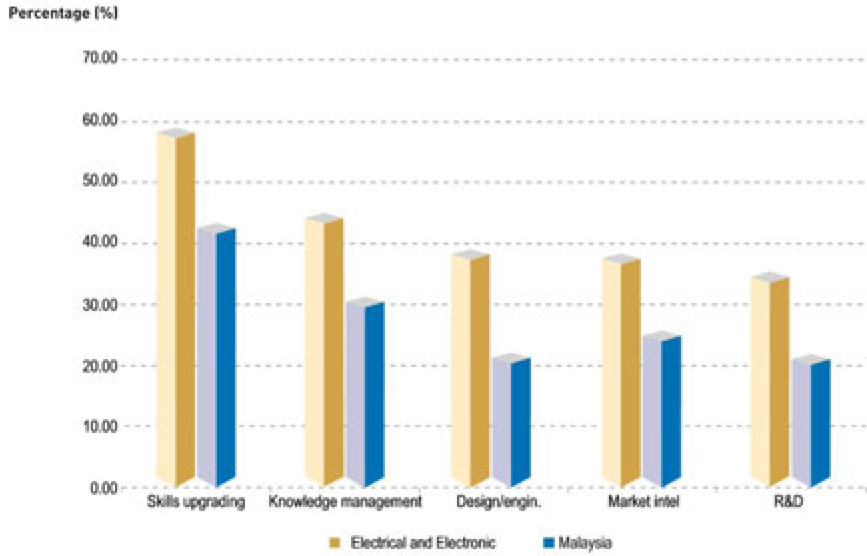
Figure 3.26: Dynamic Capability Profile of the E&E Industry

Note: For all figures and charts featuring a comparison with advanced nations' dynamic capability, the dynamic capabilities for advanced countries are an aggregate rather than a sector specific measure.

Malaysia's economic development. Figure 3.26 shows the E&E sector is performing better than the Malaysia's industry aggregate in all areas, including absorptive capability, adaptive capability, innovative capability, process improvement and product-market development/innovation.

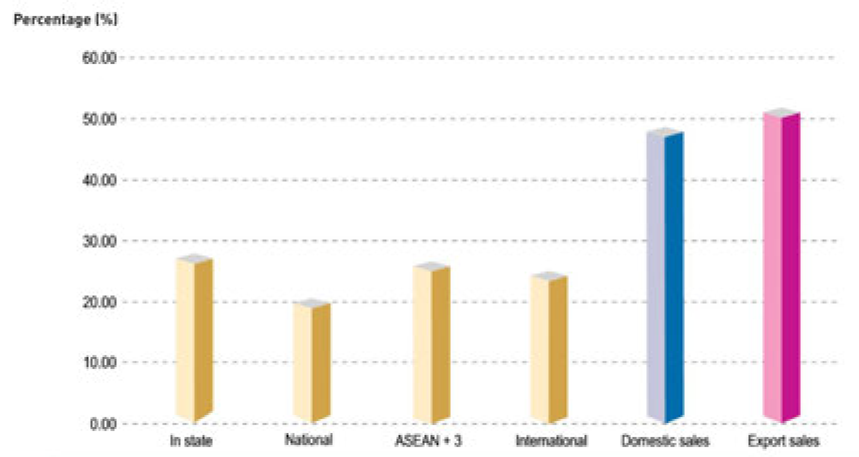
The E&E industry, especially the front-end depends heavily on a highly capable workforce. Compared to other manufacturing sectors, the E&E industry possesses a relatively strong sectoral employee profile, with many employees coming into the industry with an educational background in E&E engineering, computer science, and software development. In terms of supply of skills, the sector stands at more than double the level of the national aggregate. Despite this, the pipeline of talent is not able to meet the skills demand, especially of highly specialist skills, required in the front-end activities of the sector.

In line with skills investment, Figure 3.27 shows that E&E firms have devoted greater resources to enhance their dynamic capabilities activities than the Malaysian aggregate. Across all areas, the Malaysia's E&E firms have made higher investments in skills upgrading (59.2%), knowledge management systems (44.8%), design and engineering (39.2%), market intelligence (38.4%) and research and development (35.2%). These results indicate that the E&E firms are making significant effort to enhance their adaptive and innovative capabilities, which is critical for success in dynamic and fast-changing industry environments.



Reference: Economic Planning Unit (EPU) (2016[a])

Figure 3.27: Knowledge Intensive Activities in the E&E Industry



Reference: Economic Planning Unit (EPU) (2016[a])

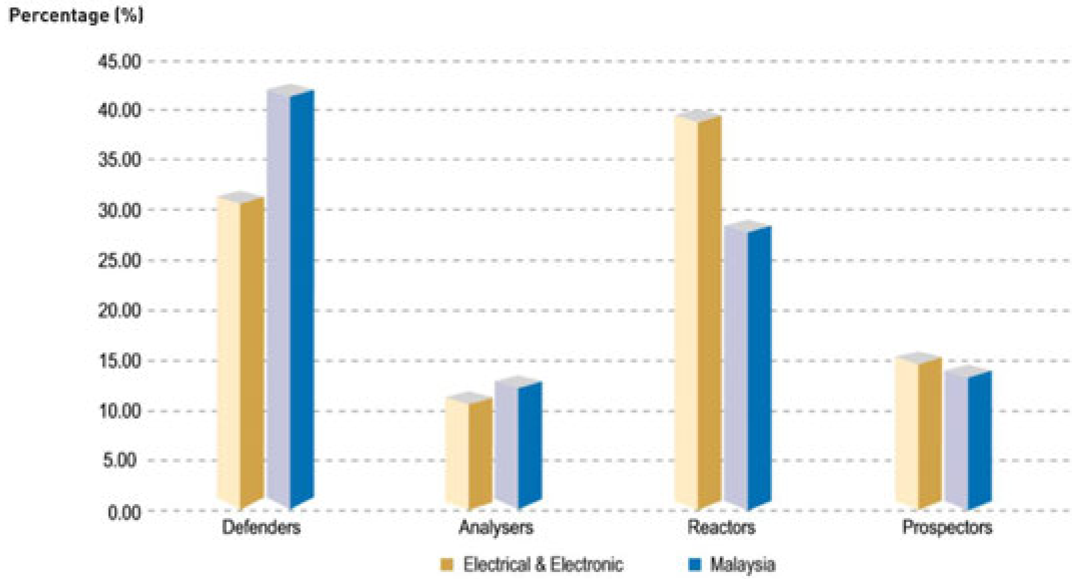
Figure 3.28: Market Presence of the E&E Industry

As noted earlier, the E&E industry has developed into Malaysia's largest contributor to exports, economic outcomes and employment. Its significance is shown in Figure 3.28 where total export sales (ASEAN plus International - 51.71%) are higher than the domestic sales (48.29%). This can be attributed to its positive brand recognition in international markets. Malaysian E&E products have gradually established themselves in export markets by positioning themselves to offer consistent product quality at highly competitive pricing. Through positive brand building, E&E products have made significant inroads into export markets within the ASEAN bloc, China, Japan, and South Korea and other nations.

To understand the E&E industry's performance within a broader perspective, it is necessary to look at the structure and dynamics taking place at the firm level. This can be observed from the strategic profile of E&E industry. Figure 3.29 shows that the sector possesses a small group of Prospector firms (16%), which is just slightly higher than the Malaysian aggregate. This is a positive sign as these E&E firms are risk-takers, capitalise on new market opportunities and focus on research and development. However, it is worrying to note that the smallest group of the firms are Analysers (12%). These firms are typically 'second-movers' and possess the financial wherewithal to scale emerging innovations and penetrate new markets.

Defenders and Reactors firms form the two largest groups in the industry. This suggests an underlying weakness in E&E industry. Defenders and Reactors firms do not sufficiently innovate or respond adequately to changes in the market and competitive environment. Such firms tend to be stuck in low value activities and find it difficult to pull themselves out of the negative cycle once significant disruptions emerge within their competitive horizons.

The E&E knowledge ecosystem for Malaysia has shown robust performance over the years, and the industry is classified as a pace-setter among the 21 industries in Malaysia. However, the strategic profile in conjunction with dynamic capabilities of the sector indicate impending issues if the industry ecosystem is not strengthened to cope with the emerging STI shifts.



Reference: Economic Planning Unit (EPU) (2016[a])

Figure 3.29: Strategic Profile of Firms in the E&E Industry

Key challenges that impact the industry are:

- Fragmented industry structure requiring greater consolidation and co-ordination to allow firms to scale up and build skills and financial strength to compete in the high-value front end of the E&E sector;

- Weak supply pipeline of high-end skills to penetrate the high-value front end of the sector;

- Rapid pace of STI change in the sector, requires continuous streams of investment just to keep abreast of changes and advances;

- New opportunities on the horizon from the digitalization era. The digitalization spans both industry (manufacturing and services) as well as consumer device needs;

- Local ecosystem gain versus International ecosystem gain. The E&E sector has been innovating and developing through the use of highly skilled Malaysian talent. Unfortunately, much of the skilled local talent is employed by MNCs, and therefore the IP gains are not easily accessible by Malaysia's ecosystem.

KEY INTERVENTION

1. **Investment is needed for this industry to build its competitiveness in the high-value front-end IC fabrication and design and development. Substantial investment will help in doing advanced R&D and advanced production. It will also help in training and nurturing talent with high level of technical skills and specialist scientific knowledge.**

IT Industry

The information technology (IT) industry, also referred to as the information communication technology (ICT) industry, is not only a significant wealth contributor for the country, but it plays a crucial role as a driver in enhancing productivity of other industries, particularly through its enablement of digitalization and adoption of IR 4.0 technologies. It is a critical piece of the jigsaw in moving Malaysia up the innovation value chain, and increasingly ICT services are becoming a fundamental driver to transform Malaysia into a knowledge-based society.

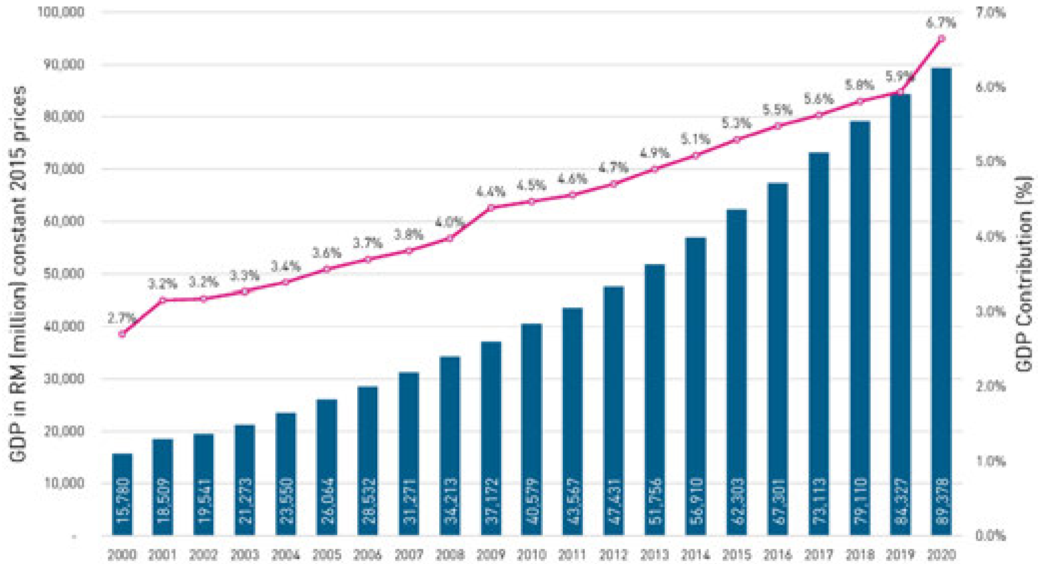


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Figure 3.30: Malaysia's IT Services Industry: GDP and GDP Contribution

In 1996, the National IT Council (NITC) promulgated the National IT Agenda (NITA) to provide a framework for the systematic roll-out of ICT infrastructure and services in Malaysia. The Multimedia Super Corridor (MSC) Malaysia which was conceived much earlier was approved by NITA to spur new growth industries. The MSC Malaysia was envisioned to nurture an ecosystem to spur creativity and innovation in the ICT sector. Numerous inducements were provided to local and foreign ICT companies to enhance ICT adoption and enable faster technology transfer. In addition to its focus on new frontier technologies in ICT areas, MSC Malaysia also focussed its effort on the development of the local creative industries.

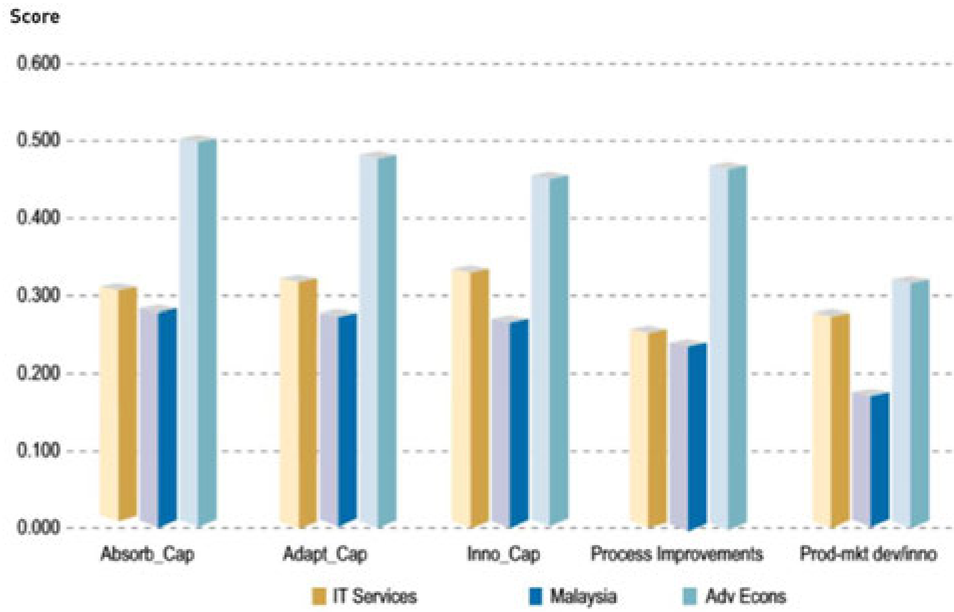
Investments over the last two decades have led to the strengthening of the ICT industry in services, trade, manufacturing, e-commerce, creative content and other multimedia. This has fuelled growth of the ICT industry. The share of the industry as a percentage of the GDP has grown steadily over time. Over the course of this period, the industry also saw a transition from manufacturing of ICT products to ICT services. This is reflected by an increase of the services, content and media industry contribution to GDP from 2.7% in 2000 to 6.7% in 2020 (Figure 3.30).

From as early as the decade beginning in the 1990s, the ICT industry has been undergoing major transformation: transitioning from components manufacturing to become a service driven industry. The shifts taking place within the ICT sector have led to the emergence of numerous new technologies and innovations, necessitating major investment in training to keep abreast with the changes. These shifts have necessitated the ICT sector to change its skills and competency requirements to align with the emerging needs of the sector.

The ICT sector has in recent times been one of the fastest growing sectors in Malaysia. From 16.8% GDP contribution in 2015, it had grown to 18.5% in 2018, and at this rate is anticipated to go above 20% over the next two years. According to statistics from DOSM, the digital economy had expanded to RM267.7 billion in 2018. And in terms of contribution to GDP, ICT contributed 18.5%, which represents a Gross Value Added (GVA) of ICT industry to be 12.6%, and e-commerce for non-ICT industries sat at GVA of 5.9%. DOSM points out that by 2018, GVA for the overall ICT sector had reached RM182.4 billion, and ICT services industry dominated the share by holding 43.2%, followed by ICT manufacturing at 34.1%. The growth in ICT services is primarily accounted by growth in Telecommunications services, whilst the ICT manufacturing was driven by electronic components & boards, communication equipment and consumer electronics (DOSM, 2019).

Spending in the sector is driven by rapid growth in digital adoption. Major areas fuelling ICT growth are cloud computing, data analytics, storage, cybersecurity, mobility and business process outsourcing. According to Department of Statistics Malaysia (DOSM, 2020a), the Gross Value Added (GVA) of the ICT industry increased from RM183 billion in 2018 to RM195.6 billion in 2019, close to 6.6% increase. The share to the GDP also increased from 12.7% in 2018 to 12.8% in 2019. The major contributor to the GVA of the ICT industry is the ICT services (43.5%), followed by ICT manufacturing (33.7%), ICT trade (15.4%) and content & media industry (7.4%). The GVA for e-commerce increased significantly from RM89.1 billion in 2015 to RM127 billion in 2019. The industry employed approximately 1.14 million persons, who are primarily in the ICT manufacturing sector (36.6%), followed by ICT services (28.7%) and ICT trade (21%). The growth of ICT in Malaysia has been further propelled by Government policies, such as the "Industry4WRD" plan, which were designed to transform the manufacturing and services sectors through digitalization and automation between 2018 to 2025. Supporting this plan is the "Malaysian Economy Digital Footprint" and IR4.0 Policy launched in 2021. The plans are envisaged to transform Malaysia into a knowledge-intensive economy that will enhance the socioeconomic development of all segments of the population as outlined in the Shared Prosperity Vision 2030.

The transformation from manufacturing to services led sector has placed new demands on the ICT ecosystem. Figure 3.31 shows that overall, the absorptive, adaptive and innovative capacity of firms in the IT services industry to be higher than the national average. Even though the ICT industry registers a higher knowledge generation compared to the national average, deeper exploration of this parameter shows that large foreign firms dominate knowledge generation, followed by large local firms (EPU, 2016b). The low levels of knowledge generation among Malaysian firms points to the inability of Malaysian firms to move up the innovation and knowledge value chain.



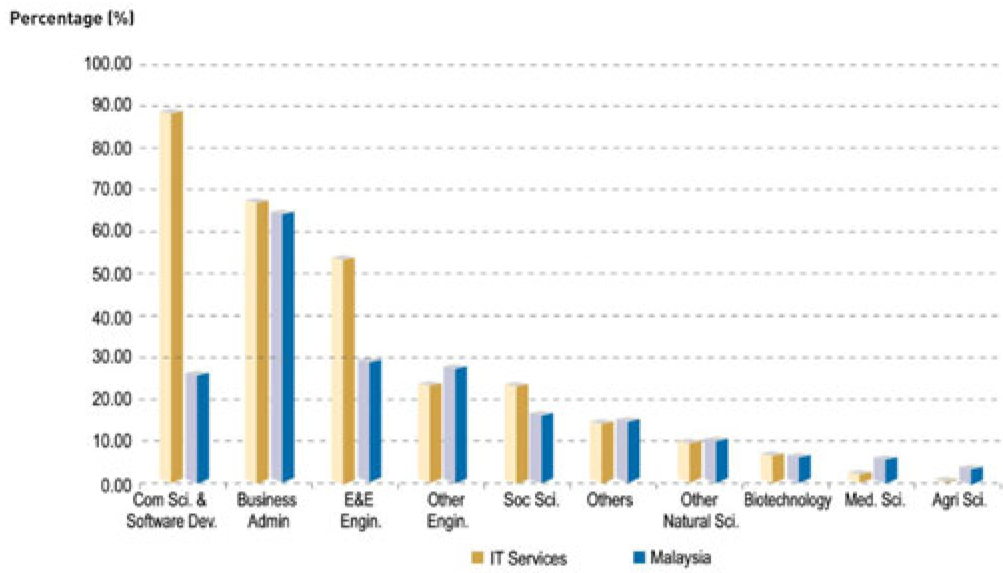
Reference: Economic Planning Unit (EPU) (2016[a])

Figure 3.31: Dynamic Capability Profile of the IT Services Industry

Note: For all figures and charts featuring a comparison with advanced nations' dynamic capability, the dynamic capabilities for advanced countries are an aggregate rather than a sector specific measure.

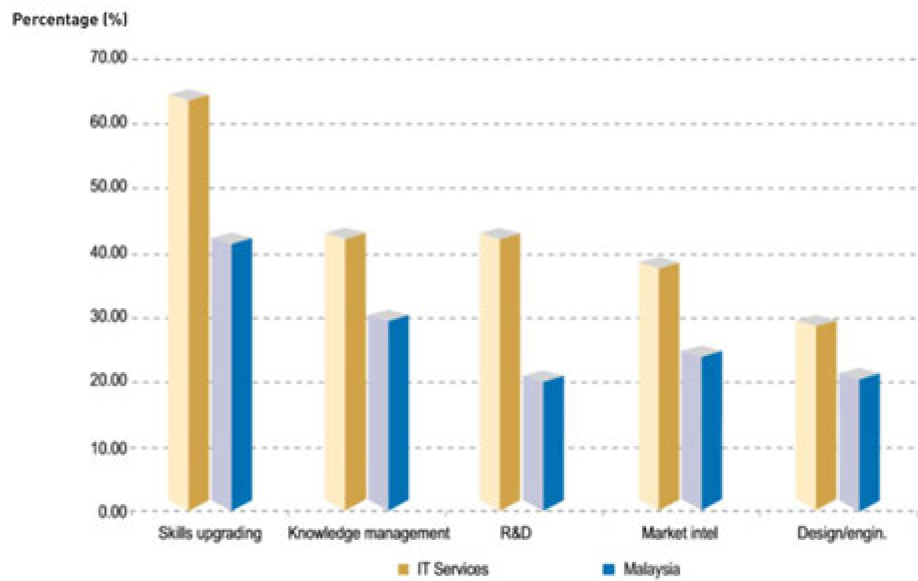
The IT industry's ability to adapt to the changes taking place in the industry are strongly associated with the stock of talent within the industry. A strong presence of graduates in the computer science and software development skills, business administration and electrical and electronics areas shows that the IT industry has a solid foundation to move up the innovation value chain (Figure 3.32). The strong presence of graduates in these areas also demonstrates that the IT industry is able to quickly seize opportunities in emerging areas, such as Business Analytics, Big Data and IoT industries.

The knowledge-intensive activities taking place within the IT services industry (Figure 3.33) indicates that the industry invests at a higher level than the national average in skills upgrading, knowledge management, R&D activities, market intelligence and design and engineering. This feeds into a higher innovative capability than the national average.



Reference: Economic Planning Unit (EPU) (2016[a])

Figure 3.32: Skills profile of the IT Services Industry



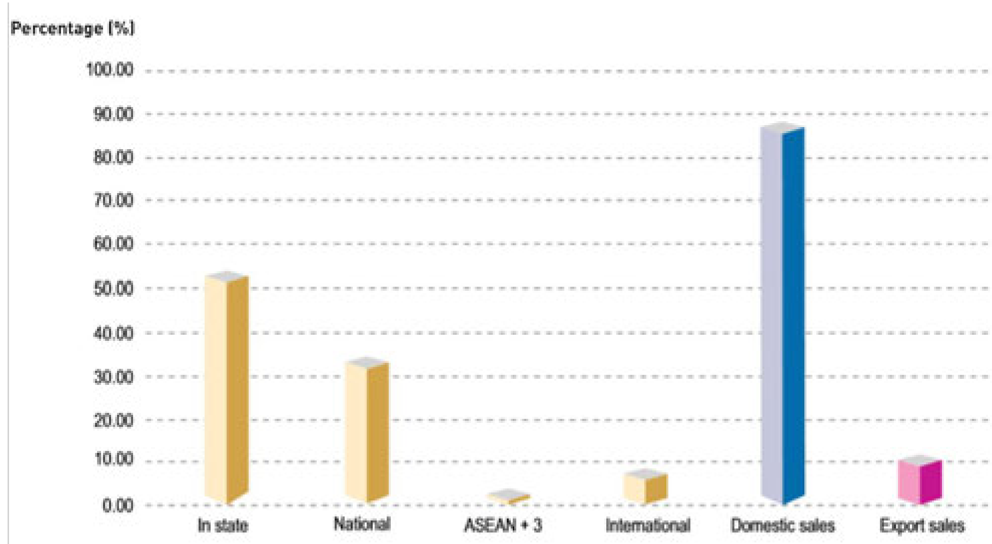
Reference: Economic Planning Unit (EPU) (2016[a])

Figure 3.33: Knowledge Intensive Activities in the IT Services Industry

Even though the IT services industry has significant export focus, the sector remains primarily domestic market-driven, with close to 88% of firms focused on servicing the home market needs (Figure 3.34). Many of the service operations take place within the state (54%), with only 34% across the country, suggesting very localised service approach. Very few (12%) are involved in international service provision, and of these 3% target the ASEAN market, while the remaining 9% are focused on other international markets.

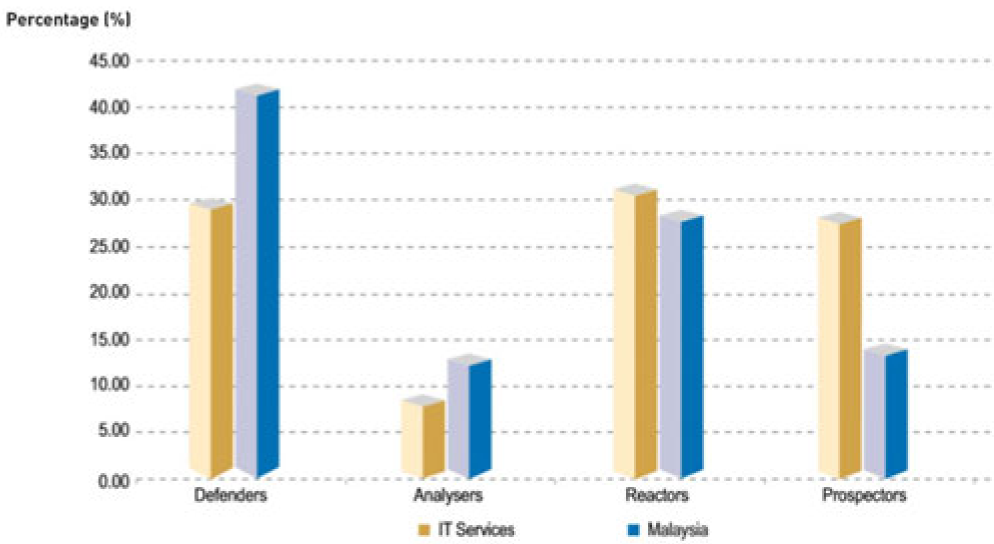
Scrutiny of the strategic position of the firms in the IT services industry (Figure 3.35) shows strong presence of Reactors (32%) and Defenders (30%). These firms are slow to respond to change despite experiencing technological or market threats. Reactors tend to operate at the lower end of the value chain and are often recipients of knowledge from more innovative peers. The percentage of firms in the IT services industry that are Reactors is higher than the national average and indicates that a large segment of local firms in the ICT industry are not investing sufficiently in R&D and innovation activity.

In contrast, the industry also has a significant group of Prospector firms (29%). These firms are proactive innovators who are willing to invest in R&D and take entrepreneurial risks. The percentage of Prospector firms in the IT services industry is close to double that of the national average. It is because of the large number of prospectors' firms in this group, that the ICT sector is often characterised as a pace setter sector. Analysers who are often firms with deep pockets to scale and penetrate large markets are the smallest segment at 9%.



Reference: Economic Planning Unit (EPU) (2016[a])

Figure 3.34: Market Presence of the IT Services Industry



Reference: Economic Planning Unit (EPU) (2016[a])

Figure 3.35: Strategic Profile of Firms in the IT Services Industry

Overall, the ICT services sector not only possesses one of the highest knowledge contents among Malaysia's 21 sectors, but also acts as a key enabler of knowledge intensity in other industries. However, while the ICT services industry is considered as a pace-setter, its knowledge ecosystem is not as strong as the ecosystems of other players in the region, such as China, Taiwan, South Korea, and other global players.

Key challenges that impact the industry are:

- ICT landscape is undergoing major structural changes because of technological breakthroughs. Firms in the industry need to continuously invest significant resources in talent and R&D and production facilities. This is especially the case for SMEs, who are increasingly falling behind because of lower financial resource capabilities;

- The demand for skills and competencies for emerging ICT services and manufacturing is not being met by the current supply pipeline. This mismatch needs to be quickly addressed to stop the sector falling behind global competitor;

- Business models in the sector remain domestic market focussed, and need to be adjusted to tackle international markets so that economies of scale and scope can be realised; and,

- The Malaysian Government has invested significant resources to enhance the ICT ecosystem and provide incentives for Malaysian firms to move up the innovation and knowledge value chain. From these initiatives, several Malaysian players and products have gained both regional and global presence. Despite the success attained by some players in the ICT services industry, a significant proportion of firms, especially micro and SMEs are finding it hard to weather competitive pressures from regional and global players.

KEY INTERVENTIONS

1. **There needs to be a concerted effort to intensify IR4.0 technologies across all sectors of the economy especially digitisation among micro, small and medium sized firms.**

2. **Ensure affordable access to ICT services for all segments of the population, especially the vulnerable and marginalised communities in rural and urban localities - this is crucial to increase the demand for ICT services and creating an inclusive society as outlined in the Shared Prosperity Vision 2030.**

Box Article 3.2: IT Services Industry in China, South Korea and Taiwan

CHINA: In 2018, China's IT services revenue was USD276.3 billion, with leading players such as Tencent, Baidu, Alibaba, Netease and JD.com with a total market value of USD1.45 trillion. The software industry in China reached USD890 billion lead by main players such as Kingdee, ZTE, Nuusoft, Founder Group and Haier.

SOUTH KOREA: To counter the intensive competition in the global market, South Korea has embarked on investing in innovative technologies such as 5G network, Artificial Intelligence and Big data to support their leading companies such Samsung Electronics, LG Electronics, SK Hynix and Naver maintain their global leadership in both the IT services and infrastructure development.

TAIWAN: Similar to South Korea, to address the competitive nature of the IT services industry and the demand for these services during the COVID-19 period, the Taiwanese government has intensified investment to upgrade a wide range of IT services from 5G, AI, Augmented Reality business application software and business intelligence related applications and other services. These is to ensure the digital ecosystem is able to be globally competitive amidst global giants in the region, such as China, South Korea, Japan and India and be an important player in the global IT supply chain.

References:
Department of Commerce, USA (2020b), Department of Commerce, USA (2020c), Liu, K.C., and Racherla, U.S. (2019)

Cross Industry Gaps

Besides the unique context issues and challenges faced by each of the industry sectors, a common thread surfaces across all three industry sectors. Examining across the industry cases highlights three high level gaps: a talent and skills gaps, competitiveness gap or industry capability gap and a market gap. These gaps feature within the ecosystems of all the industry cases.

Talent and Skills Gap. Industry ecosystems of the three industries demonstrate skills and competencies gaps that need to be addressed for efficient functioning of the ecosystem. How the gaps are created and how they are to be resolved is dependent on each industry's specific context. For the agriculture industry, the skills gaps are due to the perceived unattractiveness of the sector, in terms of salary, career prospects and societal perception of farming. In contrast, for the E&E and ICT sector, the skills gap arises from dynamic shifts taking place in the sector, and the inability of the education and training sector to keep pace with the changing needs of these industries, as they transform.

Competitiveness Gap (or Industry Capability Gap). The different industry cases indicate different levels of progress in terms of competitiveness, and each one faces unique challenges. The agriculture industry has been falling behind the global agriculture industry due to continued entrenchment in commodity products through traditional farming. The global agricultural industry has moved forward with strong levels of automation, adoption of emerging agricultural science and digitalization of farming to connect with global food supply chains. The E&E sector has performed well in the low-value add, back-end part of the E&E industry. It has built, over time, skills, capacity and capability in the back end "packaging" part of the E&E. However, in the high-value front-end IC fabrication and design and development, the E&E sector faces challenges in building competitiveness, due to issues related to the level of investment needed, scale of operations and the market size needed to operate at optimum scale and the high level of technical skills and specialist scientific knowledge needed to do advanced R&D and advanced production. The ICT sector is similarly facing knowledge skills shortages which undermine its competitiveness at the global level. The mismatch is a consequence of the rapidly evolving STI landscape that defines the ICT industry's digital and emerging AI evolution. For each sector, these are different and unique industry capability deficiencies, but they all lead to a competitiveness gap, especially when one moves beyond the capabilities needed for domestic market penetration to global market penetration.

Market and Market Positioning Gap. Inter-linked to the above two gaps is the market and market positioning gap. All the cases highlight that each industry examined is heavily dependent on the domestic Malaysian market. This is neither surprising nor interesting since virtually all industries, bar the rare exception of born-global firms that are emerging in the new digital era, have a domestic focus. However, considering the small size of the domestic market, it is imperative for Malaysian firms to have robust access to and operation in international markets to avail themselves the economies of scale and scope needed to build positions of competitive advantage. This is a prerequisite when competing with global players, who can build unassailable positions of advantage through scale. Despite strong progress, Malaysian industries have been unable to build significantly strong global competitive advantage positions across the full spectrum of their industry operations. To date whenever global competitiveness has been attained, the success has been in very narrow niches. Malaysian industry sectors need to re-examine their structural and strategic formats to transit from domestic competitiveness to global competitiveness. This transition will require reform in the industry ecosystems to enable higher level of innovation, be it product, process or service innovation. This can only be achieved, when the respective industry ecosystems are geared to develop higher levels of dynamic capabilities that underlie global competitiveness.

Box Article 3.3: Biotechnology Sector in Malaysia

About 5,000 to 10,000 years ago, humans learnt the use of biology to improve their quality of life either by making useful products or solving problems using living organisms. This practice, eventually known as biotechnology, was obvious in the agricultural sphere. Microorganisms were used to make bread or to preserve dairy products. As science and technology progressed, we became better equipped to understand the molecular and cellular levels of organisms. Consequently, we have better agricultural or medical solutions today from biotechnology integrated with transdisciplinary knowledge, such as from chemistry and mathematics.

Biotechnology was identified as the new engine of growth for the transformation of Malaysia into a developed nation by 2020. The National Biotechnology Directorate was established in 1995 and in 2005 the fifth Prime Minister Datuk Seri (now Tun) Abdullah Ahmad Badawi announced the launching of the National Biotechnology Policy (2005-2020) (NBP). The Policy with its nine thrusts and three focus sectors, namely agriculture, healthcare and industrial, was formulated to spearhead the development of biotechnology as an important area of growth. The 9th Malaysia Plan (2005-2010) also outlined a dedicated chapter on Biotechnology.

25 years on, biotechnology in Malaysia is still struggling to position itself as a global leader in niche areas, even though the nation possess one of the most biodiverse ecosystems in the world. Value of the global biotechnology industry was reported at USD51.6 billion in 2016; in that year Singapore's market size was reported as USD16 billion. Whilst 258 companies with Bionexus status have been reported in 2021, Malaysia's market size in 2019 was only USD360 million. Biotechnology is a thriving sector in many developed economies. It is projected that this sector will be worth USD133.6 billion by 2024. Major structural improvements are needed to strengthen the biotechnology ecosystem for Malaysia to be a serious contender in the global biotechnology marketplace.

References:
Arujanan, M. and Singaram, M. (2018), Britannica, T. Editors of Encyclopaedia (2021), Fortune Business Insight (n.d), BBC Research (2020), Verified Market Research (2019)

8i Framework for the Biotechnology Sector in Malaysia

1 INFRASTRUCTURE

OVERCOME DUPLICATIONS AND POOR MAINTENANCE OF EXISTING INFRASTRUCTURE

Due to duplications of effort at research institutions, many cutting-edge technology infrastructures are either under-utilised or unutilised due to lack of funds for maintenance or lack of skilled talent to operate it.

2 INFOSTRUCTURE

A NEED FOR ONE STOP INTELLIGENT DATA CENTRE

The industry data / information / landscape is not up to date despite the available data from Bioeconomy Corp. Therefore, most private investors are unfamiliar / unaware of the industry progress in Malaysia.

3 INTELLECTUAL CAPITAL

HIGH SKILLED JOB CREATION AND PLACEMENT MUST BE PRIORITISED

Mismatch in talent supply and demand is evident due to low levels of awareness of the demand for specialised talent, low industry readiness, low attractive remuneration packages and prospects for dynamic career paths.

4 INTEGRITY

THIS SECTOR WILL BENEFIT FROM BETTER GOVERNANCE AND LEADERSHIP

A vacuum in setting the direction is seen with the disbandment of BIOTEK (National Biotechnology Directorate was formed in 1995 and rebranded to BIOTEK in 2005. BIOTEK was disbanded in 2015.), relocation of Bioeconomy Corp to the Ministry of Agriculture and Food Industries (MAFI) and the inactivity of the Bioeconomy Council. This also led to lack of leadership in supporting industries to take up high-end Biotechnology and introduction to newer legislation in line with technological advancement (e.g., acts for biobanking; tissue, genetic banking, genetic information).

5 INCENTIVES

LONG TERM SUSTAINABLE FUNDING IS NEEDED TO SEE FRUITION OF PROJECTS

There are very few investors willing to ensure attractive and sustainable public funding is matched with secure private investment for high value product development and commercialization purposes. Besides Cradle Innovation Programme (CIP), there is no end-to-end public funding / incentive package offered to both private players and academia to cover the spectrum of the value chain in order to further support the product development and commercialization.

6 INSTITUTIONS

AN EXERCISE TO EVALUATE AND REPURPOSE INSTITUTIONS SHOULD BE CONSIDERED

Duplication of research efforts and roles among institutions of higher learning and COEs, research institutions, etc. were seen due to the lack of central direction and coordination as well as internal KPI targets. The National Biotechnology Policy (NBP) 1.0 too had overly wide priority areas leading to inefficient optimisation of resources in the delivery of the national initiatives.

7 INTERACTION

FORGE DEEP COLLABORATIONS FOR IMPACTFUL OUTCOMES

Deep collaboration for impactful outcomes are not forthcoming due to lack of systematic and efficient cooperation between government agencies, state agencies, institutions of higher learning and business communities' agencies towards a common goal.

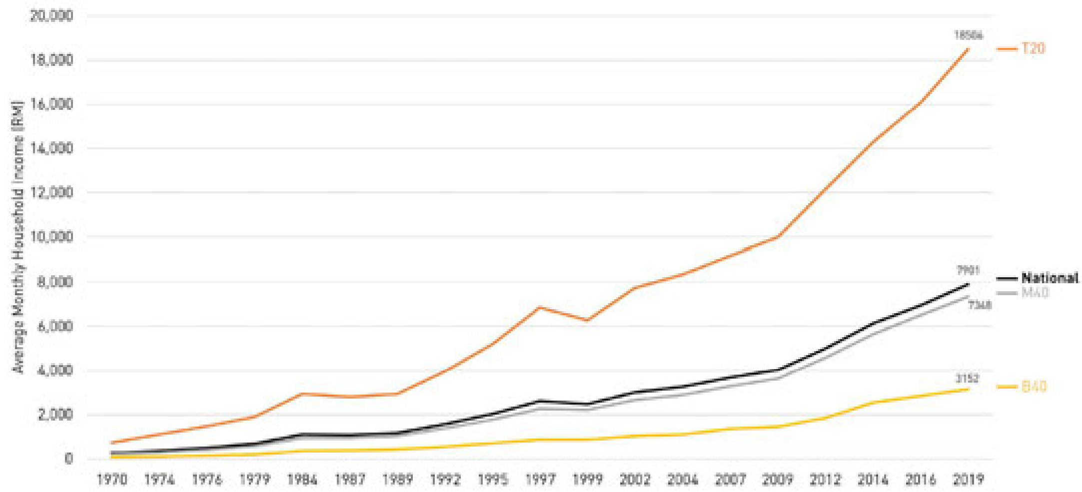
8 INTERNATIONALISATION

ENCOURAGE LOCAL PLAYERS TO GO GLOBAL

Due to lack of clear leadership and support there us limited participation in the global supply- and value- chain as well as low collaboration with international partners, resulting in limited data sharing at global level. This results in lack of investment from global corporates and foreign investors which then becomes a barrier for the locals to uptake new technology to diversify this sector.

STI AND ECONOMIC DEVELOPMENT OF VULNERABLE COMMUNITIES

The economic development plans put in place over the past three decades were crafted to reduce the wealth gap between the various communities in the country. Income levels of the communities in the top 20% (T20), middle 40% (M40) and the those in the bottom 40% (B40) of the income level have increased over the years from 1970 to 2019, as shown in Figure 3.36. The incidence of absolute poverty declined over the same sample period, as shown in Figure 3.37.



Analysed by Sunway University Research Team

Figure 3.36: Average Monthly Household Income, 1970 – 2019

During the 1960s, much of the poverty in Malaysia was in rural areas, primarily among small agriculture farms. To uplift the socioeconomic status of the rural population, the Malaysian government introduced three important agencies: Federal Land Development Authority (FELDA), Federal Land Consolidation and Rehabilitation Authority (FELCRA) and Rubber Industry Smallholder Development Authority (RISDA).

In the mid-1990s, a new land scheme was introduced called *Konsep Baru* (New Concept), to foster a three-way partnership between private plantation firms, the local community and the government to develop the land. To develop rural land under native customary rights, especially in Sarawak, the Sarawak Land Development Board (SLDB), Sarawak Land Consolidation and Rehabilitation Authority (SALCRA) and the Land Custody and Development Authority (LCDA) were established (Hassan, A.A., Ngah, I., & Applanaidu, S.D., 2018). The rural development agencies' role was to channel resources to a wide range of activities, from clearing land, planting crops and other institutional support to develop existing plots into viable agriculture land. These support schemes assisted farmers to get higher return on value, provided employment, and raised the income of the settlers. In so doing these plantations became important contributors to the nation's GDP. Financial assistance, education training and large-scale infrastructure development programs were initiated under these schemes and helped provide rural and remote communities access to electricity, water, sanitation, education, medical services, information technology and other public amenities.

The 1980s saw the transition of the economy from an agriculture to a more diversified economy, in which manufacturing and to some extent the services sector increased their share of contribution to the economy. This shift led to large number of higher paying jobs and increased the income level of the country. While significant investment in technology and capability development programs were beginning to transform Malaysia into an industrial powerhouse, the 'trickle-down' from the technological transformation did not significantly take place in the agriculture sector, especially in the rural areas. This led to four major challenges:

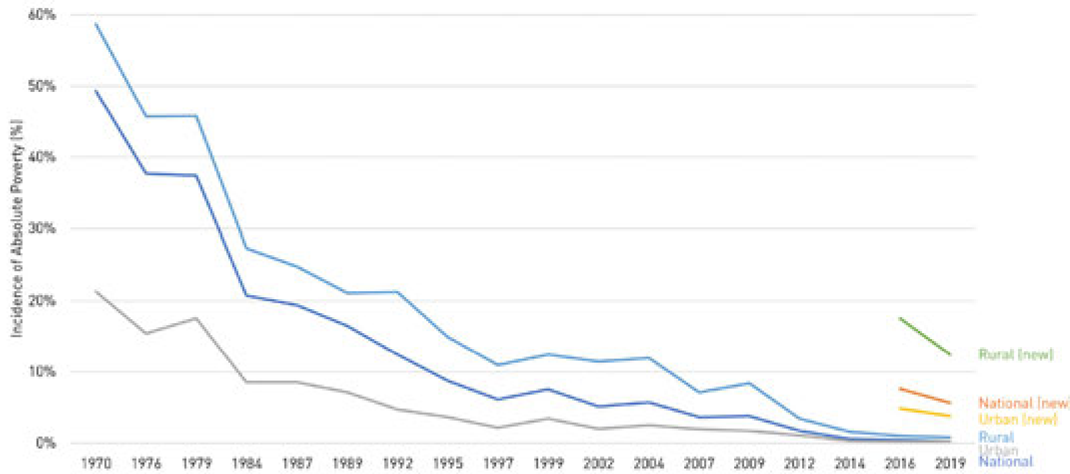
i. increase in migration of the rural population, especially the younger generation from rural to urban areas, many of whom had little to no skills to work in the economic sectors of the urban areas;

ii. mushrooming of urban ghettos that created concentrated areas of urban poverty;

iii. hollowing out of the rural areas, leading to many plantations and other rural sector to experience shortage of workers;

iv. filling of the shortage in the rural workforce by an influx of migrant workers. Malaysians who stayed on in rural areas were quickly displaced by a cheaper foreign workforce.

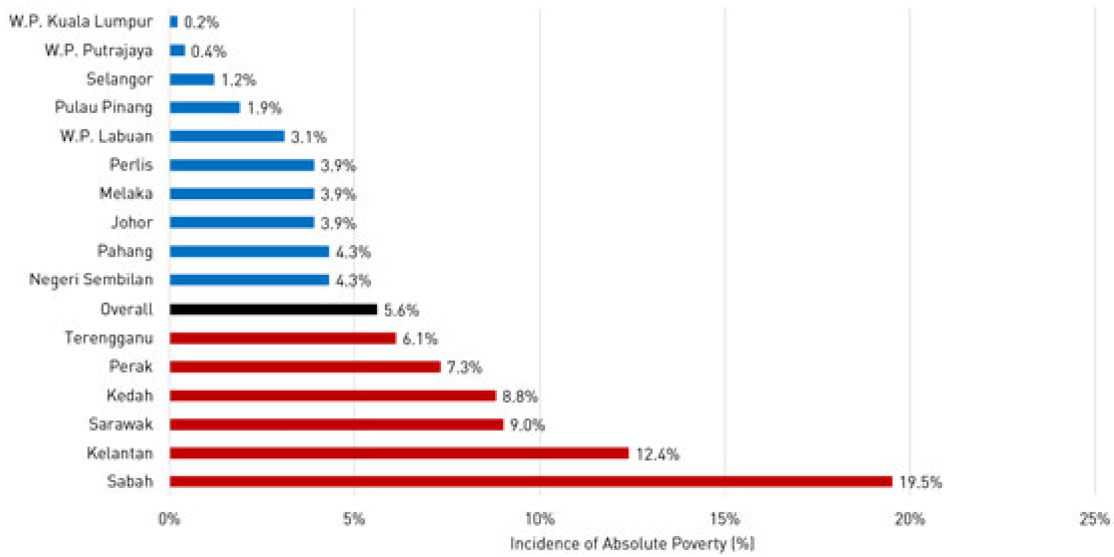
The rapid industrialisation of the Malaysian economy from the 1980s led to uneven economic development among the different segments of the populations, especially those residing in rural areas. Of concern is the fact that disparity in the income levels for the M40 and B40 have consistently remained below the national average, as shown in Figure 3.36. Further, Figure 3.37 shows that from 2016 onwards (based on new calculations of the poverty level), the incidence of poverty in rural areas is significantly higher than the national average. The level of absolute poverty also varies according to the different states based on primary economic activities. States that are dependent on the agriculture sector seem to have higher incidence of absolute poverty than the more industrialised states. For example, in 2019 (as shown in Figure 3.38), states that experience absolute poverty levels above the national level of 5.6% are: Sabah (19.5%), Kelantan (12.4%), Sarawak (9%), Kedah (8.8%), Perak (7.3%), and Terengganu (6.1%). On the other hand, the states that recorded absolute poverty levels below the national levels are Negeri Sembilan and Pahang (4.3%), Melaka, Perlis and Johor (3.9%), Labuan (3.1%), Penang (1.9%), Selangor (1.2%), Putrajaya (0.4%), and Kuala Lumpur (0.2%) (DOSM, 2020b).



Analysed by Sunway University Research Team

Figure 3.37: Incidence of Absolute Poverty, 1970 - 2019

Note: the national poverty line was revised from RM980 in 2019 to RM2,208 using a new methodology introduced in 2019. Based on the old methodology, hardcore poverty was around 0.2%, while based on the new method it 5.6%.

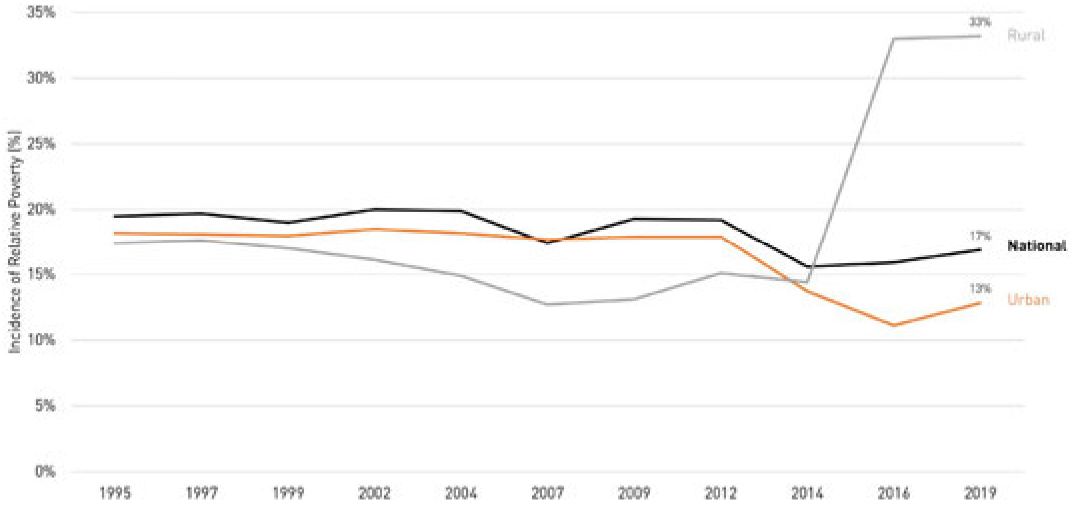


Analysed by Sunway University Research Team

Figure 3.38: Incidence of Absolute Poverty based on the Different States in Malaysia, 2019

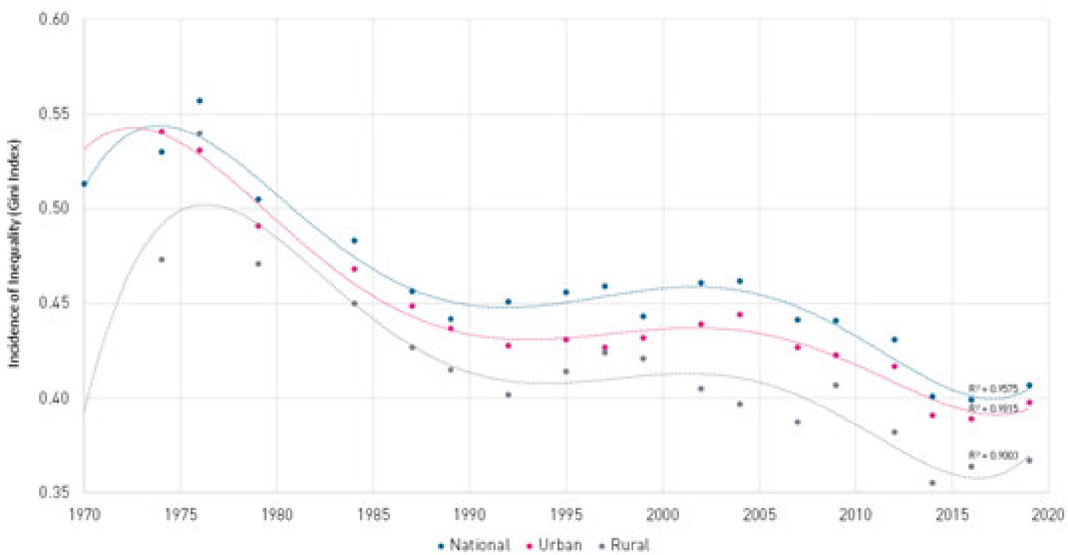
Although the various development plans were successful in bringing down the absolute poverty level in the country, relative poverty levels have remained stable in the range of 15% to 20% from 1995 to 2019 (refer to Figure 3.39). Relative poverty among the urban population has remained stable from 1995 to 2012, followed by a downward trend until 2016, with a slight increase from 2016 onwards. In the case of relative poverty among the rural population, there was a decline from 1995 to 2007; this trend was reversed with an increase in the relative poverty level until 2014. From 2014, there was a spike in the rural poverty levels to above 30% level.

The trends in both absolute and relative poverty are supported by the degree of inequality at the national, urban and rural areas (refer to Figure 3.40). From the middle of 1970s until 1995, the Gini coefficient, which measures inequality in society at the national level, has been on a downward trend. All trend lines saw a slight increase in inequality from 1995 to around 2005. This was followed by decline until 2016. The issue of concern is the upward trend indicating increasing inequality from 2016 onwards within all domains: national, urban and rural areas.



Analysed by Sunway University Research Team

Figure 3.39: Incidence of Relative Poverty, 1995 – 2019



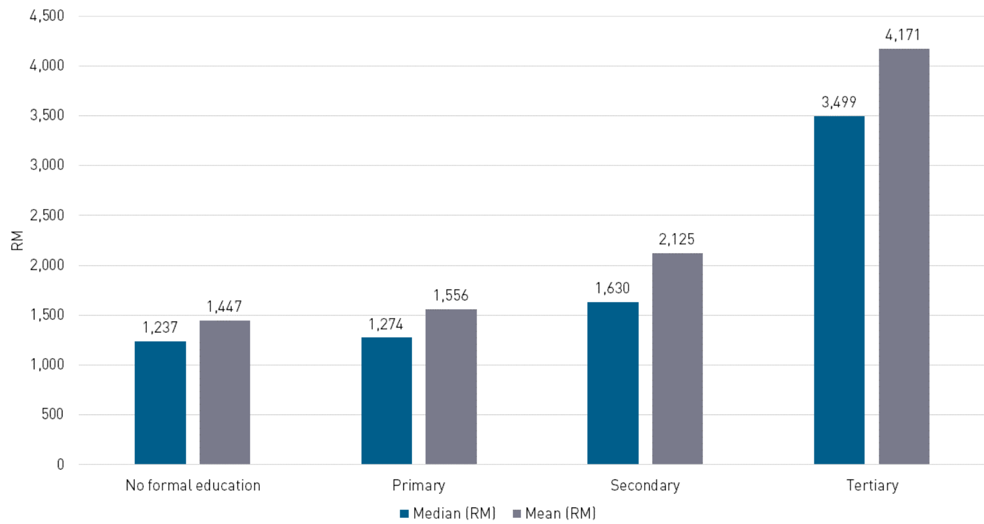
Analysed by Sunway University Research Team

Figure 3.40: Incidence of Inequality (Gini Index), 1970 – 2019

Increasing relative poverty levels and inequality in both the rural and urban areas, and more recently at the national level, can be attributed to increase in the cost of living, especially cost of rental and property prices. This issue is further exacerbated by the increasing use of automation technologies and cheap foreign labour, which have kept wages relatively low, especially for the B40 community and those employed in low skill jobs. Compounding this, many in the B40 community do not have access to digital technology or the ICT skillset to work in increasingly digital- and knowledge-intensive jobs. At the individual level, Figure 3.41 and Figure 3.42 show that workers with secondary education and semi-skilled jobs earn a mean and median monthly salary that is below the Malaysian mean and median incomes of RM2,933 and RM2,062, respectively. This problem is acute in rural areas, where agriculture is the main economic sector, and it remains one of the lowest users of technology and one of the most labour intensives. This sector is serviced by a large pool of foreign migrant workers who are paid meagre wages, thereby keeping the overall wages in these labour-intensive sectors relatively low.

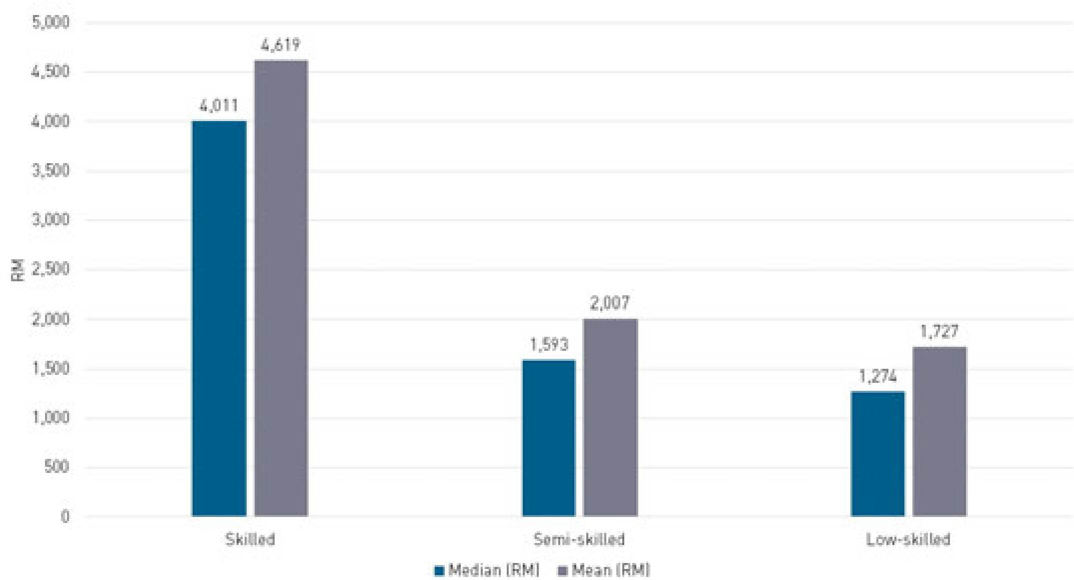
An issue of emerging concern is that the mean and medium income of those in the age group 18-29 years continue to earn a salary below the Malaysian mean income of RM2,933 and median income of RM2,062. The mean monthly income in the age group of 15-19 years, 20-24 years, and 25-29 years are recorded at RM1,415; RM1,575; and RM2,229 respectively. While the median monthly income for the three groups is RM1,211; RM1,289; and RM1,817, respectively.

DOSM reports that the average monthly income in Malaysia in 2020 was RM2,933.



Analysed by Sunway University Research Team

Figure 3.41: Mean and Median Monthly Salaries based on Education Attainment, 2020



Analysed by Sunway University Research Team

Figure 3.42: Mean and Median Monthly Salaries based on Skill Level, 2020

The above discussion highlights various measures taken by the Malaysian government to intensify industrial development increased economic growth, create new employment opportunities and high-income jobs. However, the economic development failed to trickle-down to many parts of the rural communities and vulnerable groups.

Indeed, over the years the socioeconomic gaps between the various communities and size of firms (micro, SMEs and large firms) have increased (see Figure 3.44). Key reasons for the increasing wealth gap can be attributed to the following reasons[1] :

- Uncoordinated STI institutional governance, which resulted in fragmented implementation of STI policies. This has led to uneven diffusion of technology adoption, uncoordinated capability development programs, and weak inter-linkages and knowledge transfer among and between firms and communities across the various localities of the country (urban and rural areas).
- There is low awareness and adoption of STI across many sectors of the economy and communities in the country. Hence many economic sectors, and localities housing them, have remained labour intensive, uncompetitive and with low-income jobs. The worry is that many of these economic sectors are fast becoming 'sun-set' industries due to the emerging transformation taking place through the adoption of digital technologies.
- There is increasing competition from overseas firms, who possess better technologies and have access to larger markets which enables them to build significant cost advantages. This erosion of local firm competitiveness is having an adverse impact on economic opportunities, market value and local employment.

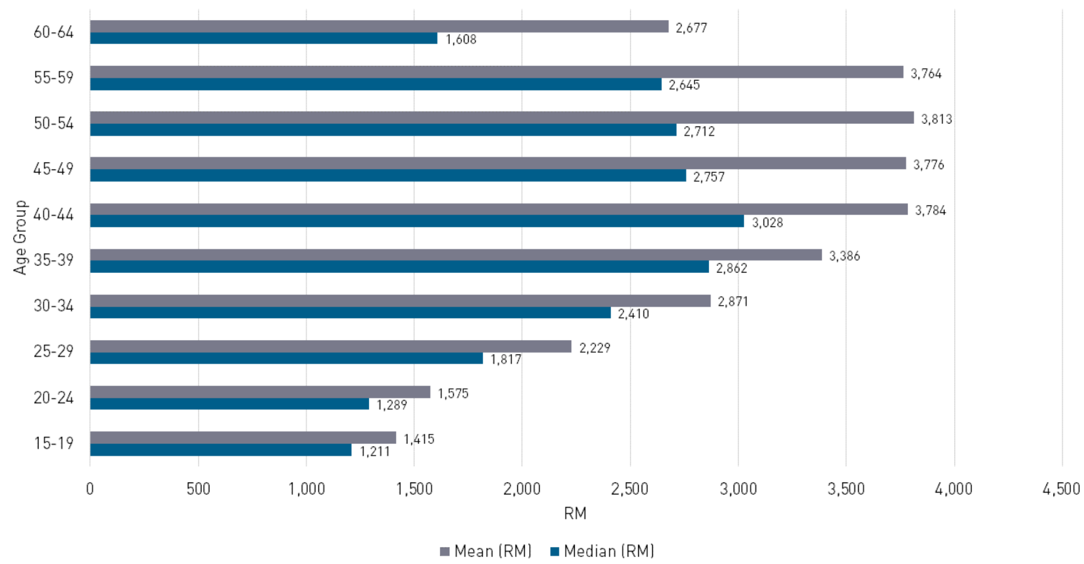


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Figure 3.43: Mean and Median Monthly Salaries based on Age, 2020

- The digital and knowledge divide between the 'haves' and 'have-nots' and MSMEs and larger firms has increased due to financial constraints, availability of cost-effective technology and training/education programs. The problem has been made more acute during the COVID-19 pandemic period.
- Unchecked employment of cheap foreign labour has kept income levels low and crowded-out the local workforce. This has delayed the transition of firms towards technology-and knowledge-intensive operations. The latter has reduced the propensity of firms to invest in capability and skills development programs relevant for a knowledge economy, and this has in turn constrained the emergence of better paying job opportunities.
- Income level among the B40 community experienced the lowest growth over the past 30 years compared to increases in the cost of property, unit rentals, food, transportation and other living expenditures. Escalating cost of living and lack of affordable homes make it difficult for the B40 communities to own homes and other valuable assets. Low-income levels, which results in low retirement savings, coupled with lack of opportunities to own a home or other asset, puts them in a vulnerable position leading many to be caught in a cycle of absolute poverty. Ironically, these very factors have led to even greater opportunities for wealthy individuals to acquire assets, leading to even greater wealth disparities.

[1]Refer to studies from 2010 to 2020 that maps the STI and economic systems of the diverse communities in Malaysia: Ishak, S. (2000); Ragayah, H. (2008); Ariff, M. (2008); Nair, M., et al. (2009); Nair, M. (2009); Nair, M., et al. (2010); Nair, M. (2010); Nair, M. (2011); Nair, M. and Vaithilingam, S. (2012); Nair, M. and Vaithilingam, S. (2013); Nair, M. and Vaithilingam, S. (2013); Liew, E.J.Y., Vaithilingam, S. and Nair, M. (2014); Dawood, S.R.S., Ghazali, S. and Samat, N. (2019); Lee, H.A., and Khalid, M.A. (2020).

The discussion highlights that uncoordinated national STI, and economic ecosystems resulted in ineffective development policies and implementation on the ground for rural and urban-poor communities. Lack of resources, mentorship and support for these communities' limits their ability to respond to changes taking place in the economy, market volatilities and uncertainties, including health pandemics such as COVID-19. Hence, disruption in supply chains due to market uncertainties and health pandemics will continue to undermine the economic development of firms in rural areas and urban-poor localities. These factors will adversely impact the quality of life of the *Rakyat*.

Weak STI ecosystems will also undermine the competitiveness of micro and SMEs across the country, especially enterprises in rural areas. To overcome these challenges, there is an urgent need to review the national STI ecosystem and align it to meet the needs of all segments of the population. Doing so will require identifying key STI priority areas and then contextualising them to the needs of specific communities and localities in the country. This will need appropriate infrastructure and technology plans, talent development strategies, strengthening of governance at all levels (federal, state, local council, industry and community organisation), effective incentives systems, and the use of collaborative partnership models to uplift the socioeconomic development of all segments of the population – so that no one is left behind in the push towards a knowledge-economy, as outlined in the Shared Prosperity Vision 2030.

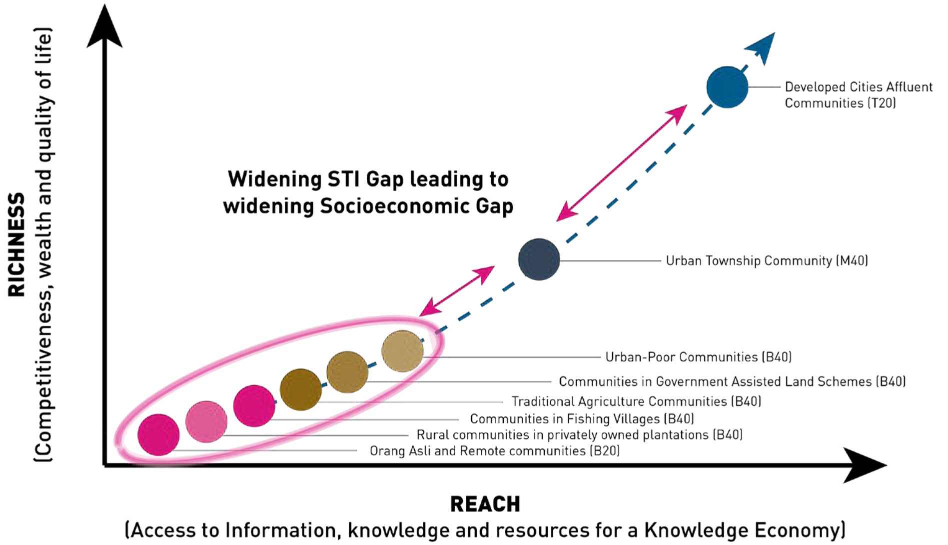


Figure 3.44: State of the STI Ecosystem and Socioeconomic Development of Diverse Communities in Malaysia

Notes: Adapted from Nair et al. (2011) highlighted that communities are in four stages of development. More recent studies and data from DOSM highlight that the gap between rural, urban-poor communities and urban communities have maintained over the last decade and in some case widened for the reasons highlighted above. Low adoption of ICT in many of the B40 communities have shown to hinder upward mobility of rural and urban-poor communities' social mobility upwards. Refer to the studies outlined in footnote 1.

KEY INTERVENTIONS

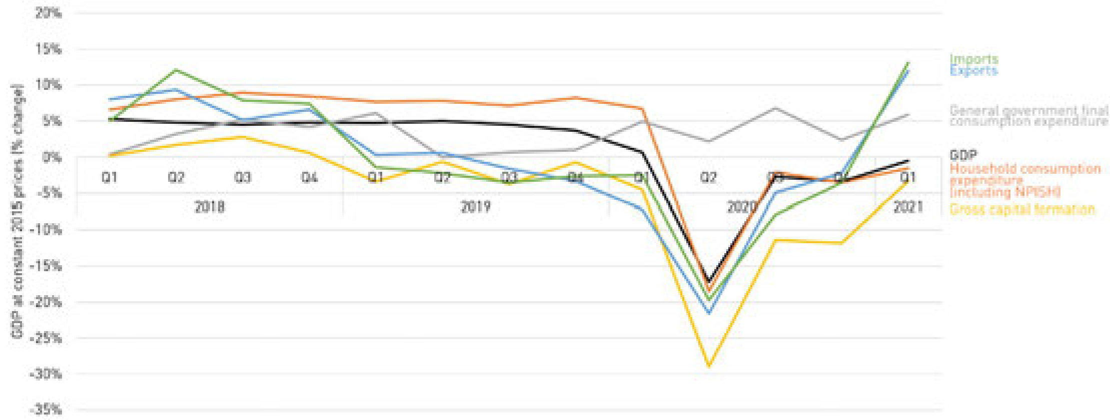
1. **Improvement of the digital architecture to support a knowledge driven economy must be in place across the country to generate network externalities that improve the quality of all segments of the population.**

2. **Specific focus to ensure affordable access to ICT services for vulnerable and marginalised communities so that they are not left behind as Malaysia transitions to a knowledge-based economy.**

IMPACT OF COVID-19 ON STI AND ECONOMIC DEVELOPMENT

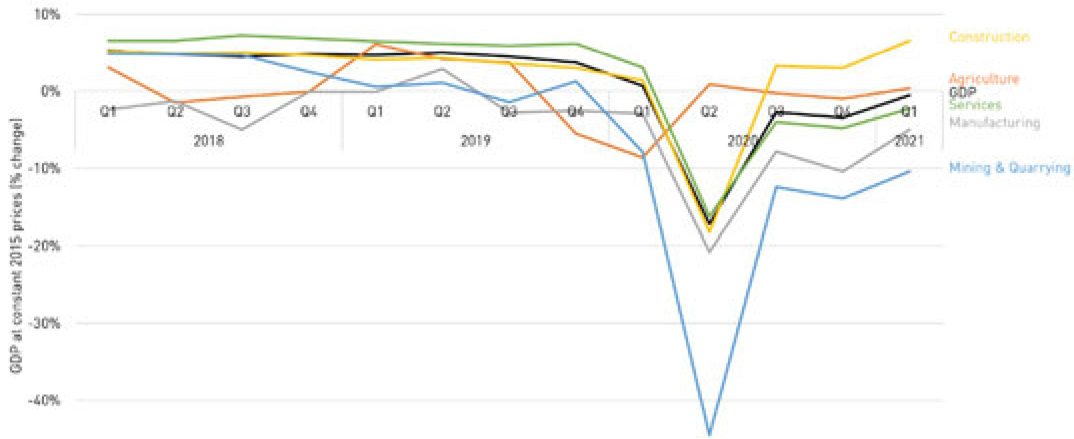
The global economy experienced major structural changes in 2020 due to the COVID-19 health pandemic. The pandemic had three major impacts on economies: disruption in the global supply chain; movement control orders to curb infections curtailed economic activities; and a sharp decline in global demand that cut the economic growth potential of countries. The crisis revealed that the Malaysia's STI ecosystem was ill-prepared to insulate the economy from the COVID-19 pandemic and its 'knock-on' impact to the economy. Figure 3.45 shows that the GDP contracted from Quarter 1 (Q1), 2020 onwards, with a peak decline of -17% followed by recovery. Similar patterns were seen for all the components of GDP. Sectoral growth in Figure 3.46 shows that mining, manufacturing and construction were the most severely impacted sectors during the COVID-19 period.

To stabilise the economy, the Malaysian government introduced a series of fiscal stimulus packages. A total of RM74.5 billion direct capital injection and RM325.5 billion of soft loans and other relief was provided. The coverage of the stimulus was wide ranging, and included the healthcare sector, tax and social security relief for rural areas, cash transfers to the *Rakyat*, wage subsidies for employer and infrastructure development[2]. While the fiscal stimulus and relief packages softened the impact of the health pandemic, the waves of COVID-19 infections and subsequent partial and full closures of the economy to curb the infection rates severely impacted firms, especially micro and SMEs. It is estimated the cost to the economy due to the various closures since beginning of the pandemic was around



Analysed by Sunway University Research Team

Figure 3.45: Quarterly GDP, by Expenditure Components (Year-on-Year Percentage Changes), 2018 – 2021



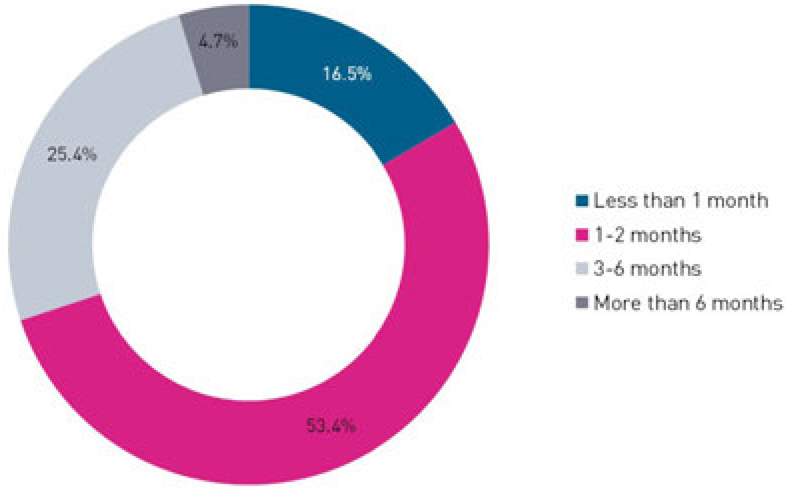
Analysed by Sunway University Research Team

Figure 3.46: Quarterly GDP, by Economic Sector (Year-on-Year Percentage Changes), 2018 – 2021

[2]Author's estimates based on Prime Minister's speech text of stimulus packages retrieved from https://www.pmo.gov.my/speech/

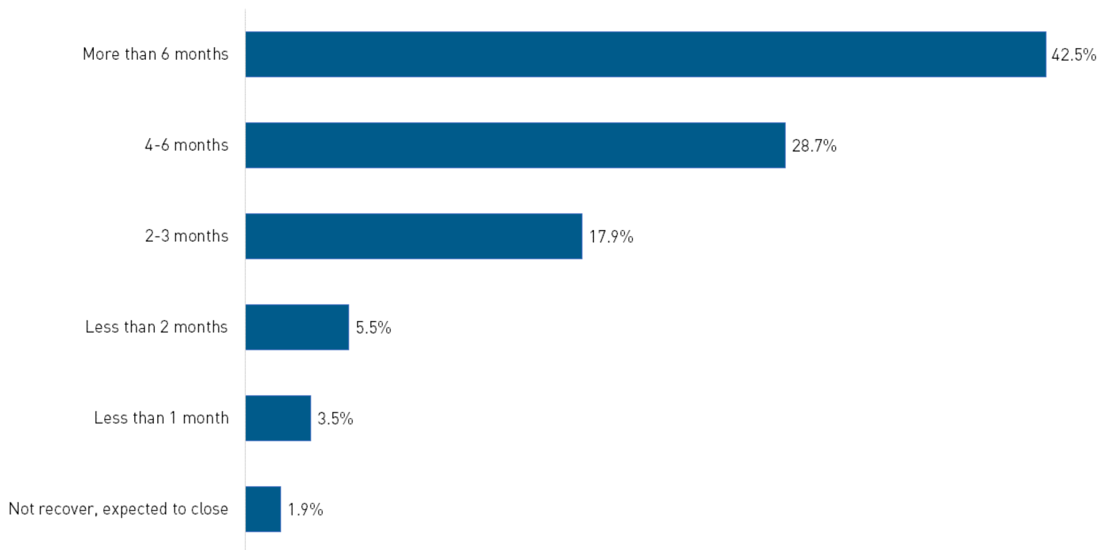
RM247 billion (Ministry of Finance Malaysia, 2021a). The pressure to increase government financial support to stabilise the economy via fiscal stimulus packages has placed significant pressure on the fiscal position of the country, increasing the national deficit level from 3.6% in 2019 to 7.3% in 2020 of the GDP (Ministry of Finance Malaysia, 2021b).

The disruption in the supply chain, business closures and decline in global demand have had adverse impacts on the corporate sector and increased the levels of unemployment. A survey undertaken by DOSM from 10 April to 1 May 2020 comprising 4,094 companies highlighted that only 4.7% businesses will be able to survive beyond 6 months (ability to pay the salaries of their staff) (Figure 3.47). Further, 42.5% of the firms stated that it will take them more than 6 months to recover from this pandemic, once the economy gets onto a path of recovery (refer to Figure 3.48). The low economic activities have had major impact on the labour market, where COVID-19 related unemployment increased, primarily among the workforce with lower education attainment. Underemployment increased from 1.12% in Q4, 2019 to 2.78% in Q2, 2020 (Figure 3.49). Further, Figure 3.50 shows that workforce with tertiary qualifications increased from 29% in Q4, 2019 to 37% in Q1, 2021. On the other hand, those with the lower educational attainments declined over the same period. This suggests workers with higher and relevant qualifications needed for the emerging digitalization were better placed to hold on to their jobs during the pandemic period. The emergence of digital platforms has resulted in a significant growth in the Gig economy (See Box 3.4). The Gig economy has provided alternate employment opportunities during the COVID-19 pandemic.



Reference: Department of Statistics Malaysia (DOSM) (2020c)

Figure 3.47: Business Survival during COVID-19 Health Pandemic

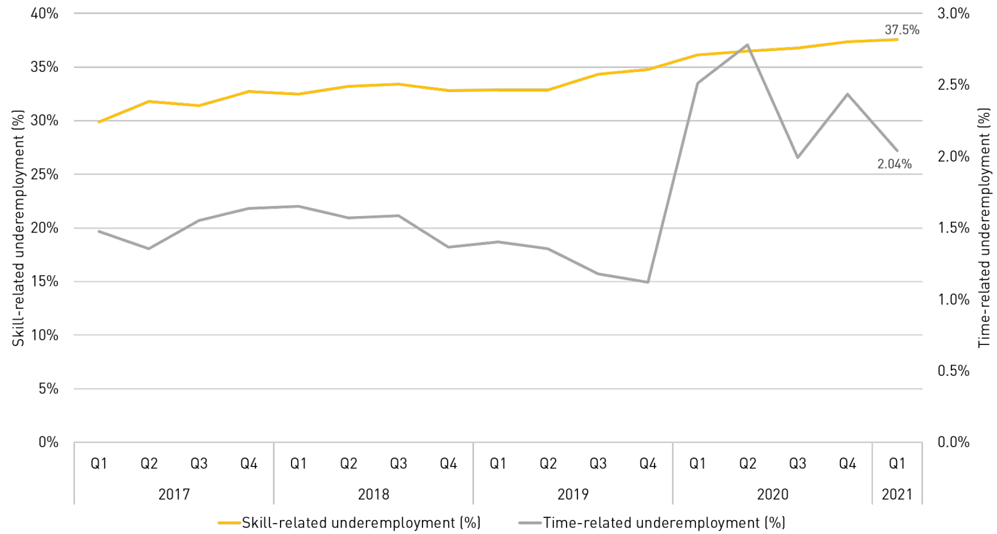


Reference: Department of Statistics Malaysia (DOSM) (2020c)

Figure 3.48: Duration of Business Recovery from COVID-19 Health Pandemic

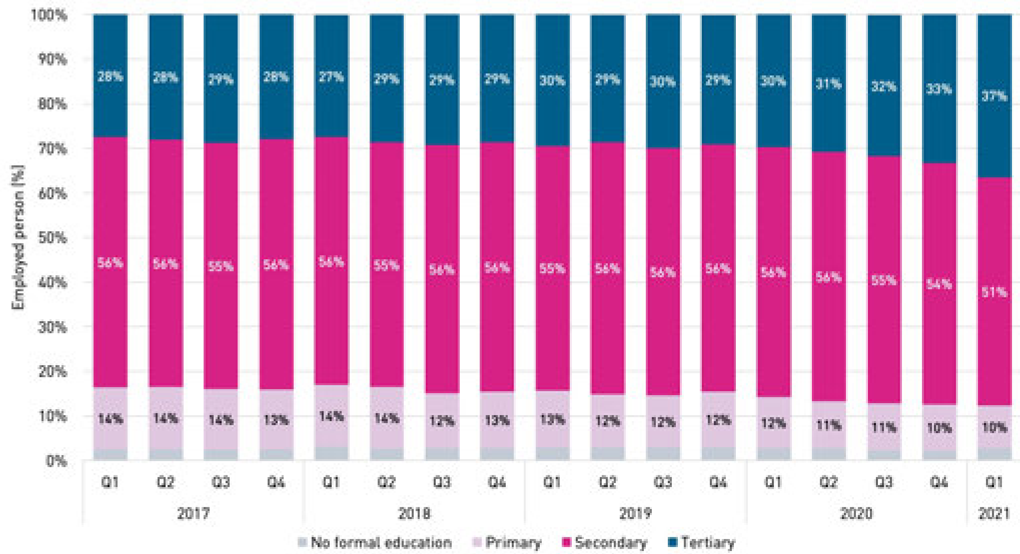
The COVID-19 pandemic highlighted that technology, in particular digital technologies enabled firms to explore new business models to keep their costs down, increase their market reach and move into new market segments. A survey of approximately 600 business leaders in September 2020 highlighted that while COVID-19 pandemic posed a major challenge, many businesses leaders were of the view that technology, in particular digital technologies, would help them keep their businesses afloat (Nair et al., 2020).

Adapted from this report, Figure 3.51 shows the top five digital technologies that helped firms understand their market needs and improve the quality of their services. The top three technologies that were considered crucial for businesses during the pandemic are: 5G technology, cyber-security and encryption technology and Advanced Intelligence Systems. At the granular level, the top three technologies that are crucial for firms over the COVID-19 induced uncertainties are: digital payment technologies; mobile technologies for customer engagement; and cloud services. Firms that adopted Industry 4.0 technologies are more confident of attaining higher revenues in 2021. Even though business leaders expressed hope in technology playing a key role in navigating them through the economic uncertainties arising out of the COVID-19 crisis, they noted challenges related to weaknesses within the ecosystem are likely to hinder them from adopting many of these technologies. The top three challenges include: financial constraints, lack of training and capability programs and weak technological infrastructure and support system.



Analysed by Sunway University Research Team

Figure 3.49: Under-Employment During COVID-19 Health Pandemic



Analysed by Sunway University Research Team

Figure 3.50: Employed Person by Educational Attainment During COVID-19 Health Pandemic

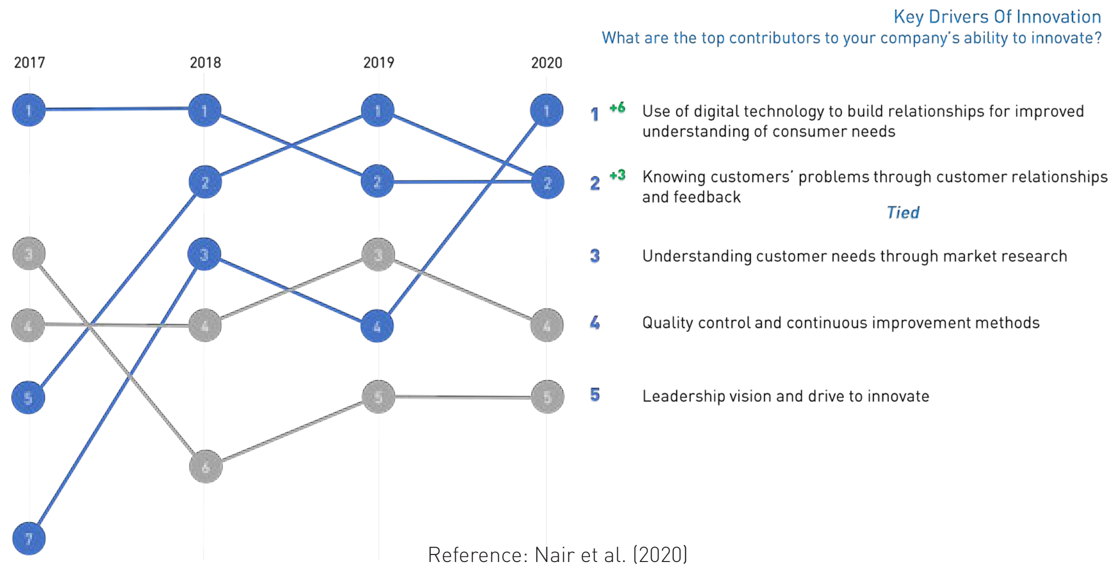
In summary, COVID-19 has resulted in a significant contraction of the Malaysian economy. The movement control orders to curb infection rates have had negative impacts on business activity and contributed to rising unemployment. The challenging economic environment induced by the health pandemic has led proactive firms to undertake radical transformations. Many have adopted new business models underpinned by a technology strategy to reduce costs of operations, enhance market reach and improve the richness of their products and services. Adoption of new digital technologies has been an important catalyst for firms to build business resilience and economic competitiveness. Firms that have not embraced or kept pace with the digital revolution have found it hard to stay competitive in a fast-changing world.

Box Article 3.4: Gig Economy

The Gig economy is defined as the demand and supply of short-term or task-based working activities matched through online labour platforms and on-demand apps. Also known as 'platform economy', 'on-demand economy', and 'sharing economy'; it creates employment opportunities for a large population of part-timers and freelancers who work on a contractual or ad-hoc basis.

Over the past decade, the rise of the Gig economy can be attributed to the increasing spread of digital connectivity and the growing number of young job seekers entering the labour market. The Gig economy's market was worth USD248.3 billion in 2019 and the COVID-19 pandemic accelerated the growth further.

References:
Chang, J. (2021), De Stefano, V. (2016), Jobstreet (2021), REFSA report (2020).



Reference: Nair et al. (2020)

Figure 3.51: Key Drivers of Business Innovation

KEY INTERVENTIONS

1. **Put in place competitive incentives systems (fiscal and non-fiscal incentive, such as taxation, subsidies, grants, equity finance, angel investment and access to testing facilities) to enhance and intensify the dynamic capability position of the workforce, industries, and organisations to remain resilient in future economic downturn.**

2. **Help transition entrepreneurs to scale and develop sustainable business models using emerging STI platforms. To enable this, technology incubators should help identify and license the right business angels, crowdfunding platforms or private equity to invest, mentor and nurture technology-based start-ups.**

KEY CHALLENGES AND RECOMMENDATIONS

The last three decades have seen the global economic landscape become more complex and volatile due to the forces of globalisation, liberalisation, regionalisation and digitalisation. An interesting phenomenon that can be observed is that digitalisation has speeded the remaining three forces. The level of complexity has intensified with the emergence of converging and disruptive technologies driven by higher digital economy footprint, stronger diffusion of information and knowledge, widening integration of global supply chains and expanding international trade. These factors have intensified competition for resource and markets, and the pressure is particularly magnified for small open economies, such as Malaysia. In recent years, the challenges were further exacerbated by issues related to climate change, trade disputes among major trading partners and the health pandemic.

Turbulence induced changes to the global economic architecture have brought several spill-over benefits, such as greater access to STI, information, knowledge and other resources for socioeconomic development. The shifts have simultaneously intensified competition for resources and markets across the globe. Countries and communities that have developed robust, agile and responsive STI ecosystems have been able to develop globally competitive industries through the active nurturing of a highly talented workforce. This has allowed them to unlock greater return on value and investment from their natural assets and talent. Effective STI ecosystems in these countries have also ensured equitable distribution of wealth to all segments of the population, especially their vulnerable and marginalised communities. Malaysia over the last three decades has put in place strategies to build a strong industrial-based economy, powered by STIs. These initiatives have enabled Malaysia to make great strides in becoming a strong production-based economy in the ASEAN region. Malaysia also embarked on a journey to transform itself into an information- and knowledge-driven economy. However, many of the initiatives to become a knowledge-based economy failed to fully materialise due to the following reasons:

- There is no clear champion for STI, who has sufficient clout to bring all ministries, government agencies, industry associations, and community organisations together and bind them to a 'collective vision' that enables the nation to move up the global innovation value chain.
- The absence of a champion has meant that there is no clear long-term integrated, holistic national STI plan which sets and coordinates the direction for relevant ministries, government agencies, industry associations and community organisation to mobilise their resources and effort to build dynamic capabilities (absorptive, adaptive and innovative capabilities) of economic agents in the country, especially within key sectors and areas of strategic priority. This shortcoming has hampered the STI ecosystem's ability to amplify the development of the socioeconomic drivers (key economic sectors and industries) in high-value parts of global supply chains.
- Lack of integrated STI and economic development plans has meant that the various plans and policies devised by the government agencies and ministries have simply taken place in silos. Consequently, many initiatives have not realised the level of outcomes that were originally envisaged. This shortcoming has had major implications on the competitiveness of Malaysian industries as well as the well-being of the Rakyat.
- Weaknesses in the coordination of STI and economic development plans has meant that the Malaysian ecosystem has been able to nurture only a few globally competitive industries. And even in these pace setter industries the majority of the leaders are foreign multinational firms. For the most part, local industries and economic sectors have been slow in embracing and investing in R&D or shown interest in actively building a dynamic STI ecosystem. This has had an impact on the dynamic capabilities (absorptive, adaptive and innovative capabilities) and economic competitiveness of Malaysian industries.
- Lack of congruence between STI and economic policies has also resulted in uneven development of knowledge and technology intensive industries. Major economic sectors, such as agriculture, which is an important contributor to GDP and employment, have remained labour intensive and exhibit low utilisation of technology. As a result, wages and economic development in many rural areas remains low.
- Lack of economic opportunities in rural areas has led to a continuous migration from rural areas to urban areas. This has a dual impact; firstly, it has led to a hollowing out of the rural areas as workers, particularly the young talent, moved out to seek better prospects

in cities and secondly, the migration of rural unskilled workers has fuelled the increase in the density of urban poor communities. The urban poor communities lack the skills set needed for semi-skilled and skilled jobs. Most of them end up in low paying jobs and find it hard to cope with the high cost of living in cities, creating a vicious cycle of poverty.

- As Malaysia transitions to technology and knowledge-intensive it has had the effect of simultaneously reducing economic opportunities for the segment of the local workforce that was unable to upgrade their skills and competences. Given that opportunities for development and training are unequal, the poorer and vulnerable segments are finding that they are increasingly being left behind. The relatively well-off have good access to education and training to update their skills and competencies. In contrast the poorer communities find it extremely difficult to avail themselves opportunities to upskill themselves. The increase in the knowledge and opportunity gap between the 'haves' and 'have-nots' is widening the income gap and making the aspiration of Malaysia as an inclusive society without strong divisions increasingly difficult to attain.

In summary, the global economy has become increasingly complex, volatile and competitive. To move up the global innovation value chain, Malaysia must transition from a production-based economy to a knowledge-based economy. This will require a major reform of the national STIE ecosystem to ensure STI development plans are forward looking and lead to robust economic development and global competitiveness of the country. This can be done through a Whole-of-Government and Whole-of-Society governance framework orchestrated by a "Champion with Clout," in a manner that is designed to enable organic innovations that unlock return on value from within the local ecosystems spread across the country. Only by so doing is it possible to leave no one behind, as outlined in the Share Prosperity Vision 2030. To improve Malaysia's STI global footprint, economic competitiveness and ensure equitable distribution of economic wealth to all segment of the population, the following recommendations are proposed.

Pillar Specific Recommendations

1. To value-add every economic sector of the country through STI

There is an urgent need to review the current STI governance structure to fully transition it to a Whole-of-Government and Whole-of-Society approach. This will involve putting in place integrated STI policies and initiatives. It will also require defining how the STIs can value-add to every economic sector of the country. In this context, sound, integrated and holistic development of STIE (science, technology, innovation and economic) ecosystem will allow inter-sectoral knowledge transfer and network externalities needed to build strong sectoral dynamic capabilities and economic competitiveness. The recently formulated DSTIN and 10-10 *My*STIE frameworks are steps in the right direction to strengthen the nexus between STI and economic development across all sectors of the economy.

2. To have in place governance framework orchestrated by a "Champion with Clout"

A strong STIE institutional governance framework under the Economic Planning Unit (Prime Minister's Office), working in partnership with the Ministry of Science, Technology and Innovation is critically needed to operationalise the 10-10 *My*STIE framework through the Whole-of-Government and Whole -of-Society approach. A key feature of this institutional governance set-up would be to ensure regular national fore-sighting is undertaken, which then would input and inform all national research and development priority areas in the STI focus areas for the country. These STI focus areas need to be incorporated in all national and state level socioeconomic development plans.

Intersecting Case Study

Multimedia Super Corridor (MSC) Malaysia

Background

The Malaysian government recognised the importance of information technology (IT) in transforming the nation into an information society and knowledge-based economy. An ambitious strategic initiative to leapfrog its development in the information age was mooted in the form of the Multimedia Super Corridor (MSC) Malaysia in 1995 with a two-pronged approach:

1. to create the ideal multimedia environment for world class companies to use Malaysia as a regional hub; and
2. to catalyse a highly competitive cluster of Malaysia's home-grown multimedia/IT companies that would eventually become world-class

This approach was expected to nurture regional leaders that would enhance domestic productivity and then take Malaysia into the global arena in the information age. The value created from these businesses is envisioned to be a virtuous cycle for Malaysia to leapfrog as a global contender.

To achieve this vision, the Government established the National IT Council (NITC) in 1996 to coordinate and plan the nation's IT infrastructure development. The NITC spearheaded the National IT Agenda (NITA), which provided a systematic development plan for Malaysia's digital architecture and establishing the MSC and the Multimedia Development Corporation (MDC). MDC now rebranded as Malaysia Digital Economic Corporation (MDEC) is under the purview of the Ministry of Communications and Multimedia Malaysia (KKMM). MDEC is the one-stop centre which leads the country's ICT and digital economy growth.

The MSC was envisioned as a vibrant digital ecosystem that would attract leading global players to use Malaysia as testbed for innovative discoveries in the ICT domain to fostered local intellectual capital development, strengthen science, technology, and R&D to transition Malaysia to a globally competitive knowledge-based economy as delineated in Vision 2020.

The development of the MSC, located to the south of Kuala Lumpur, with a physical area of 50km by 15km was planned under the phases as follows:

- **Phase One (1996-2003)**:
  To successfully create the MSC Malaysia
- **Phase Two (2004-2010):**
  To grow MAS Malaysia into a global ICT hub
- **Phase Three (2011-2020):**
  To transform Malaysia into a knowledge society

The MSC plan had also several initiatives for a digital ecosystem, namely: digital infrastructure, e-government, smart school system, multipurpose card system, telehealth, R&D clusters and, e-commerce. The initiative included the development of physical infrastructure to support a vibrant and dynamic information-based economy. It entailed investing significant resources to build the twin smart cities of Cyberjaya and Putrajaya to spearhead the informatisation of the nation. Cyberjaya is a high-tech centre to build local ICT-related industries and attract world-class technology companies to set up their R&D infrastructures and business facilities. Cyberjaya also hosts a university focused on multimedia technologies, the Multimedia University (MMU).

On the other hand, Putrajaya was envisaged as a modern administrative capital of the nation equipped with prevailing ICT capabilities. The administrative capital was used as a testbed for adopting state-of-the-art technologies to drive public sector transformation for a digitally connected society and economy. Both Cyberjaya and Putrajaya are located near the Kuala Lumpur International Airport (KLIA) and have easy access to modern logistics and transportation systems.

Achievements

Talent and Capacity Building:

Besides a dedicated university to lead research and education in ICT development (Multimedia University), significant investment was also channelled towards upskilling society towards an information-driven economy through the establishment of the following: smart school system; establishment of research and training centres; introduction of programs for capability developments offered to assist software companies in achieving recognized certifications like Capability Maturity Model-Integration (CMMI), Project Management Institute (PMI) and software testing; continuous roll-out of new ICT training and data science programs to future-proof the talent of the country; fostered strong collaboration between education institutions and industry to ensure talent meet the needs of the industry; and developing a database on the expertise and talent stock in the country.

Regulatory:

Digital regulatory architecture and cyber laws which include the Digital Signature Act and the Data Privacy Act were established. Improvement in the digital governance system led by the MSC initiative was critical in ensuring clear rules of engagement and building trust among all stakeholders in the digital environment. These developments played a crucial role in increasing Malaysia's digital economy participation by both local and foreign firms. One of the impacts of the digital signature act is it ensures the security of any related legal issues regarding electronic transactions, especially in internet banking businesses. Today, this act has demonstrated the government's commitment to pushing Malaysia to become a trusted international e-commerce hub, especially in the business and financial services sector. It also contributes to our strengths in start-ups; 57% of Malaysian start-ups belong to the Business and Financial services sector.

Testbed:

The MSC initiative provided privileges to investors such as freedom of ownership and freedom to source capital globally and receive special tax breaks, which transformed Malaysia into a test-bed for innovation and new technologies. The conducive investment climate provided by MSC resulted in the emergence of supply chain clusters within the digital economy. It attracted a full spectrum of upstream and downstream activities led by major multinational companies. These initiatives led to the emergence of new growth areas in electronic technology and creative multimedia.

Home-grown local companies:

To promote innovation through R&D, the Malaysian government allocated RM200 million to MDEC to establish the Malaysia R&D Grant Scheme (MGS) in 1998 with the aim of financing R&D projects among local SMEs in software and hardware development. As of 2010 (end of Phase 2 MSC), the revenue generated was RM291.11 million, while as of Q3 2019, the revenue generated amounted to RM513.6 billion (MDEC, 2021). Among the home-grown local companies that emerged from these initiatives are Jobstreet.com, IRIS, Green Packet, REDtone International and the first recipient of STAR Grant, British Telecom's Asian Research Centre in Cyberjaya. Twelve companies gained their listing on MESDAQ with a total capitalization of approximately RM827 million as of April 2006 (Chooi, J.T.K., 2009).

Supply chain clusters:

Over the years, MSC Malaysia has spawned supply chain clusters that support MNCs in their upstream and downstream activities in other localities. For example, the E&E manufacturing sector is based in Penang, Kulim and Shah Alam. Currently, world-class giants like Siemens, Intel and others have set up successful export operations. Many of these companies have set up design centres in Malaysia to nurture local talent in producing world-class products and services. MSC is also creating spill-over benefits for key economic sectors through multimedia technology to support the edutainment industry. MSC has become a global ICT hub, focusing on connecting with other industrial clusters across Malaysia. These include expansion to the northern industrial areas such as Bayan Lepas Industrial Park and Kulim High Tech Park, and other regions in the Klang Valley.

MSC Status companies:

The MSC initiative has created a vibrant digital economy that is a significant contributor to economic wealth for the nation. As of May 2019, there are 2,954 active MSC Status companies, and by 2018, these companies have generated 182,538 jobs and close to RM472 billion in revenue for the nation. The national digital architecture rolled out under the MSC initiative has provided the country with a stronger foundation to embrace the Fourth Industrial Revolution to become a globally competitive nation.

The ensure the success of the MSC initiatives, seven flagships' applications were introduced in 1996. The desired end-state of the original MSC was to achieve exponential growth by creation of world-class infrastructure in the Cyberjaya and MSC areas to attract world-class companies who are expected to collaborate with domestic companies in increasing economic productivity. This then is envisioned to spur regional champion if not a global champion to take endogenous technology to the next level. The achievements of these flagships after 24 years are reported here:

MSC Flagship	Achievement
The Electronic Government was introduced towards having a paperless administration. The aim was to have a paperless Prime Minister's office by 2000. Eventually, most inter-departmental communications and interactions with the public will be conducted via electronic and multimedia channels, including card- based birth and marriage registration, and drivers' licences. Selected Ministries and departments will also be equipped with multimedia mobile offices, video conferencing, digital archiving, shared databases, and digital signature facilities.	Partially achieved
Smart Schools: Referring to the original Vision 2020 statement from 1991, the government had identified the need to generate a more high-skilled workforce. However, the only education element from the flagship initiatives was the Smart Schools, and there was no flagship project relevant to tertiary education, whether for University or TVET institutions. The aim of the Smart Schools initiatives was to ensure that all of its schools have Internet access within two years as a way to rapidly enhance information technology (IT) literacy. There are still many more waiting to be connected (TwentyTwo13, 2019). The establishment of the MSC was clearly inspired by Silicon Valley as a highly innovative industrial cluster. The success of Silicon Valley is driven by the excellence of Stanford University, which not only helped to generate high-skilled talents but also was key in kickstarting techno-perineurial companies in R&D. Despite this, HLI were not identified as critical players during the first phase of development of MSC.	Not achieved
Telemedicine: The key elements of telemedicine planned include distance learning; remote consultation, diagnosis, and treatment; virtual patient records; and a national, electronic medical network. In 1997 the Telemedicine Act was enacted to provide for the regulation and control of the practice of telemedicine and for matters connected therewith. The Selayang Hospital was identified as the pilot hospital to use Electronic Medical Records (EMR). MOH has requested for budget to test out the use of EMR at other hospitals. An R&D cluster of universities and companies focused on developing new applications to position Malaysia as a centre of excellence in telemedicine has not materialised.	Partially achieved
R&D Cluster: This was visualised to be at the forefront of R&D of next-generation multimedia technologies by developing collaborative R&D centres between corporations and universities. MMU was expected to be the catalyst in creating a research community which will utilise MSC's unique environment to test new multimedia and IT applications.	Partially achieved
National Multi-Purpose Card: Malaysia was undoubtedly one of the first countries to roll out the MyKad program to all citizens successfully. The MSC was envisioned to be the testbed for a world-first, national multi-purpose card issued to all Malaysian citizens. This smart card was designed to serve as a national identity card, an "electronic purse" for purchasing small-ticket items, a credit card, telephone card, club membership card, and will ultimately be used in all electronic transactions with the Government. Today, applications available on MyKad, are limited such as Touch and Go.	Partially achieved
Borderless Marketing Centre was expected to serve as an excellent platform for companies' customer service operations, such as telemarketing, technical support, "backroom" data processing, and local customisation of marketing materials.	Partially achieved
Worldwide Manufacturing Web was designed for companies to use the MSC to establish regional hubs for real-time control, monitoring, and delivery of operational support to their regional networks of design, manufacturing, and distribution centres. Using the MSC's low-cost, high-performance information and logistics networks, regional operations can be linked with operations across the globe 24 hours a day, 365 days a year.	Partially achieved

Impact

As of May 2019, there are 2,954 active MSC Malaysia Status companies. By 2018, MSC Malaysia had generated RM472 billion in revenue and created 182,538 jobs. Based on the MSC Malaysia Annual Industry Report 2010-2011, MSC Malaysia-status companies were performing very well in phase two. According to Multimedia Development Corporation, cumulative GDP contribution by MSC in phase two accounted for RM34.57 billion, and a total of 111,367 jobs were created with an average monthly salary earned of RM4,385 per job. Total revenue generated in phase two by the MSC Malaysia companies, including MNCs and home-grown companies, amounted to RM103.8 billion. In addition, with an almost 70% increase in investment to RM2.5 billion in 2011 compared to 2010, coupled with the excellent infrastructure development, it was expected that rapid growth would continue to boost the impact even further in phase three. Despite the good performance in the country's economic sector during phase 2, the Flagship projects of MSC did not realise their full potential.

The 10th Malaysia Plan had highlighted the role of ICT in propelling Malaysia towards a high-value economy. ICT and innovation were also identified as key focus areas in both the New Economic Model (2011-2020) and the Economic Transformation Programme (2010-2020). The aim of the third phase of development (2010-2020) was for Malaysia to become a knowledge-based economy, with Cyberjaya and Kuala Lumpur as home to many world class high technology companies. The first cyber court would be established, and 12 smart cities built around the country.

While there are pockets of success, the initial aim of Malaysia building its competitiveness in the multimedia sphere and, then going global has not been fully achieved. Malaysia has largely been dependent on the MNCs. 98.5% business establishment in Malaysia are SMEs (DOSM, 2016), but only 20% of these SMEs were reported to have used ICT applications actively while 55% of SMEs responded of not knowing how to use the internet (FMM ICT Adoption Survey, 2016). With SMEs being the backbone of Malaysia's economy and for Malaysia to be part of the global value chain, the savviness to create deep meaningful collaborations through collaborative networks is an important element. In today's borderless world, ICT is the main connector to uplift Malaysia's domestic productivity and build global prominence. As such, literacy in ICT of SMEs must be given special attention.

Box Article 3.5: The Cabotage Exemption

On 17 August 2021, most local dailies reported that tech giants Facebook and Google have announced a new undersea cable named Apricot. This new undersea cable will boost internet connectivity and speed in the Asia Pacific region. It is also expected to meet the growing demand for 4G, 5G and broadband services in the region.

Apricot is a 12,000km long submarine cable slated to connect several countries like Japan, Taiwan, the Philippines, Indonesia, Singapore and Guam. Unfortunately, Malaysia has missed the opportunity to be part of this mega-infrastructure project. Most Malaysian leaders claim that the evocation of a cabotage exemption is a likely reason.

Under the present Cabotage Policy, without an exemption, undersea cable repairs take up to 27 days in Malaysia. It takes only 20 days in the Philippines, 19 days in Singapore and 12 days in Vietnam.
In Malaysia's quest to leverage the information age, exemption from some of the usual cabotage requirements for undersea cable layout projects, maintenance and repair work must be considered to expedite the entire process from approval to execute the project. Malaysia risks losing foreign investments and lose regional competitiveness.

References:
Barrock, J. (2021), MITI (2019)

8i Framework for the Malaysia's Multimedia Super Corridor (MSC)

1 INFRASTRUCTURE

TO COVER THE LENGTH AND BREADTH OF MALAYSIA

MSC initiated the development of smart cities such Cyberjaya and Putrajaya. It also led to the emergence of a number learning centres, technology parks and modern industrial centers (such as in Klang Valley, Penang, Kulim and other localities across the country). A stronger foundation for the adoption of next-generation technologies such Industry 4.0 technologies throughout Malaysia must be rolled out.

2 INFOSTRUCTURE

INTERNET AS BASIC NEED

The roll-out of high-speed internet in many of the technology parks, industrial & business centers and schools. The adoption of e-commerce, multimedia technology and other advanced ICT tools are on an upward trend. However, the roll-out of high-speed internet and adoption of ICT tools in other localities, particularly in rural areas of the country have been slow. The internet should be treated as a basic need to spur Malaysia's knowledge-based economy.

3 INTELLECTUAL CAPITAL

KEEPING ICT TALENT AT PACE WITH TECHNOLOGICAL DEVELOPEMENT

There is an increase in talent in the multimedia and ICT areas with the emergence of MMU and other learning institutions that focus on ICT education. Many of them are also important providers of international education. Various industry-based training and certifications programs such as PMI and CMMI have been introduced to upskill the workforce and ensure they adhere to global best practices.

4 INTEGRITY

TIMELY UPDATES OF THE REGULATORY ECOSYSTEM

New regulatory architecture to govern the digital environment (such as new cyber laws - multimedia acts, data privacy, digital signature etc.) are developed to foster harmonization with existing regulatory ecosystem.

5 INCENTIVES

INCENTIVISE FOR SUSTAINABLE, HIGH VALUE R&D

Fiscal incentives such as grants and tax exemptions were given to encourage more firms to undertake R&D activities and use Malaysia as a testbed for undertaking innovations in the ICT areas. Non-fiscal incentives include no barriers on ownership requirement, employment of foreign staff and a host of other business-friendly policies to encourage investments in the MSC initiatives. More high-end R&D are needed for higher valued products and services.

6 INSTITUTIONS

MDEC TO LOOK INTO EMERGING TECHNOLOGIES

MDEC is the 'Champion' for ensuring the success of the MSC initiatives and acts as a "One-Stop" Center for MSC companies. Other key institutions that play a key role in the development of the digital ecosystem include the various ministries that are spearheading the e-government initiatives and industry associations in the ICT related industries. MDEC needs to know re-look into strategies to attract technopreneurs of the emerging technologies.

7 INTERACTION

STRONGER INTERACTIONS WITH SMEs IS NEEDED

The multi-stakeholder partnership model adopted by MDEC has played a key role in nurturing partnerships with government agencies, education & research institutions, industry, industry associations and community organisations. These have enabled to acculturate society and workforce on a digitally connected society. Strong partnerships and cooperation among all stakeholders generated the multiplier-effect: emergence of local innovation and technologies and spawned new high-tech industries and products and services; however not all SMEs have taken the leap to embrace digitalisation.

8 INTERNATIONALISATION

PRESENCE OF HIGHER VALUE WORLD CLASS COMPANIES IS NEEDED

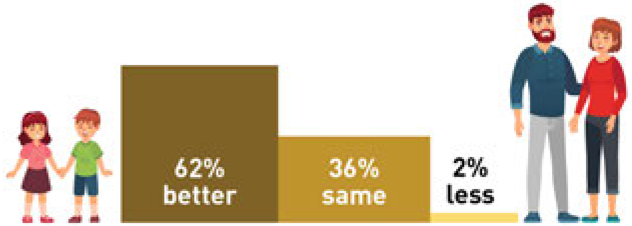
MSC has attracted MNCs, industries and expertise into the country. Malaysia is also regarded as an education hub in the ICT area for many developing countries. There has been a transition from absorptive capabilities in the early days to building adaptive and innovative capabilities of local players. Strong participation in international ICT knowledge networks have enabled local firms and workforce to adhere global best practices, create innovations and become important technology providers for other international supply chains. But MSC is not contributing enough to the economy hence the right MNCs should be scouted for Malaysia's ecosystem.

04

Societal Impact Pillar

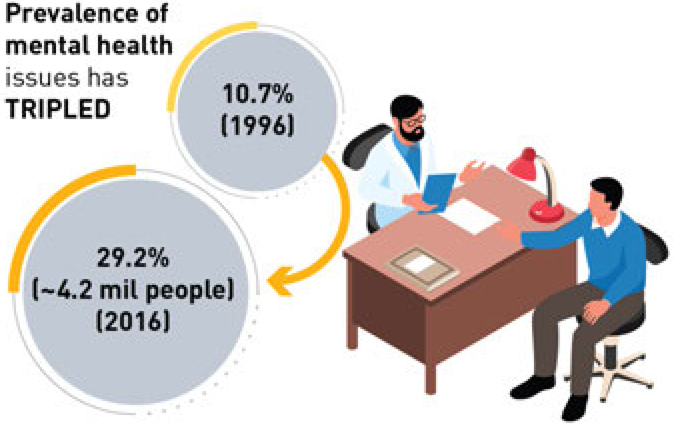
Traditional Literacy Rate
2018 : 94.85%
1957 : 50%

Digital Literacy rate
2020 : 11.11%
2017 : 7.49%



Improved education mobility
62% children obtain better education than their parents

Prevalence of mental health issues has **TRIPLED**



- Increased **suicidal attempt and suicide mortality**
- 1 in 3 Malaysians have experienced mental health problems
- Only 1 psychiatrist per 100 000 population
- Poor **mental health conditions** at the workplace estimated to **cost RM14.46 billion**

The median house price in Malaysia is **4 times** the annual median household income in 2019, making houses **"seriously unaffordable"**

Unhealthy dietary habits
Rising fresh food cost
Lifestyle change
Lack of physical activity
Affordable processed and fast-food cost
Low income to afford quality nutritious food

50% of adult are overweight or obese
- 1 in 5 have diabetes
- 4 in 10 have high cholesterol level
- 3 in 10 have hypertension

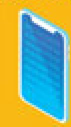
Major contributing factors of heart disease which is the #1 killer in Malaysia

Children under five years old
- 21% stunted
- 12% suffer from wasting

30% of children from 5 to 19 years are overweight and obese

SOCIETAL IMPACT PILLAR

Broadband subscription (2020)



89.7%

34.2%

Fixed broadband average download speed
Global Average (Dec. 2020): 96.43 Mbps
Malaysia Ranked (Dec.2020): #44

Mobile broadband average download speed
Global Average (Dec. 2020): 47.20 Mbps
Malaysia Ranked (Dec.2020): #87

Household Internet Access
2020 : 91.7%
2013: 58.6%

Rural
2020 : 83.9%
2017 : 36.2%

Urban
2020 : 93.5%
2017 : 68.5%

Human advancement is complex, and its expression differs in every region and stage in time. This chapter provides a succinct snapshot of the progression of Malaysia's society in relation to the nation's science, technology, and innovation (STI)-related policies.

STI AND SOCIETAL PROGRESSION

Science, technology, and innovation (STI) springs from human curiosity and creativity to solve problems. This needs-driven enterprise influences human lives both directly and indirectly, influencing aspects as wide-ranging from culture, behaviour, education, social interaction to health.

For thousands of years, humankind lived scattered all over the surface of the planet with a few concentrated urban centres that rose and fell with the ebb of civilisation. The world population finally reached one billion people circa 1810, doubling this number within 120 years, and today more than seven billion humans are found on Earth. This staggering population growth can be attributed to STI developments that prolong lifespan, cut down early deaths due to preventable diseases, as well as the increase in food production (Kinder, 1998).

Human progression in the 21st century is propelled by the biggest STI developments in the previous millennium; i.e. the explosion of computerisation technology and the birth of the Internet. The widespread availability of computing instruments has led to more sophisticated mechanisation and automation across all industry, shifting the job market as production moved from developed to developing countries and transforming global demographics in unprecedented ways.

The touchscreen smartphone is a massive game changer; it has become the single touchstone technology that everyone relies on for communication, work, play, and socialisation. It is key to the meteoric rise of social media which reshaped entertainment consumption and production, blurring the line between work and play. Most importantly, social media has given marginalised communities and social movements their voices that were previously silenced through conventional media. Censorship of internet content and social media platform has been used in citizen control and to quell civil uprisings (Momen, 2019) while deplatforming on social media have been used to reduce hate speech of extremist voices (Rogers, 2020) and minimise the spread of misinformation of anti-vaccine conspiracy theorists (Burki, 2020).

> The Research Council UK defines impact as demonstrable contribution of research to society and the economy (ESRC, 2020). The term societal impact itself is referring to the impact of science and technology on various levels and areas of society, beyond the scientific impact (Holmberg et al., 2019; Penfield et al., 2014; Wolf et al., 2014).

It is clear that there is no segment of society that is untouched by science and technology, so what are the best ways to calculate the impact of STI on the population (Dinsmore et al., 2014)? Walter et al. (2007) and Wolf et al. (2013) had highlighted some of the attempts to track and measure impact of science on society, but the gold standard remains elusive (Holmberg et al., 2019).

Malaysia is populated by a diverse population and the social dynamics in the country has become more complex as the nation continues to advance. The combination of strong economic and population growth as well as rapid urban migration has led to wider income disparity, an increase in the rural urban divide and other socio-geographic differentiation (SPV, 2030). The Government's commitment to drive the nation's progression with STI strengthens the need to monitor Malaysia's societal well-being to ensure that all the citizens get to enjoy the prosperity equitably and no one is left behind.

GAUGING THE NATION'S SOCIETAL WELL-BEING

Analysing societal impact using absolute measurement is difficult, so measurable indicators influenced by factors such as economy, geopolitics, culture, and religion are evaluated as impact parameters. The Department of Statistics Malaysia (DOSM) came up with the Malaysian Well-being Index (MyWI) in 2000 to assess the *Rakyat*'s well-being from an economic and social perspective (DOSM, 2020a) based on 14 components (Figure 4.1).

Overall, the selected indicators had shown a modest increase over the years; most of these improvements attributed to the growth in economic well-being. The indicators that did not show desired increase were the health, culture, and family components which demonstrate that although Malaysians are doing better economically, their quality of life is not progressing in tandem.
The minimal improvement in the health sector was quite concerning. This observation is laid at the feet of factors such as long queues in public hospitals due to increased demand

for subsidised healthcare, its reduced or inequitable supply, and system inefficiencies (Khor, 2019). Malaysia's increasing health expenditure may indicate a change in various factors such as growing population in general, population structure, and income. Whether in the urban, suburban, or rural areas, lifestyle-related diseases from being sedentary as well as inappropriate nutrition are on the rise, which leads to increased demand for healthcare.

Transport, communications, education, housing, social participation, and public safety has made good progress in this nineteen-year period. The greatest increase was for transport, reflecting the increase in ownership of private motorcars and motorcycles, road length per capita, and Road Development Index (RDI). Improvements in public transport services in terms of route expansion and service hours, particularly like Light Rail Transit (LRT), Mass Rail Transit (MRT), *Keretapi Tanah Melayu* (KTM), and feeder buses that serve the areas with greatest population density also contributed to this increase.

The next section of the report views Malaysia's societal performance through the lens of basic human needs, foundations of well-being, and opportunity in the past thirty years.

PROVIDING BASIC UTILITIES FOR SOCIO-ECONOMIC DEVELOPMENT

Malaysia has achieved almost universal access to basic utilities such as water, closed sewage, and electricity for all citizens in the past thirty years. However, gaps still exist, particularly in rural areas that are too far from points of access for the utilities. The availability of piped water in Malaysian households is almost universal at 95.9% as of 2019. As expected, the rate is lower in rural compared to urban areas at 84.7% and 98.7% respectively (EPU, 2021). The interiors of Kelantan, Sabah, and Sarawak make up three per cent of the population who are unable to access potable water, making them vulnerable to water-borne diseases and other water-related health issues (e.g. physical pain from hauling water from source to home). Without steady water supply, these areas also have difficulty developing sustainable economic activities to support the people. Lack of potable water access often comes hand in hand with sanitation problems which leads to sewage contamination of water sources, worsening the water supply issues.

Energy is essential for economic development (Energy Commission, 2017) and a key enabler of human productivity and well-being (AIM, 2017). The electrification in Malaysia is close to 100% with pockets of isolated rural area without access to energy infrastructure. Some rural areas in Sabah and Sarawak are still unable to access the utility grid or suffer from unstable electrical supply due to geographical factors. To address this, the Rural Electricity Supply (BELB) Programme was launched in 2010 under the purview of the then Ministry of Rural and Regional Development (KKLW) to construct infrastructure for alternative methods of electrification such as via solar energy, generator sets, solar hybrid, and the like (KKLW, 2016). The Sarawak state government has begun its Rural Power Master Plan to speed up electricity coverage to rural communities to support Sarawak's digital economy agenda to transform Sarawak into a developed state by 2030.

Figure 4.1: Malaysian Well-Being Index, 2000-2019

Although Malaysia has achieved 95% of piped water access, certain states are yet to be fully covered. The states are as follow:
Kelantan: 67.9%
Sabah: 84.7%
Sarawak: 86.4%

Reference: Economic Planning Unit (EPU) (2021)

Box Article 4.1: Electricity in Malaysia

The earliest record of power generation in Malaya can be traced back to a small mining town in Rawang, Selangor when Loke Yew and Thamboosamy Pillai installed an electric generator in 1894 to operate their tin mines. In the same year, private supply for street lighting purposes was extended to Rawang town and in 1895 the railway station in Kuala Lumpur received its first electricity supply. In 1900, the Sempam Hydroelectric Power Station in Raub, built by the Raub Australian Gold Mining Company, became the first power station in Malaysia.

Until the mid-1920s, electricity was generated by small private plants using a variety of fuel including low grade coal, local wood, charcoal, oil, and hydro power. As the demand for electricity rapidly increased, large scale planning became essential. The Central Electricity Board (CEB) was established on September 1st 1949 to ensure fair share of electricity for all with development of a national grid as a main priority.

On 22nd June 1965, CEB was renamed as National Electricity Board of the States of Malaya (NEB). The National Grid was one of the plans in full motion to link electricity generation, transmission, distribution, and consumption in Peninsular Malaysia. The loop was successfully completed in the 1980s. On 1st September 1990, NEB was privatised and rebranded as Tenaga Nasional Berhad (TNB).

TNB supplies electricity in Peninsular Malaysia and co-owns Sabah Electricity (SESB) with the state government of Sabah. SESB also receives an annual subsidy allocation of around RM700 million a year from the Federal government (Malay Mail, 2020b). Electricity in Sarawak is supplied by state-owned Sarawak Electricity Supply Corporation.

Due to high start-up costs of setting up power grids and power stations, TNB remains a natural monopoly due to its first mover's advantage and large workforce with supporting diverse skillsets for operation. Even with other players coming into the market, the national grid operations and electricity distribution will continue to operate under TNB.

ENERGY COMMISSION: Taking over the role of the Department of Electricity and Gas Supply, the Energy Commission began its operations on 1st January 2002. The Energy Commission aims to balance the needs of consumers and providers of energy to ensure safe and reliable supply at a reasonable price, protect public interest, and foster economic development and competitive markets in an environmentally sustainable manner.

MESITA: Malaysian Electricity Supply Industries Trust Account (MESITA) or *Akaun Amanah Industri Bekalan Elektrik* (AAIBE) was set up in 1997 by Ministry of Energy, Green Technology and Water (KeTTHA) as a vehicle for the electricity supply industry to meet its social and national obligations. Every power generation companies in Peninsular Malaysia including TNB contribute 1% of their electricity sale to the fund for the following activities:

1. Rural Electrification Programme;
2. R&D Programmes and new renewable energy projects;
3. Human resource development programmes for the industry;
4. Energy efficiency projects;
5. Development and promotion of the electricity supply industry;
6. Advance for Projects Approved by Trustee of Electricity Trust Fund.

References:
Tenaga Nasional Berhad (TNB) Website (2021), Sabah Electricity Sdn Bhd (SESB) (N.D)

Uneven utility access can be improved by using STI to generate energy, supply clean water, maintain a steady communication network, and sanitation decentralised from main grids of more developed locations in the country. For example, solar panels and wind farms to supply the energy grid in the isolated highlands of Borneo.

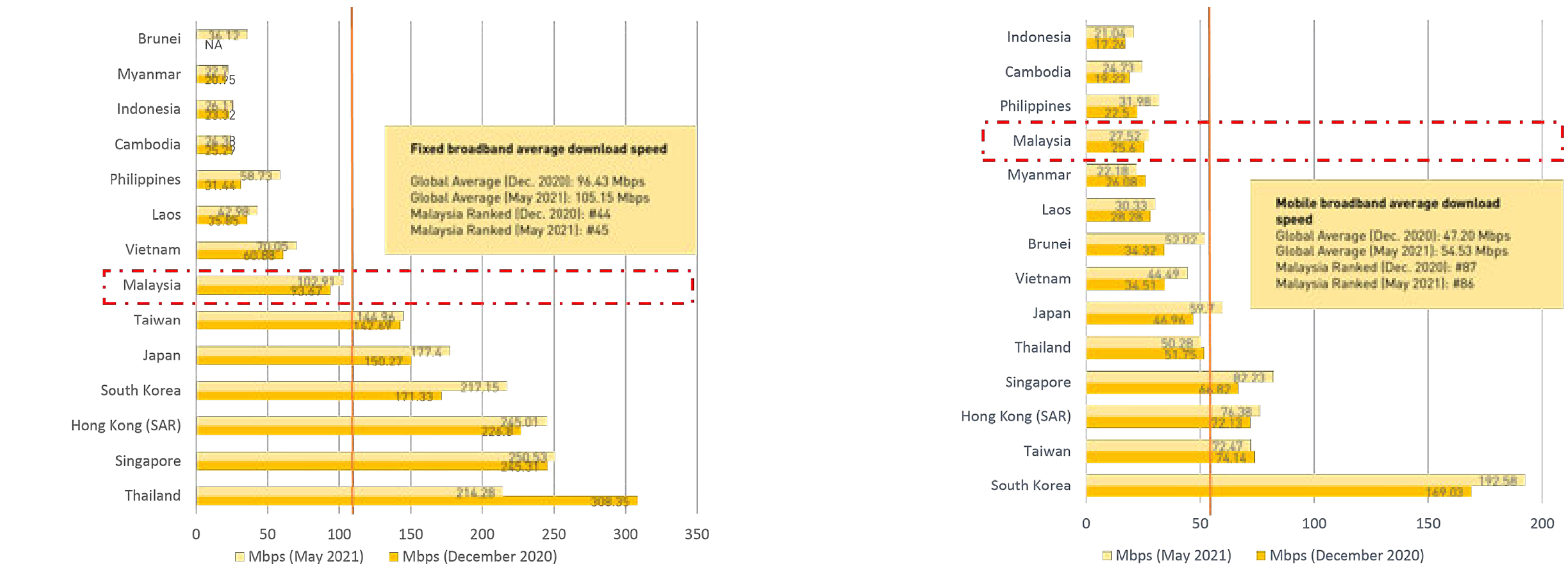


Figure 4.2: Fixed Broadband Average (left) and Mobile Broadband Average (right) Download Speed of ASEAN and Selected Countries (MBPS), December 2020 and May 2021

The central role of data in contemporary society has led to the United Nations (UN) declaration that access to the internet is a basic human right (Jackson, 2021). Malaysia's acknowledgement of this fact led to the designation of "knowledge economy" as a national priority, which was why even in the 1990s, Malaysia's internet penetration was one of the highest in Southeast Asia at more than 62 percent (Jeffrey, 2015). This importance is carried through in the Malaysian Economy Blueprint that was released in 2021; broadband is a basic utility and thus internet access must be included in all land developments.

Broadband can be categorised into fixed broadband and mobile broadband. Fixed broadband requires a physical connection to internet cables and has a higher download speed than mobile broadband; however, not every region has fibre optics connectivity. Telecommunication companies offer wireless broadband on mobile broadband networks such as 4G LTE in areas that do not have fiberised fixed broadband. Opensignal and MCMC reported that the best mobile broadband service was by Maxis based on download speeds data (KRI,2021).

Malaysia's present internet speed is dreadful when compared to neighbouring countries in the region (Figure 4.2), ranking at 45 (102.91 Mbps) and 86 (27.52 Mbps) worldwide in fixed- and mobile-broadband average download speed (Speedtest Global Index, 2021). From December 2020 until May 2021, there is no significant improvement in mobile broadband while in fixed broadband, the average download speed showed a slight improvement from 93.67 Mbps (December 2020) to 102.91 Mbps (May 2021). However, Malaysia is still behind the global average in both index while South Korea, Singapore, Hong Kong, Taiwan and Japan had exceeded the global average. Poor internet connectivity will be a choke factor in the Government's plan to diversify and expand Malaysia's digital economy; it is hoped that the *Jalinan Digital Negara* (JENDELA) initiative will mitigate this issue (Box Article 4.2).

Households with internet access in Malaysia had increased gradually from 2015 to 2020 (Figure 4.3) with 89.7% subscribing to mobile broadband and only 34.2% subscribing to fixed broadband (DOSM, 2020b).

Households that do not subscribe to the internet cite the lack of need to use the internet (70.7% get access at their work place), lack of confidence, knowledge and skills issue to use the internet (59.5%), and cost of equipment (51.2%) (DOSM, 2020b) as factors hindering them from doing so. It is expected that these figures to change as more people shift to work from home (WFH) and students undergo online learning at home due to the COVID-19 pandemic.

Massive and prolonged school closures at the height of the COVID-19 pandemic necessitated online learning (PdPR) to take place and highlighted the digital divide between the privileged and underprivileged. Datuk Dr Mohd Radzi Jidin, the Minister of Education, reported that 36.9% school students in Malaysia do not own an ICT gadget needed for online learning (NST, 2020a). Students outside of major cities and townships are at a disadvantage to keep up with their contemporaries, particularly if they are to sit for a major examination. This was illustrated by the case of Veveonah Mosibin from Pitas, Sabah who stayed up on a tree for 24 hours to get better internet connection for her Foundation in Science examination.

High connectivity appears to be concentrated in major cities with less attention being given on connecting rural areas with ICT access. Although Malaysia has high mobile broadband network coverage (91.8% covered by 4G network), the quality of the service is still not satisfactory. This is because some areas do not have telecommunications towers, while some areas have issues of internal coverage

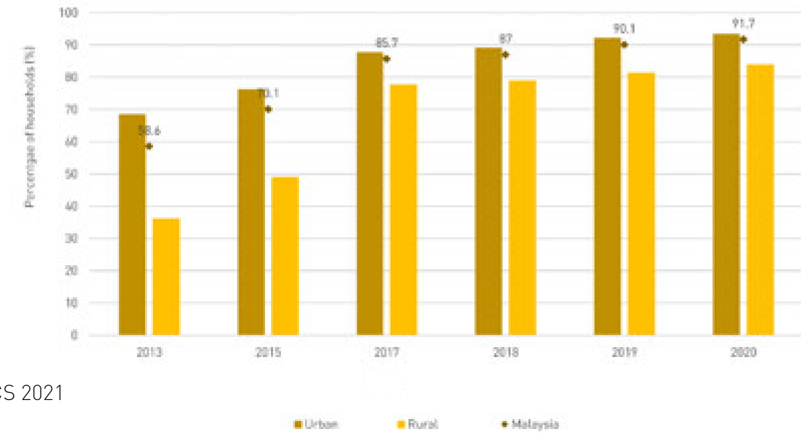


Figure 4.3: Percentage of Internet Access (Households) by Strata

Box Article 4.2: National Digital Network (JENDELA)

This prioritisation to increase coverage of quality and affordable broadband services to move Malaysia into digital economy continues into the 11th Malaysia Plan (2016-2020) (MCMC, 2018). In 2019, the Government introduced the National Fiberisation and Connectivity Plan (NFCP) 2019-2023, a five-year plan to improve affordable broadband quality and coverage.

The Government has allocated RM12 billion to push ICT development strategies in rural communities through the National Broadband Initiative (NBI) (Halili, 2018). Internet connectivity for Government schools was established by 1BestariNet via several platforms; i.e. 4G highspeed broadband connection, Asymmetric Digital Subscriber Line (ADSL) connection, Very Small Aperture Terminal (VSAT), and the latest one, fibre connection. In total, 96.3% of schools were reported to have internet accessibility in 2018 (PADU, 2018).

In August 2020, the National Digital Network (Jendela), a digital infrastructure plan under the responsibility of the Communications and Multimedia Ministry (KKMM) and the Malaysian Communications and Multimedia Commission (MCMC), was launched to ramp up Malaysia's digital connectivity and prepare for the transition to 5G technology. Jendela's first phase expands 4G mobile broadband coverage from 91.8% to 96.9% in populated areas, increase fixed broadband speeds from 25Mbps to 35Mbps, and enable 7.5 million premises with gigabit fixed broadband access.

Phase 2 will focus on boosting the 4G network and strengthen the foundation for 5G with gradual retirement of 3G networks by the end of 2021. 382 new communication towers will be added, and 924 existing communication transmitters will be upgraded in Sabah while in Sarawak, 977 existing communication transmitters will be upgraded, and 636 new communication towers will be built.

This initiative has improved Malaysia's mobile speed between the first and second half of 2020 by upgrading 3G sites to long term evolutions (LTE), adding LTE layers with Carrier Aggregation features, and changing antennas to support MIMO features (Phillips, 2021).

References:
Malaysian Communications and Multimedia (MCMC) (2020), Halili et al. (2018), Education Performance and Delivery Unit (PADU) (2018), Philips (2021).

such as network congestion, preventing peak performance even with tower nearby (KRI, 2021). Broadband infrastructure such as fibre internet has yet to reach beyond large townships; the penetration along the east coast of the Peninsular as well as Sabah and Sarawak are still low. Low speed connectivity impedes appropriate data reach and prevents residents of the interior from taking full advantage of all the internet has to offer.

KEY INTERVENTIONS

1. **Fixed broadband must be included as compulsory basic utility feature in all future mid- to low-level real estate development projects. There is an urgent need to enhance the existing internet access for wider coverage and better quality in rural and urban areas.**

2. **There is socio-economic immense potential in setting-up wireless community networks for the rural and marginalised communities by utilising low-cost Wi-Fi-based equipment for connectivity.**

Other ASM publications on utilities:

1. Integrated Urban Water Management (IUWM) in Peninsular Malaysia (2019)
2. Strategies to Enhance Water Demand Management in Malaysia (2018)
3. Ensuring a Better Water Future for Malaysia (2017)
4. Transforming the Water Sector: National Integrated Water Resources Management Plan Strategies and Road Map (2016)
5. Sustainable Energy Options for Electric Power Generation in Peninsular Malaysia to 2030 (2013)
6. Increasing Broadband Penetration and Quality for National Transformation (2013)

Box Article 4.3: Telekom Malaysia (TM)

The first telegraph line in Malaya was laid to connect the British Resident in Kuala Kangsar to the Deputy British Resident in Taiping in 1874 (Telecom Review, 2020). In the early days, postal and telegraph services were consolidated into a single entity, governed by the Post and Telegraph Department. The Telecommunications Department of Malaya was established in 1946.

In 1968 Telecommunications Department of Malaya merged with the Telecommunications Department of Sabah and Sarawak to form the Telecommunications Department of Malaysia. Almost 20 years later, the Department of Telecommunication Malaysia was corporatised to form *Syarikat Telekom Malaysia Berhad* (STMB) in 1987. The nation's first privatised entity, STMB was re-branded into *Telekom Malaysia* (TM) in 1991. TM has a long-standing history in contributing to the nation's progress and throughout the years, has been at the forefront in building the nation's critical infrastructure for the *Rakyat*.
With the creation of the Malaysian Communications and Multimedia Commission (MCMC) as a regulatory body in 1998, the telecommunication industry began to transform from TM's monopoly to a more liberal infrastructure that encouraged competition and efficacy. Nevertheless, TM remains the country's incumbent telecommunications service provider.

Listed below are some significant telecommunication initiatives and achievements over the years:

1. **1962:** Subcriber Trunk Dialling (STD) between Kuala Lumpur and Singapore via the long-distance microwave link was introduced
2. **1970:** The first international standard satellite earth station was commissioned in Kuantan, marking the advent of live telecasts in Malaysia
3. **1979:** Introduction of International Direct Dial (IDD) facilities.
4. **1980:** Malaysia commissioned its own submarine cable linking Kuantan and Kuching.
5. **1984:** Introduction of packet switch technology, leading to Malaysia's own public data network.
6. **1985:** Commissioning of the ATUR service using 450 analogue cellular radio technology, the first in Asia.
7. **1996:** Multimedia University (MMU), Malaysia's first ever full-fledged private research university and a government-linked university owned by TM was established.
8. **2001:** TM Net was established as the largest internet service provider in South East Asia.
9. **2013:** TM launched three new initiatives to enhance Malaysia's connectivity – My1Hub, Iskandar International Gateway (IIGW) and Cahaya Malaysia. Cahaya Malaysia was the first private international submarine network which complete its connectivity route connecting Malaysia with Japan and Hong Kong.
10. **2020:** Telekom Research & Development Sdn Bhd (TMRND) was appointed as MDEC's Data Technology Partner under MDEC's Data Technology Partnership Programme initiative.

References:
Telekom Malaysia Berhad (2014), Company Histories (2021)

Transport and Mobility

Moving people and goods in a sustainable system is a fundamental necessity for societal and economic growth. Transport should not just provide "access" to jobs, markets and opportunities; it should be equitable, efficient, safe, and climate responsive, especially in light of Malaysia's decision to embrace the United Nations sustainable development goals (SDGs) to support the nation's developmental roadmap.

Malaysia's economic development can be traced by mapping the roads and highways, intra- and inter-city rail tracks, shipping ports, and airports across the country. The Government invested heavily in roads, airports, public transport infrastructure, seaports and river jetties, as well as other related transport and mobility infrastructure, with the highest amount spent in 2017 due to new road and rail infrastructure projects. However, transportation infrastructure in Malaysia is still uneven; large swaths of Sarawak and Sabah still rely on poorly maintained non-paved roads as well as river boats to connect with major towns and public amenities such as schools and hospitals. The lack of convenient and timely transportation is impeding the socioeconomic growth of these regions, making it difficult for the population to enjoy the largess of the nation.

The establishment of the MRT in Greater Klang Valley with more extensive routes connecting the suburbs with the city centres has increased the number of rail passengers from 2017 onwards and contributed significantly towards elevating the transport component of the MyWI Index. This indicates there is an appetite for better public transport services especially in high density area and how it feeds towards elevating the *Rakyat*'s quality of life. However, the connectivity from the first miles to the last miles is still an issue in rural and certain urban areas; attention is needed to ensure higher utilisation of public transport services.

Box Article 4.4: Bridging the Infrastructure Gap

The Pan Borneo Highway connecting Sarawak and Sabah is expected to be a game changer for the Borneo states. The 2,325km Pan Borneo Highway will start at the tip of Sarawak in Semantan all the way to Tawau in Sabah. It is three times longer than the country's current longest expressway, the North-South Expressway (PLUS), which is 772km long connecting the West Coast of Peninsular Malaysia from Bukit Kayu Hitam in Kedah to Johor Bahru. The construction of the Pan Borneo Highway was officially launched in 2015 in Sarawak and 2016 in Sabah.

Although slated to create 400,000 jobs, the construction of this infrastructure will however have some early negative impacts. About 161 km of the Pan-Borneo Highway in Sarawak will traverse forested landscapes and approximately 55 km will traverse peatlands, increasing the carbon footprint of development in this region.

Reference:
Alamgir et al. (2020)

Malaysia Transport Infrastructure and Services

Length of Roads (KM) (2019)[1]
Paved: 188,416
Non-Paved:64,119
Total Toll Highway Distance: 2018.66

Ports (2019)[2]
No. of seafarers: 35,000
No. of port calls: 40,285

Length of Rails (KM)(2018)
Rail: 2,783[3]
Single Track:1,735.43[4]
Double Track: 3,094.6[4]

No. of aircraft movements operated by airport (2019)[5]
Peninsular: 677,564
Sabah: 125,295
Sarawak: 148,897

The number of registered vehicles increased from 20 million in 2010 to 31.2 million in 2019. Congested roads also resulted in an increase in road fatalities and injuries by 2.86% in 2019 compared to 2018 (MOT,2019).

References:
Department of Statistic (DOSM) (2019), United Nations Conference On Trade And Development (UNCTADSTAT), 2020; World Development Indicator (N.D), MAMPU (2020), Ministry of Transport (MOT) (2019).

KEY INTERVENTION

1. **To introduce advanced intelligent systems to monitor and manage public transportation services efficiently for enhancing first to last mile connectivity in urban, suburban, and rural areas. Integration of various technology application such as high-speed networks technologies and real-time digital tracking allows control centre to monitor and communicate with drivers and gather information on vehicle positioning, location, and speed for safety and, to reduce congestion on city streets.**

ASM publication on transportation:
1. Mega Science 2.0 – Transportation Sector (2016)

Housing

MyWI indicates that affordable shelter is a matter of great concern for Malaysia's population, particularly those living in high density localities. The Government allocated around RM1.2 billion and RM1.7 billion for the housing subsector in 2018 and 2019 respectively, primarily towards People's Housing Project (PPR), civil servants' quarters, rehabilitation of abandoned private housing projects as well as maintenance and repairs of public housing (MOF, 2019). However, the trend for the price of housing outpacing the earning capacity of regular Malaysians has been noted since early 2000s (Figure 4.4a).

The median house price in Malaysia is four times the annual median household income in 2019, rendering house prices "seriously unaffordable"; the national median income was RM5,873 (DOSM, 2020d).Table 4.1 below shows the number of households according to income group. Malaysia's affordable house price is estimated at RM211,000 and below (Lee,2020) however, this varies among states as each state has respective median household income. On the other hand, the median house price in Malaysia was RM289,646 in 2019 (Puteri & Theebalakshmi, 2021) that is 37% higher than an average affordable house price category.

For example, Kuala Lumpur has the highest median household income (RM10,549) and the median house price is RM470,000, nearly 24% higher than affordable house price category (RM380,000 and below). This indicates a high possibility that the B40 and some M40 group living in Kuala Lumpur could not afford to own a house in the capital city. Table 4.2 below shows home ownership by strata.

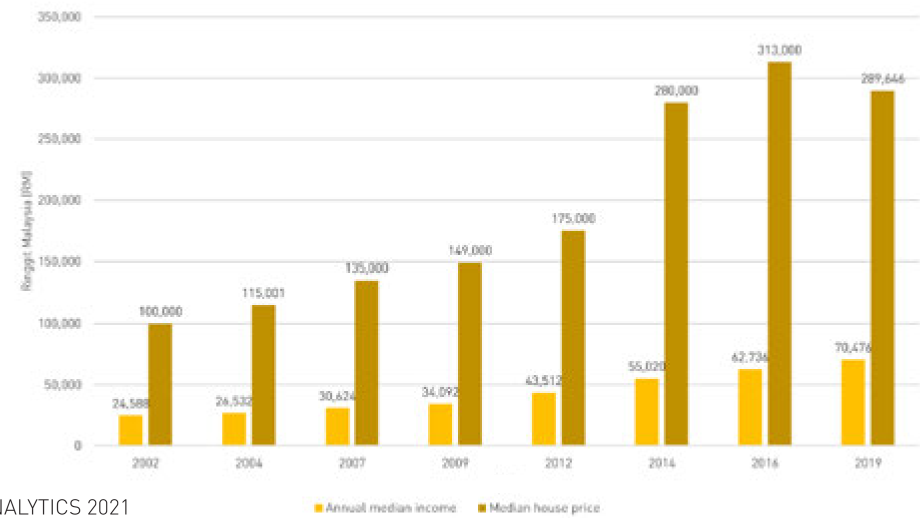


Figure 4.4a: Household Income vs. House Price, 2002-2019 (RM)

Table 4.1: Number of Households and Median Income by Income Group in 2019

	Number of households ('000)	Percentage of household (%)	Median income (RM)
National			5,873
B40	2,896.2	39.8	3,166
M40	2,943.5	40.5	7,093
T20	1,436.6	19.7	15,301

Reference: Adapted from Department of Statistics Malaysia (DOSM) (2020d)

Table 4.2: Percentage of Home Ownership by Strata, Malaysia, 2019

	Urban (%)	Rural (%)	Total (%)
Owned	74.5	86.4	76.9
Rented	22.8	7.7	19.8
Quarters	2.7	5.9	3.3

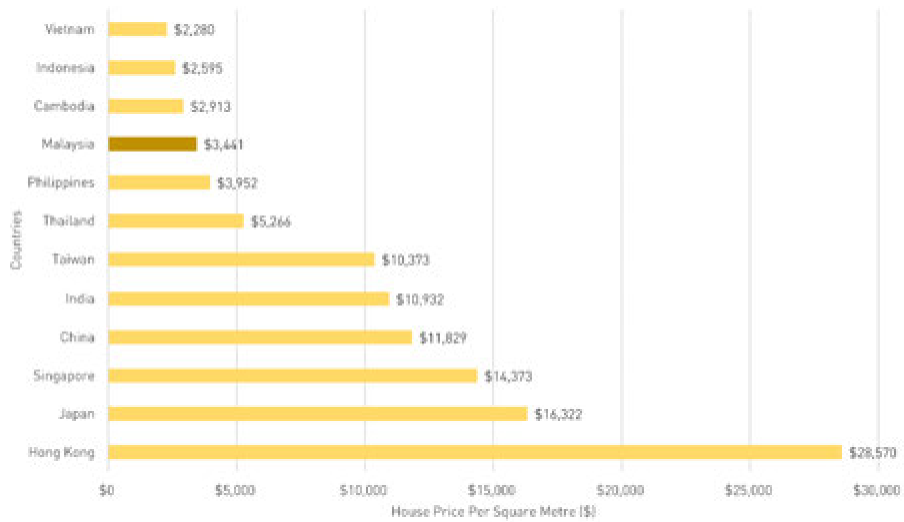
Reference: Adapted from Department of Statistics Malaysia (DOSM) (2020d)

Through DOSM's survey respondents of 7,276,700 people, 5.6 million or 76.9% of households in Malaysia owns a house with higher home ownership in the rural areas. More people rent properties in the urban areas most probably due to it being more reasonable in managing with the cost of living, transport, insurance and other commitments. It is notable that home ownership has increased by 0.6% from 2016 to 2019.

Although house price per square metre in Malaysia is much lower in comparison to land scarce Asian countries (Figure 4.4b) based on the National Affordable Housing Policy in 2019, 50% of Malaysian workers earn less than RM2,160; they cannot afford to own a house based on the median house price of RM250,000. However, only 24% from the newly launched residential units are priced at less than RM250,000 (KPKT, 2019). This is worsened by the slower increase in median households' incomes relative to median house prices (KRI, 2018).

Real estate development should be more tightly regulated to discourage unoccupied white elephants that take up much needed space for housing. Malaysia could learn from the lessons of other countries to address the issue of real estate overhang. For example, the Hong Kong government proposed to charge developers a 200% tax on the estimated annual rental value of unsold units (The Straits Times, 2019). Singapore developers risk being hit with a 25% levy if they fail to build and sell all units at a site within five years from the time of purchase of land (Real Estate, 2019).

Making Industrialised Building System (IBS) mandatory as well as adopting innovation from other countries have been suggested to reduce construction cost and bring down house prices. IBS was introduced to Malaysia as the



Reference: Adapted from Global Property Guide

Figure 4.4b: House Price per Square Metre in Asia (USD)

solution to issues related to dependencies of foreign workers, raising demand for affordable accommodations, and improving image, quality and productivity of construction industry (Amin et al., 2017). The usage of IBS in Malaysia has increased from 24% in public sector projects in 2014 to 87% in 2020, and from 14% in private sector projects in 2014 to 41% in 2020 (CIDB,2021). However, the IBS adoption in Malaysia remains low (Box Article 4.5).

The policies on housing and construction need to be reviewed in the face of changing lifestyles, norms, and sustainability. The constantly shifting population in urban centers may mean that urban and suburban homes should be slated for rental instead of sale which would remove them from the housing market.

The high market prices are an outcome of favourable policy, market optimism from the buyers, and market sentiment from the developers.

Reference:
Foo, C.H. (2020)

Box Article 4.5: Factors Impeding the Adoption of IBS in Malaysia:

Developers unwilling to adopt IBS as they are used to the conventional methods.

Specialised machineries and high-skilled workers are required.

Transition to IBS is deemed complicated and costly for the developer.

Availability of cheap foreign labour.

References:
Amin et al. (2017), Sashitharan et al. (2014), Nasrun et al. (2015), Hamid et al. (2008), Meynagh et al. (2014)

KEY INTERVENTIONS

1. **To have aggressive strategies in place for wider adoption and use of the IBS for mass construction of affordable houses especially for public housing development projects.**

2. **Undergraduates in related fields must be exposed to construction technology including robotics courses to reduce dependency on foreign labour. Additionally, train and upskill local workers in the domestic construction industry for valid industry license acquisition.**

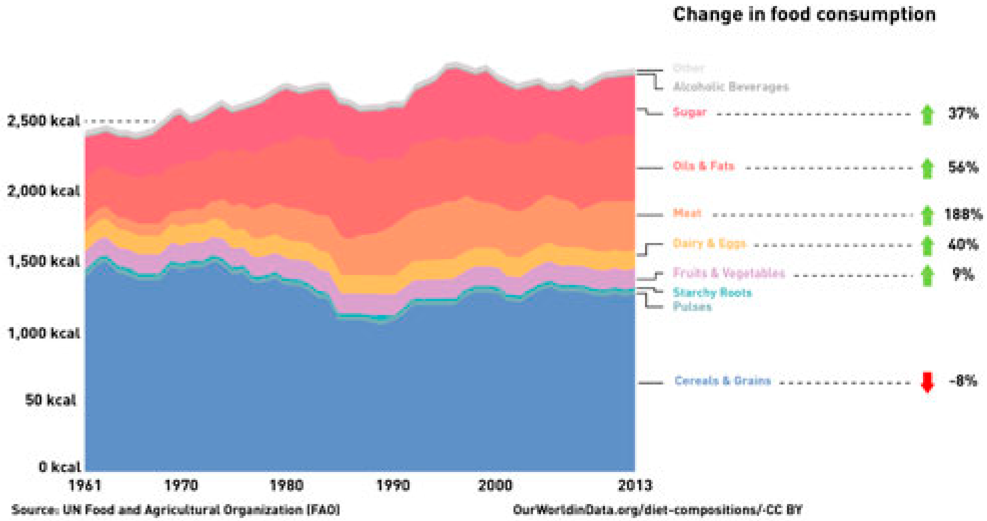
NURTURING THE GROWTH OF A HEALTHIER NATION

Malaysians are enjoying greater prosperity and access to more food than in the previous generation, likely due to the reduction of absolute poverty from 52.4% in the 1970s to 5.6% in 2019 (DOSM, 2020d). Improved transportation and logistics technology, as well as advances in food technology allowed a greater variety of food from all over the world to reach Malaysia's shores, further changing the nation's food consumption pattern.

Food and Nutrition

As seen in Figure 4.5, cereal-based calories intake has declined from 61% in early 1960s to 41% in 1997, in contrast to high calorie food groups like meat, oils and fats, dairy and eggs and sugar (Noor, 2002). Meat consumption is also on the rise, due to greater disposable income as well as lowered barriers to meat production and import.

However, casual observations at the supermarket and grocery stores show the most accessible protein in Malaysian diet comes from processed meat (e.g. nuggets, sausages, burger patties, etc.). Processed food is also relatively cheaper and have higher shelf-life because of added preservatives. Due to higher sugar and salt content, processed foods have



Reference: Adapted from Our World in Data, (N.D)

Figure 4.5: Dietary Compositions by Commodity Group and Change in Consumption in Malaysia over 50 Years

more calories for less nutrients (Gupta et al., 2019) and are not a healthy option in the long run or in large quantities.

This change in food consumption pattern parallels the increase in non-communicable diseases (NCDs) incidence in Malaysia. High protein and carbohydrate consumption is linked to risk factors for type II diabetes, heart disease, and non-alcoholic fatty liver disease (Fappi and Mittendorfer, 2020). Children who consume high protein diets in early childhood are prone to developing childhood obesity (Lind et al., 2017). Diabetes, hypertension and high cholesterol are three major risk factors for cardiovascular diseases (CVDs) affecting 1.7 million Malaysians. Individually, 3.9 million or 1 in 5 people have diabetes, 6.4 million or 3 in 10 people have hypertension and 8 million or 4 in 10 adults have raised total cholesterol level. CVDs such as stroke and coronary heart diseases are the principal causes of death in Malaysia (NHMS, 2019).

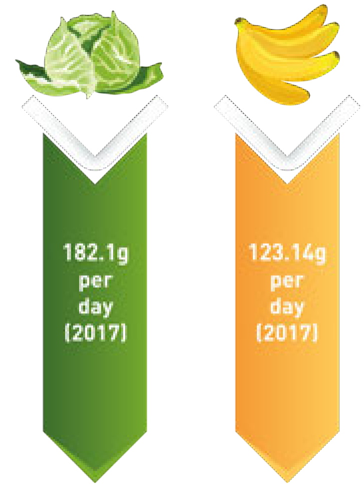
Despite the growth in national wealth, the poorest segments in Malaysia – particularly the urban poor – are unable to afford fresh vegetables and fruits. Dietary fibre from fruit and vegetable sources are vital for the prevention of diabetes, obesity, coronary heart disease, gallstones, and certain types of cancer. In addition, higher fruits and vegetables consumption are linked to reducing the risk for high blood pressure and high blood lipid levels (i.e. cholesterol and triglycerides), both contributing to heart disease (Li and Komarek, 2017).

About 26% of household's food consumption are high import content items like beef, fish, dairy, and fruits (BNM, 2019a). Protein sources like red meat and certain fishes are among the items which record lower self-sufficiency ratio (SSR) and higher imports; the production of these proteins is not self-sufficient to support domestic demand. Hence, when a household either urban or rural consumes more food items with high import content, their exposure to import costs increase (BNM, 2019a). Food production issues are discussed further in Chapter 5.

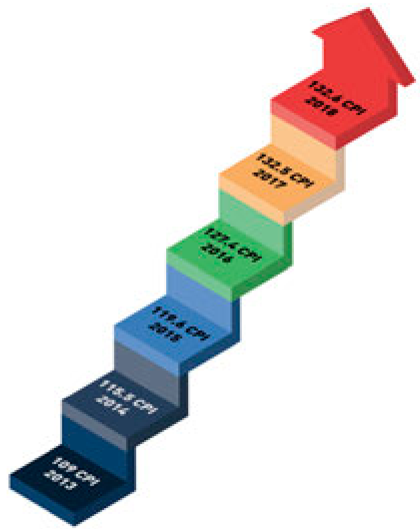
Food consumer price index (CPI) has increased by 69% from 2003 to 2017, which affects the type and quality of food that is affordable to those with lower income (Sundaram and Tan, 2019). Upper-middle to high-income household purchase foods based on preference while lower-middle to low-income household with less alternative make need-based purchases. Low-earning households spend larger portion of their income on food compared to higher earning households; they are more affected by food price increase which makes them vulnerable to malnutrition (Sundaram and Tan, 2019). The B40s faced heightened food insecurity during the pandemic as many of the households lost a significant chunk of their income, which worsens the issue of child malnutrition (UNICEF, 2020). Many malnourished children do not consume enough fruits and vegetables due to the cost and their family's lack of nutrition education.

Vegetables and fruits consumption are decreasing on average. Malaysians' consumption of these food items has not reached the recommended minimum requirement of 200 to 250g per day.

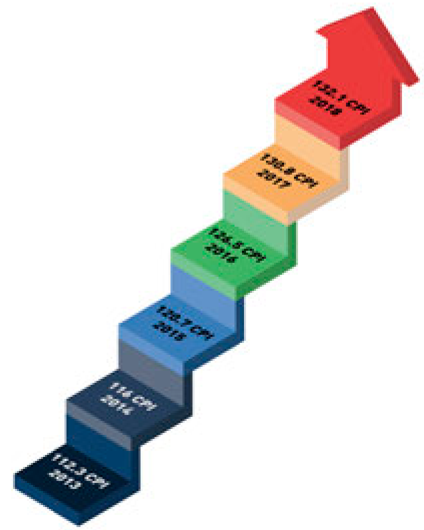
FOOD SECURITY: United Nations' Committee on World Food Security defines as all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preference and dietary needs for an active and healthy life.



Vegetables CPI trend 2013 - 2018



Fruits CPI trend 2013 - 2018



Reference: Adapted from Statista.com, (N.D)

Figure 4.6: Consumer Price Index for Vegetables and Fruits

UNSDG target 2.2 aims to end all forms of malnutrition by 2030, including achieving the internationally agreed targets on stunting and wasting in children under five years of age as well as addressing the nutritional needs of adolescent girls, pregnant and lactating women, and older persons by 2025. Unfortunately, Malaysia is faced with the double threat of stunting among children and obesity across the population and has yet to achieve the targets on Zero Hunger based on the Sustainable Development Report 2020. This double burden is usually caused by children not getting nutritious food or not eating enough of nutritious foods (UNICEF, 2019a). Undernutrition in young children and being overweight later in life increases the risk of costly non-communicable diseases (NCDs) (UNICEF, 2019b).

Although the problem of malnutrition, stunting, and obesity are more prevalent in the cities, it also occurs in the rural areas as well (UNICEF, 2019b). Malnutrition is a cross cutting national problem due to accessibility to unhealthy foods. Food with low nutritious value is easily found in small towns thanks to improved distribution network as well as giant fast-food chains penetrating the rural areas.

21.8% of children under 5 years old in Asia are stunted, which is slightly higher than the global average of 21.3% (Global Nutrition Report, 2020). There is a wide difference in underweight prevalence between Malaysia and the world average which indicates improvements made by the country in curbing underweight issues. However, the drop to 1.9% in 2015 is making it urgent to refocus the attention towards children nutrition and health. In 2016, Malaysia's child stunting rate was higher than Ghana (18.8%), Sri Lanka (17.3%) and Thailand (10.5%), making it more

Box 4.6: Wealthy and Unhealthy?

Obesity prevalence in Malaysia has skyrocketed since 1990 and the country has become the most obese country in ASEAN. This is due to lack of physical activity, lifestyle change, improved economic standards, and rising cost of fresh food alongside lower cost of processed and fast food. One in two Malaysian adults are overweight or obese, that is about 50% of adult population while nearly 30% of children are overweight. One in four adults are not physically active and generally prefer passive modes of transport and leisure activities that require minimal physical energy.

According to ASM-Academy of Medical Sciences UK workshop report on obesity, among the key challenges identified in developing a national obesity strategy is insufficient large-scale research causing a lack of national data that are required to develop policy measures. Additionally, research outcomes of obesity studies are not disseminated widely. As such, periodical collection of national level data for timely interventions was recommended.

References:
World Population Review (2019), Inquirer.net (2019), Ministry of Health (MOH) (2019), UNICEF (2018), Academy of Sciences Malaysia (ASM) (2017).

This double burden especially affects the urban poor with affordability and accessibility to nutritious food being the most common problem. Households with:

Food quantity insufficiency	**25.0%**
Food variety insufficiency	**25.5%**
Practised meal size reduction	**21.9%**
Skipped main meals	**15.2%**

Reference: Ahmad et al. (2020)

One in four Malaysians turn to cheaper food

One in five Malaysian households could not afford to feed their children a variety of foods

Reference: UNICEF (2018); Ahmad et al. (2020)

Malnutrition is deficiencies, excess or imbalances in intake of energy and/or nutrients. Malnutrition covers undernutrition which encompass stunting, wasting and underweight. As well as overweight and obesity.

Stunting: Children having low height-for-age because of chronic or recurrent undernutrition.

Wasting: Children having low weight-for-height. It is severe weight loss due to inadequate feeding.

Underweight: Children with low weight-for-age. Underweight children may be stunted, wasted or both.

Overweight and Obesity: A result from an imbalance between energy consumed and energy expended occurring due to consuming high sugar and fat. Body mass index (BMI) classifies overweight individuals to be 25 or more and obese to be 30 or more.

Reference:
WHO Factsheet on Malnutrition (2021)

imperative than ever for Malaysia to address this issue comprehensively (FAO, IFAD, UNICEF, WFP & WHO, 2019).

In Malaysia, 20.7% of children under five are stunted while 11.5% suffer from wasting (UNICEF, 2019a). Undernutrition among children under the age of five in Malaysia has been rising from 2006 to 2016 (Figure 4.7). Children from households with total earnings of less than RM1,000 per month are more likely to be stunted and underweight compared to children from higher income households. In 2016, more than 20% of Malaysian rural children experience undernutrition compared to children in urban households. This alarming situation is correlated to various factors such as income, ethnicity, and location (Wan Muda et al., 2019). Access to clean water and sanitation is another marker for early child nutrition related to poverty (Shakhshir, 2017; Soboksa et al., 2021). Clean water supply and adequate sanitation are also associated to positive child development (World Bank Blogs, 2020). Partap et al. (2019) also observed the correlation of increased stunting risk to water and sanitation infrastructure quality on children and adolescents in Segamat, Johor.

The Malaysian Government undertook various food and nutrition policies and programmes to improve the living conditions of the population. Earlier policies focussed on the rural population and these efforts are shifting gradually to accommodate demographic shifts (see Figure 4.8). Impact study by Chen (1989) demonstrated that protein-energy malnutrition rates declined after two years of *Rancangan Makanan Tambahan (RMT)* implementation; the prevalence of underweight children dropped from 15.3 to 8.6%, stunting from 16.3 to 8.3%, and wasting from 2.6 to 1.7%. Kandiah and Tee (1990) also found that these programmes helped increase school attendance particularly for children from poor families. All of these improvements had a significant impact in elevating the quality of life for Malaysian children.

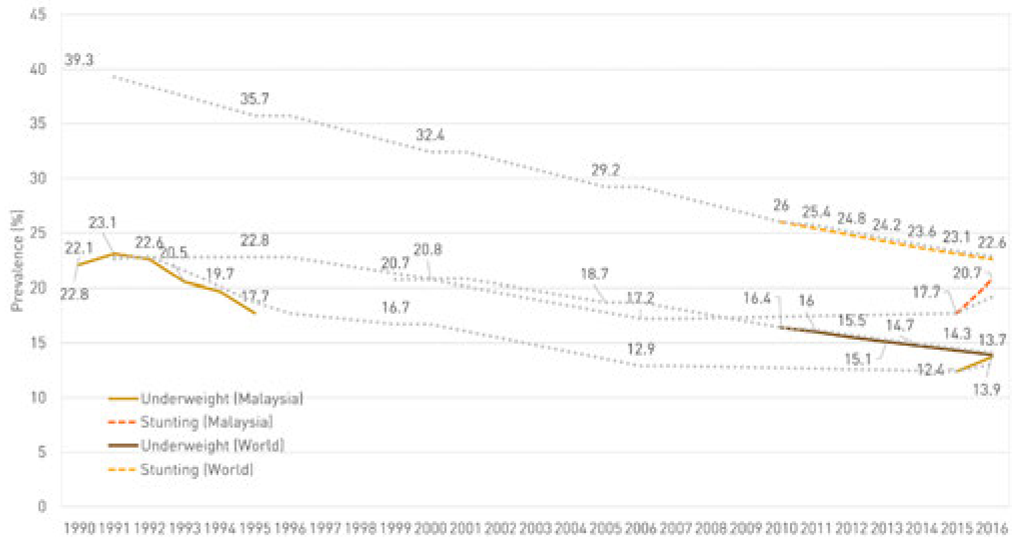


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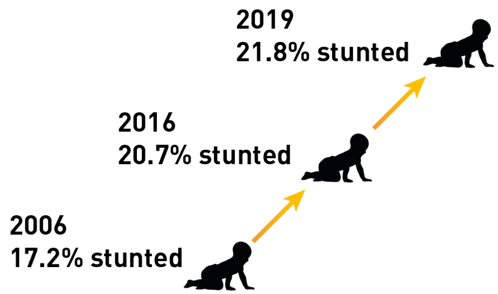
Figure 4.7: Prevalence of Underweight and Stunting in Malaysia for Children Under Five Years Old

Note: Dotted gray lines are interpolated from World and Malaysia's average data points

Kelantan, the state with the lowest GDP per capita and with seven districts identified being among the poorest in the country, has the highest number of stunted cases at 34% in 2016 well above the 20.7% national prevalence. Stunted cases in the state also increased by 83% from 10 years before.

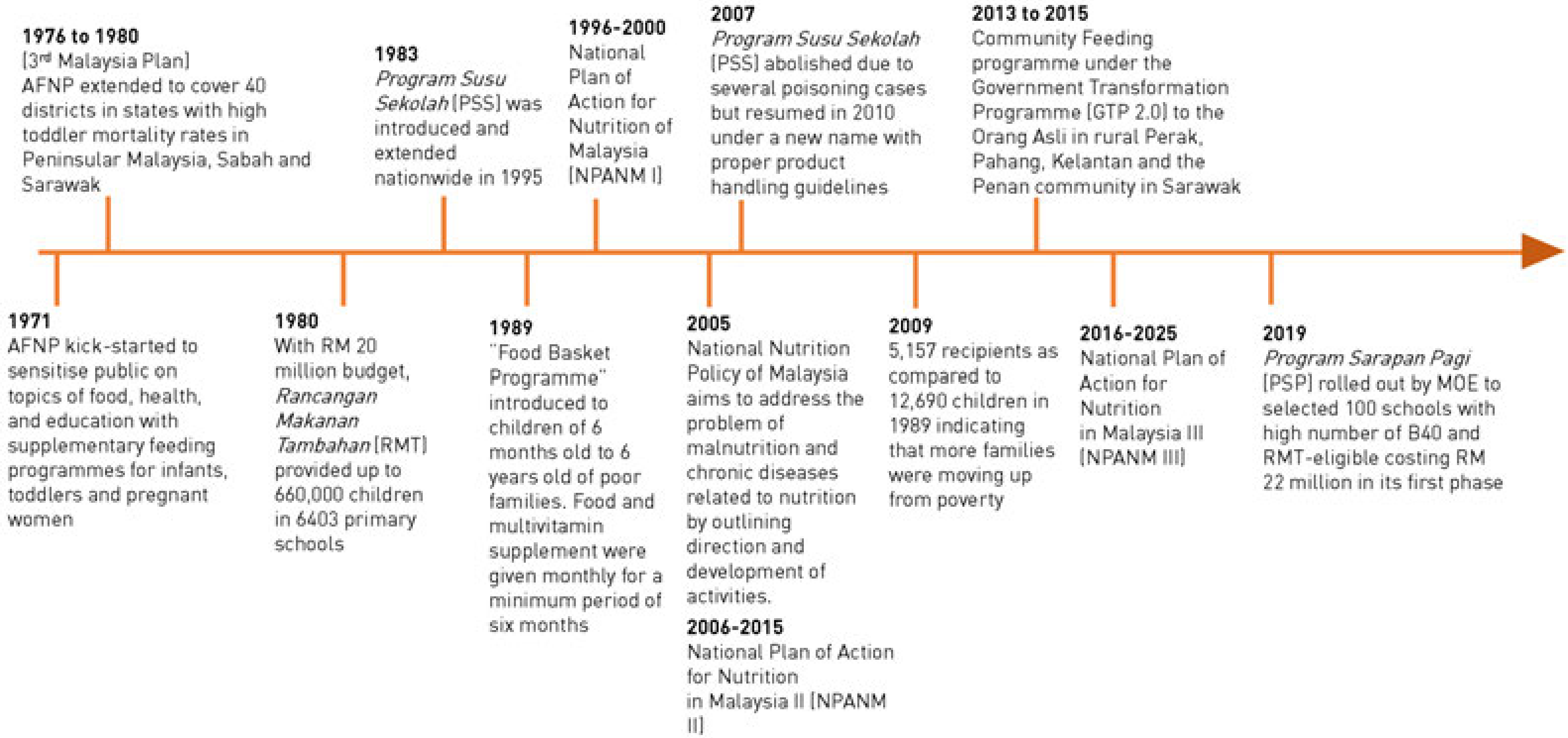
References:
Wan Muda et al. (2019), Ministry of Health (MOH) (2016)

Long-term effects of undernourishment include weak cognitive function, language and sensory-motor capacities, poor educational performance, poor health, and increased risk of degenerative diseases later in life.
References: NHMS (2019), NHMS (2016)



Difference in underweight prevalence between Malaysia and the world average:

- 0.7% in 1990
- 5.1% in 1995
- 4.1% in 2000
- 5.8% in 2005
- 1.9% in 2015



References: Wan Muda et al. (2019), Khalidi & Tan, (2020), Rancangan Malaysia ke-3 1976-1980, MOH Official Portal, Budget 2021 (MOF)

Figure 4.8: Food and Nutrition Initiatives in Malaysia over the Course of 50 Years

Such vital initiatives to secure the healthy future of Malaysian children should be further bolstered by including more stakeholders to the efforts. One way is to have dietitians and nutritionists from MOH to work together with community members and schools in developing food supplementation programme in a holistic manner while respecting dietary rules of ethnic minorities so that the children from all walks of life and background can equally benefit from the programmes. Another way is by teaching healthy cooking and food shopping skills to young people so that they learn to make the right food choices that suits their circumstances early.

KEY INTERVENTIONS

There is a need to formulate multifaceted policies and action plans:

- **that address the whole chain of issues from food security (shifting from rice self-sufficiency approach only) and agri-food sustainability to logistics, monopolies and food price control, enabling equitable access to nutritious food for all, and;**
- **focusing on the country's urban poor and hidden poor (those working but still struggling to make ends meet).**

Healthcare

Malaysia's health indicators have been increasing by leaps and bounds since the nation's independence. The average life expectancy at birth has increased from 71 to 76 years in the past thirty years, and the country's success in improving its maternal and infant mortality rate has been a sterling example for developing nations in many regions (WHO, 2018).

In the post-independence years, infectious diseases were considered to be important cause of deaths and disabilities for the citizens. Strategies to mitigate preventable infections was put in place since the first Malaysia Plan which led to the diminishing number of deaths from diarrhoeal diseases, parasitic infections, and tuberculosis (MOH Annual Report, 2011). With infrastructure development in the rural areas followed by proper intervention programmes and activities, Malaysia was able to reach zero indigenous human malaria cases in 2018, two years ahead of schedule as targeted by WHO's E-2020 initiative. Malaysia is one of the first countries in the Pacific to achieve zero mother-to-child HIV and syphilis transmission (WHO, 2018).

Nonetheless, Malaysia is still vulnerable to vector-borne diseases with dengue having the highest number of incidences in urban and peri-urban areas. Climate change is a prominent factor as warmer ambient temperature promotes insect vectors to feed and increase in numbers, leading to greater number of dengue infection (History and Epidemiology of Dengue, Accessed on 4 Sep 2020). Indiscriminate rubbish disposal and lack of efficient solid waste management is another major contributor to the increase in vector-borne diseases.

Malaysia's healthcare expenditure is equivalent to one third of what the world spends on average and its healthcare expenditure per capita ballooned by 162% within 10 years (2000 to 2010) from US$111.34 to US$292. There was a further 46% increase in the following eight years. In 2018, the healthcare expenditure per capita was highest at US$427.22 in the 18-year period of the data collection. However, this is insufficient as there are greater reliance on the health services provided by Government medical centres and clinics as seen by the waiting time and number of patients attended at those facilities.

Malaysian households spend about 40% of their household income on healthcare, almost double of the world average. As of 2017, the out-of-pocket (OOP) expenditure is the highest source of financing in the private sector at 77% with an increase of 7 times over 21 years from RM3,166 million in 1997 to RM21,573 million in 2017 (MOH, 2019a).

When a health system relies largely on OOP spending, more households are exposed to financial hardship as their ability to secure education, housing, and food diminish. Hence, health coverage policies design and implementation are critical to improve financial protection for a majority of average income households (WHO, 2019). This is worrisome as the rise in ageing population as well as the increase in non-communicable diseases (NCDs) will exert more pressure on the overall health care spending (WHO, 2011).

Gross out of pocket (OOP) expenditure includes user charges of hospitals and medical centres under the Ministry of Health, university hospitals, National Heart Institute, gross revenues from private hospitals, clinics, and dentists, private pharmacy sales, medical supplies, medical durables/ prosthesis/ equipment, ancillary services, traditional medicine, and traditional treatment provider. OOP excludes any prepayment for health services, such as in the form of taxes, specific insurance premiums or contributions.

References:
Ministry of Health (MOH) (2011), World Health Organisation (WHO) (2020).

Another factor affecting the national health budget is the reliance on imported material in healthcare delivery, from medication and instrumentation to consumables. Drugs make up more than 37% of the public sector health expenditure and it is growing more each year as more seek treatment at Government health centres for chronic illnesses (Medina, 2020). Imports of pharmaceuticals have doubled between 2006 to 2016 (Hamzah et al., 2020). The pharmaceutical industry in the country is insufficient to fulfil the demand; 69% of the manufacturers are categorised as producers of traditional medicine and only 27% produce pharmaceuticals needed by the health sector (MIDA, 2020). More local medical innovations could help improve this, but to date, Malaysian-made medical innovations are rarely taken up by the national medical community which led them to be used abroad but not locally.

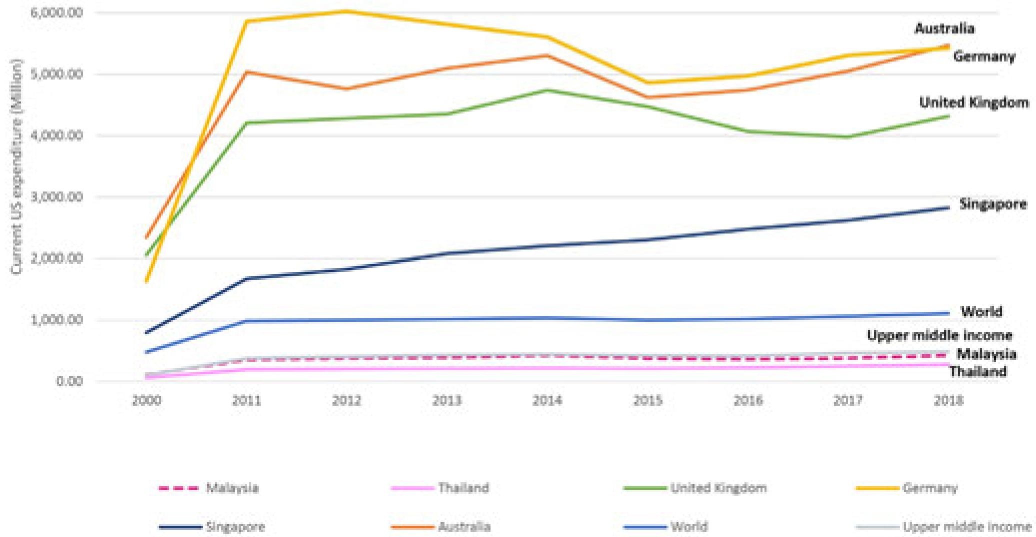


Figure 4.9: Malaysia and the World's Current Health Expenditure Per Capita

Non-communicable diseases (NCDs) have emerged as the leading cause of human mortality and morbidity in low-, middle- and high-income countries. NCDs range from diabetes, hypertension, heart disease, respiratory disease as well as mental illness. The rising incidence have been attributed to greater availability of unhealthy food in the market, lack of recreational space to encourage exercise and physical exertion, increasing pollutant levels in the air and water, as well as greater stress in today's lifestyle, and urbanisation.

The increasing affordability of sweetened beverage has been a global trend from 1990 to 2016, making type II diabetes more prevalent in the developing economies (Blecher et al., 2017). As part of the efforts to nudge Malaysians to consume less sugar, an excise duty of RM0.40 per litre was imposed on sugary beverages in 2019; it is expected to reduce consumption by 10% to 12% (MOH, N.D.). To support rising healthcare cost, it was suggested that the revenue from cigarettes and alcohol sales be earmarked for national health priorities (Galen Centre, 2018).

Mental health is another NCD of concern; the diseases are invisible but can have devastating effects. Based on the National Health and Morbidity Survey (NHMS) 2019, one in three Malaysians is reported to have experienced mental health problems and roughly half a million adults suffer from depression in the country. Prevalence of mental health issues in Malaysia has tripled from 10.7% in 1996 to 29.2% or 4.2 million people in 2016. Sabah and Wilayah Persekutuan Labuan recorded the highest prevalence among adults, more than 10% higher than the national average. This finding is also borne out by a survey of more than 17,000 employees from 230 organisations where 50.2% of employees have at least one dimension of work-related stress. The survey also found that mental issues could lead to staff absences and turnover (AIA, 2020).

More than 400,000 children aged 5 to 15 years old suffer from mental health problems, most dominantly contributed by peer pressure (MOH, 2019). Depression and anxiety are also two disorders commonly seen in adolescents. Occurrence of suicidal ideation among youths of 16 to 24 years old was recorded at 2.4%. According to Berry et al. (2018), causes of mental health issues among youths in Malaysia include academic pressures, childhood adversity, socio-familial factors, and economic inequality. Unfortunately, no data from previous years are available for comparison purposes.

School counsellors are slated to help students with their academic and career goals, address behavioural issues, taking action in cases of neglect and abuse, and support for disciplinary issues. It is clear that the role of school counsellors in providing mental health support – be it diagnoses and follow up – for students must be strengthened through appropriate training. Collaboration between MOH and Ministry of Education (MOE) can help fill the capacity building gap to be supported by appropriate guideline from MOE.

Bottom 40 (B40) households are the most vulnerable to mental health issues, followed by the Middle 40 (M40). Between 1996 and 2015, the difference in prevalence rate was higher in groups earning RM3,000 and above at 23.2% as compared to groups earning less than RM1000 at 18.9%; however, the prevalence among the latter increased by 2.5 times within that time period. Rohde et al. (2016) suggested that the increase is associated with factors such as job insecurity, income reduction and volatility, inability to meet essential needs, and restricted access to emergency funds experienced by these groups. The feeling of material inadequacy, lack of financial safety net during emergencies, and inferiority complex

Box Article 4.7: The Threat of Non-Communicable Diseases (NCDs)

The most recent National Health and Morbidity Survey (2019) indicates that the prevalence of overall high blood glucose in Malaysia is 18.3% and 30.0% for hypertension; these numbers are increasing with age. Major risk factors for type II diabetes and high blood pressure are unhealthy diet (calorie dense and insufficient dietary fibre), high salt intake, and physical inactivity. These two chronic diseases are major contributing factors of heart disease, which is the number one killer in Malaysia. Data collected by MOH also indicated the rise of mental illness and associated mental health issues.

The National Strategic Plan for Non-Communicable Diseases mapped out the prevention and regulatory interventions to address the NCD epidemic which includes stakeholders across the Ministries to ensure whole government intervention, and whole society stakeholders such as non-governmental organisations, professional organisations, industries and the media.

However, the messages seem incomplete and lack direction. For instance, the national guideline for local authorities on the sale of unhealthy food and drinks outside school compounds to reduce child obesity are rarely enforced. The lack of comprehensive database on the salt content of processed food in Malaysia is a significant barrier to successful implementation of the salt reduction initiative in the country. Enforcement of real estate development with designated green lungs and design to encourage physical activities appear to be patchy. The lack of accessible communal recreation infrastructure in the suburbs and inner city makes it hard for the community to exercise and build social network around physical activities. Ministry of Agriculture should play a greater role in enhancing the production of fresh food and working together with the relevant agencies to ensure the stability of the food supply chain, which vulnerabilities were exposed by the first movement control orders (MCO) in second quarter of 2020. Greater mental health support across all demographics – whether urban, suburban, or rural – is desperately needed but unmet due to the lack of trained professionals in psychiatry, psychology, and counselling.

The factors influencing the rise of NCDs in Malaysia are complex and intersectional; all stakeholders need to work together to push and implement coherent policies and actions that can effectively address the fundamental issues needed to support healthy living for all Malaysians such as poverty, social security, education, food safety and security, and infrastructure.

References:
Department of Statistics Malaysia (DOSM)(2020e), Ministry of Health (MOH)(2016), Shahrir et al. (2019)

Table 4.3: Number of Mental Health Personnel from 1991 to 2019

	1991	1995	2000	2005	2010	2015	2019
Psychiatrist (Ratio per 100,000 population*)	10 0	34 0	45 0	NA NA	229 ~1	360 1	400 1
Clinical psychologist	NA	NA	NA	NA	3	14	29
Counsellor	NA	8	12	45	95	159	148
Trained nurse	NA	NA	NA	NA	NA	NA	920

NA: Data not available [Courtesy of Planning Division, MOH, 2020] *Estimation based on population of the year can lead to stress, anxiety, and depression (Rodman, 2019). These two groups tend to lack the resources needed to address their mental health issue, which can worsen other co-morbidities, reduce quality of life, as well as reduce capacity for socioeconomic mobility (Shahar et al., 2019).

Untreated mental health issues can lead to suicide and chronic suicidal thoughts may occur in individuals with a long-term crisis, often with intense but invisible psychological pain outsiders (Freedenthal, 2017). According to WHO, nearly 800,000 people die from suicide every year; it is the second leading cause of death in 15 to 29-year-olds (WHO, 2021b). Based on the last published data in 2009, the suicide rate in Malaysia was 1.18 per 100,000 population. What is of greater concern is the increase in suicide mortality by 17.4% between 2000 to 2016 (see Figure 4.10). The latest statistics revealed a staggering record of more than 400 suicide cases within the first five months of 2021 (The Malaysian Reserve, Accessed on 1 Jul 2021), or an average of nearly four suicide cases every day (Choon, 2021), due to severe emotional and psychological distress, as well as family and financial problems that arise from the COVID-19 pandemic.

Section 309 of the Penal Code that punishes suicide attempts need to be revised as this further stigmatises mental health issues, prevents suicidal people from getting the help they need, and place unnecessary burden on the criminal justice system. This underlines the desperate need for Malaysia to have better social safety net that can provide a buffer against such difficult times.

Box Article 4.8: Mental Health Personnel and Facilities

Although the number of mental health workers have increased over the years, the number is insufficient considering the need per capita. Psychiatric services are heavily weighted in the urban areas and the numbers of clinical psychologist are still desperately low. Malaysia only has one psychiatrist to 100,000 population; the recommendation by the American Psychiatric Association and the World Health Organization is one psychiatrist per 10,000 population. In 2018, only 15 clinical psychologists were employed in the public health service sector.

MENTARI was initiated by MOH under the Mental Health Act 2001 which provisioned for community-based treatment and care. MENTARI are community mental health centres aimed to improve interaction and reintegration of mental health patients into the community. These centres provide accessible continuous treatment, psychosocial interventions, and promote screening and early treatment of mental illness. Each MENTARI is led by a psychiatrist with supporting medical officers, occupational therapists, nurses, medical social workers, and volunteers for non-clinical assistance. The centres are managed by Department of Psychiatry and Mental Health of the nearest public hospital.

References:
Lim, S.L. (2018) and Chua, S.N. (2020)

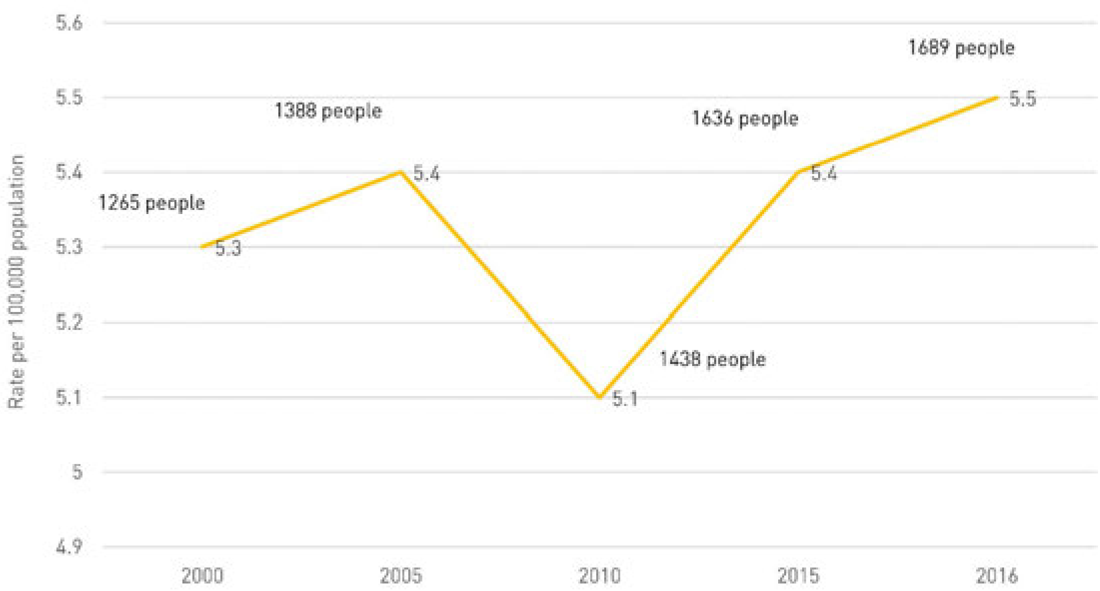


Figure 4.10: Suicide Mortality Rate in Malaysia, 2000-2016

Mental health problems do not only affect those suffering from it, it is also detrimental to the economy. In 2018, poor mental health conditions at the workplace were estimated to cost RM14.46 billion to the national economy and a total of RM345 million was spent on mental care and treatment (Chua, 2020). However, in 2019, the budget allocated for psychiatric and mental health was reduced to RM335 million (Galen Centre, Accessed on 13 Nov 2020). Spending related to mental illness is estimated to be only one per cent from the total health budget which is inadequate in the face of increasing mental health burden.

Table 4.4: Estimation of Economic Loss Cost Due to Mental Health Burden in 2018

Size of labour force	15.23 million
Mean daily wage	RM 134
Total cost of absenteeism due to mental health conditions	RM 3.28 billion
Total cost of presenteeism due to mental health conditions	RM 9.84 billion
Total cost of staff turnover due to mental health conditions	RM 1.34 billion

Reference:
Chua, S.N (2020)

Note: This table shows estimation of labour force affected, daily wage and costs incurred in terms of staff absenteeism, presenteeism (working while unwell) and turnover due mental health conditions (for year 2018)

KEY INTERVENTIONS

1. **There is an urgent need to increase the number of psychiatrists and clinical psychologists to achieve WHO recommended level.**

2. **It is also timely to Improve the provision of adequate mental health professional support by training and reskilling more graduates, first responders, and teachers on psychiatry and psychology.**

3. **Alternative medical intervention via tele-health consultation for health professionals to scale up patient reach should be scaled-up.**

BUILDING AN INCLUSIVE AND EQUITABLE MALAYSIA

One of the goals in nation building is for the citizens to have the opportunity to enjoy a better life than those before them. This involves fair and equitable distribution of wealth and sustainable growth that provides the citizens opportunity to move up to a higher level of education or income group without being hampered by their gender, race, class, or other disadvantages. Promotion of socioeconomic mobility is the foundation to reducing income disparity, foster fiscal growth, as well as building social cohesion (KRI, 2016). Among the dimensions used to determine socioeconomic mobility are education, occupation, and income (WEF, 2020). Nearly all of the national development plans incorporate these three parameters in one form or another.

Education

Education is a fundamental human right entrenched in the Universal Declaration of Human Rights (UDHR) as articulated in Article 26 of the UDHR that everyone shall have the right to free and compulsory education, at least in the elementary and fundamental stages (SUHAKAM, 2013). The right to education is also one of the key principles underpinning the United Nations Education 2030 Agenda and Sustainable Development Goal 4 (SDG4) to ensure inclusive and equitable quality education and promote lifelong opportunities for all.

The Malaysian education system has made tremendous progress in laying the foundation for the talent of the nation. The Rahman Talib report initiated free education at primary level since 1961, making basic literacy and numeracy skills accessible to the poor. In 1970, *Bahasa Melayu* was introduced as the official medium of instruction in all government schools and this change was implemented at the tertiary level in the mid-1980s. This reform increased access to education especially for the rural people and became an important tool to integrate the multiracial society as well as to eradicate poverty as addressed in the New Economic Policy (NEP).

For all its shortcomings, the education system has been instrumental in the dramatic increase of adult literacy rate in Malaysia from 50% in 1957 (Pandian, 1997) to more than 94% by 2018, which is way higher than the world average and only less than 1% lower than the average of East Asia & Pacific region countries (Figure 4.11). The change in adult literacy occurred mainly through formal education at a young age (UNESCO, 2017).

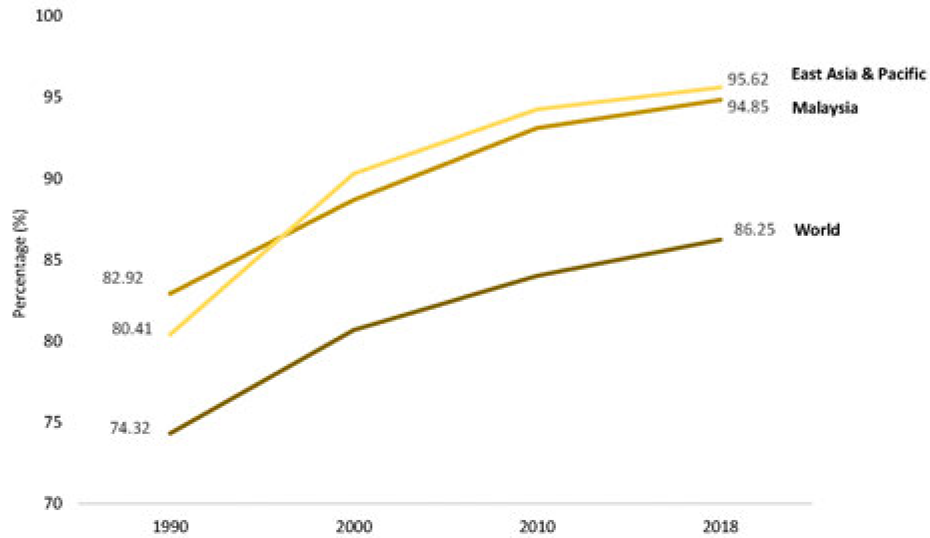


Figure 4.11: Growth of Malaysia's Literacy Rate as Compared to East Asia and Pacific Countries and World

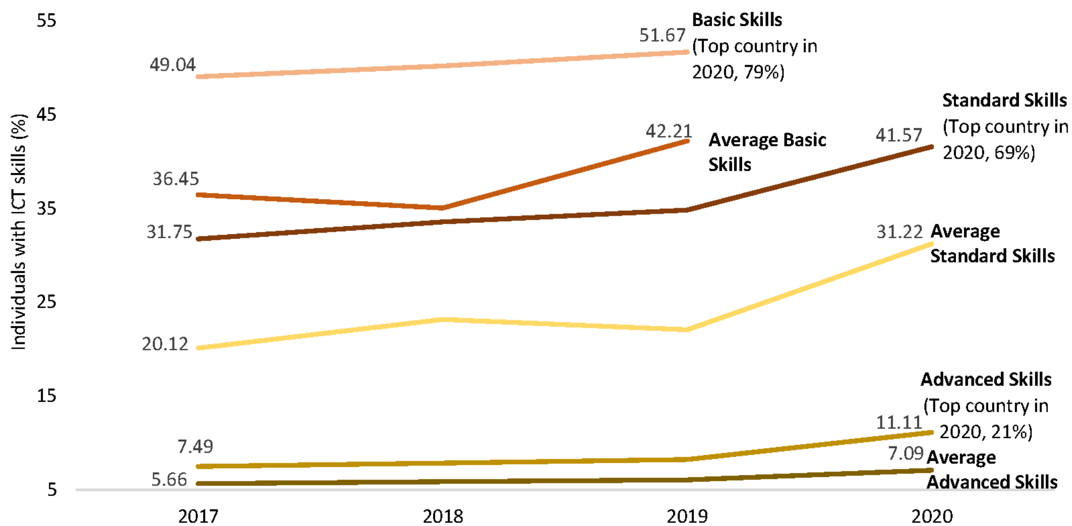


Figure 4.12: Growth of ICT Skills in Malaysia as Compared to Other Countries (2017-2020)

Notes: Data for basic ICT skills for year 2020 is unavailable

Literacy has a direct impact on the standard and quality of living in today's life. A person with good literacy skills can gain the qualification needed to better their chance to secure a good job for their future; however there is still a small number of people who are illiterate due to no opportunity for schooling, early dropout, and inappropriate education approach (Abadzi, 2003).

Poverty is one of the significant factors that affect literacy. Children from the low-income background are most likely to be out-of-school, at risk of dropping out, live in a remote location that has no school, little awareness of the importance of education (MOE, 2013), experience domestic violence, lack of discipline or undocumented citizens (KPM, 2017). Furthermore, children are also more likely to be out of school if their parents have no formal education. Poverty and parental apathy towards education results in many boys skipping or dropping out of school to work and girls foregoing their education to help with chores and caregiving duties (UNICEF, 2019c). Learning and other disabilities also contribute to this issue; at least half of registered children with disabilities are not enrolled for school at all levels of education (Zaki et al., 2019). They are also more likely to be absent from school compared to children without disabilities (UNICEF, 2019c).

Only six years of primary education is compulsory in Malaysia while secondary enrolment is optional; another factor why transition rate of primary student to secondary school in Malaysia is only 91.05% in 2016. The Government implemented Zero Student Dropout Programme in 2018 *(Program Sifar Murid Cicir)* to increase enrolment and to ensure all Malaysian children of school age is getting proper education (KPM, 2017). The enrolment rate increased positively after the implementation of the programme where the transition to secondary school has increased to 98.42% in 2019 (MOE, 2020).

The other important component is the digital literacy. The importance of digital transformation is gaining traction in most developing economies as such building proficiency in digital literacy skills are imperative.

Malaysia too has been progressing over the last four years (Figure 4.12). The MyIkrar programme under the recently launched Malaysia Digital Economy Blueprint (MyDigital) aims to enhance efforts to increase digital literacy and skills of Malaysians (EPU, 2021b).

Technical and vocational education and training (TVET) to build capacity for semi-skilled and technical talents is no longer the undesirable option for the less academically inclined, but a competitive avenue for post-secondary opportunities. RM6 billion was allocated in Budget 2021 to strengthen TVET stream through various initiatives (NST, 2020b). The mounting demand for tertiary education in the 1990s eventually led to a higher education reform which included the expansion of private tertiary education institutions. This growth was funded by the Perbadanan Tabung Pendidikan Tinggi Nasional (PTPTN), which provide loans for higher education to those from the M40 and the B40. The gross enrolment in tertiary education increased from 7.2% in 1990 to 43.1% in 2019, with the highest enrolment in 2016 at 46.8% (World Bank, 2020b).

Basic ICT Skills: The highest value among the following four computer-based activities: copying or moving a file or folder; using copy and paste tools to duplicate or move information within a document; sending e mails with attached files; and transferring files between a computer and other devices.

Standard ICT Skills: The highest value among the following four computer-based activities: using basic arithmetic formula in a spreadsheet; connecting and installing new devices; creating electronic presentations with presentation software; and finding, downloading, installing and configuring software.

Advanced ICT Skills: The value for writing a computer programme using a specialised programming language.

Reference:
International Telecommunication Union (ITU) (2021)

National Dual Training System (NDTS)

This programme was adapted from the Germany Vocational Education and Training system (VET-system) and caters to eligible school leavers and existing workforce. Students were taught theoretical knowledge at the training centres, while the work-based learning was carried out at participating companies. Graduates receive national skills qualification by the Department of Skills Development (DSD) upon successful completion of the two-year programme.

This programme is hampered by the industry's lack of preparedness to be part of TVET development. This is supported by the findings of the Critical Skills Monitoring Committee (2020) that local employers – particularly the small and medium enterprises (SMEs) – are not ready to adapt to the changes demanded by the global economy.

References:
Ali, J. M. (2019) and Critical Skills Monitoring Committee (CSMO) (2020)

Box Article 4.9: TVET in Malaysia

The first TVET institution, Teacher Technical School was built in 1904 to train technician to work for the Departments of Railways, Survey, and Public Works of the Federated Malay States. In 1941, this school was upgraded to a technical college, and it is now known as Universiti Teknologi Malaysia.

Since independence till present, Malaysia has established numbers of vocational and technical secondary schools, polytechnics, community colleges and technical universities to prepare skilled or semi-skilled talent.

TVET programmes are offered at certificate, diploma, and degree levels by several ministries. Ministry of Higher Education (MOHE) offers accredited TVET programmes while the skills training programmes are under the Ministry of Human Resources (MOHR).

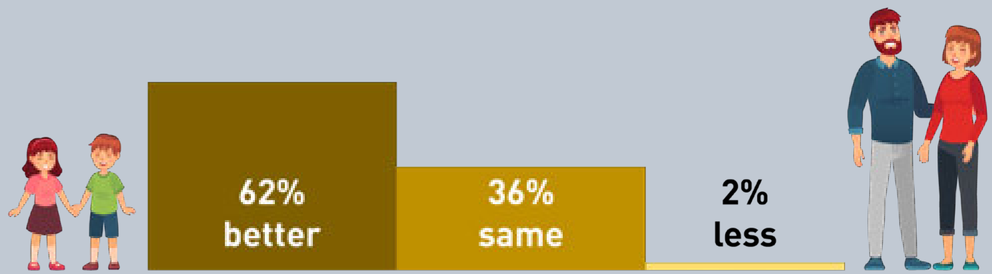
The National Competency Standard was introduced in 1996 as reference for TVET provider; sadly it has not realised its full potential due to the lack of harmonisation between the standards developed by the Department of Skills Development and the different academic and vocational qualification framework that has multiple levels of specificity. To address this, a national level Technical and Vocational Education Training Empowerment Committee was set up in 2019.

In 2021, the National TVET Council (MTVET) was established to improve the coordination of the country's TVET ecosystem to support the national growth agenda.

Reference:
Universiti Teknologi Malaysia (UTM) (N.D.)

Box Article 4.10: The Level of Children Education Compared to their Parents

Khazanah Research Institute conducted a study on intergenerational socioeconomic mobility in 2016 and found that the educational attainment is one of the factors that help to improve socioeconomic mobility (Figure 4.13). It is good to note that education mobility is high in Malaysia; 62% of children obtain better education than their parents, 36% had the same education level, while only 2% had a lower education level than their parents. Furthermore, among those born to parents without formal education, 33% have attained tertiary education, while those born to tertiary-educated parents mostly are highly educated regardless of ethnicity. This indicate that most Malaysian parents acknowledge the importance of good education as a critical factor in promoting upward socioeconomic mobility, apart from saving, gender, and location, particularly for the B40 group.



Reference: Adapted from Khazanah Research Institute (KRI) (2016)

Figure 4.13: Children Education Compared to Their Parents

Employment

Although many studies indicate that higher education and advanced training pave the path towards higher income bracket, the reality on the ground is not as straightforward. Graduate unemployment and underemployment in Malaysia have long been a perennial issue; extensive analyses on this issue are available in previous Science Outlook reports.

Pre-pandemic data indicated that the rate of graduate employment has gradually increased throughout the years, with 63.5% in 2019, the highest in the six years (Figure 4.14). In 2019, the youth unemployment rate in Malaysia was at 11.77%, which is comparable to neighbouring Singapore at 11.5% (World Bank, 2021b). However, the COVID-19 pandemic increased the youth unemployment rate to 13.6% by May 2021 (DOSM, 2021a), contributing to one out of every two youngsters' lives in absolute poverty (UNICEF, 2020).

Furthermore, the available data on the employment is insufficient to determine whether the graduates are employed in the areas of their training or making do with any jobs available, or if they are building a business instead of working for others. The lack of information makes it difficult to formulate measures to bridge industrial needs and training of talent resources in the country. The MOHR produced the Critical Occupations List periodically to identify skill gaps needed in the job market; however, the translation into changes in education at all levels are still slow.

Data from DOSM indicated that most Malaysians are employed in semi-skilled jobs, followed by skilled and then low-skilled (Figure 4.15). At present, the skill-related underemployment accounted for 2.09 million persons or 37.5% of the total employment with tertiary education. The share and number of employed persons in this category were increasing as more graduates in the country are taking up jobs which do not match their qualification to make up for slower demand of skilled jobs (DOSM, 2021b). This suggests that the economy has not created sufficient high-skilled jobs to absorb the number of graduates entering the labour force (BNM, 2018).

The Critical Occupations List reflect a similar trend; nearly all the jobs listed fall either in the high-skilled or semi-skilled category, (CSC, 2020), which means access to higher education and training is an important driver in pushing socioeconomic mobility. However, more data is needed to examine whether the job market is in step with the talents need and vice versa.

The development trajectory for Malaysia to become a high-income nation in 2030 and the need for relevant human capital to power that growth are discussed in **Chapters 3 and 6**.

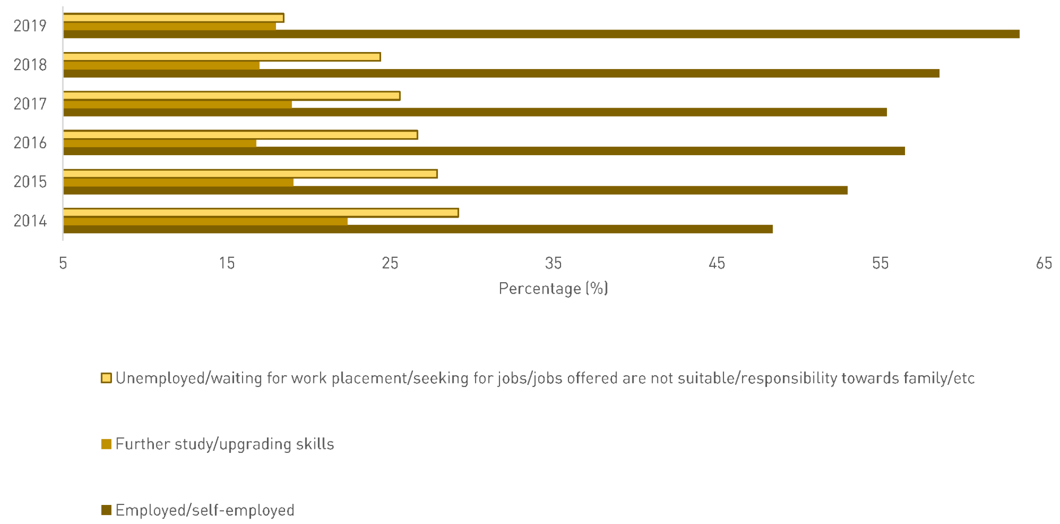


Figure 4.14: Graduate Employment Rate, 2014-2019

Skilled: manager, professionals, technician and associate professionals

Semi-skilled: clerical support workers, service and sales workers, skilled agricultural, forestry, livestock and fishery workers, craft and related trades workers, plant and machine operators and assemblers

Low-skilled: elementary workers

Reference:
Ministry of Human Resources (MOHR) (2020)

Note: Skill levels were classified based on the Malaysia Standard Classification of Occupation (MASCO) 2013

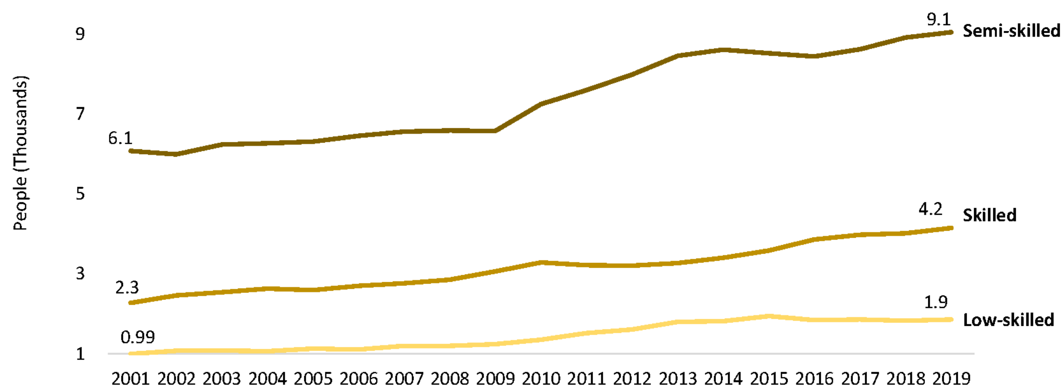


Figure 4.15: Employed Person by Occupation Sector (2001-2019)

The unemployment rate has risen to 5.3% in May 2020, the highest in 30 years, due to the trend for automation and COVID-19 global recession (DOSM, 2020f). To curb the unemployment issue, job mismatch, and create more opportunities for fresh graduates and retrenched workers, the Government established the National Employment Council (NEC) chaired by the former Prime Minister, YAB Tan Sri Muhyiddin Yassin in December 2020. This council is mandated to create and preserve jobs in line with the first objective of Budget 2021, "People's Well-being" and address issues related to underemployment and equal opportunity for the vulnerable. The council aims to create about 500,000 jobs in 2021 to cater needs of the nation through several platform under MOHR, such as UpskillMalaysia, MYFutureJobs and e-LATiH (PEMERKASA, 2021).

Roughly 1.5% of the Malaysian population lives with a disability (HRDF, 2019). The Persons with Disabilities Act was introduced in 2008 to promote and protect the rights of persons with disabilities (PWDs). Provisions of the act include promoting access to physical, social, economic, and cultural environment, to health and education that enable PWDs to fully participate in society. In terms of employment, the private sector employs almost three times as many PWDs compared to the civil service, with the largest segment of the jobs in sales and services as well as manufacturing operators and assemblers (HRDF, 2019). Qualified and trained PWDs are an enormous untapped human capital; tax breaks and grant incentives are available to encourage employers to take up PWDs as part of their workforce. The pandemic is a watershed that illustrate how considerations for PWDs to be employed such as flexible working hours, accessible recruitment process, conducive work environment, and assistive technology can be made the norm rather than the exception. Through the Wage Subsidy Programme 1.0 *(Program Subsidi Upah)*, 494 PWDs had successfully secured jobs during this difficult time (DOSM, 2021c).

UpskillMalaysia: Provides access to training programmes, job opportunities, entrepreneurship skills, advisories, career planning support and details on employment laws.

MYFutureJobs: Provides universal employment platform and free labour market services for all job seekers, encouraging social inclusion particularly in recruitment processes and delivering efficient labour market policies.

e-LATiH: Provides access to 300 and more courses that meets the demands of various industries.

Women in Malaysia have made inroads in all aspects of development in the country since before the Independence. Their input and struggles shaped the social, economic, and political landscape of the nation. They have unrestricted access to education and make up 56.17% of the students in Higher Learning Institutions (HLIs) across Malaysia in 2019. The number keeps increasing throughout the years (Data Terbuka Malaysia, 2021). Women with higher education qualifications have a higher labour force participation rate (LFPR) than men (Figure 4.16).

World Bank's Enterprise Survey (ES) shows that about a quarter of all Malaysian firms have a female top manager (Figure 4.17). Female top managers are more likely to be found in large firms than in small firms, mostly in the retail sector, and in exporting than in non-exporting firms (Figure 4.18). In contrast to what the literature elsewhere might suggest, in Malaysia, firms with a female top manager have higher labour productivity on average than firms with a male top manager (Figure 4.19) However, the business environment, along with several important dimensions such as the regulatory burden, corruption, and the crime and security environment, is more difficult for firms with female top managers (Amin and Zarka, 2018).

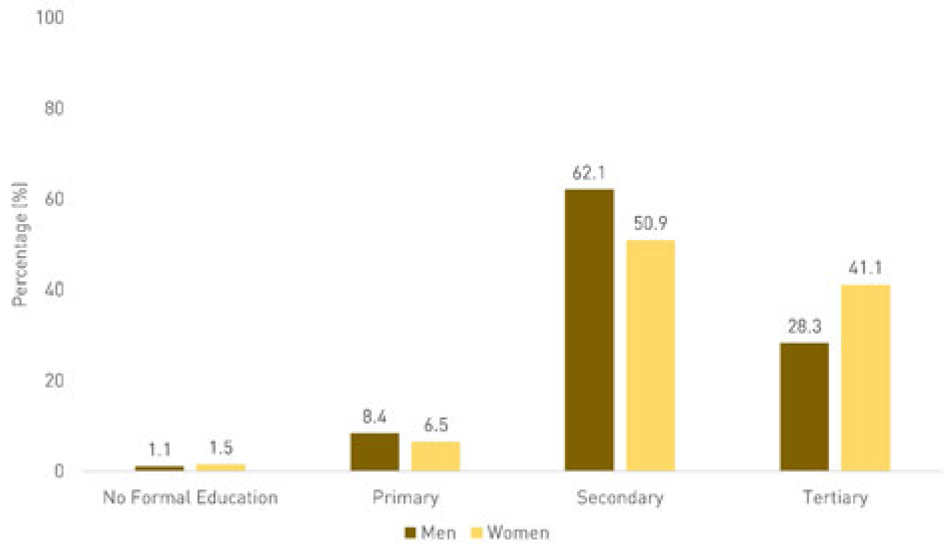
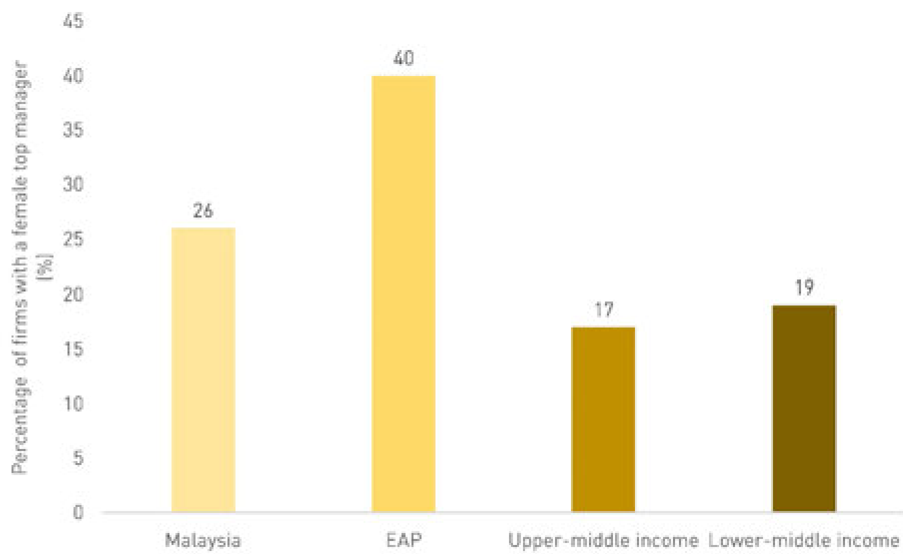


Figure 4.16: Employed Malaysian by Educational Attainment based on Gender, 2019



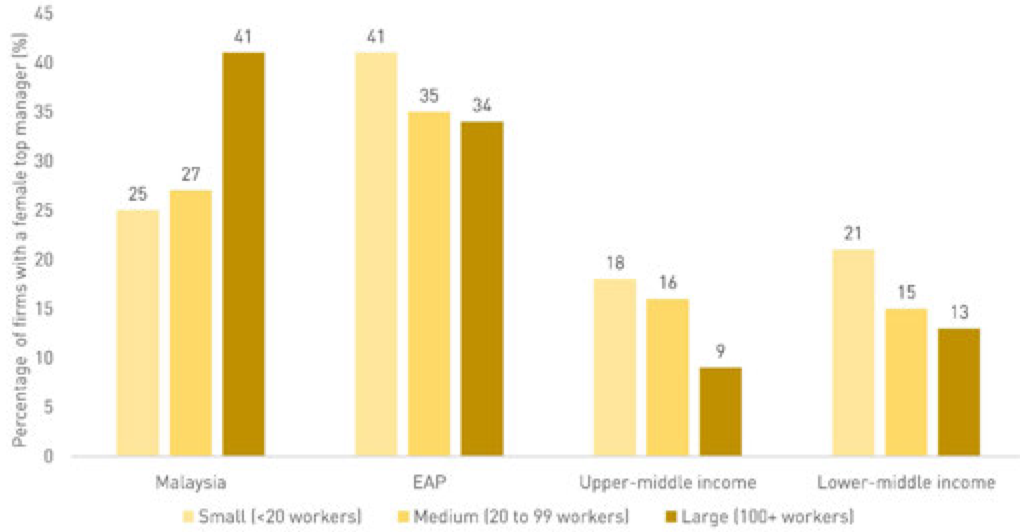
Reference: Adapted from Amin, M & Zarka, A (2018)

Figure 4.17: Comparison of Percentage of Firms with Women as Top Manager

Note: EAP - East Asia & Pacific

In Malaysia, there is virtually no barrier for females to enter any industry or occupations. Most women are employed in wholesale and retail trade, followed by manufacturing, education, and accommodation and food service activities. However, after the prime age of 25-34, LFPR dropped and continue to decrease across the age groups of labour force (DOSM, 2020g). In 2020, a total of 4.9 million women were outside of labour force and about 60.5% do so because of family responsibilities, further decreasing the availability of skilled talents in the nation (DOSM, 2021b).

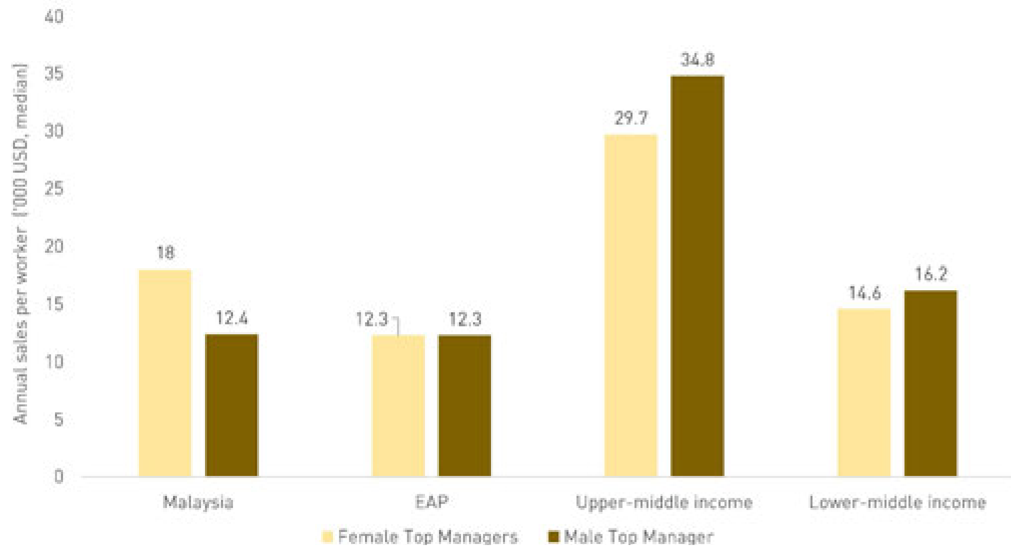
To encourage women to return to the labour market, the Government established several initiatives such as TalentCorp's Career Comeback Programme and Career Comeback Tax Exemption, and the Women@Work programme. Transforming state-sponsored caregiving and childcare support could be the solution to women struggling to balance the needs of their profession as well as duty to their family, as well as reducing economic loss from absenteeism, presenteeism, and loss of skilled talents.



Reference: Adapted from Amin, M & Zarka, A (2018)

Figure 4.18: Size of Firms with Women as Top Managers

Note: EAP - East Asia & Pacific



Reference: Adapted from Amin, M & Zarka, A (2018)

Figure 4.19: Productivity and Sector of Women-Managed Firms

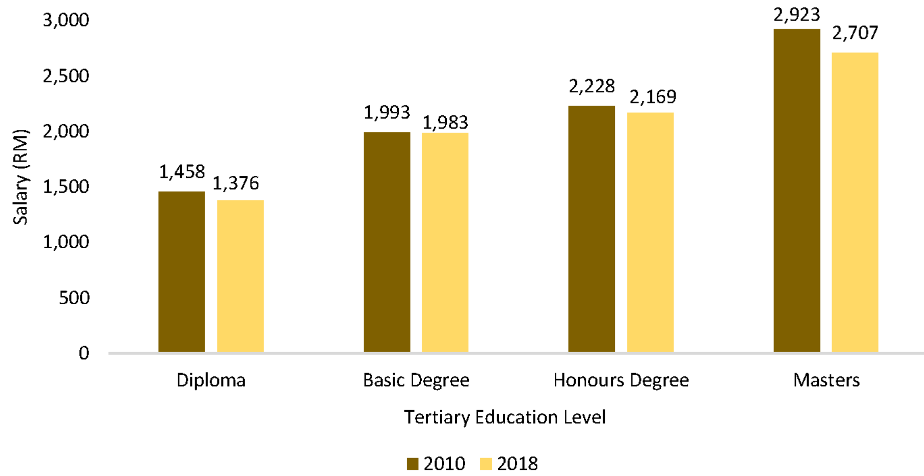
Note: EAP - East Asia & Pacific

Income

The number of graduates produced between 2010 to 2017 has surpassed the number of jobs created (BNM, 2019b), which lowered wages in private firms compared to the public sector. In fact, the median monthly income for those between 20 to 29-years-old with tertiary education has been stagnant since 2004 (World Bank, 2019) and their starting salaries has been on the decline between 2010 to 2018 (BNM, 2018) (Figure 4.20).

The wage for some areas in the private sector is even below Malaysia's poverty line income of RM2,208. The economic contraction caused by the pandemic lowered the salary of fresh graduates even further; their salary now is between RM1,001 and RM1,500 in 2020 as compared to RM2,001-RM2,500 in 2019 (Malay Mail, 2021). Graduates in Malaysia who managed to secure a job within their field earn around RM 2,000 per month (USD485), which is nearly on par with graduates in Thailand and Vietnam who earned USD480 and USD380 respectively, while graduates in Singapore can command USD 2,722 per month (Aun, 2020).

Although Malaysia has managed to eradicate absolute and hardcore poverty, relative poverty continues to worsen. The poverty line income used in crafting the policies was too low in comparison to the nation's growth which masked the true picture of socioeconomic disparity in the country. One of the focus areas in the mid- term review of 11th Malaysia Plan (11MP) is to set a target in raising the B40 households into the middle-class community by raising the B40 household income distribution from 16.8% in 2014 to 20.0% by 2020. Unfortunately, it declined instead to 16.4% in 2016, and 16% in 2019 (DOSM, 2020d). The income imbalance is reflected in the Gini coefficient which increased to 0.407 in 2019 as compared to 0.399 in 2016 (Figure 4.21).



Reference: Adapted from Bank Negara Malaysia (BNM) (2018)

Figure 4.20: Real Minimum Monthly Basic Salary for Fresh Graduates, 2010 and 2018

Household income has been rising unevenly in the past thirty years; this progress was affected by the various global financial crises and slowdowns in this time frame (see Figure 4.22). The sluggish wage growth affects socioeconomic mobility of the B40s who make up about half of Malaysian workers, or 4.4 million people who earn RM2,160 or less a month (BNM, 2018). This partly reflects unbalanced job creation and wage distribution across different occupational skill levels.

Theoretically, the increase in income will indirectly increase the purchasing power. However, as the B40 group experienced slower income growth throughout the years, the increase was almost completely offset by the increase in the cost of living especially for people in the urban area. Furthermore, they also have to grapple with subsidy rationalisation, the introduction of Goods and Services Tax (GST) followed by Sales and Services tax (SST), and the depreciation of the ringgit.

In contrast, the T20 and M40 households possess higher income buffers due to their greater income increase. The uneven distribution of income and the cost of living prevent some households from realising their aspiration for a higher standard of living, or even enjoying meaningful societal participation and opportunity for personal or family development (Zukki et al., 2018).

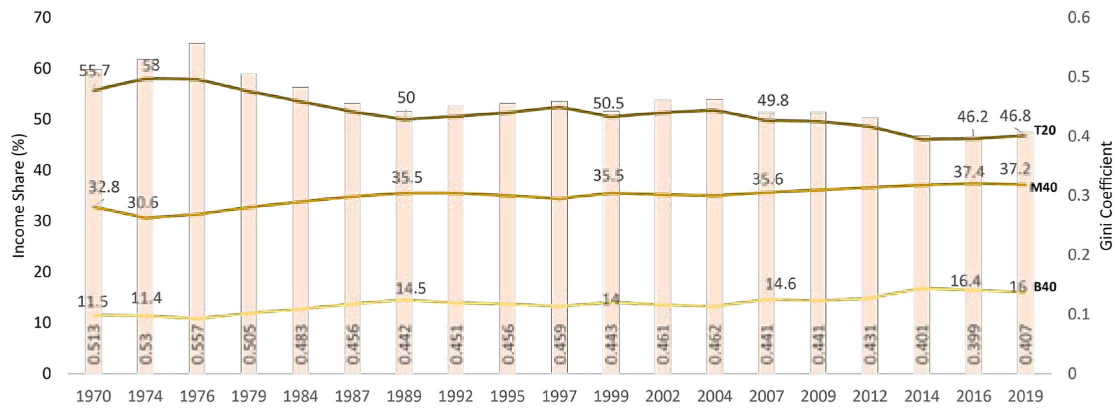
The unabated rise in the cost of living and COVID-19 pandemic has dealt the urban poor a devastating blow. The pandemic highlights the financial precariousness of many Malaysians due to reduced job prospects and a lack of precautionary savings. It is reported that seven out of ten heads of households were having trouble meeting basic needs. Around 37% were unable to buy enough food, and 35% could not pay their expenses on time (UNICEF, 2020). Most of the assistance provided to alleviate financial hardship from the pandemic is aimed for the B40s. Unfortunately, the M40s receive little help for them to sustain themselves. This may increase the section of the B40 to become B50 as more of those on the lower end of M40 has slipped down the economic ladder. The Economic Action Council (EAC) had announced that 600,000 of M40 households, or at least 8% of Malaysian households, have slipped into the B40 category due to the pandemic (The Star, 2021). In fact, in the Salaries and Wages Report 2020, it is reported that the salary for all workers, regardless of the education level, occupational skill (skilled, semi-skilled, low-skilled), age, gender and location (urban and rural) declined in 2020 due to the pandemic and MCO (DOSM, 2021d). Therefore, targeted social security schemes are of paramount importance to address this issue, and the data collected must be disaggregated appropriately for proper analyses to be conducted.

KEY INTERVENTIONS

1. **Starting salaries (with allowances) must be revised and adjusted to be higher than the poverty line. This review must be done periodically, preferably with every Malaysia Plan.**

2. **A policy to ensure competitive starting salary for graduates employed both in public and private sector must be formulated to enhance upward socioeconomic mobility.**

3. **Formulate multifaceted strategies to reduce inequities suffered by Malaysians and promote upward mobility through social cohesion and economic stability from deep analytics of the socioeconomic disparity data.**



Reference: Adapted from Department of Statistic Malaysia (DOSM) (2020d)

Figure 4.21: Time Series of Gini Coefficient and Income Share by Household Group, Malaysia, 1970-2019

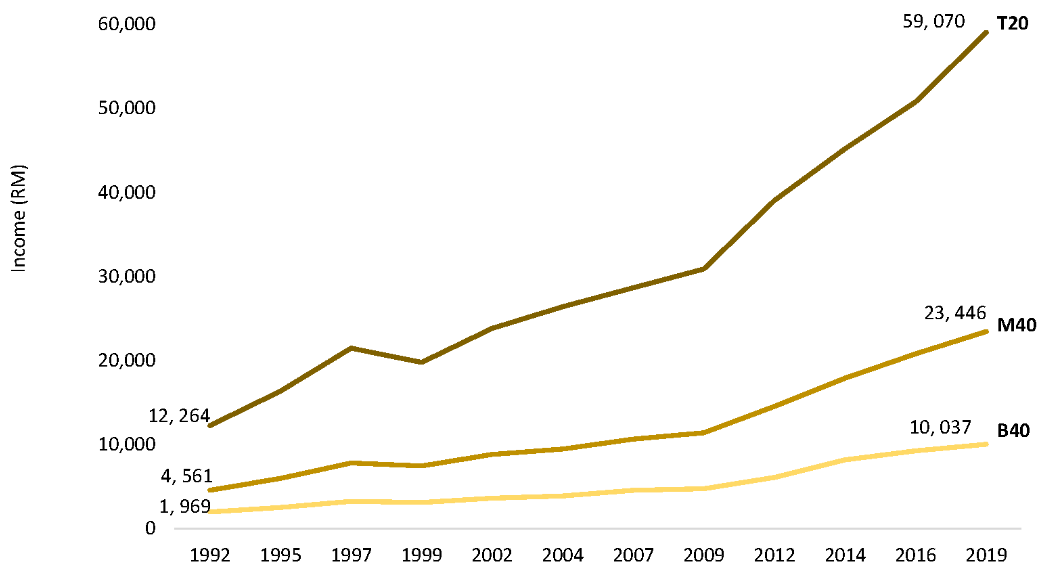


Figure 4.22: Mean Household Income based on Household Group

Box Article 4.11: Women in Science

Far too often, women scientists do not get their due recognition due to the implicit bias against women in science. Malaysia is extraordinary in that the country's female graduates from STEM field outnumber the male graduates. Malaysian girls tend to do better in middle secondary and thus are selected to enter science stream, leading to them entering STEM fields at tertiary level. The United Nations has acknowledged Malaysia to be a world leader in encouraging girls and women to participate in science. However, high number of women graduating in STEM (Figure 4.23) do not translate into more women researchers; women make up less than 50% of local scientific workforce. Nevertheless, gender parity in science for Malaysia is better compared to developed country such as the United Kingdom, Republic of Korea, and Japan with high researcher densities and sophisticated technology. (Figure 4.24) World average records only 33% of the world's researchers are women.

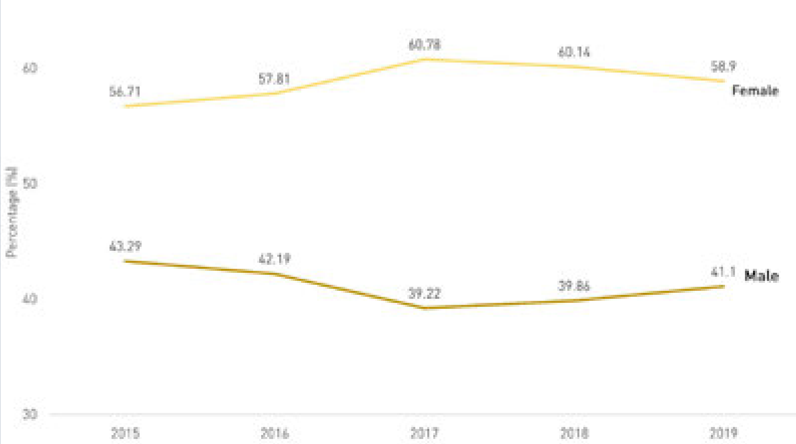


Figure 4.23: STEM Graduates by Gender from 2015-2019

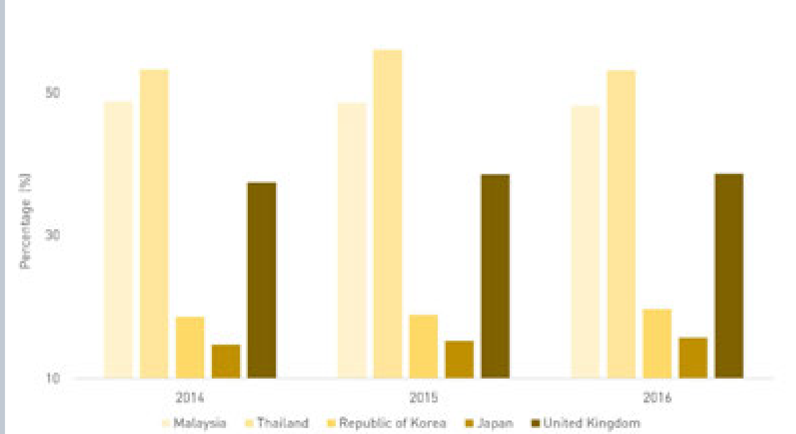


Figure 4.24: Percentage of Female Researcher from 2014-2016

Malaysian women in science, like other fields, face several career barriers, from limited opportunities for leadership roles, to difficulty in juggling work-home responsibilities. The lack of support in this area led to many women sacrificing their career progression to focus on their families. This is even worse after the COVID-19 pandemic hit the world in 2019. It has impacted the women in the science workforce tremendously. They are more susceptible to losing the job as most are not in a senior-level position. The overlapped of professional and domestic roles such as childcare, supervising online learning of the kids, and other household duties have negatively impacted their work productivity and mental health.

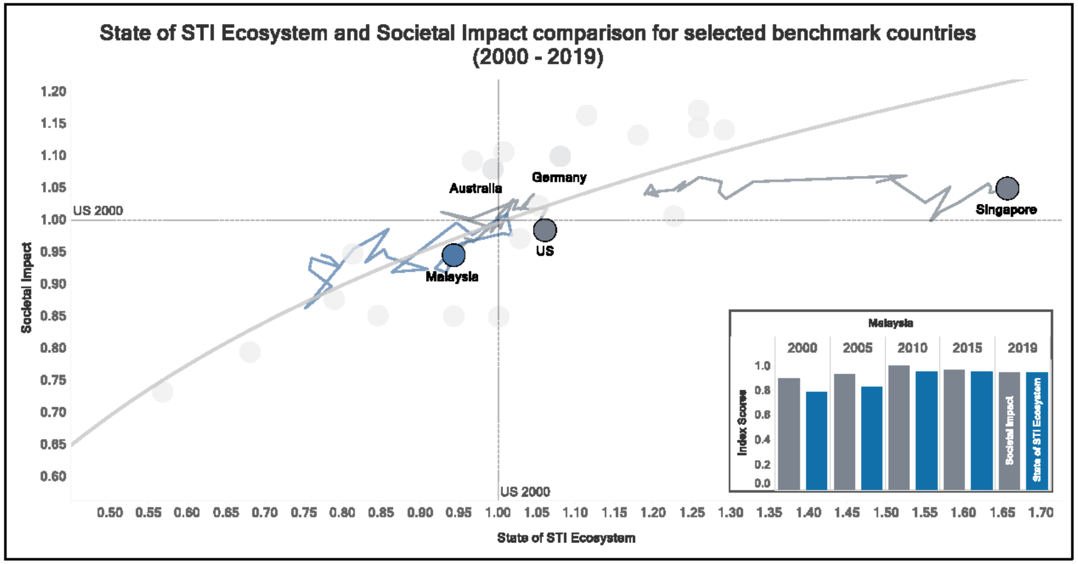
Nonetheless, women scientists continue to bloom in Malaysia. The UNESCO Science Report (2015) reported that women researchers in information technology (IT) sector are equal to their male counterpart in both government and private sectors. Malaysian women are close to achieving gender parity in the engineering sector as well; among them is the former Vice Chancellor (VC) of the Universiti Teknikal Malaysia Melaka, Professor Datuk Wira Dr Raha Abdul Rahim.

Among the outstanding women scientists in Malaysia is Professor Emerita Dato' Seri Dr Mazlan Othman FASc, the first female astrophysicist in Malaysia, who served as the Director of United Nations Office for Outer Space Affairs (UNOOSA) in Vienna for seven years and is the Director of the International Science Council (ISC) Regional Office for Asia and the Pacific. Professor Datuk Dr Asma Ismail FASc is another luminary, the first woman to be appointed the VC of Universiti Sains Malaysia (USM) and Universiti Sains Islam Malaysia (USIM), Director-General of Higher Education at the Higher Education Ministry of Malaysia, and President of Academy of Sciences Malaysia. Another prominent figure who made headlines with her appointment as WHO Science Council member is Professor Datuk Dr Adeeba Kamarulzaman FASc. An infectious disease expert she is also the President of the International AIDS Society.

References:
Australian Academy of Science (2021), Huyer, S. (2015), Whiting, K. (2021)

SOCIETAL IMPACT AND STI ECOSYSTEM

The correlation of the development of STI ecosystem on societal impact for Malaysia and several developed and developing economies is depicted in (Figure 4.25). The state of STI ecosystem and societal impact shows that Malaysia's progress has been rather erratic from 2000 to 2019. There was progress in social impact in the early years, but in the latter years there was noticeable decline in the social impact factors. The figure also shows that Malaysia still trails many of the developed countries with respect to STI development and social impact.



Analysed by Sunway University Research Team

Figure 4.25: State of STI Ecosystem and Societal Impact Comparison for Selected Benchmark Countries, 2000-2019

Note: The circles on the chart represent data of the respective country in 2019 while the trails from the circle show the movement of the country from 2000 to 2019.

In short, Malaysians have enjoyed tremendous improvements to their quality of life over the past thirty years. Many of these progress can be attributed to policies designed to push STI agenda in the country's development, but the rising cost of living outpace the slow wage growth, affecting household budgets and diminishing socioeconomic gains of the population. Access to basic utilities have improved to near universal access except for pockets in the rural areas, which is only to be expected. The urban-rural disparity continues across many dimensions, but this dynamic may change with increasing urbanisation. The lack of mitigation plan to address greater concentration of the urban population and its associated demand for resources and services will continue to affect the society, with those from the lower socioeconomic strata suffering the greatest impacts.

The greater access to education opportunity has transformed the societal landscape of the country. Nonetheless, the education system is still a work in progress; raising the pedagogy standards is an uphill battle as the system struggles with policy backtracks and interventions that are not aligned to long-term strategies. This is a poor foundation for developing the talent pool needed by the country to become a knowledge-intensive economy.

Access to high quality modern medical technologies, treatments, and interventions have significantly improved the health system delivery and healthy life expectancy. The challenge now is to maintain a fiscally sustainable healthcare delivery model that can achieve universal access for the underserved areas and communities while protecting the poor from falling into poverty due to catastrophic health spending.

Malaysia's uneven upward socioeconomic mobility trend has affected the nation's social cohesion and unity (see Vision 2020 review). Building a united national identity must be central to all policies to ensure that the country's progress to be an inclusive advanced economy where all have a share in Malaysia's prosperity. The national identity must be grounded in an integrated social model, celebrating the richness of the country's diversity, and empowering the *Rakyat* to ensure that no one is left behind.

Box Article 4.12: Nation Building Efforts Through Education

Nation building is often used interchangeably with state building, democratisation, modernisation, political development, post conflict reconstruction and peace building, depending on the context. The evolution of nation building through social cohesion of the country is shaped by many national agendas. The first nation building project is the Malayan Independence in August 1957 when the main ethnic groups and ethnic-based political parties worked together and succeeded in gaining independence. Formation of Malaysia in 1963 had expanded the multiracial composition of the society.

The Rukun Negara was formulated post the May 13, 1969 bloodshed with the intention of providing guidance for nation-building efforts and was officially proclaimed on 31st August 1970 during Malaysia's 23rd Independence Day celebration. It is guided by the five principles: Belief in God, Loyalty to King and country, upholding the Constitution, sovereignty of the law, and good behaviour and morality.

The recital of Rukun Negara was encouraged on official events and the morning assembly in all public schools, thus instilling its aspirations in Malaysian children from a young age. This was complemented by the Falsafah Pendidikan Negara (now known as Falsafah Pendidikan Kebangsaan (FPK)) which was introduced in 1988 to nurture knowledgeable and competent citizens with high moral standards who will then contribute to the harmony of the society and the nation at large. The Education Act 1961 stipulated for Bahasa Melayu to be used as a medium of instruction to build trust and unity among the various ethnicities.

The Rahman Talib Report (1960) incorporated elements of civic education for non-Muslims and Islamic studies for Muslims in the curriculum. The civic subject was replaced with moral education in 1983. The decision to teach civic and moral education to only non-Muslim students is not a good move towards nation building. Thus, Sivik dan Kewarganegaraan subject was introduced and to be taught to Years Four and Six and to all secondary school students in 2005. In line with the FPK, this subject aims to build awareness about the citizens' roles, rights, and responsibilities to society and the nation. In 2019, four core values namely love, joy, respect, and responsibility became the focus of this subject. For effective implementation, this subject is conducted for one hour in the fourth week of each month by embedding the lesson in five subjects; Bahasa Melayu, English, Islamic Studies, Moral, and History. The civic element is highlighted in chapter seven of the Malaysia Education Blueprint 2013 to 2025 (Preschool to Post-secondary Education), with emphasis on enhancing unity in school through initiatives such as Rancangan Integrasi Murid Untuk Perpaduan (RIMUP) programme, sports and co-curricular activities including community service projects.

Holistic development of the youth was the underpinning of the National Youth Master Programme launched in 1991. Its primary goal is to foster multidimensional youth development while building unity among Malaysia's multi-ethnic youths while maintaining an active lifestyle. The programme was rebranded in 1994 as the Rakan Muda Programme.

In 2004 the Program Latihan Khidmat Negara (PLKN) was launched. This three-month mandatory course for school leavers or youths aged 17 years or older from all ethnic background was to foster racial unity and national integration while instilling a caring spirit and promote volunteerism among the younger generation. The programme was not without its issues as there were complaints of ill-treatment, antisocial behaviour, as well as poorly designed and implemented regiments; it was dissolved in 2018.

Have these programmes help build better social cohesion among Malaysians over the years? Students in these cohorts are adults in today's social fabric. At this point we can only guess based on our observations as present measures are rather subjective. However, eight indices will be created to measure the success of the Shared Prosperity Vision 2030 (SPV 2030) among which are the Unity Index and the Religious Harmony Index which may give a better insight of the societal relations in Malaysia.

Social cohesion refers to the extent of connectedness and solidarity among groups in the society identified by a community's sense of belonging and the relationships among its members. Strengthening social cohesion using the Bangsa Malaysia concept introduced in 1991 is constantly at loggerheads with policies that inadvertently skew the nation towards ethnocentrism. Widening inequality, inter-generational divide, and political polarisation also worsen the situation. What is needed is for members of the society to inculcate respect for one another, practice openness, and acceptance to reduce extreme inclination to preserve one's religion, tradition and culture. All in all, education has and will remain the largest accessible platform to shape one's *jati diri* (core identity), celebrate cultural diversity, and unite the society.

References:

Derichs, C. (1999), Government of the Federation of Malaya (1960), Marca, A.R.(2014), Saad, (2012)

Pillar Specific Recommendations

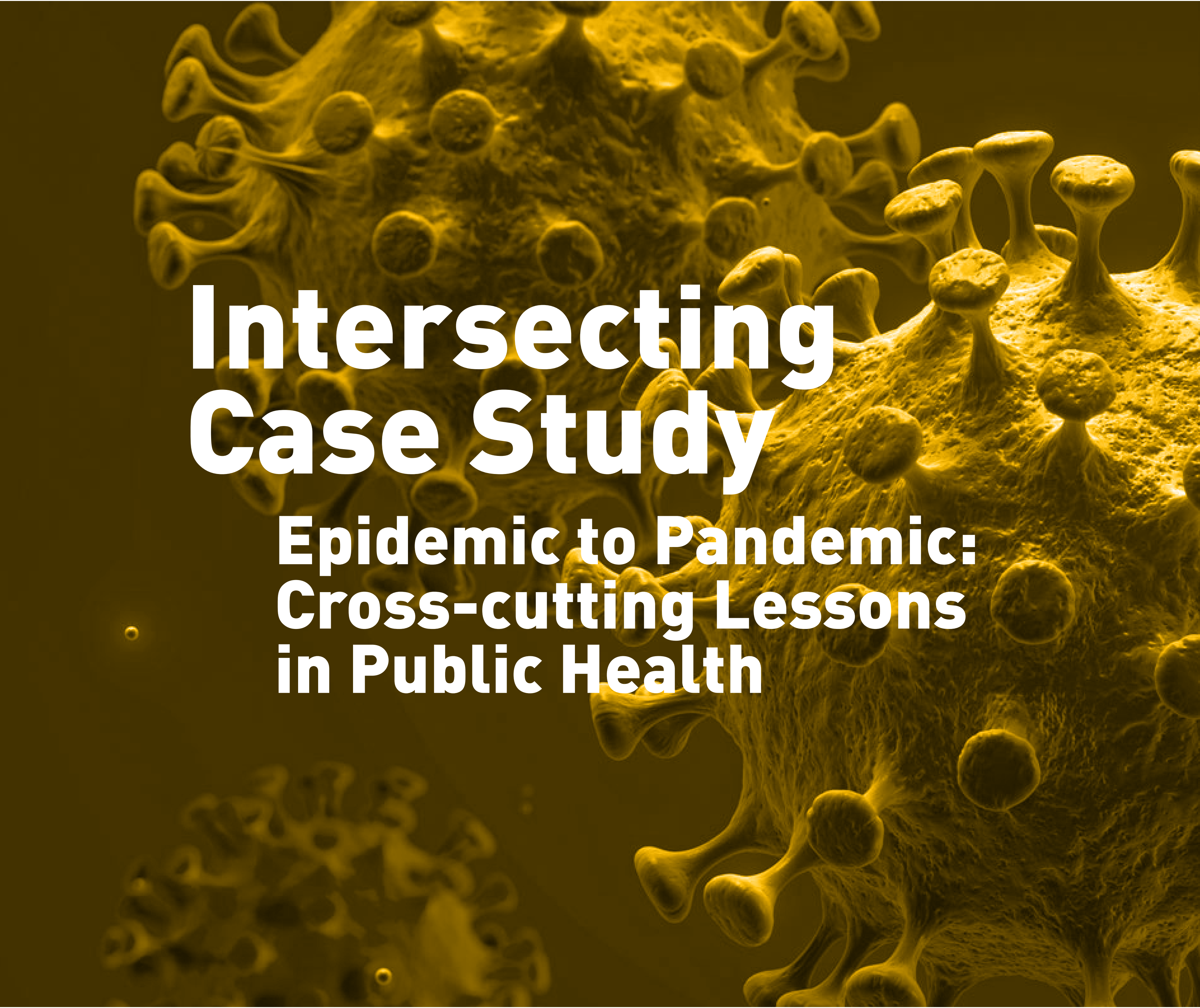
1. **To finance longitudinal study and digital registry to better manage the national healthcare system**

Continuous financial support to carry out a longitudinal study that links intersecting societal, economic and environmental factors is imperative to drive health outcomes towards formulating long-term health policies. These multifaceted policies with stronger emphasis on preventive care need to be in place to manage the burden on the national healthcare system. For sustainability, the whole-of-government and whole-of-society approach is most feasible as healthcare must be seen as a collective responsibility.

It is also envisioned that reintroducing a comprehensive and secure digital registry with end-to-end data collection and monitoring of health status, especially mental health, will be useful for timely diagnosis and, intervention and care management. This calls for a single interoperable platform for patient record (i.e. children to adult patient, causes of hospitalisation, status of patients from follow-up treatment) to combat stigmatisation and criminalisation of mental health sufferers. A surveillance system that draws data from a combination of sources and timeline must be established. This system using data analytics to streamline reporting and monitoring effort for targeted interventions is to be linked to the digital registry.

2. **To formulate and institutionalise Talent Masterplan based on the 10-10 *My*STIE Framework**

To ensure Malaysia remains competitive and to improve living standards of its people, the dependence on low-skilled foreign talent must be replaced with local talent. Malaysia has an adequate supply of appropriately skilled graduates to transform Malaysia into a high-tech nation but often the talent is either oversupplied, mismatched or lost (brain drain) as existing jobs do not match the skillsets or the number of jobs with a certain skill are limited. With emerging technologies, the future readiness of talent has become even more urgent. Hence a longitudinal study on graduate employment matched against the needs of the country based on the 10-10 *My*STIE Framework is proposed. This exercise will be the basis of drafting relevant competency frameworks and then formulating the Talent Masterplan for future ready talent pool. Institutionalising the Talent Masterplan is imperative for sustainability of Malaysia's competitiveness.



Intersecting Case Study

Epidemic to Pandemic: Cross-cutting Lessons in Public Health

Malaysia has its fair share of infectious disease emerging over the last few decades, some of which had resulted in significant deaths and disabilities. Many novel viruses whose origins have been linked to bats and other animal hosts, with varying levels of infectious danger to humans have been discovered in Malaysia over the last three decades (Tee, 2009). Large outbreaks of hand-foot-and-mouth disease due to enterovirus-71, with rare cases of fatal neurological complications, were reported in young children in 1997, 2000, and 2003. Other infectious diseases such as rabies, SARS, avian influenza (bird flu), influenza A (H1N1), and MERS-CoV had also tested the national healthcare system.

The Nipah virus encephalitis in 1998 was one of the most devastating outbreaks the country has experienced in recent times. The endemic resulted in 265 cases of acute encephalitis with 105 deaths and an estimated loss of USD136 million tax revenue (UNFAO, 2002) with more than a million pigs, identified as the amplifying host, were culled (Looi and Chua, 2007).

This outbreak accelerated novel molecular technology uptake from the need to identify the virus identification as well as tracking and confirming the disease transmission from bats to pigs in the farm. The scientific discoveries inspired by the outbreak led to better understanding of zoonotic diseases in Malaysia and the potential catastrophe when cross-species transmission occurs (Looi and Chua, 2007).

Experiences from these outbreaks have primed the Malaysia Strategy for Emerging Diseases and Public Health Emergencies (MySED), which was valuable in mapping out the healthcare services response to the SARS-nCoV-2 – which was later named COVID-19 – outbreak in late 2019. Malaysia's first COVID-19 case was detected in three Chinese nationals in January 2020. On 18th March, the government imposed a Movement Control Order (MCO) to control the spread which was later extended in phases and categories to curb the surging numbers of positive cases nationwide.

Resource mobilisation for surge capacity readiness to manage a sudden influx of patients started early in the pandemic. The healthcare system is lopsided with private healthcare having more specialists and utilising lesser personnel causing the public healthcare to be overburdened. To curb with the influx, MOH requested the Public Service Department to appoint 1899 medical officers on contract to support the healthcare service during the pandemic period. Each state has designated hospitals for treating COVID-19 patients with severe symptoms so that other patients requiring non-COVID-related management can receive the care they need. Quarantine centres and field hospitals to manage patients with mild symptoms were also set up to diffuse the pressure on COVID-19-specific hospitals. Unprecedented learning and collaboration across the country and the globe had been accelerated in the course of handling the pandemic to improve clinical management, vaccine development and delivery, and make critical recommendations for treating the patients.

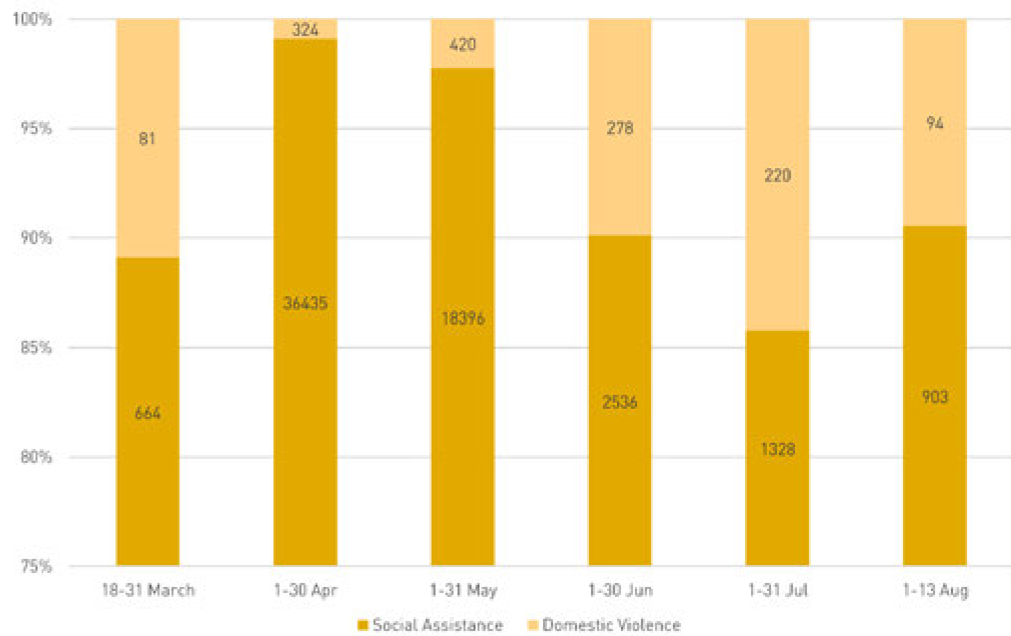
Contact tracing technology and application like MySejahtera was one of the earliest STI outcomes of the pandemic in Malaysia to collect surveillance data through a self-reporting mechanism as well as providing risk assessment, hotspot tracker information, and vaccination registration. It is a crucial component of the Government's legislative and non-pharmacological interventions to stop the spread of COVID-19. In addition to direct pandemic management, related applications are also used to reduce economic impact to the population via social safety net registration, supply chain support, and open new market avenues (Clavier & Ghesquiere, 2021).

Pharmacologic legislation, procurement, and administration underwent rapid adjustment as part of the resource mobilisation. An additional budget of about RM35.4 million was allocated to MOH for procuring COVID-19 drugs. The off-label use of 15 medications for treating COVID-19 led to the establishment of a special monitoring mechanism to supervise the drugs' utilisation and safety profile active surveillance in 76 MOH hospitals. The Malaysian Alliance for Embedding Rapid Reviews in Health Systems Decision Making platform (MAera) shares information through a dashboard on the progress and outcomes for ongoing and completed projects especially on Malaysia's COVID-19 health systems response.

Active inter-ministerial collaborations are vital in maintaining the supply chain for COVID-19 management. Among them, the approval given by the Ministry of International Trade and Industry (MITI) for pharmaceutical manufacturers and related companies to operate at full force during the MCO. A joint effort of the Ministry of Higher Education and the Ministry of Science, Technology, and Innovation with MOH had mobilised additional diagnostic laboratories for the pandemic effort. This is the proof of concept that it is possible to break the silos for a whole government engagement. Government-to-government engagement with Japan, India, Bosnia, China and Taiwan through the MOH Policy and International Relations Division helped push the import of pharmaceutical products as well as active pharmaceutical ingredients (API) into Malaysia. Other development plans were also discussed with Russia, Turkey, Singapore, South Korea, USA, UK and Germany. In the future, international collaboration should be incentivised to encourage state of the art technology transfer to local technology players to accelerate vaccine and therapeutics development and manufacturing capabilities.

Greater mental health and social support activities were observed during the COVID-19 pandemic. The quarantine aimed to stop the spread of the disease has created an environment where violence at home became more frequent and more severe (UN Women, 2020). *Talian Kasih* saw a 57% spike in distress calls just within 18 to 26 March; the month of May 2020 showed the highest calls related to domestic violence showing while calls seeking for assistance due to loss of source of income intensified in April as more businesses closed down (Figure 4.26). The MOH Crisis Preparedness and Response Centre (CPRC) and Mercy Malaysia created a support hotline and developed guidelines for mental health and psychosocial support during COVID-19 in March 2020. MOH also developed a mental health kit for patients and healthcare workers with measures to assess staff burnout.

Malaysia's response during the pandemic's first wave was a success, thanks to the combination of a well-structured public health system, early preparedness and planning, previous pandemic experience, strict lockdown measures and precautionary measures including contact tracing mechanisms. Success was short lived however, when number of cases surged from zero case in August 2020 to more than 20,000 cases per day a year after. The dramatic rise was the result from lack of



Reference: Ministry of Women, Family and Community Development (KPWKM), (2020)

Figure 4.26: Domestic Violence and Seeking for Social Assistance Related Calls Made to *Talian Kasih* from 18 March to 13 August 2020

adherence to standard operating procedures as well as socioeconomic considerations and political factors influencing decision-making.

The investigation of COVID-19 clusters arising from manufacturing and construction sector had shone a light on the poor living conditions of migrant workers which made them vulnerable to the virus. It is clear that public health actions against the pandemic must not serve just the citizens of the nation, but access to healthcare and decent living standards for the other population – particularly marginalised ones like migrant workers, refugees, and the stateless – must also be part of the framework.

8i Analysis for Malaysia's Epidemic and Pandemic Management

1 INFRASTRUCTURE

RESOURCE MOBILISATION FOR SURGE CAPACITY READINESS

Diagnostics capacity increased from 6 to 43 laboratories optimising public and private laboratories as of January 2021.

TECHNOLOGY UTILISATION FOR INFECTIOUS DISEASE MANAGEMENT

Low utilisation and integration of new and advanced technologies for surveillance, data management analytics and foresighting has contributed to less-than-optimal use and management of physical and natural infrastructure. Limited public transport and poorly connected health facilities and services in rural and remote areas have affected accessibility for vaccination. Technologies must be adopted to increase analytical capabilities while linking facilities can assist monitoring and pre-emptive measures.

2 INFOSTRUCTURE

REPORTING, MONITORING AND INFORMATION SHARING

The Pharmacy Information System (PhIS) was improvised for reporting and monitoring of daily drug stock balance status at MOH facilities. Digital infrastructure is underutilised and does not integrate multiple research facilities and stakeholders to share information. Weak digital connectivity in rural areas result in slow dissemination of information and low vaccine registration. Spread of anti-vaccine narratives, conspiracy theories and false information in social media cause doubts among public. A one-stop portal for expertise, verified data and other support systems for managing public health should be established.

3 INTELLECTUAL CAPITAL

LOCAL EXPERTISE, RESEARCH AND DIAGNOSTICS CAPACITY

The Institute for Medical Research (IMR) had designed and developed primers and probes specific for COVID-19, ahead of the Center for Disease Control (CDC) in the US. IMR was able to develop its own in-house reverse transcription polymerase chain reaction (RT-PCR) testing technique before the WHO developed the detection protocol. The public healthcare personnel faced a critical shortage of specialists and were overburdened with increasing patients. More than 50% of 933 health personnel experienced burnout during the early phase COVID-19 pandemic. Hence, emergency readiness protocols is needed for collaboration between private and public healthcare sectors for emergency situations.

4 INTEGRITY

STANDARD PROCEDURES, LEGISLATION AND ADMINISTRATION

During the Nipah virus outbreak, new standard operating procedures (SOPs) were developed in a joint effort between MOH and other agencies to break the transmission chain, evacuate the population and cull farm animals. Introduced SOPs need to be enforced without prejudice. Lack of adherence to guidelines and haphazard implementation of regulations have contributed to the rise of COVID-19 cases. Policies requiring undocumented migrants to be reported, threat of arrest and deportation forces migrants to remain in hiding and risk further spread of COVID-19. As a way forward, a Pandemic Act supported by a multi-institutional collaborative governance system that continuously undertake risk assessment and pre-emptive measures must be introduced.

5 INCENTIVES

TAX MEASURES AND STIMULUS PACKAGES FOR PEOPLE AND BUSINESSES

PRIHATIN packages worth billions of ringgit was introduced to support a wide spectrum of beneficiaries from single mothers, low income earning individuals and households, small traders to students. The National Economic Recovery Plan (PENJANA) was introduced to counter economic fallout includes 40 initiatives worth RM 35 billion involving a proportion of direct fiscal injection by the government.

LOW SUPPORT FOR LOCAL TECHNOLOGY DEVELOPMENT AND UPTAKE

Vaccine development and clinical trials are low due to fragmented, small financial support system and dependent on government input. Improvement is needed in fiscal and non-fiscal incentives for development and usage of indigenous technology.

6 INSTITUTION

DIAGNOSTIC CAPABILITIES AMONG MULTIPLE INSTITUTIONS

Diagnostic laboratories increased by 86% with the involvement of IMR, Malaysian Genome Institute, public health laboratories, university laboratories, Malaysian Armed Forces laboratories and private laboratories. However, these institutions need to be streamlined to be positioned at the forefront of STI development in public health research and management.

7 INTERACTION

WHOLE-OF-GOVERNMENT AND WHOLE-OF-SOCIETY COLLABORATION

Joint effort between MOH, MOSTI and MOHE had mobilised additional diagnostic laboratories. The Special Committee on COVID-19 Vaccine Supply (JKJVA) co-chaired by MOSTI and MOH ensured cooperation between multiple players and smooth running of the national immunisation programme.

8 INTERNATIONALISATION

INTERNATIONAL ALLIANCE AND RESEARCH JOINT EFFORTS

Malaysia is the first Asian country to enrol patients in the WHO Solidarity Trial to collect data and compare safety and effectiveness of treatment protocols using different drugs combination. As a member of Clinical Research Coalition, Malaysia has the advantage to adapt or develop new research protocols according to national priorities. Malaysia should aspire to build equitable partnership with global centres of excellence and industry players in on-going vaccine development and other clinical research.

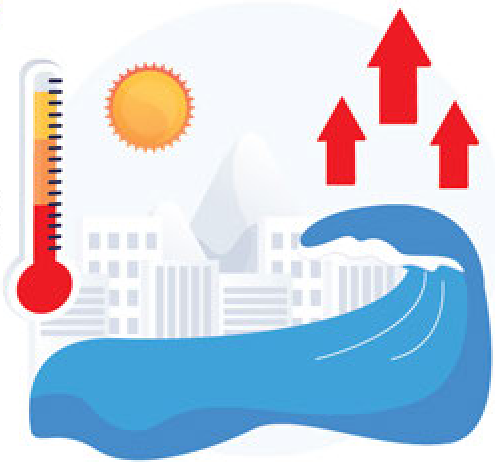
05

Environmental Impact Pillar

Alarming Climate Risks

Annual average surface temperature has **WARMED**

0.13 - 0.24°C per decade over the last 46 years



RISING SEA LEVEL

At an annual rate of 4.22 mm **ABOVE GLOBAL AVERAGE**

Rapid development at the cost of the disaster hazards

3.5x INCREASE on disaster incidences
31 cases **(2014)** to **110** cases **(2018)**

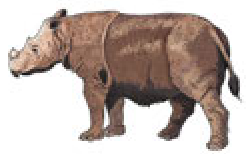
Persistent **FLOODs** responsible for damage cost estimated at **RM915 MILLION** in the 2000s

Worrying threats to Biodiversity

Depleting forested areas
1990: 59%
2018: 56.5%

Alarming reporting for THREATENED SPECIES

Malaysia Red List for Mammals: One EXTINCT out of 223 species assessed



Malaysia Plant Red List for Peninsular Malaysia: 567 THREATENED out of 1,600 species assessed

ENVIROMENTAL IMPACT PILLAR

Insignificant Sustainability Performances

114 / 156 GeGalo Index 2019
43 / 113 Global Food Security Index 2020

Costly Environmental-related Issues

RM39.8 BILLION annual cost for environmental-related issues **1995-2019 which is equivalent to 3% of GDP (2019 & 2020)**

Human progress reshapes the environment; sometimes for the better, but often, for the worse. This chapter provides an overview of Malaysia's growth in the past 30 years from an environmental perspective with respect to science, technology, and innovation (STI)-related policies.

CAPITALISING ON NATURAL ASSETS FOR PROGRESS

The birth of agriculture in the Fertile Crescent of the Middle East marked the period when humankind began to leave a lasting mark on the face of this planet. The ability to domesticate plants and animals ensured survival during periods of deprivation, leading to an explosive growth of the world population and giving rise to civilisations.

The discovery of fossil fuel plus exploitation of natural assets from the Industrial Revolution to the present day has changed the natural landscape more than human existence in the past 12,000 years had ever done. The transformation of commerce into a manic race to accumulate material wealth was paid in natural capital, from topsoil depletion, desertification, incalculable biodiversity loss, air, land, and water pollution to climate change.

Malaysia is blessed with an abundance of natural capital – ranging from timber, mineral, fertile soil, to amazing biodiversity – on which the nation's wealth is built. However, the move from a commodities-based economy towards a production-based economy has changed Malaysia's reliance on natural capital in the past 23 years (Figure 5.1). Malaysia has been struggling to manage our global portfolio of assets sustainably, as evident by the decline in the estimated stocks of natural capital per person beyond 50%, as compared to the global average of nearly 40% (Dasgupta, 2021). Similar declining trends are also seen in all other countries and economies that reaped economic benefits through other revenue streams but had suffered near to complete loss of natural capital. Efforts to preserve and restore the nation's natural capital is crucial for a healthier environment by putting into balance the ecological limits of our socio-economic systems based on our demands and Nature's supply.

Natural assets – Naturally occurring living and non-living entities that together comprise ecosystems and deliver ecosystem services that benefit current and future generations.

Natural capital – The stock of renewable and non-renewable natural assets (e.g. ecosystems) that yield a flow of benefits to people (i.e. ecosystem services). The term 'natural capital' is used to emphasise it is a capital asset, like produced capital (roads and buildings) and human capital (knowledge and skills).

Reference:
Dasgupta, P. (2021)

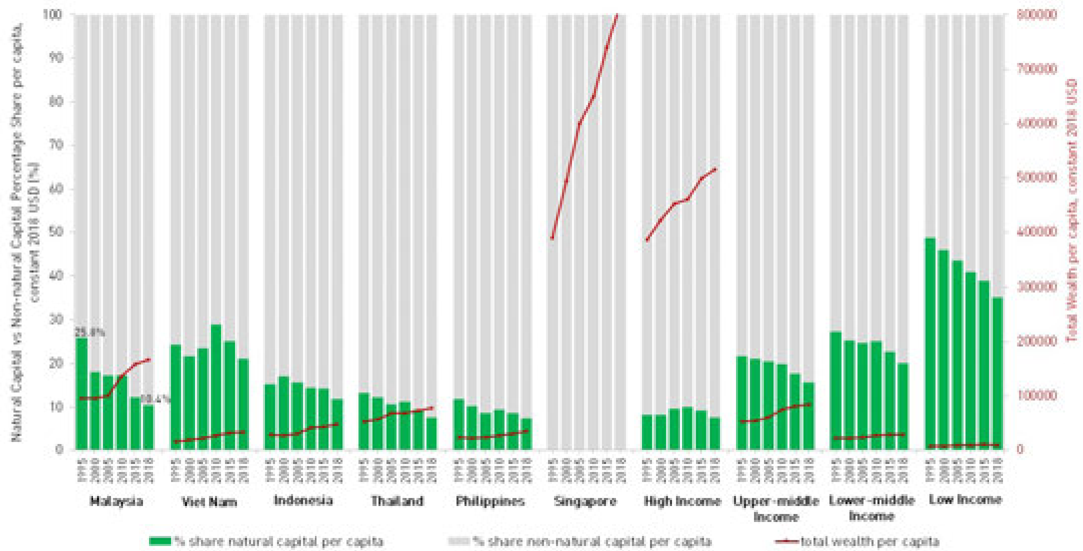


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Figure 5.1: Share of Natural Capital and Total Wealth, 1995-2018

Malaysia engages with the international community on various platforms for sustainable utilisation of the nation's natural resources and to conserve the environment (see Further Reading 1). These commitments must be balanced while accomplishing the Shared Prosperity Vision 2030 (SPV2030), which is set to propel the nation to be a high-income country with equitable wealth distribution so that no citizen is left behind. The expansion of the nation's coffers must not be at the expense of Malaysia's environment so that the *Rakyat* may enjoy both the country's economic and natural wealth.

ENVIRONMENTAL PERFORMANCE ASSESSMENT

Malaysia's standing in the Environmental Performance Index (EPI) by the Yale Centre for Environmental Law and Policy has been fluctuating (Figure 5.2); the country's performance in selected core areas indicate that Malaysia has been improving only in its climate change index but has declined in other areas, scoring below 50 in vital spheres such as pollution emissions, forestry, water, and fisheries.

It should be noted that countries that rank highly in the EPI tend to be developed nations with abundant economic resources to conserve their environment. Nonetheless, there are many lessons that Malaysia can learn from these nations on how to capitalise on good governance and informed initiatives to protect the country's natural resources and human well-being while generating economic growth.

The annual World Economic Forum's Global Risk Report 2021 highlighted top environmental-related global risks under the "likelihood" category; namely extreme weather, climate action failure, human environmental damage, and biodiversity loss. The next section of the chapter provides a scan of Malaysia's performance in these categories over the past 30 years and formulates mitigating strategies to improve them for a better future.

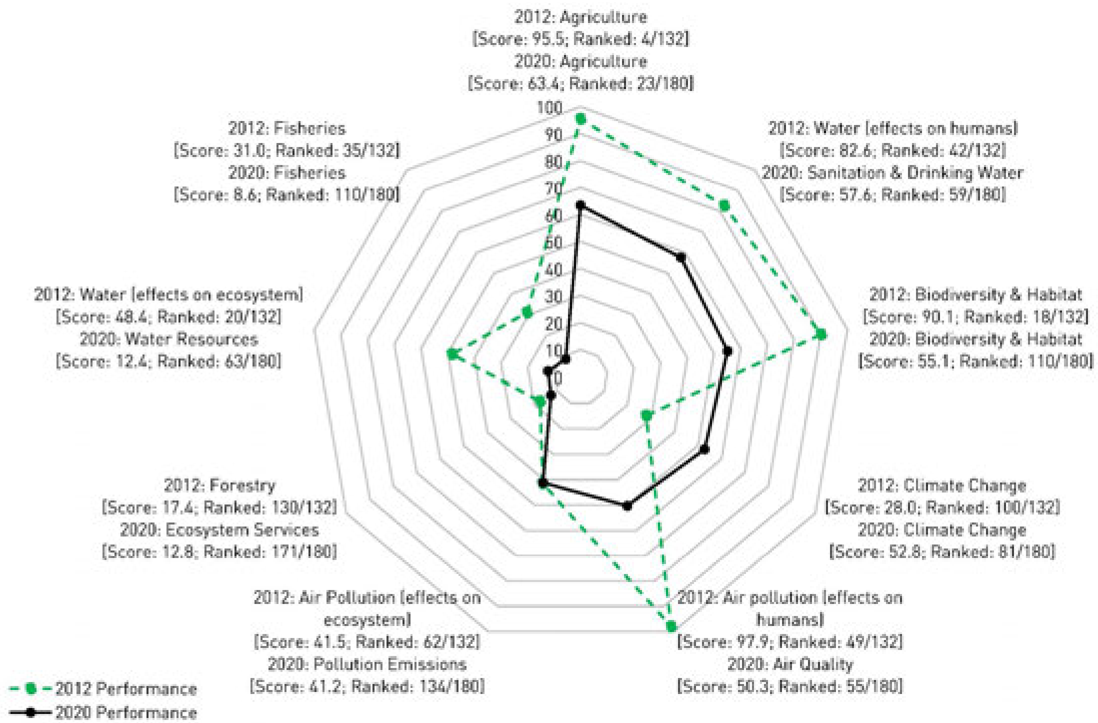

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Figure 5.2: Malaysia's Performance in EPI 2012 and 2020

Greenhouse Gas (GHG) Emission

Human activities such as burning of fossil fuel, production of greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) from industrial and agricultural practices, and deforestation have been recognised as major accelerators of climate change. The impact of climate change includes global temperature increase, rising sea levels, shrinking glaciers, accelerated desertification, longer and more devastating droughts, as well as higher frequency of catastrophic forest fires and massive flooding. The effect of climate change affects some parts of the planet worse than others, as seen from the heavier winter storms in North America, increasingly intense wildfires in Australia, the Americas, and Europe, as well as greater dust storms in China.

In the past 28 years, Malaysia's carbon footprint per capita has been rising, outpacing most of the neighbouring countries except for Singapore (Figure 5.3). Malaysia's carbon footprint per capita in 2018 was 2.5 times higher than in 1990, largely due to the fast pace of industrialisation. As a signatory of the COP21 Paris Agreement, Malaysia pledged to reduce its GHG emission intensity equivalent to 45% of the gross domestic product (GDP) by 2030 relative to the equivalent emission intensity of GDP in 2005. However, the GHG emission in 2016 increased by 30.7% compared to the 1995 values, but with land use land use change forestry (LULUCF) removal, the GHG emission had reduced to 22.3% from the 1994 level. This clearly shows the effectiveness of proper forest management as well as the use of carbon-intensive and low-carbon technologies to reduce GHG emissions, paving the way for Malaysia to substantially reduce its emission from all sectors in the future (KASA, 2020a).

The major contributors to this rise were the rapid pace of industrialisation together with mushrooming growth of high-carbon service sectors, such as energy generation and transport (Figure 5.4). The increasing demand for electricity has pushed up the GHG production by the energy sector while emissions by other sectors have fortunately been tapering to a plateau. This difference could be attributed to the other sectors adopting green technology measures in their operations.

The energy sector's heavy reliance on fossil fuel has led to it being the largest GHG emitter; this can be reduced by increasing the sector's share of renewable energy (RE). In the recent Special Meeting of ASEAN Ministers on Energy and The Minister of Economy, Trade and Industry Japan held on 21st June 2021, the Government has announced new targets for RE to reduce carbon emission from the power sector up to 60% by 2035. Furthermore, the Power Purchase Agreements (PPAs) of coal power plants with more than 7000 MW will expire by 2033 to be replaced mostly by gas and RE will help to lower Malaysia's carbon emissions (KETSA, 2021). Figure 5.5 shows how CO_2 emissions in the energy sector can be reduced by increasing the adoption of solar photovoltaic cells. Strategic use of biomass generated by the agriculture sector, especially oil palm plantations, offers a great potential for conversion into energy with a lower carbon footprint, given the size of the palm oil industry.

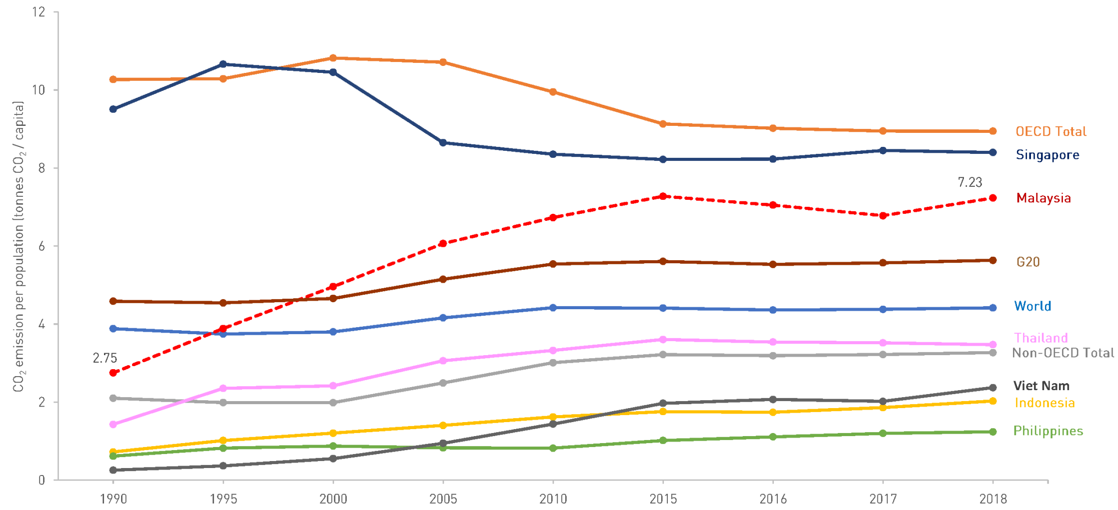

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Figure 5.3: Comparison of Malaysia's Carbon Footprint, 1990-2018

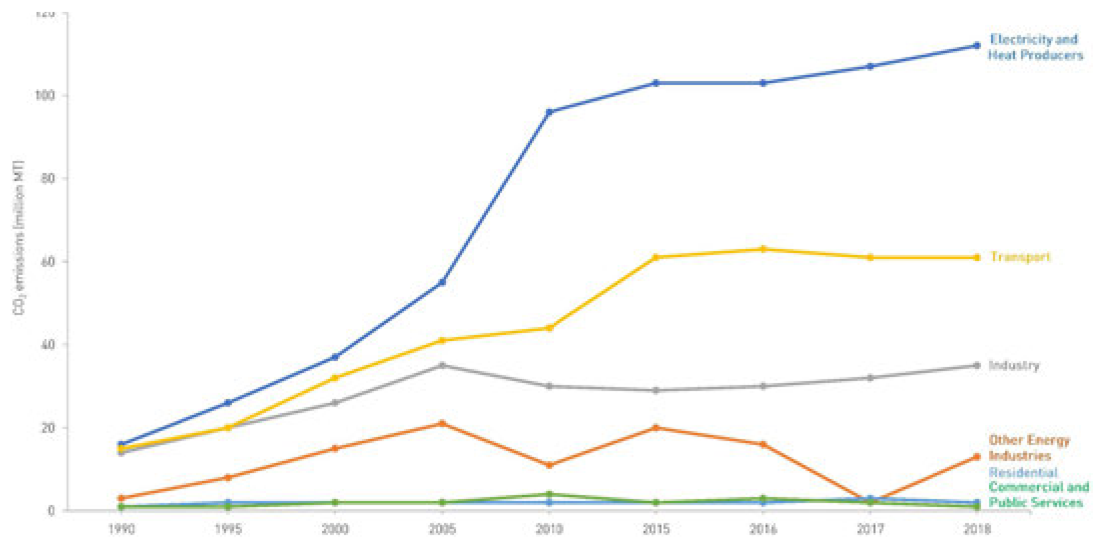

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Figure 5.4: CO_2 Emissions by Sector, Malaysia, 1990-2018

The transport sector is another GHG emission culprit. The International Transport Forum in May 2019 projected that global transport-related CO_2 emission is expected to grow above 60% by 2050 due to the sector's reluctance to shift towards renewable alternatives. Proper adoption of Malaysia's Green Technology Master Plan 2017-2030 (GTMP) which has mapped initiatives to move the nation's transport sector towards adopting more energy efficient vehicles and to encourage a greater use of public transportation will be essential to lower Malaysia's CO_2 emission (KeTTHA, 2017).

The manufacturing and industrial sectors (largely small, medium enterprises or SMEs) also consume copious amounts of energy in its operations and logistics, thus contributing to GHG emission. The sector has been encouraged to adopt RE, green products, and green processes in their business operation with relevant incentives to support the shift (KeTTHA, 2017). However, energy efficiency is a low priority for these firms due to a lack of technical know-how and/or unwillingness to adopt more expensive methods, both of which will slow down the implementation of the GTMP (Fernando and Hor, 2017).

Among the GHGs, N_2O and CH_4 emission by the agriculture sector has been rising since 1990 before peaking in 2009 (MESTECC, 2018a). The emissions decreased significantly thereafter due to the Government's efforts in encouraging sustainable agricultural practices, such as the use of organic fertilisers.

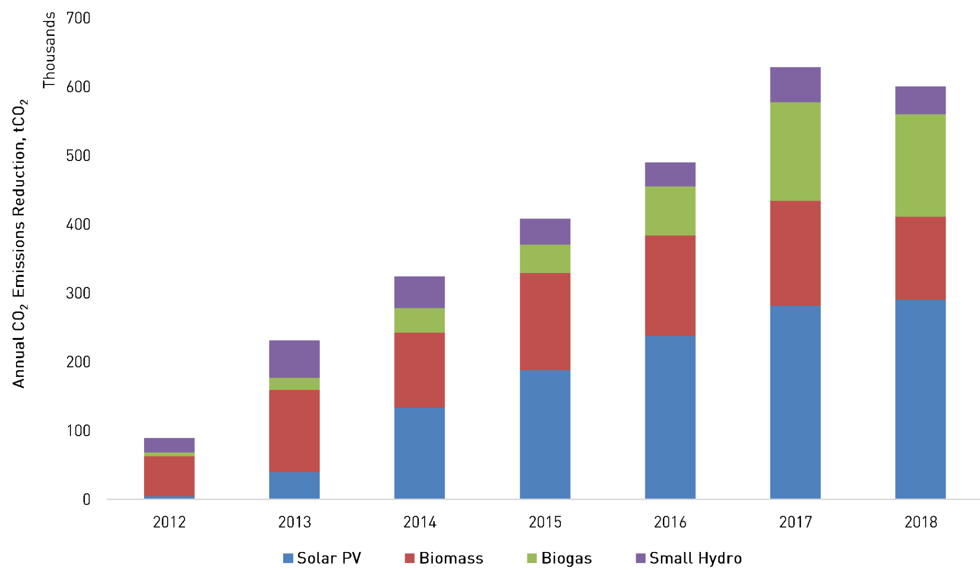

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Figure 5.5: Annual CO_2 Emissions Reduction from Commercialised RE Projects, 2012-2018

Another cause for concern has been the loss of carbon sinks due to deforestation and conversion of tropical peat swamp forest to drainage-based agriculture, which worsened Malaysia's GHG emission problems. It is estimated that more than 1 million hectares of peatlands in Malaysia were converted for agricultural use – particularly for oil palm plantations – over the last two decades (ASEAN Peatland Forests Project, 2020). The 30-year life span of oil palm plantations in Malaysia and Indonesia cumulatively have attributed to 21.3% share of GHG emission for Southeast Asian region and 0.57% of the global total GHG emissions each year from the conversion of peat swamp forest into oil palm plantation (Cooper et al, 2020). Currently, GHG emissions from tropical peatlands that have been drained and converted to plantations (e.g. oil palm) are not considered in GHG emissions budgets by the United Nations Framework Convention on Climate Change (UNFCC).

Malaysia has reduced the annual timber felling rates (coupe) in each Malaysian Plan over the past 15 years in order to minimise the impact of climate change and biodiversity conservation (Forestry Department, 2018). Overall, sustainable management of forests helped to reduce emissions by 9%, from 18,710 Gg CO_2eq to 20,308 Gg CO_2eq in 2014 and 2016, respectively (KASA, 2020a). Figure 5.6 provides a snapshot of Malaysia's commitment to reduce the nation's carbon footprint at both the international and local arena.

KEY INTERVENTION

1. To establish clear sustainable adaptation and mitigation plan for low emission strategies aim towards a carbon neutral economy

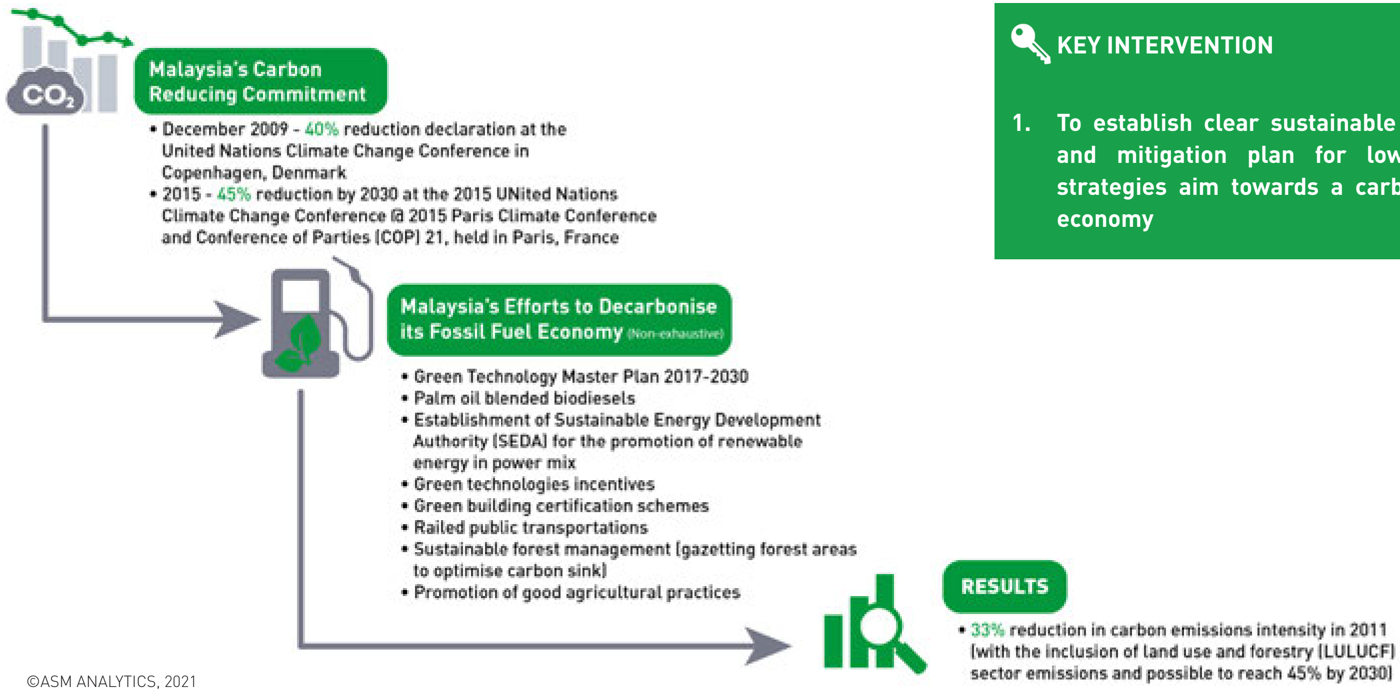

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Figure 5.6: Malaysia's Commitment to Reducing its Carbon Footprint

Energy

The country's economic growth has been largely fuelled by its energy sector – accounting for approximately 20% of the total GDP in recent years – making Malaysia the fourth largest economy and the second largest oil and natural gas producer in Southeast Asia. Electricity generation in the country mainly utilises fossil fuels, followed by hydropower and other sources of renewable energy (Figure 5.7). This reliance on fossil fuels has made this sector the country's largest GHG emitter. This is alarming and is totally unsustainable on both the fiscal and the environmental front.

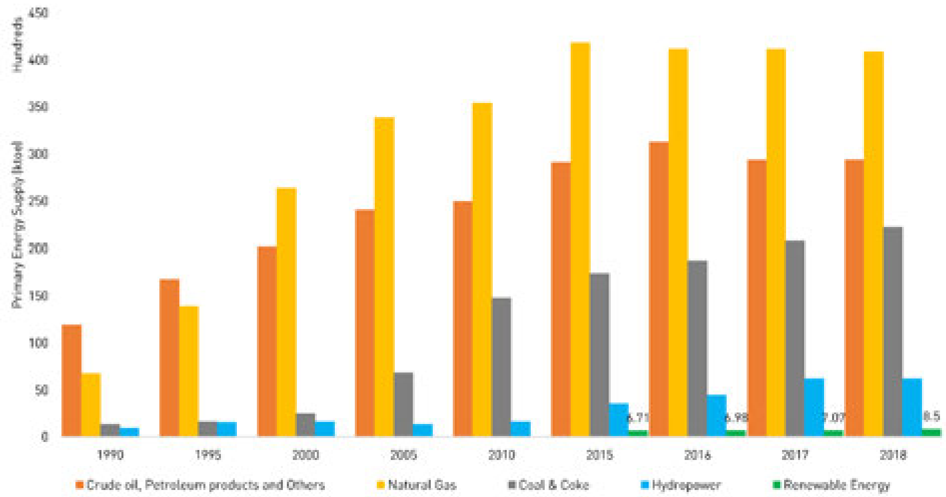

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Figure 5.7: Primary Energy Supply in Malaysia

Malaysia ranked 114 out of 156 countries in the Index of Geopolitical Gains and Losses after energy transition (GeGaLo Index) in terms of renewable energy investment (Overland et al., 2019). Malaysia's RE targets together with other ASEAN member states were depicted below (Figure 5.8).

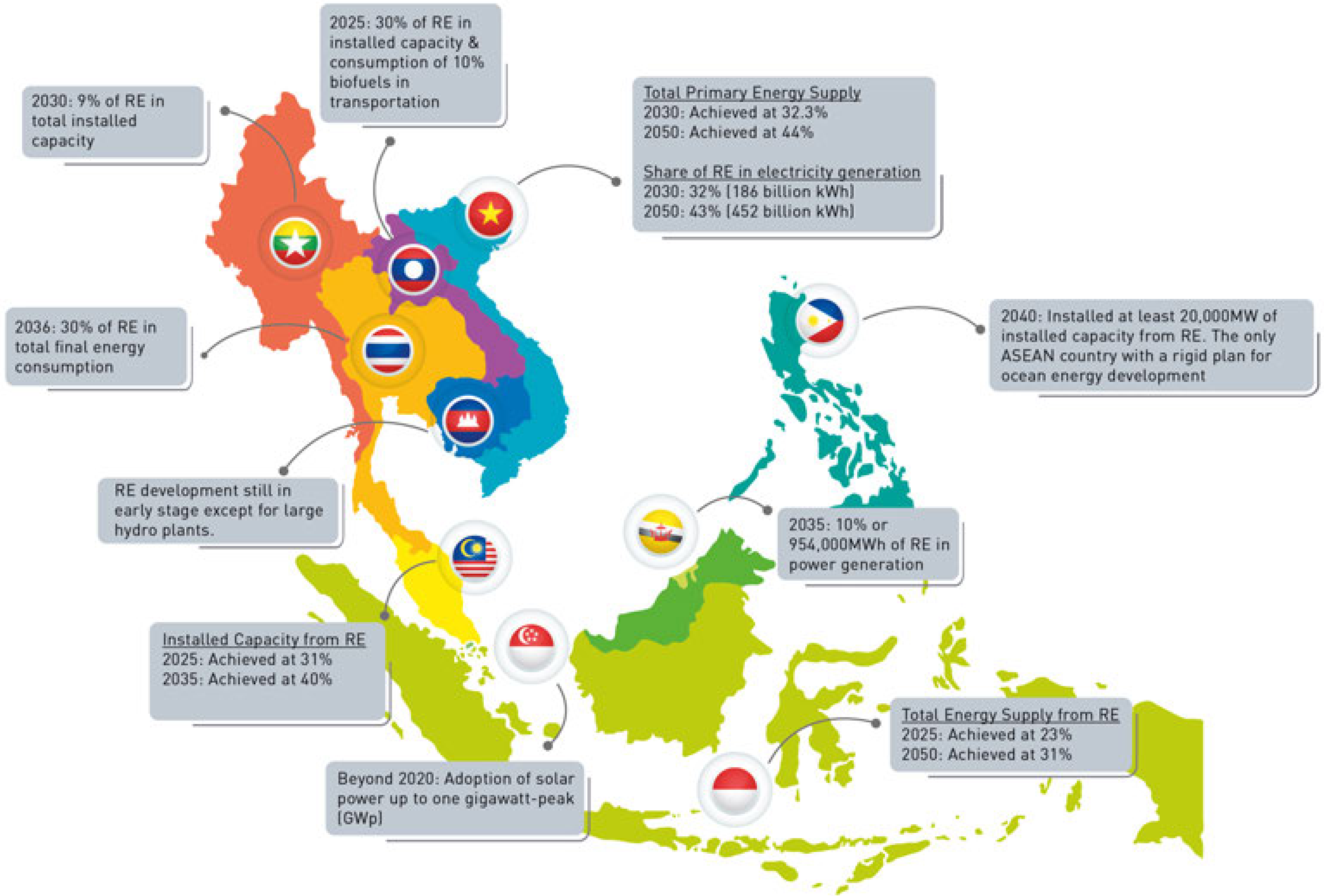


Figure 5.8: Renewable Energy Targets of ASEAN Member States

Although the establishment and implementation of the Feed-in Tariff (FiT) scheme under the Renewable Energy Act 2011 was expected to propel RE in Malaysia, its share of primary supply was only 1.0% as of 2018 (Energy Commission, 2020). RE only contributed 18% of the present installed capacity with hydropower taking up the lion's share (Dave and Priyanshu, 2021), hence the target to increase RE to 31% of the installed capacity by 2025 without hydropower is significant (KETSA, 2021).

To support RE uptake, Malaysia needs to develop a comprehensive mechanism for assessing and improving electricity network connections, use, pricing, and renewable energy integration mechanisms (World Bank, 2018). This requires the Government to be a major facilitator by harmonising existing energy-related STI initiatives with the GTMP across various energy players in the country and improve energy governance in the country.

Renewable energy can be a cost-effective solution for rural areas unable to connect to the central electricity grid. Biogas generation could feed into the circular economy of agriculture regions to generate clean energy and remove agro waste efficiently. A reliable source of RE to power these remote locations will improve the rural population's quality of life and expand their socio-economic opportunities. Effective Government-private partnerships are needed to encourage the adoption of RE to replace environment damaging fossil fuels and gain invaluable environmental credits for the country.

Increasing the nation's share in RE is integral to Malaysia's commitment on the various climate change, biodiversity, and sustainability agreements (Figure 5.6). The international market, particularly those from advanced economies, have begun to deny the entry of products deemed to be from unsustainable sources. Increasing the RE share in Malaysia's energy pie, e.g. through the use of ocean thermal energy conversion (OTEC) (see Box Article 5.1), will not only help the country manage its resources better for future generations and conserve the environment, but it will also neutralise possible objection from economies with protectionist policies.

Box Article 5.1: Ocean Thermal Energy Conversion (OTEC)

Ocean thermal energy conversion (OTEC) uses the temperature difference between cold ocean water and warm tropical surface waters to generate electricity. The warm surface water is used to heat ammonia (or a similar liquid) that boils at low temperature and the resulting gas is used to drive turbines that produce electricity. The gas is then cooled by cold water pumped up from the dark ocean depths and the resulting fluid is recycled to help generate power.

OTEC technologies complement all 17 UN Sustainable Development Goals (SDGs) by going hand-in-hand with the aim to tackle climate change and preserve oceans and waters.

Although OTEC has been identified as one of the 21 most impactful and emerging technologies to achieve Progressive Malaysia 2050 status. There are no national agencies championing it other than the UTM Ocean Thermal Energy Centre.

Malaysia has the potential to generate 26,000MW of energy which is valued at USD780 billion via OTEC. The Northwest Borneo Trench – about 200km wide, 300km long and almost 4km deep – has been prospected as a target site. With the right partnership, OTEC Malaysia will be able to produce hydrogen for export to countries like China, Japan & Korea as well as to supply the national power grid.

References:
ASM (2017a); UTM OTEC (2019)

KEY INTERVENTION

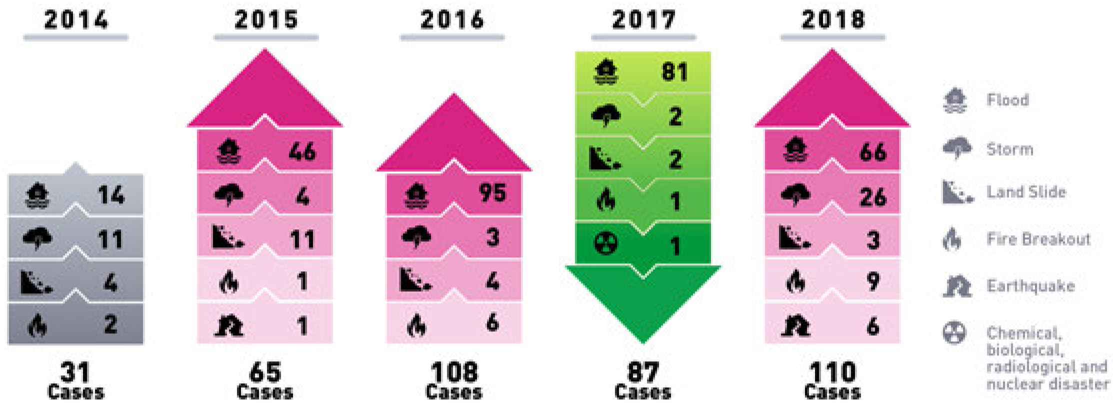
1. **To harness public-private partnership for sustainable financing for research, development, demonstration and deployment (R, D, D & D) of renewable energy technologies which include new capacities for renewable energy integration mechanisms**

Other ASM publications on energy and GHG emissions:

1. The Blueprint for Fuel Cell Industries in Malaysia (2017)
2. Carbon Free Energy – Roadmap for Malaysia (2015)
3. Energy Usage and Efficiency in Transportation (2015)

Climate Change Impact

No country is immune to the impact of climate change, which ranges from an increase in land and ocean surface temperatures, inexplicable changes in rain pattern, higher risk of droughts, rising ocean levels, and an increased frequency of bad weather. The projected increase in climate-related GHG in the atmosphere is likely to change the balance of seasonal temperature variations worldwide, which can affect food production and ultimately lead to famine (Haliza, 2018). The 6th edition of the Intergovernmental Panel on Climate Change (IPCC) report confirms the widespread, rapid, and intensifying climate change globally (IPCC, 2021). Malaysia must put in place measures to address climate change and implement strategies to protect the people and its natural capital.



Reference: Adapted from NADMA, (2018)

Figure 5.9: Malaysia Disaster Occurrence, 2014-2018

Malaysia is blessed in its geological characteristics although the country is at the very fringe of the volatile Pacific Ring of Fire. With the exception of floods, the 2004 tsunami, and the 2015 earthquake in Ranau, the nation experienced very few natural disasters unlike many of the neighbouring countries. Flood is the most common natural disaster, followed by storms and landslides (Figure 5.9). The unexpected 2004 tsunami killed 68 people along the west coast of the Peninsula, resulting in a strong push for a tsunami warning system (see Box Article 5.2).

Box Article 5.2: Tsunami Response

Three hours after an earthquake measuring nine on the Richter scale struck northwest Sumatra in December 2004, the tsunami's first wave swept into Malaysian waters, causing much devastation in Penang, Perlis, Kedah, and Perak. The nationwide death toll was 68, of which 54 deaths were in Penang with some victims still missing and presumed dead. 138 homes were destroyed, 551 large fishing boats were damaged, and 1,195 cases of property damage were reported.

The tsunami caught the country completely off-guard; at that time Malaysia had no experience in dealing with an earthquake or its aftermath. The destruction made it clear of the need for an early warning system as well as protective measures against tsunami. Within a month after the disaster, two multi-agency taskforces were formed; one to set up a tsunami early-warning system and the other the National Special Task Force for Rehabilitation of Coastal Forests.

Malaysia went on to establish its own early-warning system complete with sensors and communication links right down to the ground and rescue personnel. These efforts were supported by the Guiding Principles for Post-Tsunami Rehabilitation and Reconstruction, namely to reduce vulnerability to natural hazards by establishing a regional early warning system, greenbelts, and other "no-build" areas.

In 2006, ASM published 'Seismic & Tsunami Hazards in Malaysia', a study funded by MOSTI. It outlined the need for Malaysia to be a tsunami-ready society with rapid response time and action when faced with unexpected disasters. MetMalaysia has undertaken a series of workshops targeting coastal villagers, with the cooperation of the National Security Agency and State Governments. Its excellent training programmes are also conducted for regional participants.

References:
Keizrul et al. (2005); UNEP (2005)

The estimated average cost from annual flood damage was estimated to be around RM100 million in the 1980's and this has increased to RM915 million in the early 2000s (Che Ros et al., 2019). These figures do not include the cost borne by the Government for disaster relief, flood mitigation, as well as drainage maintenance. Private businesses in urban areas suffer greater financial losses from floods compared to rural areas (Abdullah et al., 2019). Urbanisation, extensive logging, deforestation of peat swamp forests as well as reclamation of mangroves are all contributing factors of the record-breaking floods in the past 30 years. Floods do not affect all states equally as seen in Figure 5.10 and Table 5.1; some states are worse affected than the others. This is due to geographical factors, socio-economic activities in the region, as well as the intensity of the flooding.

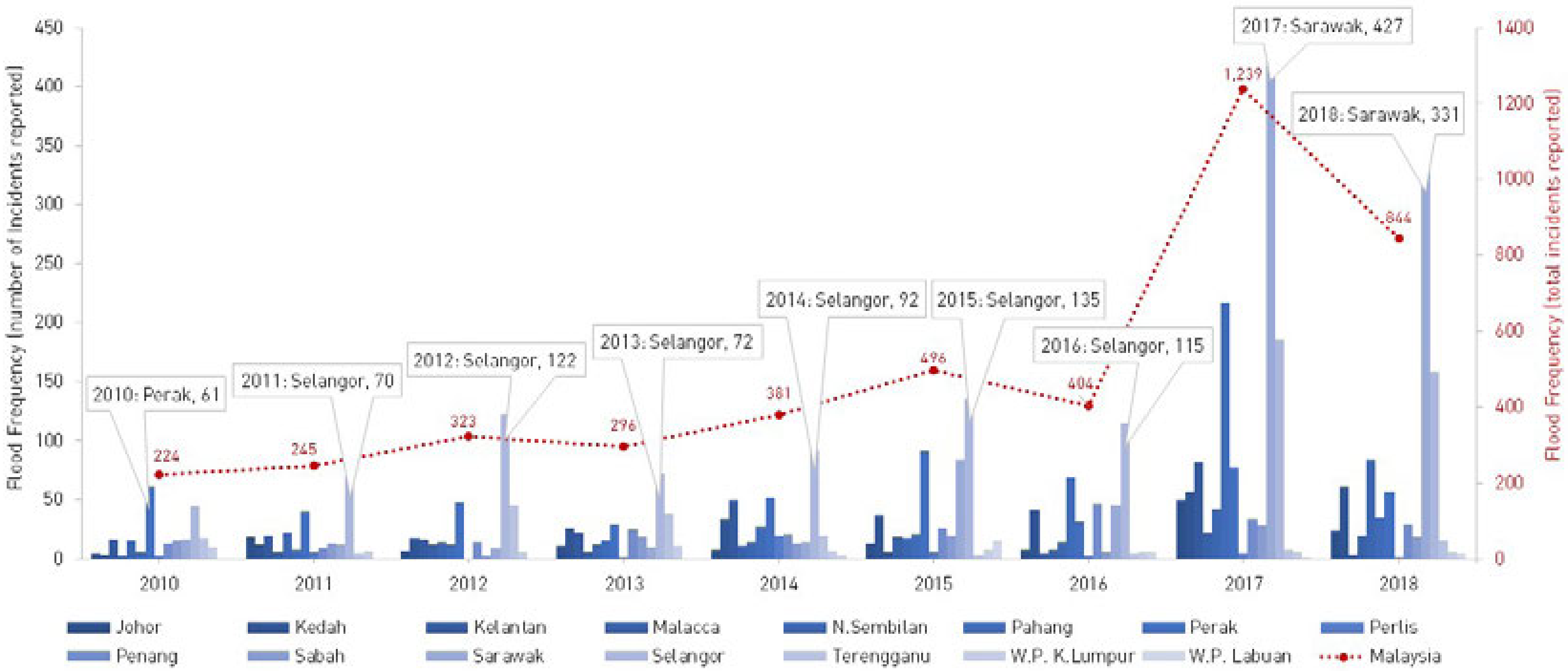


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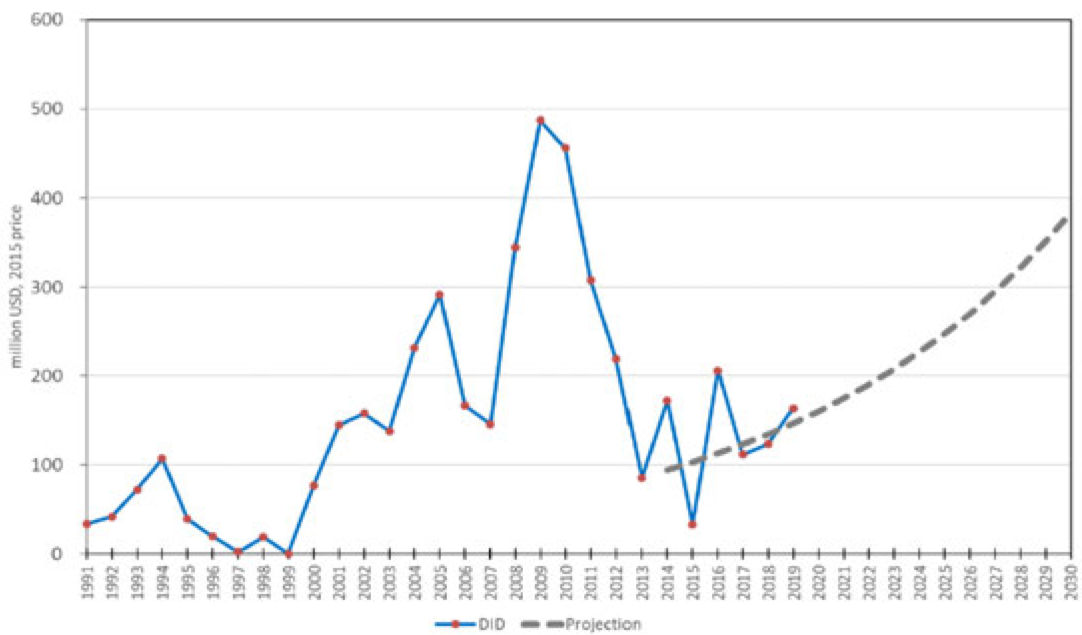
Figure 5.10: Flood Frequency of States in Malaysia, 2010 – 2018

The Government has earmarked a total of RM1.7 billion between 2005 and 2020 for flood mitigation under the 9th, 10th and 11th Malaysian Plan (Che Ros et al., 2019). These monies are for setting up the National Flood Forecasting and Warning System (NaFFWS) as well as scheduled irrigation, river basin studies, and drainage master plans for major towns together with other structural and non-structural measures. However, this may be insufficient as the number of areas affected by flooding increases and project costs rise (Figure 5.11). The SMART Tunnel is one of the innovative measures to mitigate floods in the KL metropolis (see Box Article Box 5.3).

Table 5.1: Summary of Flood Conditions in Malaysia

State	Flood prone area (km²)	Affected population (2000 census)	Avg annual damage (RM mil)
Johor	2,367	290,570	64.00
Kedah	209	117,368	30.20
Kelantan	1,640	714,287	93.32
Malacca	81	27,811	2.29
N. Sembilan	129	40,887	3.96
Pahang	6,272	615,128	76.15
Perak	663	275,374	22.64
Perlis	27	12,736	2.75
Penang	207	342,254	44.52
Selangor	1,789	669,217	75.76
Terengganu	2,223	425,396	101.58
Sabah	3,284	652,173	140.96
Sarawak	10,896	478,491	157.65
K.Lumpur	13	157,302	99.30

Reference: Adapted from Che Ros et al., (2019)



Reference: Adapted from Che Ros et al., (2019)

Figure 5.11: Projection of Flood Mitigation Budget, 2020-2030

Box Article 5.3: SMART Tunnel to mitigate flash floods in Kuala Lumpur

Stormwater Management and Road Tunnel (SMART) was one of Malaysia's megaproject initiated by the Federal Government in 2003 and was completed in 2007. It was a joint venture between the Malaysian Mining Corporation Berhad (MMC) and Gamuda Berhad with the Department of Irrigation and Drainage Malaysia and the Malaysian Highway Authority as the executing government agencies. Registered as Expressway 38, SMART is a 13.2m diameter tunnel and a 9.7km long stormwater by-pass tunnel built using cutting edge construction engineering innovative design. It is the longest stormwater tunnel in South East Asia and the second longest in Asia. The project has gone on record as one of Malaysia's major breakthroughs with local engineers coming together to manage and construct SMART below congested roads while dealing with challenging geological conditions.

The SMART project was estimated to cost RM1.9 billion (68% from the Government and 32% from the contractor) using a mechanised tunnel boring machine (TBM) technology, which was more cost effective and advanced than the conventional drill and blast methods. The Slurry Shield TBM selected for the project helped to minimise negative impact from the soil conditions and helped overcome the groundwater drawdown problem – the root cause of sinkholes – thus making it suitable for boring through the karstic limestone and high ground water table underlying the city. Karst features such as cliffs, pinnacles, cavities, collapsed cavities and sinkholes, are among the most complicated ground condition that can pose a variety of geohazards to the foundation of structures.

The SMART tunnel layout for stormwater management and the unique nature of the road tunnel have earned the project recognition both at the national and international level. In 2016, CNN named SMART as one of the top 10 greatest tunnels in the world, alongside the 57km Gotthard Base Tunnel and the UK-France Channel Tunnel. In 2011, the SMART project was awarded the UN-Habitat Scroll of Honour Award as one of the most innovative projects in the world for effectively solving an urban issue of managing stormwater and peak hour traffic. SMART uses data analytics via a supervisory control and data acquisition (SCADA) system that operates on real-time data analysis and flood forecasting information that supports the traffic system and incorporates a modern flood detection system which uses automated image detection via video footage to identify unusual conditions or behaviour within the tunnel.

SMART has helped to mitigate the frequent flash floods around the city that arise from the poor drainage system that is unable to cope with an increase in yearly rainfall in the KL metropolitan city and the resultant overflow at the confluence of the Klang River/ Ampang River and Klang River/ Gombak River. The capacity of the reservoir ponds and flood diversion tunnels is 3 million m^3; the diversion tunnel starts from Kg. Berembang holding pond at Ampang's upstream towards the south and ends at the attenuation pond in Taman Desa before releasing the flood water to Sg. Kerayong through the Twin Box Culvert.

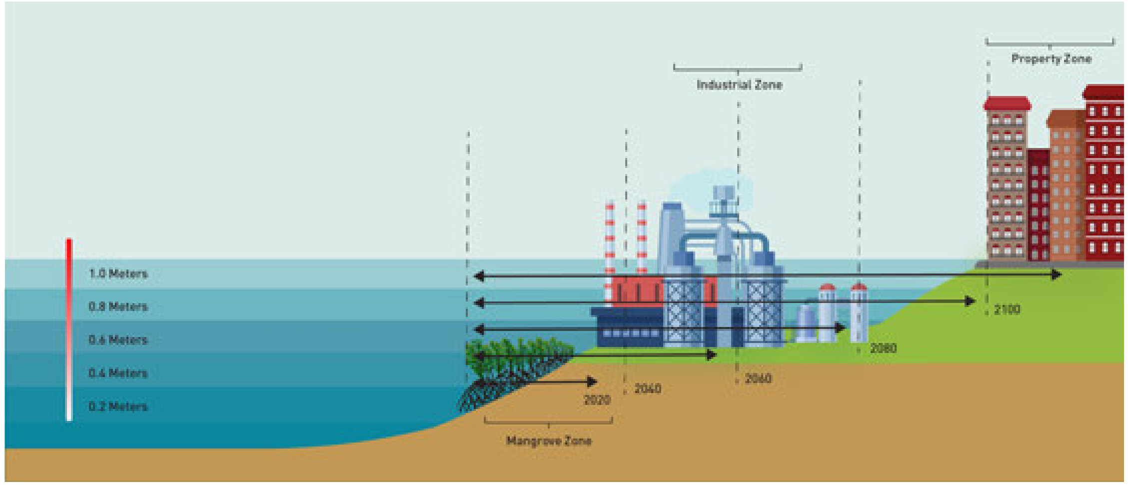
In the 12 years of its operation, SMART has managed to mitigate 45% of the total flood risk disasters in Klang Valley; it even successfully accommodated and diverted 3.5 million m^3 of water during a particularly heavy deluge in 2018 which was well beyond its expected capacity. However, it is envisaged SMART may be burdened beyond its capacity and thus lose its effectiveness in the future, attributed to the rapid increase in hard surface covers from unceasing development in the city centre, coupled with increasing rainfall intensity driven by climate change.

References:
CNN Travel (2016); Department of Irrigation and Drainage, (2019); Jessie Lim, (2018); Lembaga Lebuhraya Malaysia, (2008-2019); MMC-GAMUDA, (N.D.a); MMC-GAMUDA, (N.D.b); The Star, (2015); TRX City, (N.D)

One of the effects of climate change is the rise of the mean surface temperature in Malaysia which has been rising by around 0.13°C to 0.24°C per decade over the last 46 years (MESTECC, 2018a). Between 1993 and 2015, the cumulative sea level rise around Malaysia was 50mm at an average annual rate of 4.22 ± 0.12mm per year, a rate that exceeds the global rate of 2 - 3mm per year (Hamid et al., 2018). Climate change modelling indicated that Malaysian mangroves, which act as effective barriers to coastal upheavals, will be submerged by 2040 if this trend continues and that the rise may even reach one metre by the year 2100.

The most developed and populous regions in Malaysia are located in low-lying coastal areas, making the country extremely vulnerable to sea level risings (Figure 5.12). A sustained rise of 100mm could result in 15m shoreline erosion, making the East Coast of the peninsula and outlying islands especially vulnerable due to their sandy coastlines compared to the mangrove-protected beaches of the West Coast (Hamid et al., 2018). Infiltration of saltwater into the ground water of the coast due to this rise will upset freshwater recharge rates, making water treatment more expensive and even putting drinking water supply at risk (Chun et al., 2018).

Clearly climate change-driven rise in sea level will not just jeopardise Malaysia's growth, but also threaten the well-being of its people and the natural capital of the nation. The Government needs to be proactive in addressing climate change effects on the coastline by strengthening protective measures such as constructing coastal defences, offshore barriers, flood gates, etc. Natural systems such as mangroves and peat swamp forests are crucial to alleviate the effects of climate change; their further depletion will cause even greater long-term cost to the nation than any short-term financial benefits (Ulya et al., 2020). Integrated environmental surveillance across ministries and agencies will provide desperately needed data to guide the implementation and strategies of climate change-related policies; this systemic monitoring will require the support of a digital ledger for data storage, sharing, security provision, and analyses.



Reference: Adapted from Hamid et al., (2018)

Figure 5.12: Potential Impacts of Sea Level Rise over Different Malaysian Coastal Zones

KEY INTERVENTIONS

1. **To strengthen effective governance and institutional arrangements by regular reviews of policy targets and legislation for climate change in Malaysia (inclusive of the Act on Climate Change).**

2. **To enhance the state of preparedness and increase resilience to environmental hazards and disasters by harnessing scientific research, planning, and climate engineering and modelling.**

Food Production

There is no doubt that the agriculture sector laid the foundation for the nation's wealth generation as far back as before Independence. Currently, its share in the country's gross domestic product (GDP) is only 7.1% (DOSM, 2020a). The biggest agriculture output is oil palm products – Malaysia's biggest export commodity – followed by food production, forestry and logging, and rubber.

In 2016, 26.3% of Malaysia's total land area was classified as agricultural land, an increase of 5.7% since 1991. However, this increase is largely due to the oil palm sector, which recorded a 73% increase in oil palm plantations (DOSM, 2020b). These figures do not translate into the desired value-added benefits to food production when compared to some benchmark countries (Figure 5.13).

Land productivity is essential to guarantee higher yield and food security. Unfortunately, Malaysia's food production has yet to achieve food security for the country (see Box Article 5.4) due to a high dependency on imported agricultural inputs and relatively cheap food imports which reduced the pressure on the local agricultural sector to boost productivity, yield and supply.

Much needs to be done to overcome this deficiency. Unsustainable agricultural practices such as inefficient land utilisation, pollution from chemical fertilisers, soil degradation, water leachate, and greenhouse gas emissions must cease (as discussed earlier in the Chapter). A case in point has been described in the review by Razali et al. (2018) which narrates how intensive agricultural development in Cameron Highlands had led to the loss of precious topsoil as well as degraded water quality and loss of biodiversity by unchecked and inappropriate use of fertilisers. Similar practices are also evident in the lowlands.

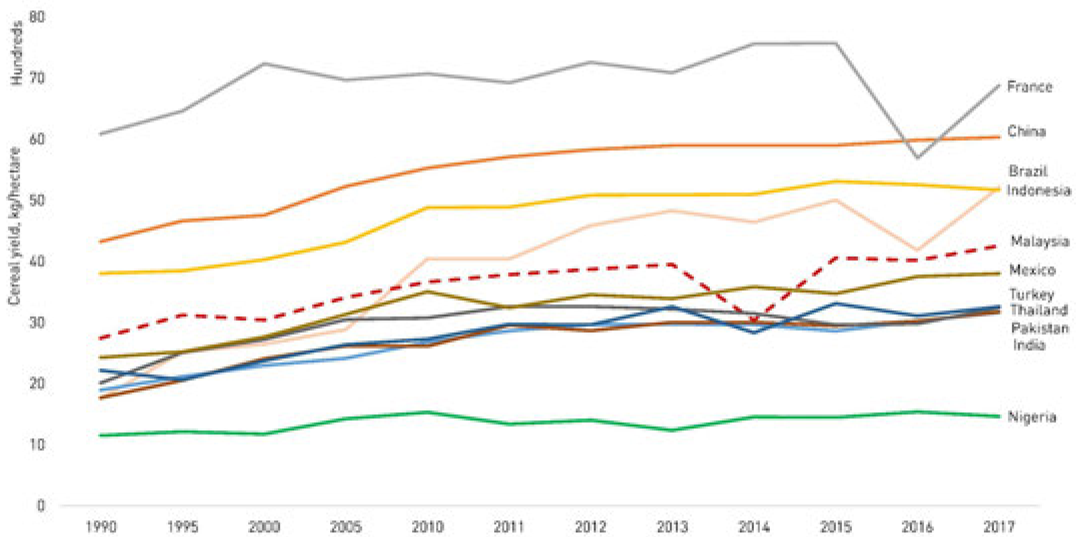


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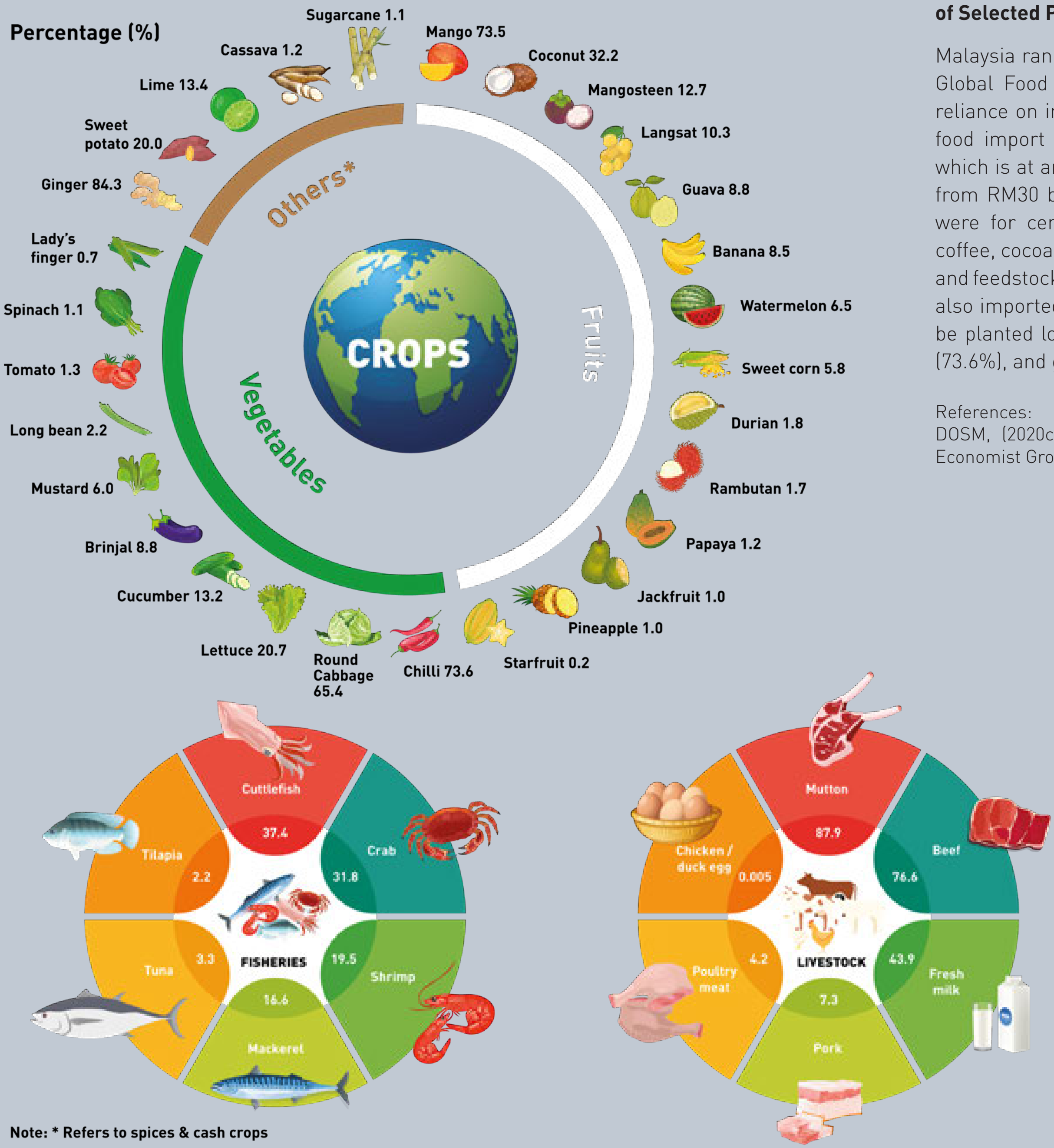
Figure 5.13: Cereal Yield Measured by Kilogram per Hectare Planted

Note: Cereal yield, measured as kilograms per hectare of harvested land, includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains. Production data on cereals relate to crops harvested for dry grain only. Cereal crops harvested for hay or harvested green for food, feed, or silage and those used for grazing are excluded.



Box Article 5.4: Import Dependency Ratio (IDR) of Selected Produce

Malaysia ranked 43 out of 113 index countries in Global Food Security Index (GFSI) 2020. Heavy reliance on imports reflected from the country's food import that reached RM50 billion in 2018 which is at an average of 6.5% increase per year from RM30 billion in 2010. The highest imports were for cereals at RM7.1 billion, followed by coffee, cocoa, tea and spices worth RM7.0 billion, and feedstock valued at RM5.9 billion. The country also imported high amounts of produce that can be planted locally such as mango (73.5%), chilli (73.6%), and ginger (84.3%).

References:
DOSM, (2020c); The Malaysian Reserve (2019); The Economist Group, (2020)

Pesticide contamination is especially destructive; it degrades the biological activity of soils, thus reducing crop yield and also disrupts biodiversity health when these agricultural inputs circulate in the environment through volatilisation, infiltration, runoff, and transport along food chains (Yang Farina, 2016). The detrimental effect of these synthetic chemicals on human health and environment can be removed by adopting technology-driven and sustainable agricultural practices, such as shifting from chemically-intensive agriculture to the use of organic inputs such as organic manure, biofertilisers, biopesticides, nanofertilisers etc. (Chandini et al., 2019).

Organic agriculture has been identified as a niche market opportunity, especially through the involvement of small-scale producers. The Ministry of Agriculture had set a target to have 20,000 hectares of organic farms by 2010 and to increase local production by 4,000 hectares per year (Somasundram et al., 2016). As of 2018, a total of 211 farms comprising only 2003 hectares have been certified to be MyOrganic (Iskandar, 2018), which is a long way off from the set target.

Fish is an important source of protein for Malaysians. The nation produces a total of 1.7 million tonnes of fish which contributes to a 0.9% share of global production (FAO Fisheries Division, 2020). The landing trend of marine fish (including shellfish collection) has been quite stable throughout the years with most sourced from inshore waters (Department of Fisheries, 2020). This is supplemented by aquaculture produce (freshwater & brackish water; Figure 5.14) for both domestic and foreign markets.

Figure 5.14: Aquaculture Production, 1990-2018

Despite the economic benefits from the expansion of this industry, aquaculture threatens the environment through the destruction of wetlands, mangroves, and marshes, which also impacts on the relevant biodiversity that the industry depends upon. Furthermore, the industry is plagued with unsustainable practices that often cause irreversible environmental degradation, e.g. The discharge of effluents from fish farms into ground and surface water.

Pesticide management is under The Pesticides Act 1974, the discharge of pesticide into the environment is regulated under Environmental Quality Act 1974, and the Food Act 1983 prescribes the maximum residue levels of certain pesticides in food. However, enforcement is an issue; banned pesticides such as endosulfan and methomyl are still widely used and available in the market.

Reference:
Jiang, S., (2017),

Yet another popular food source is from poultry and swine production, which together achieved a self-sufficient stage since the 1980s and moved to supply the export market, primarily because of successful technology transfer and adoption. However, the production systems often suffer from non-hygienic issues, namely, odour pollution and fly infestations to the surrounding areas because of the high density of animals housed in the farms as well as water pollution from irresponsible waste discharge. Farm zoning and scheduled effluent management has been introduced to reduce these issues.

Although increasing agricultural productivity is critical to ensure global food security, especially by deploying advanced technologies, this may not be sufficient and sustainable. The three common strategies to increase food supply are by increasing the production area, increasing harvest yield per unit area and producing more crops per year. However, the other opportunity that is frequently overlooked is reducing post-harvest losses. Improper handling of harvested produce throughout the supply chain leads to post-harvest losses, which contributes to food losses, lower harvest quality, and agriculture waste.

It has been estimated that Malaysia's rice post-harvest loss is around 15-20% and about 20-50% for fruits and vegetables. The main reasons for poor post-harvest handling practises are insufficient knowledge of good handling methods (36.7%), inefficient/ improper handling systems (50.3%), improper infrastructure (51.9%) and insufficient funding (38.8%) (Osman et al., 2009). When improvements in harvesting and transportation protocols have taken place, it has significantly decreased post-harvest losses, as recorded at two main granary areas in Malaysia (KETARA & MADA) where it dropped from 28.5% recorded in 1985 to 11.31% in 2015 (Mustaffa, 2016).

Post-harvest losses can also be mitigated through biotechnology and other advanced technologies. For instance, integration of end-to-end smart systems with IoT-supported predictive analytics and machine learning for farmers and warehouse managers to coordinate the current status of harvesting schedules so as to prescribe the most optimum conditions as well as best practices for harvesting and handling routines (Himanshu et al., 2016).

There are new threats to Malaysia's agriculture that could lead to future catastrophes too. One is how the encroachment of agriculture into forested areas is increasing the risk of unknown zoonotic diseases (see below, Section Case Study – Palm Oil Industry). The other is the impact of climate change on yield productivity. It has been projected that major rice granary areas in Peninsular Malaysia may face a 6-31% reduction in average rice yield production between 2030 and 2050 as a result of climate change. To make things worse, it is also projected that an increase of around 106 water deficit months could occur, while paradoxically, at the same time increasing flood risk in other areas. The granary is also vulnerable to flooding as sea levels rise, especially during the South-West Monsoon period due to their location along low-lying coastal plains (MESTECC, 2018a).

Smart and sustainable agricultural practices alongside good planning and management practices can overcome the problems identified in this section (see Box Article 5.5). As urbanisation continues to draw the nation's population away from traditional rural farmland areas, new innovations must be adopted, especially in a post-COVID era when more people may be willing to stay away from the cities if interesting job opportunities open-up even in rural areas. One such system that has been successfully established is an indoor vertical farming strategy reported recently (see Box Article 5.6 below).

KEY INTERVENTION

1. **To halt expansion of agricultural land by advocating adoption of Smart & Sustainable Agriculture technologies.**

Box Article 5.5: Smart and Sustainable Agriculture

The future of agriculture is technology-driven agro-system with prudent ecosystem management. The introduction of Climate Smart Agriculture (CSA) Approach under FAO strategic objective helps guide the transformation of agro-systems to effectively support food productivity and food security in the face of the changing climate. The approach outlines three pillars: (i) Sustainably increase agricultural productivity; (ii) Adapt and build resilience of people and food systems to climate change; and (iii) Reduce and/or remove greenhouse gas emissions, where possible.

Integration of agro-system into the circular economy will help to reduce waste and loss, preserve biodiversity and eco-system services, reduce land use, and improve soil quality. Malaysia has a vast amount of biomass that are currently under-utilised; the utilisation of this untapped resource could divert the waste streams of one supply chain into raw material for another. For example, manure from farmed animals and cuttings from oil palm fresh fruit bunch can be used as organic fertiliser to replenish the soil with nutrients.

Nutrition smart agriculture identifies approaches that need public investments to improve malnutrition of the local population as a building block of food systems that promote healthy people, a healthy planet, and healthy economies.

The agriculture sector should take up appropriate technologies that improve production with less dependency on cheap foreign labour while maintaining environmental sustainability. Omics technology can help prepare the sector to adapt to environmental and weather uncertainties from climate change by coming up with disease- and climate-resilient breeds. Precision agriculture through the use of drone, robots, and IoT-connected agro-system reduces the need for labour. Blockchain technology can be used to track compliance to standards to ensure a high-quality production. Essentially, these applications increase productivity of sustainable agricultural activities by reducing post-harvest losses, improving resource efficiency, and ensuring prudent management.

STI helps overcome issues of limited areas for farming especially in urban areas through solar powered urban vertical farming supported by automated control system. This agro-system exerts less pressure on resources through energy efficiency and optimum water utilisation and meet the food demand for the urban population. It is time for the agriculture sector to shift from conventional practices to smart and sustainable agro-system that integrates advanced technologies with nature-based solutions for sustainable management of resources and the ecosystem while ensuring yield productivity and food security.

References:
Esposito et al. (2020); Food and Agriculture Organization of the United Nations, (N.D.); Hamzah et al. (2019); World Bank, (2020)

Box Article 5.6: A Case Study on Agroz Group Sdn Bhd, Malaysia Intelligent Smart Agriculture – *Indoor vertical farms*

The home-grown Agroz Group Sdn Bhd, founded by a technopreneur, Gerard Lim King Meng, aims to address the issue of Food Safety, Food Security and Sustainability in Malaysia with its large scale industrial-grade indoor vertical farms using a myriad of advanced technologies to ensure repeatability of its farming process which are scalable and traceable via IoT, big data analytics, artificial and augmented intelligence, machine learning, blockchain and in the future, 5G, to create a sustainable approach to modern precision agriculture through indoor vertical farming. Vertical farming not only saves space and land, fresh vegetables are grown in a precision-controlled environment (using non-genetically modified organism seeds with organic nutrients that are free from harmful chemicals and pesticides, and the optimum temperature, humidity level, and lighting combinations) thereby eliminating the use of large amounts of pesticide chemicals and preservatives. Currently, the company manages a production capacity of 200kg per month and is expected to reach one tonne per day from various farms committed with further plans to build 100,000 square feet indoor vertical farms in Malaysia. The projected capacity in 2021 is to produce three tonnes of fresh vegetables daily, making it the largest of its kind in Malaysia. Indoor vertical farms are expected to generate hundreds of new high-value jobs post-COVID-19.

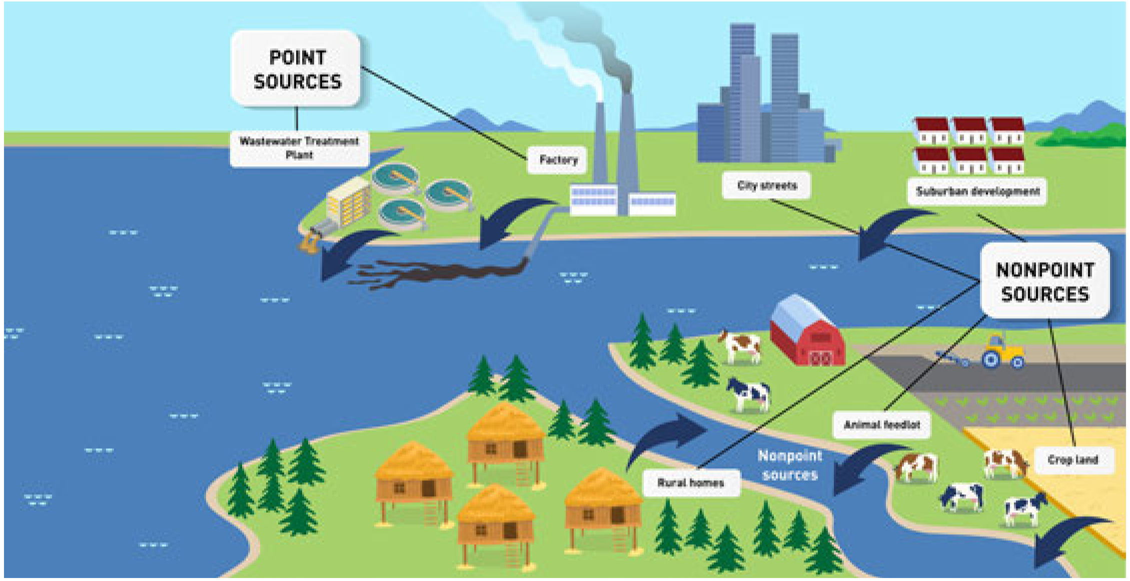
References:
Agroz, (2016); Joy Lee, (2021)

Water Quality

Life on Earth is made possible because of water, a vital natural capital. Malaysia is blessed with a wide range of water sources; however, pollution and degradation in water quality has led to water disruptions which are expected to worsen with increased urbanisation as well as intensive and expensive industrial and agricultural activities (ASEAN, 2017). Figure 5.15 illustrates the various possible sources of water pollution.

70% of Malaysia's water source comes from rivers followed by water from storage dams and ground water (DOSM, 2011-2020). The largest contributor to river pollution in Malaysia during 2019 is untreated sewage with highest loadings at 51% biological oxygen demand (BOD), 29% suspended solids (SS), and 80% ammoniacal nitrogen (NH_4) for 2019. This is followed by waste from agriculture-based industries, untreated sullage (domestic grey water discharge), as well as manufacturing industry discharge (DOE, 2019).

Although nearly all housing and commercial development in the past 30 years are well connected to public sewage treatment plants (STPs), older buildings still use individual septic tanks or private STPs, which may be poorly maintained and incapable of treating raw sewage appropriately. Many rural homes still depend on primitive sewage systems that allow untreated sewage to seep into groundwater and water-bodies such as rivers, lakes, and sea. Insufficient public awareness on sewage issues as well as inadequate regulations and implementation were identified as major factors for continued sewage pollution (Mariani and Siti, 2015).



Reference: Modified from Environmental Science, (N.D.)

Figure 5.15: General Sources of River Pollution

Due to the importance of rivers for the nation's water supply, Malaysia has the fourth highest number of river monitoring stations among the countries within the Water Environment Partnership in Asia (WEPA) (IGES, 2019). Overall, the river quality trend has been stable from 2005 to 2019 (DOE, 2010-2019). The total number of clean rivers have increased from 53% (1990) to 61% (2019) and as of 2019, only 61% of all rivers were classified as Clean Water (Figure 5.16). In 2019, only one river was classified as Class V which is a positive improvement compared to the previous year when four rivers were classified as Class V. Sungai Buluh and Sungai Tukang Batu in Pasir Gudang, and Sungai Sengkuang in Tebrau has recovered and are now Class IV rivers due to extensive efforts to clean up of Sg Kim Kim and river monitoring including the nearby rivers, after the controversial river pollution incident in early 2019 (see Box Article 5.7). Extensive animal farming and aquaculture activities across the border in Negeri Sembilan were the source of the severe pollution that relegated Sungai Rambai to a Class V river (Grace and Sarban, 2019). This makes a strong case for the need to restructure and reinforce water- and environmental pollution-related governance at federal and state level so as to address this issue comprehensively.

Appropriate sewage treatment can be channelled into circular economy through biogas production from anaerobic digestion of sewage sludge

Reference:
Siti Indati Mustapa et al. (2020)

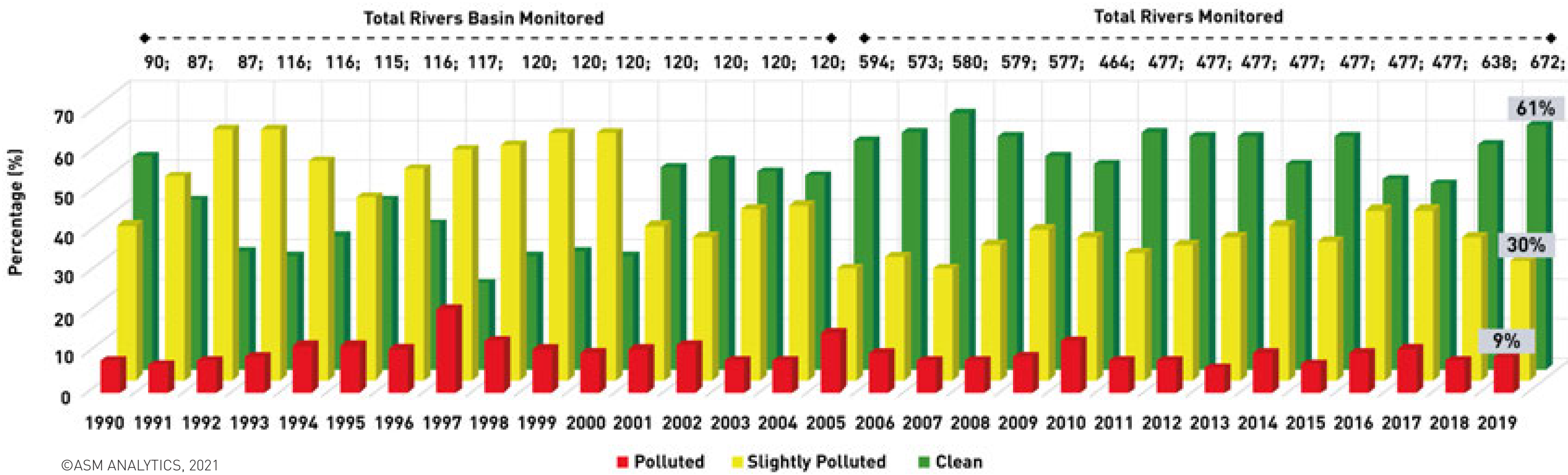


Figure 5.16: Health Overview of Monitored Rivers in Malaysia, 1990-2019

Box Article 5.7: Sungai Kim Kim Incident and Pasir Gudang Incidents

The first incident was reported on 7 March 2019 after school children in Pasir Gudang were found with breathing difficulties, dizziness, nausea, and vomiting. The cause was initially suspected to originate from the illegal dumping of hazardous chemical wastes into Sungai Kim Kim.

A total of 5,039 cases were reported and 111 schools were shut down. Another 1,178 cases, primarily children, were reported in June 2019. The clean-up cost of the river alone was approximately RM6.45 million. A nearby elevated chemical factory stack has been pinpointed as the actual source of the toxicity.

There are over 2,000 factories situated close to residential areas and other public institutions and facilities including schools in Pasir Gudang. The buffer zone for heavy industry is only 500m – a significant reduction from 1,500m in the early 1990's – which increased risk of a major industrial accident that could badly affect the nearby population of almost half a million people.

The Sungai Kim Kim incident is the disaster waiting to happen when environmental monitoring of industrial areas is lax. The three rivers in the Pasir Gudang river basin – Sungai Kim Kim, Sungai Masai, and Sungai Tukang Batu – were categorised as polluted in 2017. The rapid degradation of the rivers and their ecosystems are worsened by the lack of appropriate institutional frameworks, low capacity for integrated river basin management, and insufficient institutional focus on the conservation of riverine biodiversity.

Stronger governance of hazardous chemicals management and enforcement of municipal regulations of industrial areas are needed to prevent another similar incident. Relevant agencies should put in place highly efficient river quality monitoring system that make use of advanced intelligence system and sensors technology to monitor and identify polluters. Drones could be used to measure gases in the affected area and map the altitude and location using GPS. Additionally, big data analytics can be embedded as part of integrated data management to identify and address pollution.

References:

Academy Sciences of Malaysia, (2017b); Academy Sciences of Malaysia, (2019); Mei Mei Chu et al. (2019)

Malaysia practices conventional water treatment methods involving coagulation, settling, filtration, and chlorination to treat raw water (Zaini et al., 2008). Therefore, water treatment plant closure is inevitable whenever pollution is detected in water catchment areas. Pollution from increasing diversification of industrial and agricultural activities as well as leachate from inappropriate waste disposal and open landfill pose a critical danger to the sustainability and safety of Malaysia's water supply (Lee, 2020).

Malaysia has established two standards for industrial effluent discharge in the Environmental Quality Act 1974 to protect receiving waters and associated aquatic ecosystems as well as preventing the harmful effects of untreated effluents (DOE, 2009). Unfortunately, many industrial premises do not comply with effluent discharge standards (Regulation 8) and do not install the required effluent treatment plants (Regulation 4). This failure prevents water reclamation efforts essential to reduce dependency on precious green water for non-domestic purposes; stricter enforcement is needed to support the Government's water reclamation targets set out within the Environmental Sustainability in Malaysia 2020-2030 Roadmap (KASA, 2020b).

Up to 35% of Malaysia's water supply is also affected by non-revenue water (NRW) loss caused by pipe leakages etc. between 2014-2018 (DOSM, 2012-2019). SPAN has set up a long-term NRW target over ten years commencing from 2011 for each operator to achieve a lower national target of 25% by year 2020 for Peninsular Malaysia (ASM, 2018). Malaysia's low water tariff at RM1.38 per 1,000 litres of water for the past 20 years (NST, 2020) is making it difficult to finance the pipe replacement programme; a review of the tariff rate is long overdue.

The Department of Environment's Marine Water Quality Index (MWQI) measures the degree of pollution in land- and sea-based water sources. The year 2018 saw MWQI improvement in both coastal areas and islands in Malaysia (Figure 5.17). However, the marine water quality at the five estuaries recorded as polluted stations – namely Kuala Sungai Juru (Penang), Kuala Sungai Tengah (Penang), Kuala Sungai Klang (Selangor), Kuala Sungai Langat (Lumut), and Kuala Sungai Segget (Johor) – declined due to contamination from landfills and inland human activities (i.e. agricultural and industrial) as well as water circulation patterns which reflect the dynamic nature of these waters in comparison to coastal and island type stations (Figure 5.17).

> Policies governing water and pollution are under both federal and state jurisdiction. Strengthening the governance requires harmonising the management between the stakeholders. Strengthening the sustainability of the water sector means greater support from the private sector is needed as it is too dependent on Government funding.

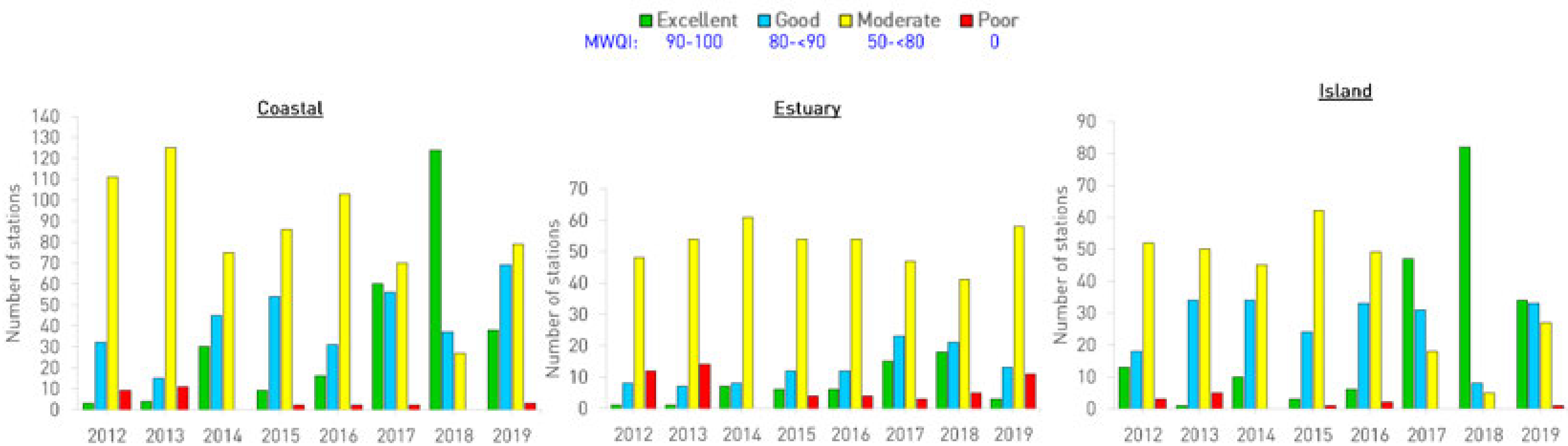


Figure 5.17: Marine Water Status, 2012-2019

Oil spills are another hazard that threatens marine and human health as well the ecosystem. Between 2006 and 2018, there were no less than ten incidences of oil spill in Malaysian coastal waters (DOSM, 2010-2020), primarily as discharge from sea vessels. The causes of these oil spill incidents vary from human errors (e.g. accidental leaks from ships and off-shore oil platforms), vessel collisions at sea, poor emergency planning and response failures, technical errors (i.e. vessel condition, ocean/coast atmosphere, pollutant discharge from ships-sewage/ pipeline leakage or contaminated ballast water, etc.), and natural disasters (e.g. typhoon).

In addition, climate change has also affected water resources due to changes in rainfall and evaporation cycles leading to too much or too little rainfall (UNESCO, 2020), which is a common cause of natural disasters in Malaysia. Compounded with pollution from industrial effluent and untreated sewage, agricultural run-off, and seawater intrusion into freshwater sources due to rising sea levels, the nation's overall water quality has deteriorated considerably (UNEP, 2016).

KEY INTERVENTION

1. **To enhance effective research and development of better monitoring and information gathering/sharing technologies to control water pollution for long-term water ecological functions and economic contribution sustainability.**

Air Quality

Malaysia's rapid industrialisation and urbanisation have come at the cost of the air quality due to emissions from fuel combustion engines (i.e. motorbikes, automobiles, lorries, aeroplanes, etc.), power plants, industries, and air conditioning. Poor air quality not only damage health, but also reduce the quality of life and harm the environment near and away from the source of pollution. It was estimated that air pollution kills more than seven million people each year and is one of the leading causes of sickness and absenteeism globally (WHO, 2018a).

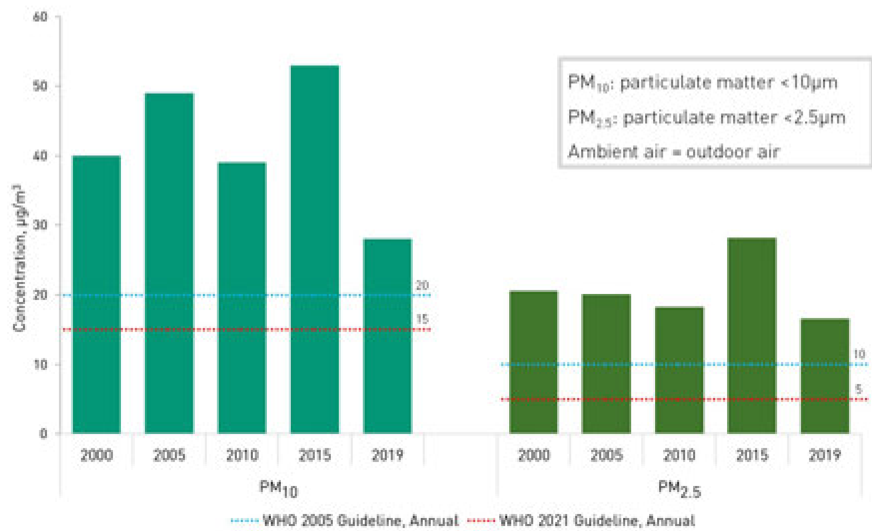


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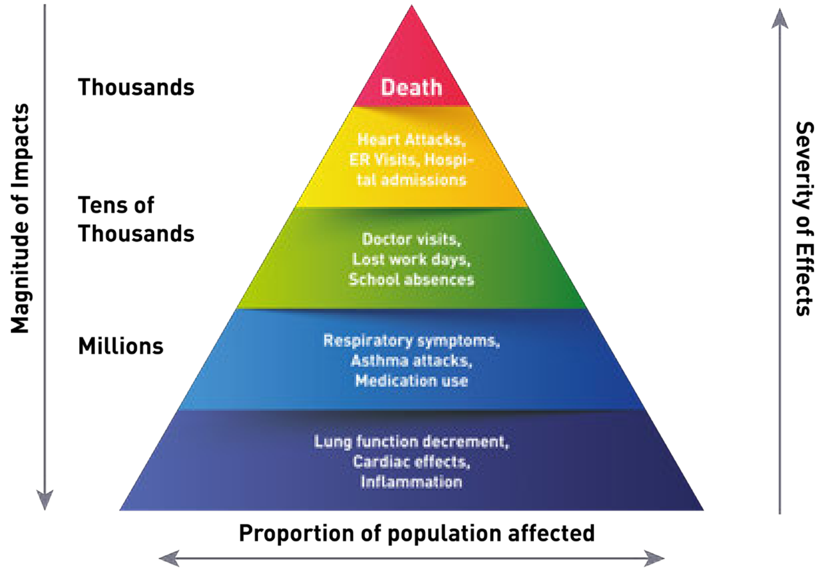
Figure 5.18: Malaysia's Ambient Air Quality Progress of PM_{10} & $PM_{2.5}$ Pollutants, 2000-2019

Malaysia's ambient air quality from 2000 to 2019 showed pollution levels above WHO's air quality guidelines (Figure 5.18), although the Malaysia's 2018 New Ambient Air Quality Standard adopted standards for pollutants' concentration limit to be strengthened in stages which divided into three interim targets, interim target 1 (IT-1) in 2015 (Annual PM_{10}: 50µg/m^3; Annual $PM_{2.5}$: 35µg/m^3), interim target 2 (IT-2) in 2018 (Annual PM_{10}: 45µg/m^3; Annual $PM_{2.5}$: 25µg/m^3) and the full implementation of the standard in 2020 (Annual PM_{10}: 40µg/m^3; Annual $PM_{2.5}$: 15µg/m^3). Studies on indoor and ambient air quality reported that the level of air pollutants were higher indoors versus outdoors, especially in urban buildings (Usmani et al., 2020). Air quality differs according to the region; more pollutants were detected in metropolitan and industrial areas, thus adding another dimension to the environmental stress from urbanisation.

Malaysians suffer a range of ailments due to air pollution from short term (e.g. skin rashes, headaches, eye and nose inflammation) to chronic illnesses (e.g. asthma, lung disease, heart problems, metabolic diseases, high blood pressure), which place a heavy burden on the nation's health system (Figure 5.19). Buildings designed to be cooled with air conditioning often suffer from poor ventilation which increases the build-up of indoor air pollutants, increasing the risk of diseases caused by chronic exposure to air pollution (Norhidayah et al., 2013).

The seasonal haze affects a swath of ASEAN countries causing a variety of socio-economic disruptions. Between 1998-2019, four episodes of severe haze attributed to uncontrolled fires in Kalimantan and Sumatra from annual slash-and-burn clearings of cropland which was heightened by drought conditions were reported (Figure 5.20). The near absence of monsoon rain to dampen the fires during that time resulted in the smoke drifting across the region to Malaysia, Singapore, Brunei Darussalam, and Thailand.

Haze seasons are costly to Malaysia and the neighbouring nations, which is why regional collaboration to manage trans-boundary haze must be strengthened. Children miss out on their education when school are closed during severe haze seasons. Economic loss from illnesses, decline in tourism, productivity loss, grounded aircrafts, cost of firefighting and cloud seeding, and a reduction of fish landings during the 1997 haze amounted to over USD300 million in Malaysia; the cost is likely to increase further with each subsequent occurrence (Latif et al., 2018). Haze mitigation both via collaboration through the ASEAN Transboundary Haze Agreement and advanced climate engineering should be a priority as part of efficient preparedness measures.



Reference: Adapted from Usmani et al., (2020)

Figure 5.19: Pyramid of Health Effects from Air Pollution

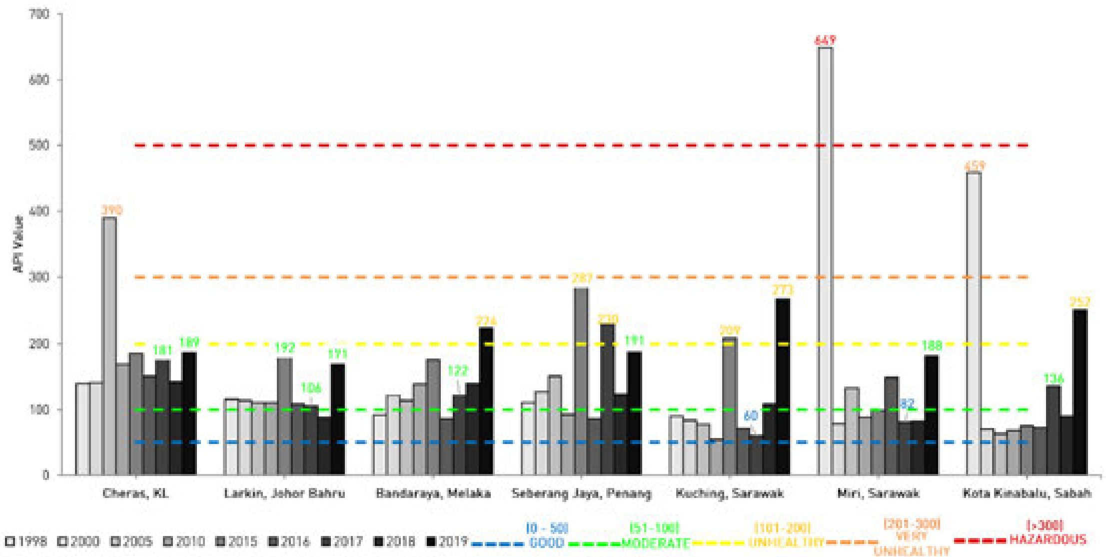


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Figure 5.20: Annual Maximum Air Pollutant Index for Selected Stations in Malaysia, 1998-2019

Prevention and control of air pollution requires policy and coordinated action across several ministries and agencies; at the moment there is no federal legislation to mandate this. Intensifying efforts to reduce greenhouse gases emissions have the added benefit of improving air quality and should be a national priority. Coordinated air pollution monitoring to provide evidence-based support for enforcing industry guidelines governing emission must be established accompanied by periodic inspections. Legal and financial instruments should also be harmonised to encourage a strong and effective buy-in by all stakeholders to reduce air pollution and GHG emissions.

KEY INTERVENTION

1. **To invest in and support innovative air quality monitoring technology for better risk management and systematic health preparedness encompassing both mortality and morbidity aspects including transboundary haze, particularly over long periods of exposure (long-term effects) and in areas of especially high exposure.**

Solid Waste Management

Solid waste management and good sanitation is an integral part of environment and health management. When both are neglected, it leads to deterioration of natural capital which affects the population's health and quality of life. For Malaysia to transition into a high-income nation, integrating waste and resource management is vital for the sustainability and equitability of its growth.

The country's solid waste generation has increased almost 98% between 2000 to 2017 even though the per capita increase is modest (0.8kg/capita/day in 2000 to almost 1.2kg/capita/day in 2017). This is primarily due to population increase, urbanisation, and massive industrialisation in the past 30 years. More than 36,000 metric tonnes of municipal solid wastes (MSW) per day are generated daily and this amount is expected to increase further to 49,670 tonnes per day by 2030.

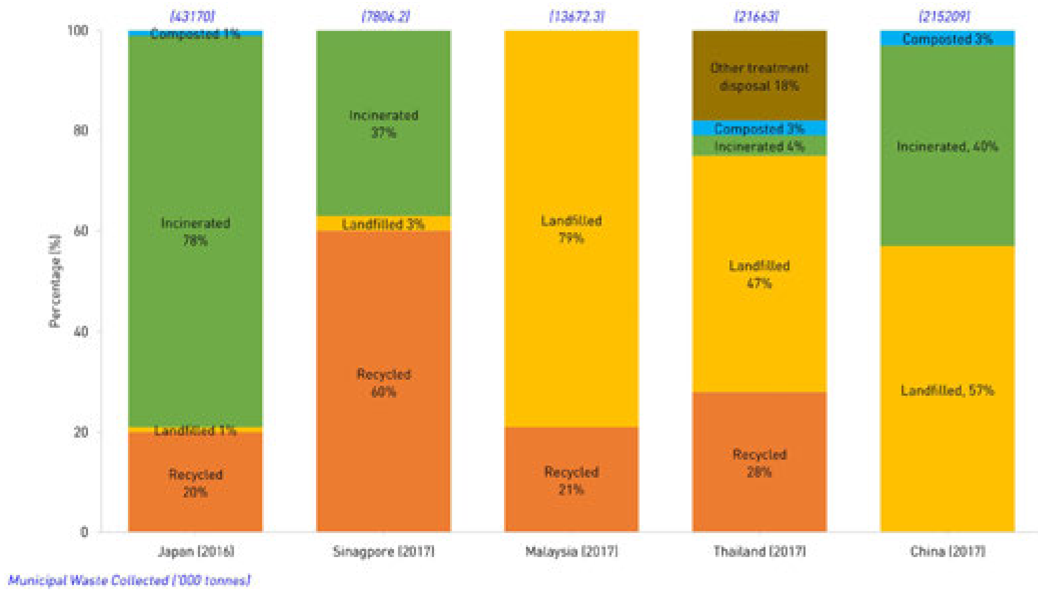

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Figure 5.21: Methods of MSW Treatments

Local MSW is still inefficient due to inadequate waste facilities, lack of funding and insufficient experts. MSW in Malaysia is largely dependent on landfills (Figure 5.21), which is economical but severely damages the environment; contaminating soil and water through leachate and increasing the country's greenhouse gases (GHG) emission from methane and carbon dioxide generated by waste decomposition (KASA, 2020a). Poorly managed landfills is also a factor in the spread of diseases by birds, insects and rodents, and the foul odour from rotting waste makes it unpleasant for those who live nearby. Some of the landfills in Selangor are located close to rivers – often the main sources for water supply – increasing pollution risks that often lead to water supply disruption in Klang Valley.

Organic material makes up the greatest percentage of MSW waste, followed by paper and plastic (Figure 5.22); further analyses of plastic waste was hampered by the lack of more recent data. Changes in the environmental legislature in China – one of the largest plastic recyclers in the world – has shifted the flow of global plastic wastes, diverting thousands of metric tonnes of legal and illegal plastic wastes to Malaysia for recycling and disposal. Most of the plastic waste brought into the country is of low quality – difficult to sort and recycle – so they often end up in illegal landfills, contaminating water sources and damaging the environment. In 2019 alone, Department of Environment (DOE) has shut down 155 illegal plastic waste recycling facilities (Nuraziatul, 2019).

In terms of domestic plastic waste, Malaysia only recycled 24% of the nation's plastic resin in 2019. This low rate of plastic recycling led to plastic material value loss of more than RM4 billion a year (World Bank, 2021). Small to medium enterprises (SMEs) form the bulk of the plastic resin recycling industry; most of them lack access to advanced technologies, standards and certifications, and are unable to scale up due to heavy reliance on informal and fragmented waste supply network. Among the measures needed to build on the growing market demand for recycled plastic content are clear government policies on the use of recycled resins in food-contact applications, better waste sorting at source, increase waste collection rates, and improve the design for recycling standards (World Bank, 2021).

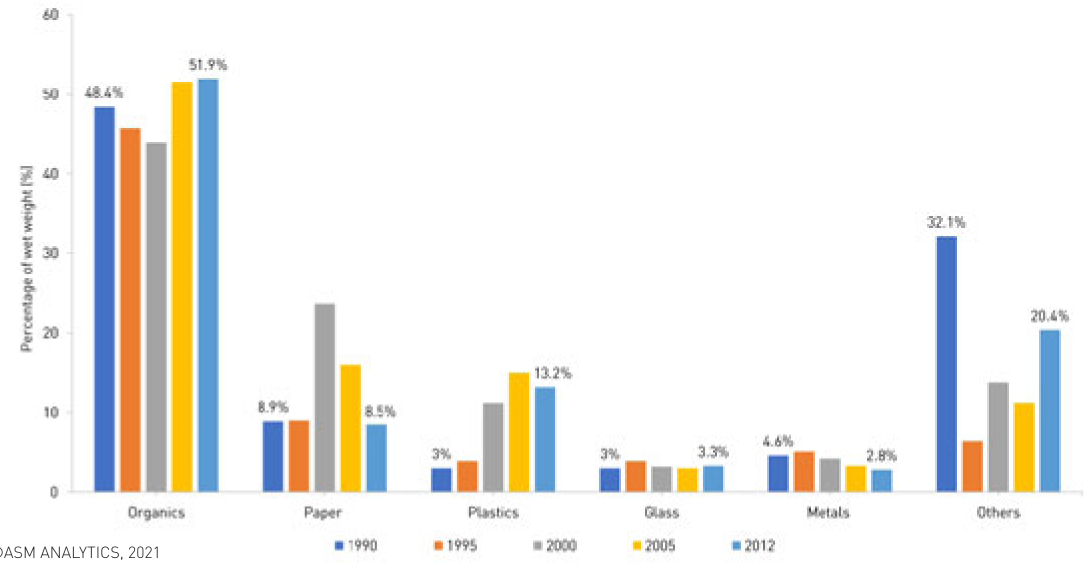

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Figure 5.22: MSW Composition in Malaysia, 1990-2012

Zero-waste circular economy (CE) is a way for resources to be utilised more effectively and sustainably through refurbishment, remanufacturing, and recycling. The 11th Malaysia Plan began to move the nation's growth in this direction by setting the national recycling rate at 22% by 2020. The Malaysia Roadmap Towards Zero Single-use Plastics by 2030 was introduced in 2019 to encourage manufacturers and service sectors to produce and use biodegradable and compostable alternatives to single-use plastics (MESTECC, 2018a).

The Ministry of Housing and Local Government (MHLG) is setting up six waste-to-energy (WtE) plants by 2025 and transform other landfill into integrated landfills in the future (Nur, 2020). WtE converts chemicals from waste residues into usable bioenergy (e.g. electricity, heat, or steam) and minimises solid waste volume to be disposed into existing landfills. At present, Malaysia only has four MSW incinerators under various stages of implementation in Pangkor Island, Labuan, Langkawi and Tioman, and a scheduled waste incinerator in Negeri Sembilan (DOE, 2020).

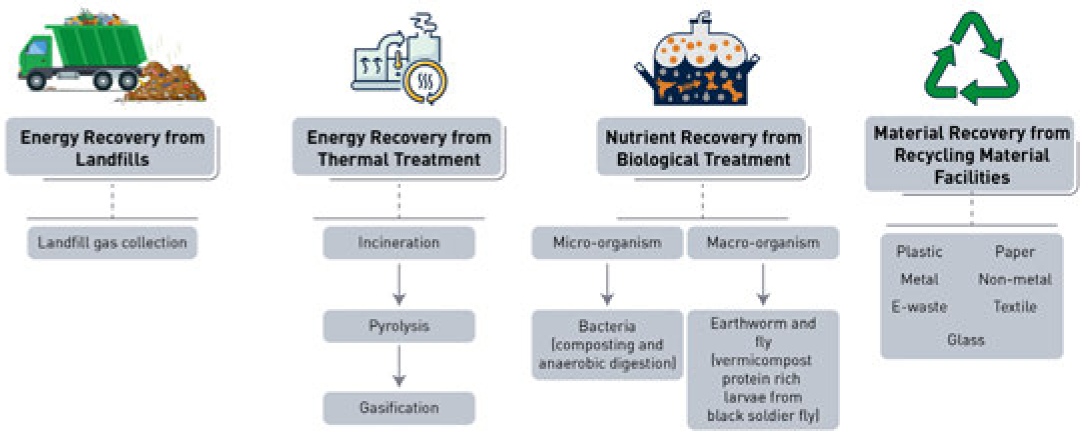
What is zero-waste:

- Striving to reduce waste disposal in landfills and incinerators to zero
- Investing in reuse, recycling and composting jobs and infrastructure
- Requiring that products are made to be non-toxic and recyclable
- Ensuring that manufacturers of products assume the full social and environmental costs of what they produce
- Ensuring that industries reuse materials and respect worker and community rights
- Preventing waste and reducing unnecessary consumption

Municipal workers are exposed to infectious waste generated from households and public places during the COVID-19 pandemic. Potentially contaminated materials include masks, gloves, tissues, and other disposable items. Careless discarding of these items adds to the risk of flash flooding and pose a danger to wildlife

Reference:
UNEP, (2020)

Technology can transform waste from environmental problem into revenue. Figure 5.23 illustrates the waste-to-wealth frontiers for a well-planned zero-waste circular economy (CE). Apart from generating energy, reducing GHG emissions, and minimising the release of environmental toxins, these technologies also extract nutrient from organic wastes to reduce dependency on artificial fertiliser. Sourcing of raw material for industry can also be reduced through material recovery and recycling, which is better for the environment as well as prolonging its lifecycle and stabilising the supply chain.



Reference: Adapted from Sheila, (2020)

Figure 5.23: Frontier Technologies as An Innovative Tool to Transform Waste to Wealth

The Extended Producer Responsibility (EPR) is a policy approach where producers are responsible for treating or disposing of post-consumer products. By placing the responsibility of managing their products' end-of-life, producers are encouraged to prevent wastes at source, rethink product design for the environment, and support public recycling. OECD and European countries have adopted the extension of EPR to new products, product groups and waste streams such as from electrical appliances and electronics. Although there were mere mentions of some form of EPR under the Environmental Quality Act 1974; the Act lacks relevant regulation for its enforcement because EPR in Malaysia is only on voluntary basis (Agamuthu & Victor, 2011; WWF Malaysia, 2020).

Waste from agriculture activity in Malaysia was 0.122kg per capita per day in 2009 and is set to double by 2025. Whether from animals (e.g. manure), crops (e.g. cornstalks, pruning), to food processing scrap and hazardous waste (from pesticides, insecticides and herbicides), nearly all agriculture waste can be processed to give it a new life in the economic cycle (Agamuthu et al., 2009; Ali, 2020). Composting and fertiliser production, biogas generation, bioethanol production from cellulosic material, or the use of rice husk ash to generate cement additives and high-performance concrete, agriculture waste has the potential to be exploited in the circular economy (Agamuthu et al., 2009; Zhang and Malhotra, 1996).

Integrated waste management system is the linchpin to minimise waste through practising the 8Rs of conscious consumption (Rethink, Refuse, Reduce, Reuse, Repair, Regift, Recover, Recycle) The impact of poor waste management on the surrounding ecosystem and water resources underscores the importance of scheduled environmental impact monitoring as an integral part of the waste management system. The Malaysia Smart City Framework outlines how smart cities should include integrated waste management and support collaborative efforts among all stakeholders both private and public, federal and state authorities to share resources and data to preserve the nation's natural assets.

Balancing economic growth against conserving the resources and the environment are discussed in Box Articles 5.8 and 5.9.

KEY INTERVENTIONS

1. **To promote financial instruments and incentives such as Polluters Pay Principle to minimise waste and pollution at source.**

2. **To enhance capacity building and improve public awareness on municipal solid waste management.**

3. **To ensure adequate funding to support Waste to Energy (WtE) facilities nationwide.**

Box Article 5.8: Environmental Impact of Textile & Fashion Industry

The export earnings of the textile, apparel and footwear industry in 2018 was worth RM13.2 billion, the 13th largest exporting industry of that year. It employs over 90,000 people with 970 registered textile factories, 400 of which make ready-to-wear garments, while others are involved in relevant sub-sectors including polymerisation, spinning, weaving, knitting, wet processing, and textile accessories. The Third Industrial Master Plan set out to promote industrial scale investments in high value-added textiles and apparels, including functional fabrics, local batik and songket.

However, the impact of the fashion industry on the environment along the supply chain are tremendous. For example, 2,700 litres of water are required to produce a single t-shirt. Unsustainable practices by SMEs in the batik and fashion industry include excessive use of water, pollution from synthetic dyes and bleaching agents, as well as the release of untreated residual and harmful wastes into rivers and waterways, as detailed below.

Out of 3.1 million tonnes of waste in landfills in 2018, 6.3% came from fabric waste, 75% of which could have been reused, recycled, or reprocessed to become solid fuel for energy generation. At present, less than 1% of fabric waste can be repurposed by separately collecting it to avoid passage into landfills. Furthermore, synthetic fabric waste – 60% of all textiles produced – are as detrimental as plastic waste and can remain in landfills for decades, with the average polyester product likely to survive for over 200 years.

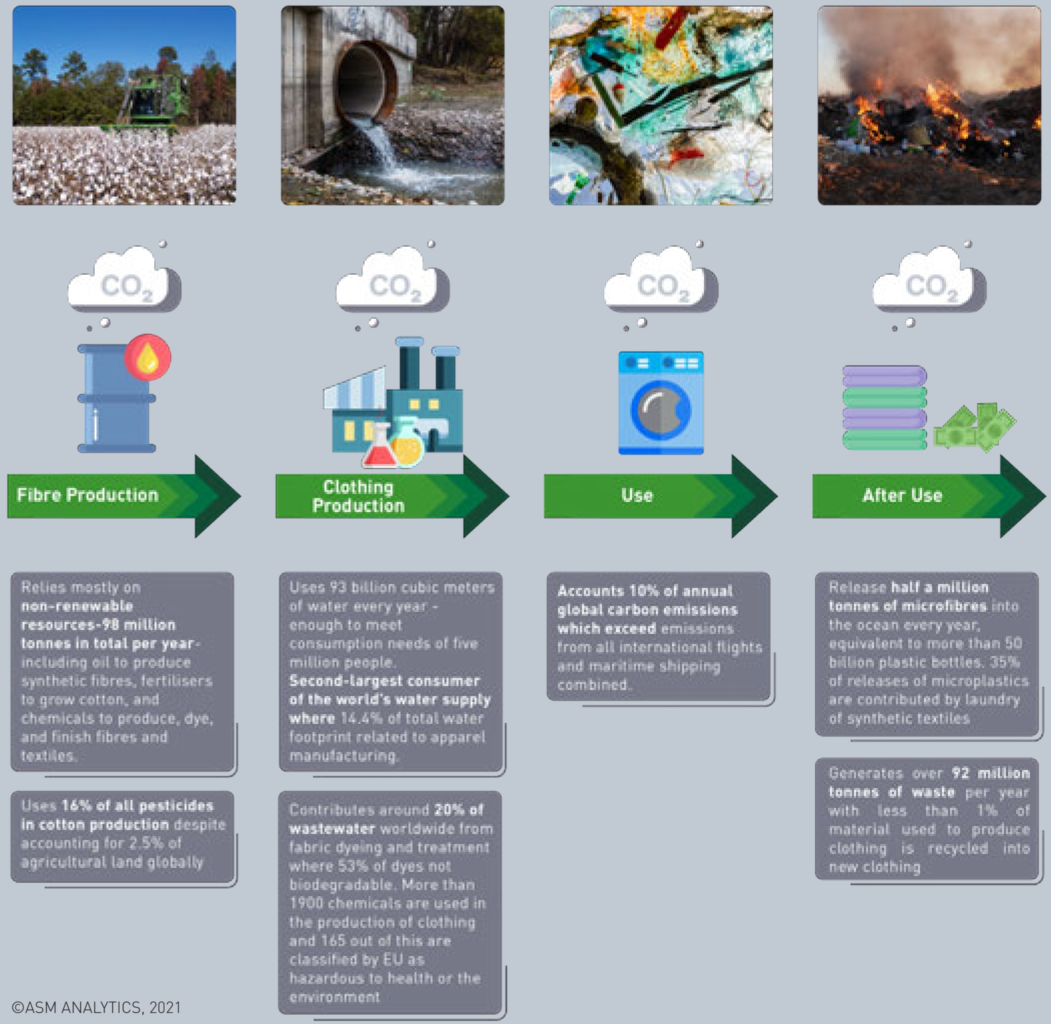


Figure 5.24: The Impact of Fashion Industry

The fashion industry needs to adopt STI-driven green initiatives throughout the supply chain to be sustainable per the example of several global brands such as Levi Strauss and Co. and their Water Less ™ Campaign, H&M through the use of advanced analytics and AI for more precise demand forecasts throughout the supply chain, ADIDAS shoes from ocean plastic waste and more. A Clean Batik Initiative was launched in Terengganu and Kelantan in 2009 to introduce sustainable practices for batik SMEs to adopt green initiatives via environment-friendly technologies, as well as marketing and entrepreneurial skills. The result was a 10 - 50% reduction in water consumption, 30% - 90% energy savings (based on the technology applied), a 25% drop in reliance on synthetic dyes, and less air pollution by changing to electric stoves and optimised woodstoves. Furthermore, the switch to natural dyes lowered production cost by 10%.

References:

Business Insider, (2018); Ellen Macarthur Foundation, (2017); European Parliament, (2019); Fibre2Fashion.com, (2011); Gazzola, et al., (2020); Karuppuchamy, A., (2017); Levi Strauss & Co, (2016); Market Research, (2019); Mei Mei Chu, (2019); MIDA, (2018); MITI, (2019); Niinimäki et al., (2020); SWCorp, (2019); Switch Asia Project, (2009a); Switch Asia Project, (2009b); The Guardian, (2012); Thomas Publishing Company, (2020); USFDA, (2019); World Bank, (2019); WWF, (2013)

Box Article 5.9: Rare Earth Elements

Rare earth elements (REE) unique properties help to reduce energy consumption, boost efficiency, durability and thermal stability of electronics, making them critical in the production of all electronic devices crucial for modern life. China has been the leader of the REE industry since the 1990s with other countries such as Russia, US, India, Australia, and Brazil only just entering the market. More than 90% of global production of REE is from China. The creation of total rare earth supply chain outside of China presents a multi-billion ringgit opportunity for Malaysia.

Malaysia has had three REE processing plants but only one is still in operation. The first was the Malaysian Rare Earths Corporation (MAREC) which was established in 1976 in Bukit Merah, Perak to process locally mined xenotime and monazite minerals to produce yttrium oxide concentrates for export to Japan, USA, UK, and Norway. MAREC ceased operations in 1982 and its site was taken over by the Asian Rare Earths Plant (ARE) in the same year. ARE ceased its operations in 1994 due to low REE prices with the entry of China in this sector, high maintenance costs, and most importantly, legal action against the company on its failure to safely dispose its radioactive thorium hydroxide wastes. The company agreed to an out-of-court settlement with the residents of Bukit Merah and the environmental clean-up had cost the company an estimated USD100 million.

The only active REE processing plant in Malaysia at present is the Lynas Advanced Materials Plant (LAMP) set up in late 2012 in the Gebeng Petro-chemical Industrial Estate, Kuantan, Pahang. Lynas Malaysia is a wholly owned subsidiary of Lynas Corporation Limited (Australia). LAMP is one of the largest REE processing plants in the world with a capacity of 80,000 tonnes per annum. The plant processes lanthanide concentrates (LC) mined and initially processed at its Mount Weld mine in Australia.

Residents near the plant expressed concern over the disposal of radioactive elements released from the ore and wastewater from the separation process and its effects on humans and the environment. LAMP is located close to the Kuantan deep-water port, adjacent to Sungai Balok in Kuantan and its metropolitan area which has a population of more than half a million. Currently, LAMP's radioactive residues are temporarily stored in specially engineered residual storage facilities (RSF) in line with the guideline from the Atomic Energy Licensing Board (AELB) to prevent any leakage into the environment.

Two Aerosol Monitoring Systems (AMS) was installed by LAMP – both onsite and in Kuantan – to continuously monitor possible airborne industrial leaks. The low thorium content in the residue has potential to be developed as nuclear fuel after enrichment and should be saved for possible future transition into alternative energy. Sulphur oxides from cracking and leaching are treated to form a gypsum product; however, the Government has declined the proposal to convert them into safe commercial products.

For more information on developing REE resources in Malaysia sustainably to pave the road the towards producing indigenous high-value products, please refer to "Blueprint on the Establishment of Rare Earth-Based Industries in Malaysia" by ASM published in 2014.

References:

Academy Science of Malaysia, (2014); Kuan, Seng How et al. (2016); Marc Humphries, (2012); Balaram, (2019)

Habitat Depletion and Destruction

The outlay in Malaysia's pursuit for socio-economic growth was extracted from the nation's natural capital at the expense of its biodiversity and environment. Nearly all of the nation's natural assets – from water catchment network, tropical rainforest, peat swamp forests, wetlands, mountains and hills of granite and limestone, to the rivers, lakes, and sea – have diminished to support Malaysia's progress.

Forests in Malaysia are categorised as permanent reserve forests (PRF), total protected areas (TPA) and state land forests. The largest are PRF and state land forest, followed by TPA. PRF and TPA are administered by the federal Government while state land forest falls under the authority of respective states. Massive quantities of primary and secondary forests were cleared for agriculture as well as real estate development particularly in the more heavily populated west coast of the peninsula. As seen in Figure 5.25, the proportion of forested areas has been declining slowly between 1990 (59%) to 2018 (55%). Sarawak has the greatest bulk of land area covered with forests among all the states. The Borneo rainforest is a treasure trove of biodiversity; home to 221 species of land-living mammals and 420 species of birds, not to mention 15,000 species of flowering plants and 3,000 species of trees (Sean, 2020).

Forests offer not just ecological health benefits and biodiversity, but also economic opportunity in the form of recreational and ecotourism activities. They also house lucrative resources like timber and other forest products such as leads for valuable pharmaceutical products. Forests also play a key role in the global carbon cycle by absorbing and storing carbon

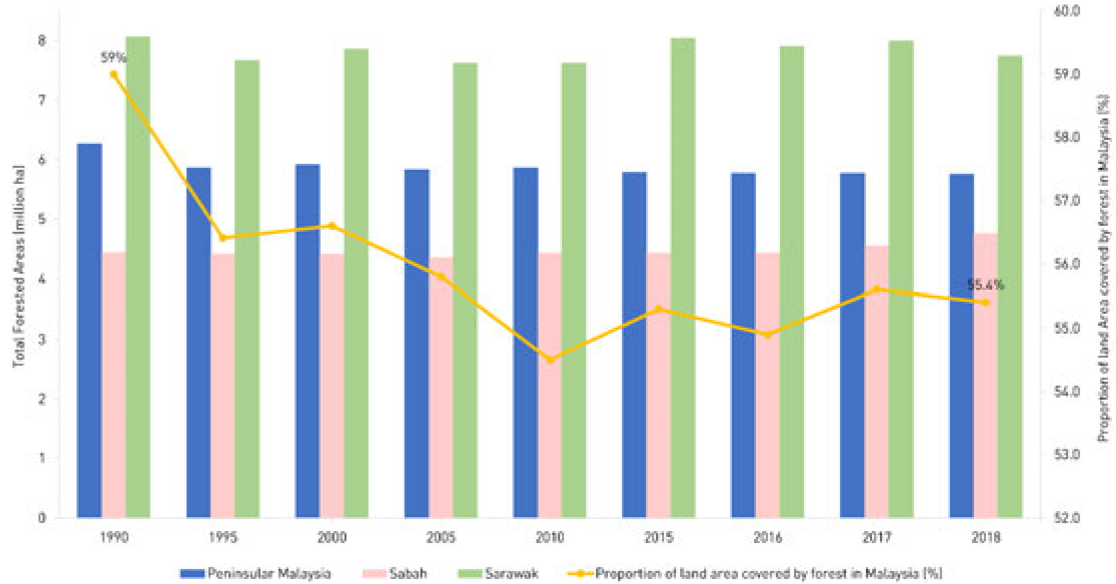


Figure 5.25: Total Forested Areas in Malaysia, 1990-2018

in their biomass and soil. Regionally, Malaysia is one of best nations in retaining its forests (Figure 5.26). However, the nation's forested area is fast shrinking to 50%; this is a matter of grave concern and require urgent reforestation efforts.

Malaysia's approach to biodiversity conservation and management is driven by the establishment of protected areas through legal gazettement. At the global level, the Convention on Biodiversity's Aichi Biodiversity Target 11 sets a target of 17% of terrestrial and inland water areas and 10% of coastal and marine regions. However, Malaysia's current status of 13% terrestrial and 3% marine protected areas (UNEP-WCMC and IUCN, 2020) falls far short of the target (Figure 5.27). To pull through, Malaysia needs to gather efforts to increase the establishment of protected areas towards achieving the National Policy on Biological Diversity 2016-2025's Target 6 of at least 20% and 10% conserved, respectively by 2025. Collectively, Malaysia needs to work towards establishing 30% terrestrial and marine protected areas by 2030 as targeted by the Campaign for Nature Initiative of the 2050 Vision for Biodiversity.

Another forested area of concern is the peat swamp forest which account for 75% of the total wetland in Malaysia's coastline. Peat swamp forest loss has been most acute over the last 24 years with 50% loss from 1990 to 2014 (Shuhada et al., 2020), reducing the diversity and abundance of microfungi vital for decomposers that support nutrient cycling, damaging the regional water cycle due to diminished water holding capacity, lowering carbon storage and increasing GHG emission (Tonks et al., 2017). When peat swamp forests are drained, the drying peat can give rise to bush fires that leads to haze; peat fire is almost impossible to put out and the sustained burning releases dangerous air pollutants and metric tonnes of carbon that have been stored for hundreds and thousands of years (Loren, 2014). Peat swamp forests also provide scarce and badly needed economic resources for the local communities, making it more imperative for Federal and State Governments to review land development policies and halt the deforestation. If this loss is not reversed in all the Southeast Asian nations, it has been forecasted that all peat swamp forests will disappear by 2030 (Miettinen et al., 2011).

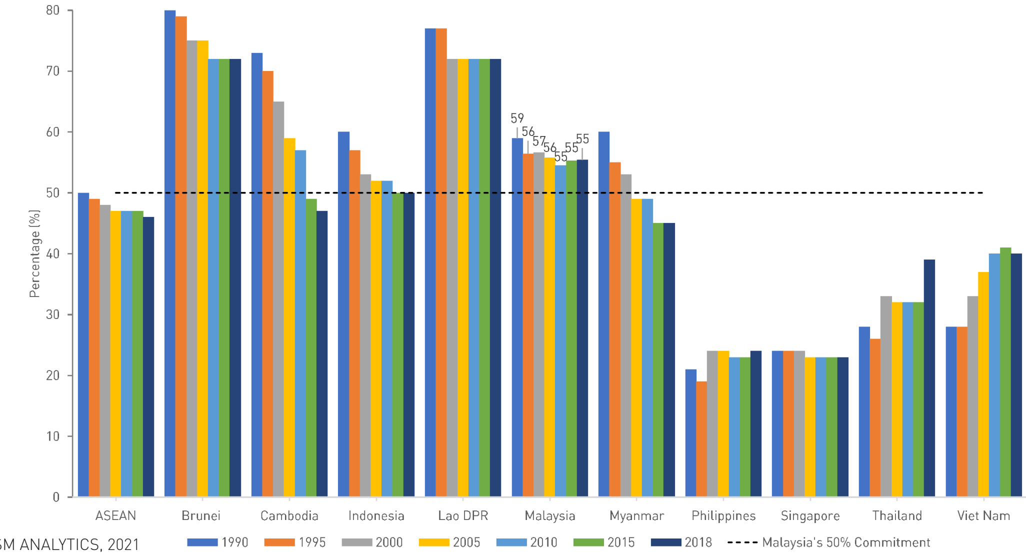


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Figure 5.26 Proportion of Land Area Covered by Forest in ASEAN, 1990-2018

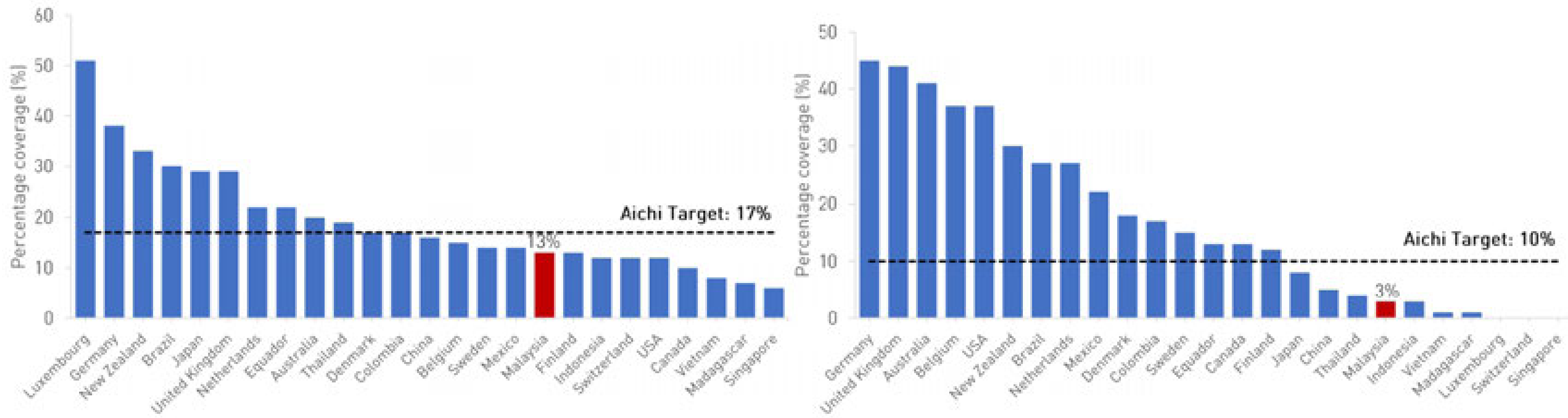

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Figure 5.27: Malaysia Protected Areas (left-Terrestrial; right-Marine) by Aichi Target, 2020

Mangrove forests are also part of the nation's protected areas. Malaysia is the third-largest mangrove-holding nation in the world with approximately 45% of the world's total mangrove forest area and home to the highest diversity of mangrove plant species (Aldrie, 2018). Mangroves fulfil various vital ecological functions but are under constant threat from over harvesting, aquaculture expansion, pollution, sedimentation, alteration of coastal flows and conversion into other development (Omar et al., 2018). There is a growing concern for the impact of climate change on the adaptability and integrity of forests as vital carbon reservoirs. As a signatory of the UNFCCC REDD+ mechanism, Malaysia is committed practice sustainable forest management; the country has successfully reduced GHG emissions by 9% from 18,710 Gg CO_2eq to 20,307.5 Gg CO_2eq in 2014 and 2016 through this measure (KASA, 2020a). However, the drastic reduction of peat swamp forests is threatening these gains as conversion of peat swamp forest into oil palm plantations are contributing 17% of the total GHG emission of the country (Cooper et al., 2020).

Mangrove ecosystem services:

- Protects coastal area from storm surges and waves
- Prevents coastal soil erosion
- Serves as nursery for marine fauna and habitat to local diversity as well as migratory birds
- Enormous carbon store in plants, root systems, and soil
- Source of food, water, timber, fuel, and other natural resources for the local population

Peat swamp forest ecosystem services:

- A vital watershed in the water cycle
- Enormous carbon store in the form of peat and soil ecosystem
- Physical buffer against storm winds and reduces flooding from heavy seasonal rain
- Source of food, water, timber, fuel, and other natural resources for the local population
- Protects against brush fire during dry seasons

The aim of Reducing Emissions from Deforestation and forest Degradation (REDD+) is to encourage developing countries to contribute to climate change mitigation efforts by:

i) reducing greenhouse gas emissions (GHG) by slowing, halting and reversing forest loss and degradation

ii) foster conservation, sustainable management of forests, and enhancement of forest carbon stocks.

References:
FAO (N.D); Forest Carbon Partnership (N.D); WWF Malaysia, (N.D.)

KEY INTERVENTION

1. To adopt and mainstream deployment of new emerging technologies including in-situ analysis for more effective real-time monitoring, rehabilitation, preservation, management of natural resources and the forest carbon reservoir.

Megadiversity Heritage

Malaysia is one of the 12 megabiodiversity in world, endowed with a wealth of terrestrial and marine flora and fauna (KATS, 2019). The Malaysia Red List for Mammals (Version 2.0) of Peninsular Malaysia reported that out of the 223 species assessed, one has been classified as extinct, four has been classed as critically endangered, 11 have been classed as endangered, 14 as vulnerable and 34 as near threatened, whereas a total 567 plant species out of the 1,600 Peninsular Malaysia plant species assessed in the Malaysia Red List have been classified as threatened. However, between 2014 and 2020, 47% of the local flora and fauna were registered in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (Figure 5.28). The Sumatran rhinoceros in Malaysia is officially extinct with the loss of the last pair of rhinos – Tam and Iman – in 2019 due to destruction and shrinking of their habitats from human encroachment and poaching (KATS, 2019). Globally, the average fall in the population of mammals, birds, amphibians, reptiles, and fish between 1970 and 2016 was alarmingly high at 68% (WWF, 2020).

Anthropogenic activities, including development of road and rail transport systems, housing and urban development as well as agricultural industry contribute to the depletion of natural resources and deforestation. The need for connectivity has also exerted a toll on Malaysia's biodiversity; a total of 2,444 wildlife was killed from 2012 to 2017 due to traffic accidents (Rashvinjeet, 2018; KATS, 2019). To reduce wildlife roadkill, measures including awareness campaigns for drivers, creating wildlife crossings as well as the use of AI and drone technologies should be engaged.

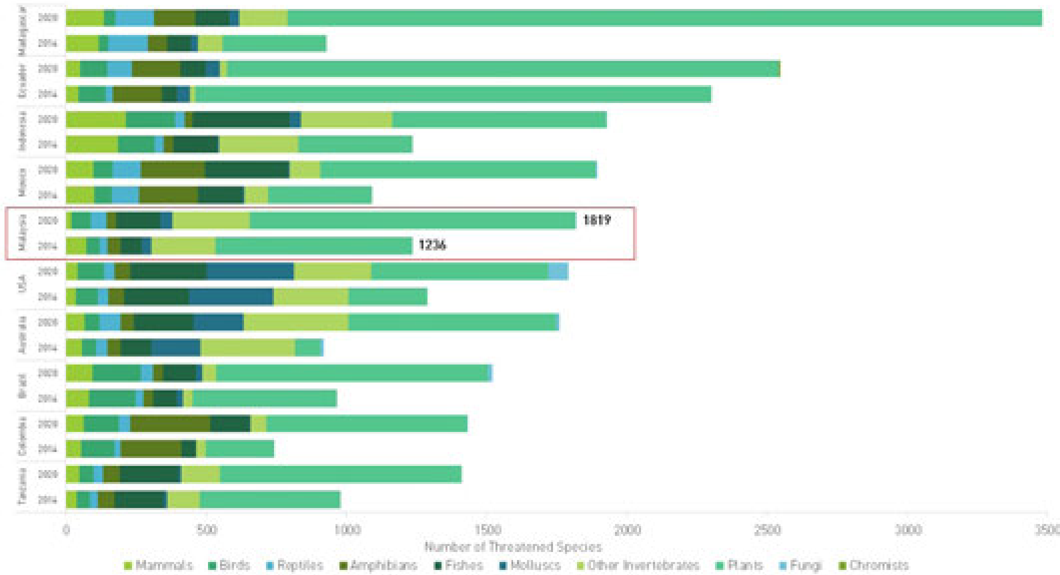

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Figure 5.28: Countries with Highest Recorded Threatened Species, 2014 & 2020

Large-scale conversion of tropical forest to oil palm plantation was a major catalyst for Malaysia's socio-economic growth, helping many Malaysians to break the cycle of poverty. Unfortunately, it also caused a devastating impact on plant and animal species, accounting for 47% of deforestation from 1972 to 2015, according to the IUCN Oil Palm Task Force. Satellite imaging showed that even the certified palm oil concessions and supply bases took over the habitats of endangered mammals (e.g. orangutans, rhinos, tigers, and elephants) and biodiverse tropical forests of Sumatra and Borneo over the last 36 years. Of the 173 RSPO-certified concessions in the Malaysian Borneo forests, 131 were located in orangutan habitats up to 1989, and 35 more by 1999 (Cazzola et al., 2020).

These unfortunate developments provided the reason for the EU's moratorium in 2019 on oil palm-based biofuels from Malaysia and Indonesia. By implementing sustainable practices to conserve the nation's biodiversity, the oil palm industry can remove such objections and be profitable while caring for the natural assets of the nation. The adoption of advanced genomic and 4IR technologies that yield robust clones with higher productivity without expansion into virgin forests.

Flora heritage loss is devastating and irreversible when the ecosystem housing the plants is damaged or gone. Seed banks are needed to conserve threatened and rare planting materials as well as providing material for cultivation and study. Keeping heritage variants of plants that are traditionally eaten helps to maintain indigenous knowledge as well as improve dietary choices while providing a form of food security. The Forest Research Institute of Malaysia (FRIM), the Forest Research Centre in Sabah, and the Malaysian Agricultural Research and Development

Institutes (MARDI) are the biggest seed banks in the country, followed by a few arboretums maintained by research institutions and organisations, as well as private entities. Unlike plants in temperate zones, the seeds of tropical plants – particularly flowering-fruiting trees of the forest – are difficult to store in laboratories and require dedicated space that match their natural habitat.

Depletion of biodiversity and natural resources threaten the delicate balance of various ecosystems, damaging ecological resilience, which then adversely affects human lives (Vanda, 2021). This disruption increases the risk of zoonotic microorganisms entering hosts that come into close contact with humans and could give rise to new outbreaks that could spread across the globe (Gibb et al., 2020). One major example is the Nipah virus (NiV) outbreak in 1997 which began when pig farms began infringing the forest that is home to fruit bats that are natural carriers of NiV. The fruit bats were attracted to the fruit orchards in the farm and their virus-laden excrement mixed with pig swill. The virus was transmitted to the workers on the farm who then become sick by contact with the contaminated swill (WHO, 2018b). Uncontrolled encroachment into wildlife habitats that are reservoirs of unknown microbes will continue to increase the risk of more outbreaks and even pandemics that are hard to treat and control as with the current COVID-19 pandemic.

Another source of rich biodiversity are the seas around Malaysia, which is home to more than 519 species from 70 genera of corals and hundreds more of fish, crustacean, seabirds, sea mammals, and shellfish species. The total acreage of coral reefs around Malaysian coasts and islands stretches around 4,006km^2. Coral reefs are also a valuable economic resource that brings in USD12.7 billion revenue per annum via tourism in Southeast Asia; coral reef-related businesses in Malaysia alone are worth approximately USD635 million annually (NRE, 2015).

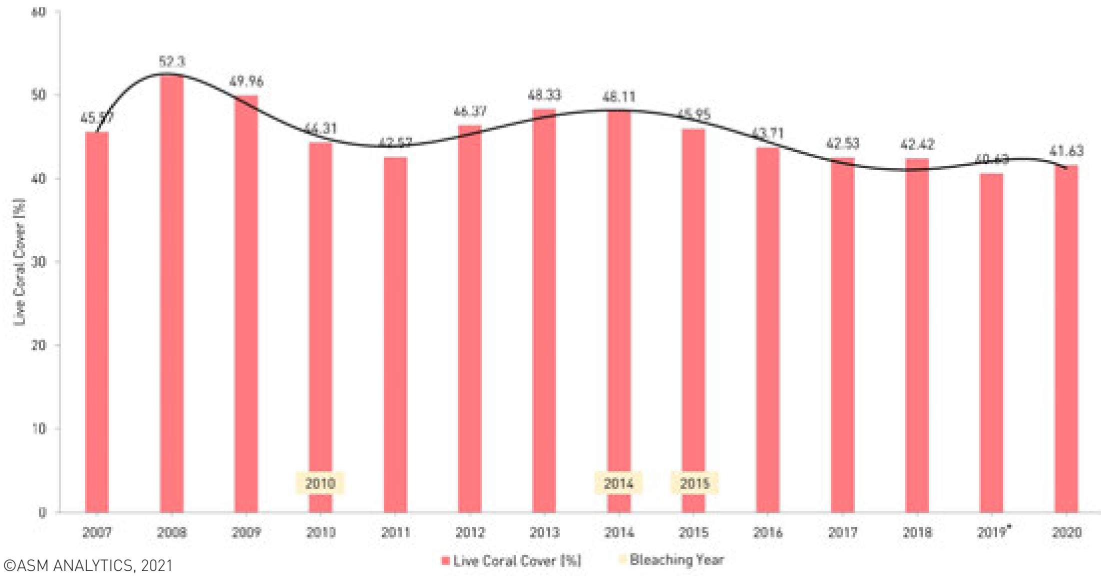

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Figure 5.29: Annual Coral Reef Health Status in Malaysia, 2007-2020

Note: In 2019, the reduction in LCC was due to the major reduction in the number of survey sites at almost 37%

However, coral reefs in Malaysia are under threat due to global warming, overfishing, coastal development, pollution, and sedimentation. The first significant mass coral reef bleaching event reported in Malaysia was in 1998 as a result of a prolonged increase in sea water temperature above the normal 27°C which killed an estimated 40% of the coral in reefs around Peninsular Malaysia. The Coral Reefs Health Survey showed that additional major coral bleaching happened again in 2010, 2014, and 2015 (Figure 5.29) when there were also signs of overfishing, poaching, as well as a declining state of coral denizens, and coral destruction from sewage discharge contamination (Reef Check Malaysia, 2019). This is an issue of major concern as marine protein is an important source of nutrition for Malaysians; the unchecked loss of the nation's marine biodiversity is a significant threat to the country's food security.

Coral reef ecosystem services:

- Provides habitat to reef dwelling fish and invertebrates. nurseries for spawning, growth, and development of many marine animal
- Tourism and recreation opportunities
- Source of pharmaceutical leads
- Erosion regulation and shoreline protection
- Biogeochemical cycling of nutrients through living and non-living spaces

Reference:
Ministry of Natural Resources and Environment, (2015)

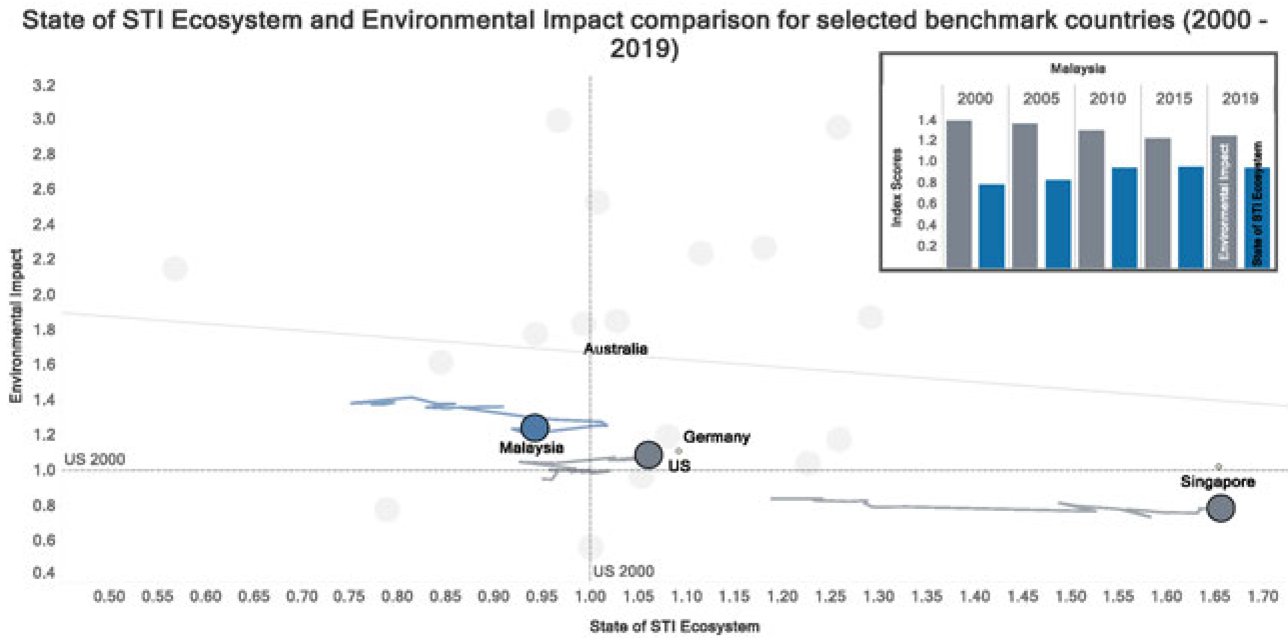
KEY INTERVENTIONS

1. To promote responsible conservation and management of biodiversity by harnessing advanced technologies in communications and molecular technologies as well as encourage nature-based solutions to manage and restore both natural and modified ecosystems.

2. To build strong knowledge networks and partnership commitments with global campaigns for collective efforts towards achieving the 2050 Vision for Biodiversity with a 30% increase in Protected Areas by 2030.

Environmental Impact and the STI Ecosystem

Between the year 2000 and 2019, the nation has performed poorly in measurements of environmental impact against the STI ecosystem in comparison to several developed and developing economies (Figure 5.30). This is not surprising because although STI development has contributed to new economic and industrial development (see **Chapter 3**), this growth has taken place hand-in-hand with environmental degradation and a diminishing in natural assets. The countries that performed well in this evaluation, like Denmark and New Zealand, are advanced economies with low population densities and with sufficient funds to finance environmental protection and were therefore able to place a lot less stress on their natural capital.



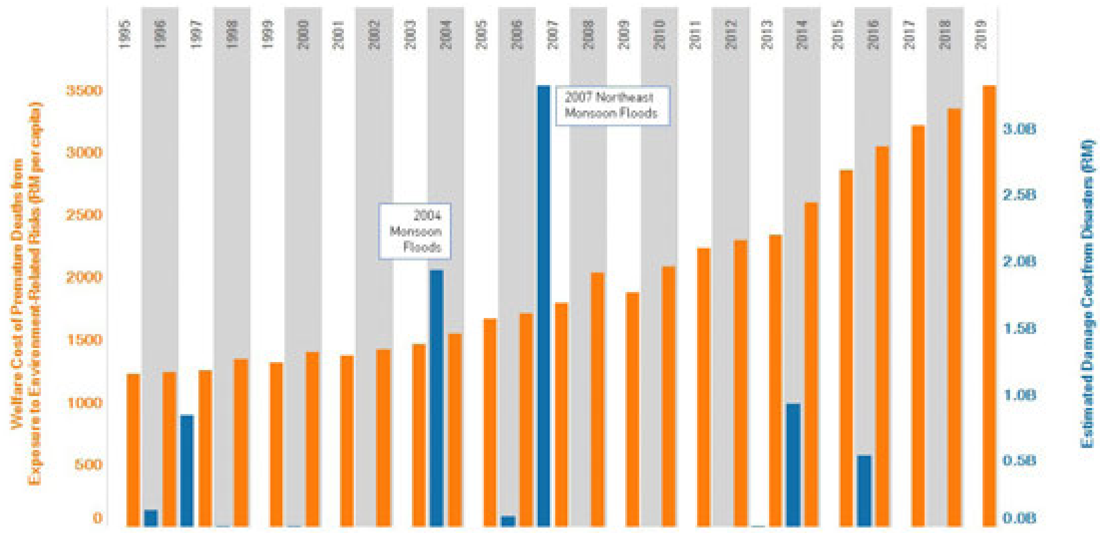
Analysed by Sunway University Research Team

Figure 5.30: State of STI Ecosystem and Environmental Impact Comparison for Selected Benchmark

Note: The circles on the chart represent data of the respective country in 2019 while the trails from the circle show the movement of the country from 2000 to 2019. See appendix in **Chapter 6** for full methodology and indicator descriptions.

Malaysia can learn from such examples on how to manage its natural capital and assets while growing its economy. Over the last 24 years, Malaysia has cumulatively lost an estimated RM7.8 billion to environment-related disasters and an estimated RM947.2 billion to welfare cost of environment-related premature deaths. That is an average loss of RM39.8 billion per year due to environment-related causes which amounts to about 3% GDP loss in 2019 and 2020 (Figure 5.31).

The country has the STI capacity and capabilities to enable Malaysia to develop in a sustainable and equitable manner. What is needed is the political will to implement evidence-based policies that align with environmental conservation to support the nation's progress. One way to push this agenda is to have a dedicated ministry for natural asset sustainability and the environment. In the past, these matters have been pegged to Ministries with multiple portfolios (Figure 5.32). In contrast, Singapore has a Ministry for Sustainability and Environment while the UK has the Department of Energy and Climate Change. Malaysia needs a dedicated ONE-STOP-CENTRE to oversee, coordinate, and enforce on all matters associated with climate change and the environment.



Analysed by Sunway University Research Team

Figure 5.31: Estimated costs of Environmental-related Issues

Note:

1. Welfare cost of premature deaths include deaths related to the following: ambient particulate matter, household air pollution from solid fuels, ambient ozone, high temperature, low temperature, lead, residential radon, unsafe water source, unsafe sanitation, no access to handwashing facility, occupational carcinogens, occupational particulate matter, gases and fumes. For further detail, see http://stats.oecd.org/wbos/fileview2.aspx?IDFile=1356df09-6bd4-4b0b-9a95-d56e145769ad.

2. Main disaster damages for Malaysia include the following: landslides, forest fires, tropical cyclones, floods, diseases such as cholera and dengue. About 75% of disaster damages in Malaysia result from flood-related damages. For full list of disaster classifications, see https://www.emdat.be/classification

Table 5.2: Evolution of Environment Portfolio throughout six Malaysia Plans (1990-2020)

6th MP (1990 -1995)	7th MP (1996 - 2000)	8th MP (2001 - 2005)	9th MP (2006 - 2010)	10th MP (2011 - 2015)	11th MP (2016 - 2020)
Ministry of Science, Technology and Environment	Ministry of Science, Technology and Environment	Ministry of Science, Technology and Environment	Ministry of Science, Technology and Innovation	Ministry of Science, Technology and Innovation	Ministry of Science, Technology and Innovation
			Ministry of Natural Resources and Environment	Ministry of Natural Resources and Environment	Ministry of Environment and Water
Ministry of Energy, Telecommunications and Posts	Ministry of Energy, Communications and Multimedia	Ministry of Energy, Telecommunications and Posts	Ministry of Energy, Water and Communications	Ministry of Energy, Green Technology and Water	Ministry of Energy and Natural Resources

It is also timely for Malaysia as a nation rich in natural assets as well as mega-biodiversity to be the global leader on strategies to avert the universal calamities predicted to arise from climate change. Malaysia could introduce the concept of Environmental Credits (EC) to appropriately assess the cost in natural capital for growth and development. Under this strategy, all projects and development activities that impact on natural resources - either primary or secondary – in any form must be vetted against environmental gains or losses from the project; approval only to be given if the balance sheet registers net gains.

A Whole-of-Government and a Whole-of-Society effort would be required to realise this vision. Financial managers, accountants, and economists need to work with STI experts and project developers to help in the evaluation process and to draw up a scale of values to award EC that are implemented in an honest, reliable and measurable way. Central to these considerations are various environmental issues, such as plastic usage and disposal, GHG emissions, natural asset depletion (terrestrial and/or marine), flood risk, pollution, as well as mitigation and remedial strategies associated with anthropogenic activities.

Globally, the concept of Carbon Credits and Carbon Offsets (CO) are already in use. COs cancel CO_2 emissions with activities that reduce CO_2 emissions. Unlike carbon credits, EC will deal with more than just reduction of CO_2. EC's coverage will more extensive with monitoring using a trackable identity which will enable the purchase of EC at checkout, if required. By utilising EC, climate change impacts on both the physical and non-physical environment – be it atmospheric, terrestrial and marine ecosystems – will be valued and monetised. A successful rollout will go a long way towards supporting the SDGs and the goals of SPV 2030 to attain the One World, One Health Initiative, for a sustainable planet.

Environmental Credits means any emissions credits, conservation credits, offsets and allowances or some other form or character, relating to environmental matters that accrue to businesses investing in projects such as that restore wetland, water and habitat resources, or reduce air pollution.

Environmental credits seek to strike a balance between non-renewable and renewable resources through sustainable consumption.

References:
Law Insider (2021); The Conversation Fund (N.D)

Pillar Specific Recommendations

1. To mainstream management and governance of the environment and natural assets (physical & non-physical)

Mainstream management and governance of the environment and natural assets (physical & non-physical) including a 30% increase in protected areas (natural-terrestrial and marine) through a Whole-of-Government and Whole-of-Society approach that is cohesive and integrative to maximise return on investment (ROI) and return on value (ROV) by gaining environmental credits. Implementation of open data sharing with systematic capturing, digitalised information storage and data accessibility through collaborative open sharing for responsible conservation, management and utilisation of biodiversity for sustainable development of Malaysia must be in place.

2. To promote compliance monitoring and enforcement activities for sustainable management of environmental well-being

Increase investment in compliance monitoring and enforcement for sustainable management of environmental well-being by harnessing next-generation technologies and the bio-revolution to ensure responsible stewardship of natural assets and the environment.

3. To strengthen institutional capacity and regulatory framework both at Federal and State levels

The fragmentation of resources and authority over environmental protection and conservation is making it hard to ensure the sustainability of Malaysia's growth. Furthermore, the existence of both federal and state environmental legislation resulted in inevitable fragmentation, lacuna (gaps) and disjointed in the overall governance. In certain cases, it led to the diversity of environmental laws in the country and jurisdictional disputes and coordination between the federal, state and local governments leaving certain grey areas unregulated. Overall, there is a need for an Apex overarching regulatory body to coordinate, mainstream enforcement efforts and strengthen environmental governance in Malaysia.

Note:

1. Physical resources are tangibles which include minerals, petroleum, natural gas, buildings and supporting infrastructures such as water supply or energy networks, etc. that provide the setting for human activities
2. Non-physical resources are living environment, plants, animals, etc
3. Terrestrial protected areas are totally or partially protected areas that are designated by national authorities as scientific reserves with limited public access, national parks, natural monuments, nature reserves or wildlife sanctuaries, protected landscapes, and areas managed mainly for sustainable use.
4. Marine protected areas involve the protective management of natural areas according to pre-defined management objectives. MPAs can be conserved for a number of reasons including economic resources, biodiversity conservation, and species protection. They are created by delineating zones with permitted and non-permitted uses within that zone.


Intersecting
Case Study
Palm Oil Industry

The palm oil industry contributes to almost 40% of Malaysia's GDP, it is a valuable source of food and manufacturing products locally and globally. The monocultivation of a non-endogenous crop that is core to the industry would not have been possible without encroaching into green spaces and forested land with its related impact on the biodiversity; here is where the environmental credits (EC) come into play by taking into consideration its impact on socio-economic development, environmental impact, and mitigation strategies.

Elaeis guineensis, or the oil palm, was first brought to Malaysia 100 years ago as an ornamental plant. The first commercial oil palm plantation was established in Tennamaram estate in Batang Berjuntai Selangor in 1917 by Henri Fauconnier. The palm oil industry was an important catalyst for reducing poverty in Malaysia through large-scale planting and small-holders participation through the Federal Land Development Authority (FELDA) scheme (Balu, 2018; Yuleng et al., 2015).

R&D in oil palm began in the 1960s through the establishment of research institutes like the Oil Palm Genetics Laboratory Consortium (1962), MARDI, Universiti Pertanian Malaysia – now known as Universiti Putra Malaysia – UPM, and the Palm Oil Research Institute of Malaysia (PORIM) which was later rebranded as the Malaysian Palm Oil Board (MPOB). These establishments spurred the growth of the industry in terms of productivity and sustainability; MPOB alone has innovated 667 technologies of which 30% have been commercialised with a market value worth billion of ringgit (MPOB, 2020).

Palm oil's share of the total GDP is 38% (DOSM, 2020a) and Malaysia's palm oil accounts for 28% of world palm oil production and 33% of world export (MPOC, 2020). The palm oil sector was identified as a national key economic area (NKEA) under the Economic Transformation Programme (ETP), setting up targets like RM178 billion in gross national income, generating 41,600 new jobs, and producing biodiesel worth RM57.6 billion by 2020 (TERAJU, 2010). As part of the national move towards sustainability, the Malaysian Sustainable Palm Oil (MSPO) Certification Scheme was launched in January 2015 for 100% MSPO certification for oil palm planted areas in the country by end 2019 (Michael, 2019).

The industry holds many potentials beyond crude palm oil (CPO) and crude palm kernel oil (CPKO) production. Despite biomass making up of 90% of the oil palm tree and the fact that Malaysia has a vast biomass resource, it is still under-utilised for electricity generation, which can help to reduce fossil-based carbon (CO_2) emissions. In 2017 alone, about 51.19 million tonnes (Mt) of oil palm waste with 888.33 peta-joule (PJ) energy potential to generate 88.03 terawatt-hours (TWh) electricity which is enough to cover ~59% of Malaysia's electricity consumption had gone to waste (Loh et al., 2017). Palm Oil Mill Effluent (POME) contains about 65% methane that may be converted into energy instead of contributing to global warming. Because of this potential, from 2014 onwards, new mills and existing palm oil mills are required to install full biogas trapping or methane avoiding facilities. From 2019, 125 biogas plants have been in operation with 30 plants connected to the national grid which can now mitigate ~5.52 mil tonnes of $C0_2$ equivalence yearly (Loh et al., 2020).

Biodiesel development in Malaysia has evolved since the launch of the National Biofuel Policy in 2006. Malaysia seeks to fully implement B20 biodiesel for transport across the country by mid-June 2021 (interfered by the COVID-19 pandemic) whereas B30 by 2025. Indonesia is ahead of the game as the leading biodiesel producer in 2019 and was the first country to implement B30 use in the world with B40 already in trial. Domestic mandate-driven demand and supporting policies are fuelling the growth of domestic biodiesel sector in that country. Another potentially useful by-product is biochar which is not only good to improve soil conditions but is an alternative source of clean fuel through sustainable biochar practices to produce oil and gas by-products. Other value-added products from oil palm are palm tocotrienols with its unique biological properties such as higher antioxidant potency and various health benefits (MPOC, 2017).

What is stopping the palm oil industry in Malaysia from achieving its full prospect was examined in the 8i analysis of the industry as shown below – figure continuation to be reconsider between palm oil case study and main ENV chapter. One of the biggest issue blocking palm oil from making the most of the global vegetable oil market is its bad reputation as an unsustainable product. More effort is needed to highlight palm oil's placement as the topmost high yielding vegetable oil; oil palm takes up only 10% of all farmlands dedicated to growing oil crops and yet produces 35% of the global volume. Malaysia has pledged to not increase land acreage in oil palm plantations per the guidelines of the Roundtable of Sustainability of Palm Oil (RSPO). Higher productivity on the same acreage is the new game plan with the use of advanced computer-linked and genome-based technologies. Stronger enforcement of land management is needed to avoid illegal deforestation and encroachment of protected wildlife habitats technology-supported integrated land surveillance using global information system (GIS) mapping and drones by all agencies involved.

8i Framework for Palm Oil Industry

1 INFRASTRUCTURE

INCORPORATING ENVIRONMENTALLY-FRIENDLY FACILITIES

Biogas from POME is 76% methane which is a GHG 28 times worse than CO_2. Biogas capture and utilisation began in 2014 but not all new and existing mills have installed full biogas trapping or methane avoidance facilities. Public private partnerships are needed to connect RE generated from OPW to the national power grid.

2 INFOSTRUCTURE

SEEMLESS INFORMATION FLOW ON BIOMASS SUPPLY & DEMAND

Oil palm biomass is severely underutilised in generating RE. Application of 4IR emerging tech to fix current logistics issues for biomass supply by networking RE producers with smallholders (40% of total production).

3 INTELLECTUAL CAPITAL

KNOWLEDGE-DRIVEN LABOUR TO OVRCOME LABOUR INTENSIVE ACTIVITIES

Land-to-labour ratio in the plantation sector is 10: 9 per hectare. There is a need to replace the aging farmers with TVET and HLI graduates who are trained for STI-driven high-end farming activities with greater yield productivity.

4 INTEGRITY

ACHIEVE 100% MSPO CERTIFICATIONS FOR INDEPENDENT SMALL HOLDERS

As of June 2020, 96% of major oil palm estates received MSPO certification in contrast to only 25% of independent smallholders. Awareness and appropriate guidance are needed to encourage smallholders to take up the certification.

5 INCENTIVES

SUSTAINED SUPPORT FOR INDEPENDENT SMALLHOLDERS BY PUBLIC AND PRIVATE SECTOR

Most smallholders are unable to afford the compliance required for MSPO certification. Smallholders can be incentivised through matching grants provided by public-private partnerships.

6 INSTITUTIONS

NEED FOR AN ALL-GOVERNMENT APPROACH TO MAINTAIN SUSTAINABILITY OF NATURAL RESOURCES

The industry is highly regulated with more than 15 laws and regulations in place. Enforcement of the legislation should be supported by emerging technology to protect against deforestation and biodiversity depletion as well as accrue environment credits (EC).

7 INTERACTION

STRENGTHEN STAKEHOLDER COLLABORATION TO ASSIST KNOWLEDGE TRANSFER

Strengthening the quadruple helix (university-industry-government-public) interaction for all parties to synergise best practices for accumulating EC and maximising gains across the board through knowledge sharing.

8 INTERNATIONALISATION

ENHANCING THE PUBLIC IMAGE OF THE PALM OIL INDUSTRY

Negative perception by certain leading economies on the sustainability of palm oil needs to be countered using science diplomacy and strategic partnerships with the support of relevant evidence.

The upstream of the oil palm industry is in desperate need of technological input to make it safer and more productive, as well as to reduce exploitation of foreign labour. Figure below illustrates some of the STI interventions to scale up the industry's upstream activities.

Greater investment is needed for the downstream sector of the industry to increase profit margin sustainably and protect against the volatility of crude palm oil prices. It is imperative that the growth fuelled by palm oil balances the national account ledger appropriately through a transparent and effective governance of Malaysia's natural assets.

FURTHER READING 1 : LIST OF MULTILATERAL ENVIRONMENTAL RELATED AGREEMENTS (non-exhaustive)

No.	Related Agreements	Details	Related Areas of the Environment
1.	Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	A Multilateral treaty to protect endangered plants and animals.	Biodiversity Purview Ministry: KeTSA
2.	United Nations Framework Convention on Climate Change (UNFCCC)	An international environmental treaty with objective to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.	Climate Change Purview Ministry: KASA
3.	United Nations Convention on the Law of the Sea (UNCLOS)	The United Nations Convention on the Law of the Sea (UNCLOS) is established to define coastal and maritime boundaries, to regulate seabed exploration not within territorial claims, and to distribute revenue from regulated exploration.	Fisheries Purview Ministry: MAFI & MoT
4.	United Nations Convention to Combat Desertification (UNCCD)	The United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa (UNCCD) is a convention to combat desertification and mitigate the effects of drought through national action programmes that incorporate long-term strategies supported by international cooperation and partnership arrangements.	Climate Change Purview Ministry: KASA
5.	Kyoto Protocol to the UNFCCC	An international treaty which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that (part one) global warming is occurring and (part two) it is extremely likely that human-made CO_2 emissions are the predominant cause.	Climate Change, Energy, Air Quality Purview Ministry: KASA & KeTSA
6.	Convention on Biological Diversity	A multilateral treaty to develop national strategies for the conservation and sustainable use of biological diversity.	Biodiversity Purview Ministry: KeTSA
7.	Cartagena Protocol on Biosafety	An international agreement on biosafety as a supplement to the Convention on Biological Diversity effective since 2003.	Biodiversity Purview Ministry: KeTSA

No.	Related Agreements	Details	Related Areas of the Environment
8.	Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (RAMSAR)	An international treaty for the conservation and sustainable use of wetlands.	Biodiversity Purview Ministry: KeTSA
9.	Protocol to amend the Convention on Wetlands of International Importance especially as Waterfowl Habitat	N/A	Climate Change Purview Ministry: KASA
10.	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes & their Disposal	An international treaty to reduce the movements of hazardous waste between nations, specifically to prevent transfer of hazardous waste from developed to less developed countries (LDCs)	Waste Management Purview Ministry: KASA
11.	Ban Amendment to the Basel Convention	The amendment prohibits the export of hazardous waste from a list of developed (mostly OECD) countries to developing countries. The Basel Ban applies to export for any reason, including recycling	Waste Management, Water & Sanitation Purview Ministry: KASA & KPKT
12.	Vienna Convention for the Protection of Ozone Layer	A multilateral environmental agreement that provide frameworks for international reductions in the production of chlorofluorocarbons.	Climate Change, Air Quality Purview Ministry: KASA
13.	Montreal Protocol on Substances that Deplete the Ozone Layer (1987)	An international treaty designed to protect the ozone layer by phasing out the production of numerous substances responsible for ozone depletion.	Climate Change, Air Quality Purview Ministry: KASA
14.	London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1990)	Changed the ODS emission schedule by requiring the complete phaseout of CFCs, halons, and carbon tetrachloride by 2000 in developed countries, and by 2010 in developing countries. Methyl chloroform was also added to the list of controlled ODSs, with phaseout in developed countries targeted in 2005, and in 2015 for developing countries.	Climate Change, Air Quality Purview Ministry: KASA

No.	Related Agreements	Details	Related Areas of the Environment
15.	Copenhagen Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1992)	Significantly accelerated the phaseout of ODSs and incorporated an hydrochlorofluorocarbons (HCFC) phaseout for developed countries, beginning in 2004. Under this agreement, CFCs, halons, carbon tetrachloride, and methyl chloroform were targeted for complete phaseout in 1996 in developed countries. In addition, methyl bromide consumption was capped at 1991 levels.	Climate Change, Air Quality Purview Ministry: KASA
16.	Montreal Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1997)	Included the phaseout of HCFCs in developing countries, as well as the phaseout of methyl bromide in developed and developing countries in 2005 and 2015, respectively.	Climate Change, Air Quality Purview Ministry: KASA
17.	Beijing Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1999)	Included tightened controls on the production and trade of HCFCs. Bromochloromethane was also added to the list of controlled substances with phaseout targeted for 2004.	Climate Change, Air Quality Purview Ministry: KASA
18.	Rotterdam Convention on the Prior Informed Consent Procedures for Certain Hazardous Chemicals and Pesticides in International Trade	A multilateral treaty to promote shared responsibilities in relation to importation of hazardous chemicals.	Climate Change, Air Quality, Agriculture Purview Ministry: KASA, MAFI & MITI
19.	ASEAN Agreement on Transboundary Haze Pollution	A legally binding environmental agreement signed in 2002 by the member states of the Association of Southeast Asian Nations to reduce haze pollution in Southeast Asia.	Air Quality Purview Ministry: KASA
20.	The Nagoya Protocol (2014)	An international agreement that provides a transparent legal framework for the effective implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilisation of genetic resources.	Biodiversity Purview Ministry: KeTSA
21.	The Paris Agreement (2016)	An agreement to serve as guidance to combat climate change, to accelerate & intensify the actions & investments needed for a sustainable low carbon future.	Climate Change Purview Ministry: KASA

06

8i STI Ecosystem Analysis of the Economic, Societal and Environmental Pillars

STI for sustainable development through an ecosystem approach

1 INFRASTRUCTURE

The access to quality infrastructure and its maintenance (both man-made and natural) must be STI driven. Attention is needed to reduce the undesirable impact on the natural infrastructure in the pursuit of building physical infrastructure for socio-economic development.

2 INFOSTRUCTURE

Coordination of digital infrastructure plans to penetrate the length and breadth of Malaysia for accessibility and quality to ensure various communities across the country are linked with the socio-economic and environmental needs must be improved.

3 INTELLECTUAL CAPITAL

Relook into talent development, upskilling and reskilling to keep pace with the knowledge demands in the fast-evolving world as to address shortages in critical areas needed by the nation to improve its economic position and wellbeing of society and environment.

4 INTEGRITY

The government must move to being more agile especially for the regulatory/legislative architecture to keep pace with the technological and global landscape. The overall governance system at present operates in-silos; hence a single point for continuity to track, monitor and measure the impacts of KPIs, implementation and enforcement of policies, plans, programmes and initiatives must be in place through e-Governance.

5 INCENTIVES

Develop and promote the use of indigenous technology through fiscal and non-fiscal incentives for better focus, coordination and strategic development of the country.

6 INSTITUTIONS

Adapt advanced technologies and knowledge management systems to manage the complex relationships between the multiple players in the ecosystem results through a strategic approach in the formulation and implementation of STI policies to overcome negative externalities such as duplication of scarce resources and turf wars.

7 INTERACTION

Strategically plan for inter- and intra-members of the quadruple helix cooperation and collaboration for socio-economy and the environment sustainability as well as effective and optimal return of value using STI.

8 INTERNATIONALISATION

Harness multi-lateral technology and knowledge transfers through quality engagements and collaborations between local and foreign players by understanding on the global best practices and standards.

The world has become increasingly complex over time. Nation states have had to adapt to external pressures to ensure robust economic development. Over the past 30 years, the pace of changes has been exponential due to the emergence of new technologies and innovation. Countries with robust STI ecosystems have been leading and shaping the changes. In the last three decades, ICT has intensified and speeded up globalisation across all facets of the economy and society.

An effective national STI ecosystem fosters a system of 'Open Innovation', allowing government agencies, academia, industries, and communities to use knowledge to accelerate internal capabilities and expand markets for innovation-driven products and services to remain resilient under conditions of environmental turbulence and change. The maturity of such an ecosystem is measured by the extent it facilitates the use of external technologies, ideas and knowledge to enhance the internal dynamic capability of both individuals and organisations, and ultimately create value for all stakeholders in society.

The STI ecosystem in this report adapts the characterisation of the eight enablers (8i) by Nair (2011). The STI ecosystem is made up of two important building blocks called the foundation conditions and driver conditions. In this report, these building blocks were referenced to measuring the progress of STI in Malaysia over the last 30 years and its impact on the three pillars.

An **ecosystem** in simple terms can be described as key stakeholders in a community that live in and interact with each other in a specific environment that nurture, use, share and develop information and knowledge for the betterment of society.

An **STI Ecosystem** is defined as the symbiotic relationships between these stakeholders that contribute to the multiplier effect in community and nation building through the nurturing, exchanging, developing and utilising of science, technology and innovation towards shared prosperity and sustainability.

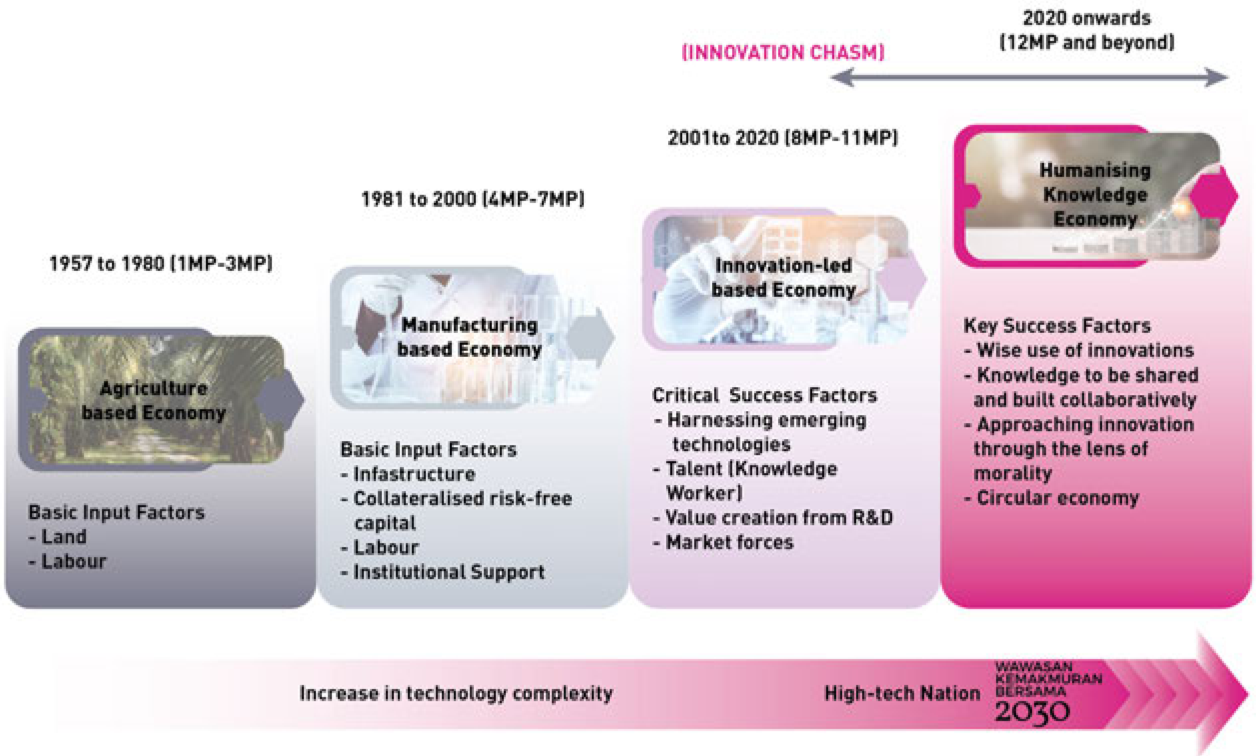
Dynamic Capabilities is defined as the ability to absorb, adapt and innovate new ideas, knowledge and STI discoveries. For more details on dynamic capabilities, which encompasses absorptive, adaptive and innovative capabilities.

The **foundation conditions** are also known as the Reach factor is the basic building block that connects people, goods, information and knowledge for all stakeholders in society. It enhances the reach of information, knowledge and markets. The **driver conditions**, also known as the Richness condition, deepens knowledge intensity in a society.

References: Nair (2011), Wang and Ahmed (2007)

STRENGTHS AND GAPS[1] IN THE MALAYSIAN STI ECOSYSTEM

Malaysia transformed from an agrarian-based economy to a production based industrial economy by the middle of the 1990s. Subsequently, Malaysia transitioned to a more information-driven society (Figure 6.1). The transformations were significantly enabled by strengthening of the STI ecosystem. Malaysia today is ranked 27th out of 63 in the 2020 World Competitiveness Ranking by IMD and ranked 27th out of 141 countries in 2019 by the Global Competitiveness Report produced by the World Economic Forum.



Reference: Modified from Academy of Sciences Malaysia (ASM) (2017)

Figure 6.1: Transformational Era of Malaysia

[1]The strengths and gaps of the STI ecosystem were identified via a combination of surveys and interviews. A survey of the 8i-enablers within the STI ecosystem, as well as its outcomes and impacts, was gathered from the industry and public's perspectives. Respondents were asked to compare each aspect of the STI ecosystem with an advanced economy such as Singapore, Australia, or the US, and state whether Malaysia's STI ecosystem was weaker or better. This was then cross-referenced with sentiment analysis of the interviews conducted, where an overall sentiment score for each of the enablers within the STI ecosystem were obtained on the current and future state of Malaysia's ecosystem. The combined insights from above were then mapped to key events and developments in the past to contextualise the strengths and gaps from a policy perspective. For more details regarding the methodology, please refer to the Appendix at the end of this Chapter.

Key Strengths in the STI Ecosystem

There are several strengths in the STI ecosystem that have contributed to the development of Malaysia. If further harnessed these strengths have the potential of transforming Malaysia into a strong and vibrant economy in the 21st century.

1. **Facilitative and proactive role of the Government:**
   Malaysia's transition from an agrarian to an industrial economy has been facilitated by the Malaysian government's strong commitment to intensify the development of the enablers of the STI ecosystem towards a higher-value-added economy. Among the key initiatives that led to Malaysia's transformation is the Look East Policy 1982, which promoted technology and knowledge transfer from Japan and Korea. In later years, there has been an inflow of FDI from China into Malaysia, which has supported development of local supply chains.

2. **Rapid infra- and info-structure development:**
   Both these developments required significant investments and use of modern technology and know-how. Where there was a lack of local expertise and technology, foreign capabilities were invited to contribute to these developments. There were significant improvements in the national infrastructure, especially highway, ports, airports and logistic supply chains. Megaprojects ensured that the consortiums that undertook these projects included both foreign and local players. This enabled knowledge and technology transfer to local players, strengthening the local supply chains and networks. These initiatives also built the capabilities

1.	UEM Group Berhad
2.	WCT Berhad
3.	MMC Corporation Berhad
4.	IJM Construction Sdn. Bhd.
5.	Eversendai Energia Sdn. Bhd.
6.	Gamuda Berhad
7.	Scomi Rail Bhd
8.	Ranhill Engineers and Constructors Sdn Bhd
9.	Sunway Construction Sdn. Bhd.
10.	Muhibbah Engineering (M) Bhd.

	Project Value RM (Billion)
Road / Highway / Bridge	32.9
Commercial Building	22.7
Power / Energy	15.5
Other	15.1
Residential Building	14.9
Mixed Development	10.6
Railway	8.4
Water / Waste Water / Irrigation	7.8
Oil & Gas	4.8
Jetty / Port	3.4
Mechanical And Electrical	3.3
Airport	3.3
Total	142.7

Reference: Construction Industry Development Board (CIDB) (2018)

Figure 6.2: Top 10 Malaysian Companies in Overseas (left); types of projects awarded, and its value (right) as of July 2018

of local players, who have expanded their horizons to regional and international markets. For instance, many Malaysian construction companies initially operating in Malaysia went on to successfully receive and complete major projects in the region and across the globe (Figure 6.2).

3. **Information and Communications Technology (ICT) Adoption:**
   Since the mid-1996, the ICT infrastructure in the country was upgraded under the National Information Technology Agenda (NITA) to support the Multimedia Super Corridor (MSC) which was established to spearhead the national ICT development. This attracted foreign industries in many of the ICT sectors which helped to nurture several Malaysian industries to enhance their dynamic capabilities sufficiently to penetrate international markets. The percentage of ICT use among the general public and industries increased with varied levels of adoption. The contribution of ICT to the economy has increased from RM105.7 billion in 2010 to RM137.6 billion in 2014 (DOSM, 2015) and RM267.7 billion in 2018 (DOSM, 2019). The launch of the Industry4WRD Policy and National Fourth Industrial Revolution (4IR) Policy has further strengthened the STI ecosystem to transition from an information-driven to a knowledge-intensive economy by adopting the next-generation technology, such as artificial intelligence, data analytics, automation, robotics and other technologies.

4. **Versatile, multi-lingual and highly literate workforce in the region:** Malaysia's public education and training sector receives one of the highest annual budgets. Within

ASEAN, except for Singapore, the Malaysian workforce continues to be in high demand due to their English and multicultural background. Key allocations provided to the Malaysian Research Universities increased the R&D manpower. High impact research collaboration was also established. Malaysia also has a dynamic private higher education sector that contributes to talent development and is a source of revenue for the country. Malaysia has positioned itself as a regional educational hub. Overall, there has been significant investment in talent development and training, thus increasing the number of R&D personnel in the country.

5. **Significant market potential:**
Malaysia is at the crossroad of three market potentials, as follows:

- Malaysia's strategic location in ASEAN, with a population of close to 650 million. Income levels in the region will increase significantly over the next ten years. This will increase the demand for goods and services to sustain Malaysia's economic growth if the STI ecosystem is strong and competitive.

- Malaysia is also seen to be one of the most industrialised and diversified economies within the Organisation of Islamic Conference (OIC) countries, which as a bloc has a growing population. OIC consists of 57 countries with a population of 1.8 billion people. This will intensify and increase the demand for halal product and services in the coming years, for example, halal food, Islamic banking and financial services. It is envisaged that the Muslim population across the globe is likely to grow, and this will open new opportunities for Malaysia in the halal economy space.

- Malaysia is a developing economy located in the tropics. Despite possibilities of challenges linked to being a tropical and developing country, such as tropical diseases, tropical crops and other natural disasters, there are opportunities within. A strong STI ecosystem can enable tropical environment specific solutions and thereby provide new market opportunities for Malaysian industries. Solutions and discoveries to ensure food security, health security (tropical diseases), and a clean environment will have significant positive spill-over impact across many of the economic sectors, from agriculture to zoonotic.

The intersection of the three market potentials creates space for development of niche products and services originating from Malaysia which will give the Malaysian economy significant life, but this can be only achieved if the Malaysian STI ecosystem can ramp up to attain global best practices and standards.

6. **Foreign trading opportunities:** Malaysia sits at the strategic gateway for two important trade agreements to foster the flow of FDIs, goods and services. The first is the Regional Comprehensive Economic Partnership (RCEP), which consists of 15-member countries in the region, making up 30% of the world population (2.2 billion people) with a global GDP of USD26.2 trillion in 2020. The second important trade agreement is the Trans-Pacific Partnerships (TPP), which consists of 11 regional economies that came into effect in March 2018. The entry of the US, following the change in the US administration, will further reinvigorate trade in the region. It is envisaged that these two trade pacts will intensify FDI and trade inflow among member countries.

Countries with strong STI ecosystems will be able to take advantage of all these opportunities to create significant economic value and impact on their socio-economy landscape. Malaysia has, over the last two decades, worked diligently to try and put in place the necessary enablers for the development a robust, strong and agile STI ecosystem. However, competition continues to intensify as other regional countries similarly race toward building and leveraging strong STI ecosystems to spur economic development.

Key Gaps in the Malaysian STI Ecosystem

The global STI ecosystem and economic landscape have become complex due to converging technology platforms and the multiplicity of stakeholders who manage different elements of STI enablers and economic value chains that transcend multiple jurisdictions and sectors. Market uncertainties or volatilities very quickly reverberate across supply chains and the ripple effect often follows through deep into the STI ecosystem and national economy.

While several favourable conditions support the development of a vibrant STI ecosystem in Malaysia, providing the nation with "shock-absorbers" to mitigate global, regional and local risks, there still remain a number of gaps in the STI ecosystem. The gaps in the STI ecosystem have significant potential for hampering the economic growth, societal development and environmental wellbeing of the country.

1. **Traditional institutional governance:**
Many of the institutions of governance (federal, state, local council, industry associations and institution of learning/ R&D) are more suited for the older industrial-based economy. Many of them have not kept pace with global STI developments that embody a knowledge economy. They tend to use legacy technologies and management systems that make it challenging to manage the complexities of emergent global forces. Lacking appropriate and integrated technologies, many institutions retain a transactional and "silo" approach in the way they manage their STI ecosystem. There is a tendency toward duplication of scarce resources, which dissipates the impact of the STI initiatives and investments.

2. **Lack of integrated and focused planning of STI and economic development initiatives:**
There are numerous plans and strategies covering STI in Malaysia. However, lack of focus, integration and sharpness in their formulation and implementation leaves adverse impact on the effectiveness. For instance, the physical and natural infrastructure quality varies across the country and economic sectors. Whilst some regions and sector have a sophisticated and well-developed infrastructure, others lag. Fragmentation in the infrastructure development plans across the country hinders the development of a fully-fledged high value-based knowledge economy.

3. **Limited digital connectivity both in terms of access and coverage:**
The information highway is the "lifeblood" of a value-based knowledge economy. However, access to high speed and affordable digital infrastructure in many parts of the country remains a challenge. Higher-order use of ICT among many stakeholders in the society is limited, especially among the micro industries, SMEs and rural population. Lack of digital connectivity limits and hinders the marginalised population in acquiring necessary services, skills and resources to move up the value chain, improve their competitiveness and wealth creation opportunities.

4. **Shortage of talent with specialised skillset:**
Over the last two decades, there has been significant investment in education. However, STEM graduates entering the workforce currently have skills that do not meet the industry needs, especially in Industry 4.0 technologies (Nair et al., 2019). Particularly, there is a shortage of talent with entrepreneurial and leadership skills as well as specialised skills in areas such as: core software engineering, data analytics, system integrators, additive engineering, biomedical engineering, neuro technologies and other specialised STI areas that power the main economic sectors. This shortcoming highlights the inability to successfully undertake an adaptive transformation of core frontier technologies for local economic sectors. Compounding the deficiencies is the fact that much of the education and training lacks multidisciplinary and inter-disciplinary skills, due in part to very little input from industry in curriculum design and training modules. Hence, there is a serious mismatch in the supply and demand for skills and talent required to propel the nation to become an STI powered economy[2] .

5. **Low adoption of digital governance system:**
Due to legacy technology, low digital connectivity and lack of specialised skills, digital governance systems are in relatively low use among institutions and industries. With the increasing complexity in managing STI and economic initiatives across multiple players and jurisdictions, traditional governance approaches appear not to be adequate in meeting the needs of a knowledge-intensive economy. Without sound digital governance systems, policy formulation, implementation, tracking performance and refining policies and strategies can be challenging. Many institutions continue to take a functional approach, thereby lack a holistic and integrated approach for effective policy formulation. Many institutions tend to be reactive instead of strategic in their decision-making process, optimise their own narrow agendas and goals resulting in increased bureaucracy, red-tape, rent-seeking, and moral hazard behaviour. These market failures undermine investor and consumer confidence.

6. **Lack of focused and targeted STI incentives:**
While there are significant incentives to support fundamental R&D, many incentive schemes are not focused and targeted to core STI programs designed to develop the country's socio-economic drivers. Support for translational and experimental

[2]Studies by Nair et al. (2018, 2019 and 2020) on the business sentiments highlight that there is shortage of skills in core technologies that will help industries build their competitive advantage. The business leaders also expressed the view that the cost of capability training is high and as such, as keen to work with institutions of learning to develop educational and research programs that meet the fast-changing economic landscape and at the same time resolve the high graduate unemployment rate in the country.

R&D is low compared to other countries in the region and OECD countries (refer Chapter 2). This hinders development of strong translational research outcomes, especially those with high commercial value and impact on society. Lack of consistent and stable funding for large scale and long-term STI initiatives also impedes the development of "blue-sky research" in Malaysia. Additionally, as incentives for investing in R&D and automation are low, many businesses continue using cheap labour instead of advanced technology to reduce costs of operations.

7. **Existence of many institutions in the ecosystem without sufficient collaboration and alignment:** A large variety of different institutions manage STI ecosystem of the country. However, the interactions among them are fragmented and lack integration to trigger significant multiplier effect and impact. This is in part due to a lack of a collaborative framework and platforms to incentivise key stakeholders to work together in the formulation and implementation of an integrated STI and economic agenda.

8. **Weak international engagement:** There is lack of expertise and understanding of international standards, particularly how to operationalise these standards within the local setting to reap maximum benefit. Hence, many local players find it hard to compete at the international level. Across many international collaborative endeavours, local industries play only marginal, peripheral roles. As a consequence, very little knowledge transfer takes place between local and foreign industries. Local industries lack leverage and are often "locked-out" due to poor design of FDI arrangements. Due to the weak collaborative participation, local industries are often not the beneficiaries of key discoveries. Over time they become highly reliant on foreign players for technology and expertise. This perpetuates a "lock-in" culture of dependency on foreign technology, which stifles local innovation.

These key weaknesses in the STI ecosystem in Malaysia are inter-related and, taken together they hinder the management of the complex STI ecosystem performance nexus. Attendant to this is the more worrying concern of other regional economies vigorously making effort to improve their STI ecosystem relative to Malaysia, giving rise to the risk that Malaysia will lose its competitive advantage. This will have a strong and adverse impact on the economic, social, and environmental performance of the country.

SNAPSHOTS OF THE ECOSYSTEM OVER THE LAST THREE DECADES USING 8i ANALYSIS

Infrastructure

Malaysia has long recognised the importance of infrastructure, which has resulted in rapid execution of various national projects (refer to Appendix 6.7), such as the Petronas Twin Towers (1992-1998), Kuala Lumpur International Airport (1993-1998), North-South Expressway (1994) and others. For example, the North-South Expressway, which was completed in 1994 at the cost of RM5.8 billion, had the aim to reduce the congestion in the Federal route. Today, PLUS highway serves 1.7 million vehicles daily, providing an essential transport link responsible for almost 70% of Malaysia's GDP. These high-quality transportation systems were critical in connecting rural and remote communities to the mainstream economy whilst simultaneously enabling the diffusion of STI initiatives, including adopting new technologies across the country. Such initiatives contributed to the economic development of multiple communities and industrial sectors across the country, raising the country's overall economic wealth position.

Science and technology (S&T) parks, such as Kulim High-Tech Park (KHTP), Technology Park Malaysia (TPM), Multimedia Super Corridor Cyberjaya (MSC) provides high-tech manufacturing, R&D and software and IT services. They were as an integral part of a new strategy to develop S&T, in which rapid transfer of R&D know-how was crucial to facilitating greater innovation in high-tech industries. The government plays a leading role in promoting the development of S&T parks, which includes providing funds for infrastructure building and variety of tax incentives to tenants. However, according to Kahaner (1995), public universities play relatively minor roles in S&T parks which contrasts sharply to the practice in the United States and Europe.

Table 6.1: Gaps in Infrastructure

Economic Impact	Societal Impact	Environmental Impact
The quality of the physical infrastructure (roads, ports, hospitals and other public amenities) and natural infrastructure (lakes, rivers, oceans, forests and others) are not STI driven and are not suited for a Value-Based economy. Industries prefer using cheaper labour as opposed to automation or the use of technology	Access to quality physical infrastructure (affordable homes, hospitals and other public amenities) is limited for many of the communities in the B40 and the poor in the rural areas. Land rights and ownership are major issues among the Orang Asli in the country. Natural infrastructure (rivers, lakes, oceans, forest and others) in many rural and urban-poor localities are in poor condition. Hence residents are unable to unlock the value of these infrastructures. Much of the infrastructure (both physical and natural) is not STI driven and is poorly maintained.	The natural infrastructure (rivers, lakes, oceans, forest and others) in the country is not well maintained due to a lack of sophistication in using new technology. The natural infrastructure suffers from poor management – plagued by pollution, open burning, encroachment and other negative externalities which leads to the rapid disappearance of natural flora, fauna and endangers species. Contamination also poses a major health hazard and has a negative knock-on effect on the sustainability of communities that depend on these natural infrastructures.

Across the Pillars

- The access to quality infrastructure and its maintenance (both man-made and natural) is not STI driven, and particularly impacts the sustainability and accessibility to the B40 communities.
- There is a need to harmonise infrastructure-related policies, both natural and man-made physical infrastructure.
- Attention is needed to reduce the undesirable impact on the natural infrastructure in the pursuit of building physical infrastructure for socio-economic development.
- Malaysia must not compromise on man-made hazards arising from economic and societal development. The infrastructure plans must be robust to preempt and manage natural and man-made disasters.

Box Article 6.1: Basic Infrastructure in Schools

Classroom buildings, library, science laboratories, computer laboratories, toilets and music room are examples of infrastructures that influence the learning ecosystem of a school besides basic infrastructure such as access to treated water and a minimum of 12 hours of electricity a day. According to Barrett et al. (2019), good quality school infrastructures and basic amenities are congruent with good educational quality and outcomes, especially for students from vulnerable communities.

While the Ministry of Education (MOE) Malaysia continues to upgrade, maintain and repair basic infrastructure in schools to fulfil the Wave 1 of the Malaysia Education Blueprint (MEB) issues concerning dilapidated school buildings and poor state of facilities which affect the quality of teaching and learning process remain. Through the Dilapidated School project, the Ministry was given RM330 million to repair and upgrade 120 schools that were classified as unsafe and in a state of disrepair. As of today, 549 dilapidated schools have been fully upgraded, 26 schools are still undergoing upgrades, 44 facing a delay and 154 schools still have not started the upgrade yet under *Program Pembaikan Sekolah Daif*.

Apart from that, the National Blue Ocean Strategy (NBOS) established a project called My New School in 2016, which aimed to transform rural schools into community hubs. This project has been continued in 2017 focusing on rebuilding dilapidated schools using prefabricated construction techniques. The Government has also taken the initiative to upgrade a total of 1,216 science laboratories (incorporating science, physics, chemistry and biology) across 560 schools across the country which cost about RM240 million. These initiatives contribute to strengthening the educational infrastructure within the school system. This will play a key role in nurturing the next generation of students with strong scientific knowledge to enhance the intellectual capital capabilities of the ecosystem.

References:
Barrett et al. (2019), MOE (2013), MOE (2020), PADU (2016), PADU (2017)

Infostructure

Over the last three decades, the digital architecture of the country has been transformed through a range of initiatives. The Seventh Malaysia Plan gave prominence to several E-initiatives (E-economy, E-public, E-services, E-community, E-learning & E-Sovereignty) to bring the private, public sector and the *Rakyat* together to effect major changes in the social and cultural fabric of the country.

Despite that, when benchmarked, Malaysia's ranking in The Global Connectivity Index (GCI) (Huawai Technologies, 2021) dropped a spot to 34 in year 2020 from 33 in year 2015 (Figure 6.3).

A recent survey conducted by a team of researchers from International Islamic University Malaysia (IIUM) (Aminudin et al, 2020) found respondents had doubts of the government's capacity to digitalise its services (Figure 6.4).

Year / Country	2015	2020	
Malaysia	33	34	⬇
Singapore	2	2	⬌
Thailand	50	46	⬆
Vietnam	56	55	⬆
Indonesia	60	58	⬆
Philippines	63	59	⬆

Figure 6.3: Comparison of Malaysia's Ranking in the GCI with Selected ASEAN Countries

Note: The GCI annually ranks 79 nations according to ICT investment, ICT maturity, and digital economic performance

The vision of the E-initiatives was as follows:

- E-Economy: All sectors of the Malaysian economy to create value and wealth through successful participation in the emerging knowledge-driven global economy.
- E-Public Services: The public, private and community sectors are to provide people-oriented, customer-focused services electronically.
- E-Community: Networks of communities to dynamically participate in governance to enhance the quality of life of Malaysians.
- E-Learning: Formal and informal networks to provide the opportunity and cultivate an ethos of life-long learning for individual, organizational, institutional and societal advancement.
- E-Sovereignty: Citizens and institutions to focus on enhancing national identity, integrity, and societal stability in the face of borderless challenges to the nation's sovereignty.

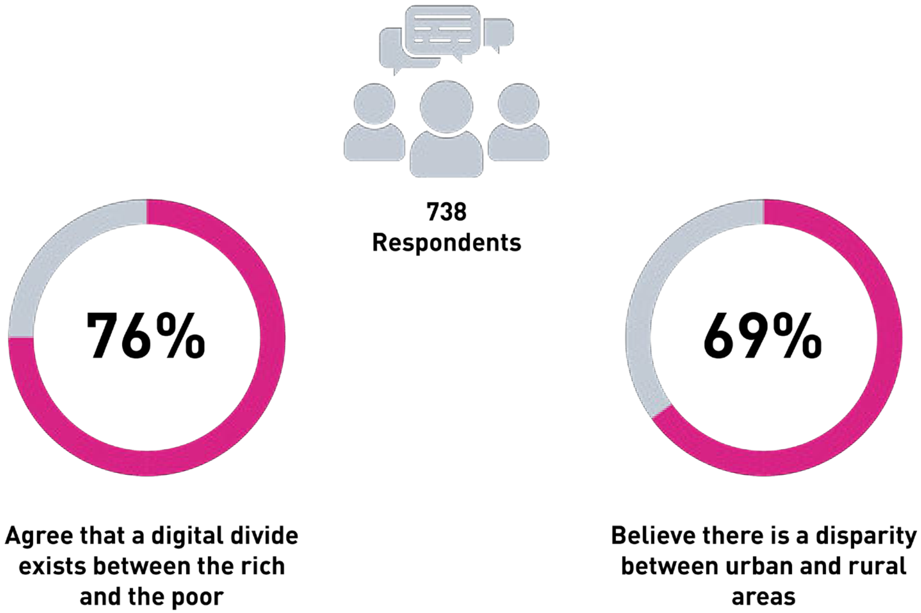


Figure 6.4: Findings from an Online Survey on Government's Capacity to Digitalise its Services

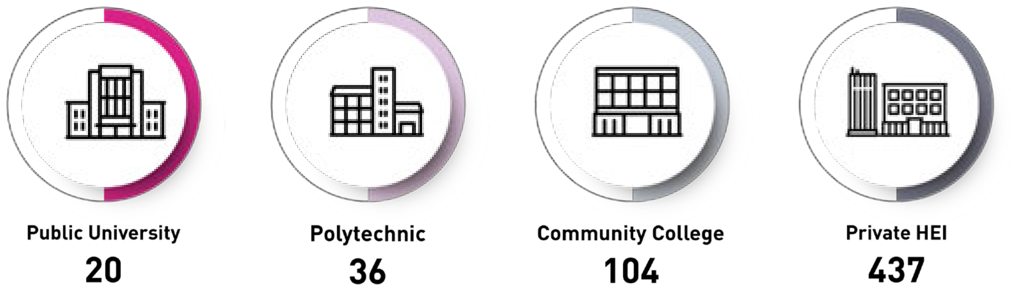
Table 6.2: Gaps in Infostructure

Economic Impact	Societal Impact	Environmental Impact
Digital infrastructure in many parts of the country is weak and not cost-effective. Low use among major stakeholders, especially SMEs and rural population.	The digital infrastructure in many of the localities where the poor live is weak. The technology is expensive for the B40 income group. Further, the digital content in the vernacular languages is limited, hence higher order use of ICT to improve quality of life continue to be low.	Weak digital infrastructure in many localities, especially in the rural areas. Hence, awareness on the potential of managing natural infrastructure and ecosystems remains a challenge.
Across the Pillars		
• Access to the expansive wealth of information contained in the World Wide Web does not penetrate the length and breadth of Malaysia due to uncoordinated digital infrastructure plans that are inter linked with the socio-economic and environmental needs of the various communities across the countries.		

Intellectual Capital

The talent stock of the nation is critical for ensuring its long-term economic sustainability and competitiveness. The importance of education and training in Malaysia is reflected by the significant allocation of the annual budget by the Ministry of Education and Ministry of Human Resources toward talent development and upgrading of workforce skills. In the Vision 2020 statement from 1991, the government of Malaysia had identified the need to generate more high-skilled workforce. Recognising it critical role, the government not only increased the level of investment in education but identified the need to focus on nurturing quality talent that will power STI developments for nation building.

In 1996, the Multimedia University in Cyberjaya was established to facilitate talent development in ICT and the multimedia sector for the MSC initiative. There have been significant efforts by this university to foster collaborative linkages, such as scholarships, research grants, joint R&D activities as well as joint ventures with private companies and universities from all the world. The government also established the Malaysia Research University Network in 2005, comprising five public universities that were mandated to conduct intensive R&D activities in key STI areas for the economic development of Malaysia. Today Malaysia has close to 600 institutions of higher learning (Figure 6.5).



Reference: MOHE (2021)

Figure 6.5: The Number of Institutions of Higher Learning in Malaysia, as of June 2021

Table 6.3: Gaps in Intellectual Capital

Economic Impact	Societal Impact	Environmental Impact
Traditional education and human resource training systems remain as dominant mode of learning. They provide high level of general skills, but lack specialised skills, leadership competences & entrepreneurial acumen. Lack of industry appropriate technical skills, especially within the TVET workforce. Highly dependent on the government for support and over-reliance on foreign technology and know-how.	Education levels remain low among the B40 strata. The concern is that many will be left even further behind in terms of skills needed for the fast-changing economy. Low levels of ICT literacy further constrain them hinders from acquiring necessary skills via online platforms.	There is significant lack of talent specialising in environment protection. There is shortage of people with multidisciplinary skills - sound technical skills, specialised skills on environmental management and understanding of global standards and best practices.
Across the Pillars		
• Intellectual capital growth is not keeping pace with knowledge demands in fast evolving world. There are shortages in critical areas needed by the nation to improve its economic position and wellbeing of society and environment.		

Box Article 6.2: Intellectual Capital – Bridging the Widening Tech Skills Gap using Non-Traditional Learning Methods

According to Future of Jobs Report, by 2025 it is expected that 85 million jobs will be displaced by a shift in the division of labour between humans and machines, while 97 million new roles may emerge that are more adapted to the new division of labour between humans, machines, and algorithms. This demonstrates that there is a major need for upskilling and reskilling for Malaysian employees to remain relevant as the labour market continues to rapidly evolve and change.

Malaysia faces talent mismatch. To address the mismatch of quality tech-graduates and build the next generation of tech talent equipped with industry-ready skills, collaboration with the industry is pertinent.

The 2u2i and 3u1i academic programmes that combines on- and off-campus learning throughout the study period has been implemented by the government to provide undergraduates with greater exposure to real working environment and experience through more learning time in their respective industries and to ensure the courses, delivery and learning methods offered by the universities are relevant and conform to industry needs through industry involvement in curriculum design. This would also lead to a stronger academia-industry network that would enable collaboration.

PhD graduates are vital for the new knowledge economy. The MyBrain15 programme was established in 2008 with the objective of generating 18,000 PhD holders by 2015 and 60,000 by 2023. It has two schemes - the standard traditional PhD programme and the PhD *Industri*. The objective of the PhD *Industri* scheme is to encourage collaboration and knowledge sharing between industry and university to create highly knowledgeable professionals, particularly in the field of engineering, science and technology.

Overall, to address the mismatch issue, curriculum co-created with seasoned industry practitioners and hiring partners from the region would facilitate development of highly sought after and skilled labour force. In this process, technology practitioners as instructors would need to be recruited to participate in education delivery, which would need to take place within sophisticated, modern learning environments, customized to the skills and learning needs of the target segment. Besides the Ministry of Higher Education's role to bridge this gap, supplementary efforts and initiatives, such as the Forward School, which teaches skills for a fast-moving world, could help in the development of a high standard portfolio of practical work skills capable of impressing both local and global technology companies.

Reference:
WEF (2020)

Integrity (good governance and adherence to global best practices)

In many countries, the complex STI ecosystem and economic development are managed through sound governance policies supported by good digital governance systems and implementation tracking. However, there must be better mechanisms to foster trust and improve integrity and transparency as corruption can impede innovation and reciprocates in unequal distribution of wealth in society (WEF, 2021). Malaysia's ranking in the Corruption Perceptions Index has declined from 54 in year 2015 to 57 in year 2020 (Figure 6.6a). A decline is also observed in the Index of Public Integrity (Figure 6.6b).

For Malaysia, multifaceted and integrated policies and initiatives are needed to foster collaboration among key stakeholders, protect intellectual property and help adherence to global standards such that the STI ecosystem can improve its Return on Value (ROV) for socio-economic development. Among the key initiatives to ensure good STI governance are the five corridor development programs that were put in place to ensure equitable economic development across the country. The initiatives were to create better economic opportunities for local communities and for industries in these regions to build strong dynamic capabilities by having access to state-of-the-art STIs.

A key component for promoting strong STI ecosystem is to have sound protection of intellectual property (IP). Prior to the trademark Act 1976 and 1983, the protection of intellectual property rights was not given much attention. In contrast, the United States of America's IP laws trace their origins back to at least 218 years ago, when the first United States Patent Act of 1790 was passed. Over the past 25 years, Malaysian IP law has changed rapidly because of its responsibilities under the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Arrangement obligations and its affiliation with the World Intellectual Property Organization (WIPO). Malaysia has ample protection of intellectual property. However, there remain gaps in the implementation of the IP rights.

Country / Year	2015	2020	
Malaysia	54	57	↓
Singapore	7	3	↑
Thailand	76	104	↓
Vietnam	111	104	↑
Indonesia	88	102	↓
Philippines	95	115	↓

Figure 6.6(a): Comparison of Malaysia's Ranking in the Corruption Perceptions Index with Selected ASEAN Countries

Note: This index measures among others bribery, diversion of public funds, prevalence of officials using public office for private gain without facing consequences, red tape and excessive bureaucratic burden which may increase opportunities for corruption and access of civil society to information on public affairs.

Country / Year	2015	2020	
Malaysia	43	44	↓
Singapore	n/a	n/a	
Thailand	48	47	↑
Vietnam	101	102	↓
Indonesia	70	68	↑
Philippines	54	53	↑

Figure 6.6(b): Comparison of Malaysia's Ranking in the Index of Public Integrity with Selected ASEAN Countries

Note: There are six components in this composite index: judicial independence, administrative burden, trade openness, budget transparency, e-citizenship and freedom of the press

Table 6.4: Gaps in Integrity

Economic Impact	Societal Impact	Environmental Impact
Low use of digital governance systems – unable to reap optimal ROV. Issues of rent-seeking and moral hazard behaviour prevalent in many sectors of the economy. Lack of policy consistency and focus– keep changing direction, milestones and KPIs. KPIs are not updated or tracked effectively. Lack of market and global intelligence on STI directions and needs of industry.	The level of use of digital governance systems for managing the social programs is relatively low. Hence, tracking the implementation of social programs, milestones and assessment of performance leaves considerable scope for improvement. Weak governance tends to encourage rent-seeking and moral hazard behaviour in the management of social programs.	Due to low ICT use and lack of talent, as well as low use of digital governance systems, the environmental management of the country's natural resources remains weak. There is a lack of tracking, traceability, monitoring of milestones and assessment of performance in the management and protection of natural infrastructure in the country. Weak governance systems and accountability has led to rent-seeking and moral hazard behaviours, including regular violation of environmental best practices.
Across the Pillars		
• E-government, one of the flagships of the MSC, was not implemented in a holistic way across multiple sectors of the economy and across localities. • The overall governance system at present operates in-silos and lacks a single point for continuity to track, monitor and measure the impacts of KPIs, implementation and enforcement of policies, plans, programmes and initiatives. • The lack of agility in the governance system has rendered many of the regulatory/legislative architecture unable to keep pace with the technological and global landscape.		

Box Article 6.3: Integrity - The Malaysia Open Science Platform (MOSP)

In recent years, the Open Science movement is gaining traction in many countries with international bodies, such as International Science Council (ISC), Organisation for Economic Co-operation and Development (OECD), United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the World Bank championing and advocating Open Science globally. The international principle of making research data Findable, Accessible, Interoperable and Reusable (FAIR) will not only democratize knowledge, but it will help reinforce open scientific inquiry and integrity, enable better research management and promote open innovation, citizen science as well as data intensive research. Integrating the diverse data streams and huge datasets across multiple disciplines offers unprecedented insights and solutions towards local, regional and global complex challenges.

The Ministry of Science, Technology and Innovation (MOSTI) has launched the Malaysia Open Science Platform (MOSP) Pilot Initiative on 7 November 2019. Through the Academy of Sciences Malaysia (ASM), the Malaysia Open Science Alliance was formed to pave the way towards realising MOSP as a strategic transformative initiative to strengthen STI Collaborative Ecosystem for Malaysia. The aim of this initiative is to make Malaysia's research data as a valuable national asset by developing a trusted platform that enables accessibility and sharing of research data, aligned to national priorities and international best practices. The Pilot Initiative with five Research Universities (RUs) is a two-year (2020-2021) project funded by the MOSTI, spearheaded by Malaysia Open Science Alliance and implemented by the ASM. Three focus areas to be explored in this project are as follows:

- Policy and guidelines
- Capacity building and awareness
- Infrastructure

Incentives

The First National Science and Technology Policy (NSTP) (1986-1989) was launched to promote Malaysia's self-reliance in S&T through the process of upscaling local capabilities in R&D and improving the infrastructure of science and education by strengthening investment for STI. Double deduction tax incentives were given to spur R&D activities in the country. During the period of 1990 to 2000, incentives were continued and were observed to be the strongest drivers of the STI ecosystem. This emphasis started under Fifth Malaysia Plan (1986-1990) when science and technology were identified as critical drivers of economic growth.

- **Fifth Malaysia Plan (1986-1990):** Intensification of Research in Priority Areas (IRPA) grant with a total of RM413.8 million disbursed to intensify R&D activity. This aimed to push research and development as a transformative mechanism for economic development, with strong focus given to the agriculture and manufacturing sectors.

- **Sixth Malaysia Plan (1991-1995):**

  IRPA grant was continued, with the amount being disbursed increased to RM629 million.

- **Seventh Malaysia Plan (1996-2000):**

  In this plan, R&D activities started to be viewed as the potential source of income. The Government decided to focus on two research areas, namely the Information and Communication Technology (ICT) and Biotechnology by creating two special grants: the BIOTEK grant and the Malaysia R&D Grant Scheme (MGS grant). RM200 million was allocated to MDEC to establish the MGS grant in 1998 with the aim of financing R&D projects among local SMEs, especially in software and hardware development.

- **Eight Malaysia Plan (2001-2005):**

  In 2003, The Strategic Thrust Areas in Research (STAR) Grant, a variant of MGS was introduced. The main objective of STAR Grant was to develop centres of excellence in emerging technology areas, which at the time were wireless and mobility, advanced software, and microelectronics. According to the seventh and eighth Malaysia Plans, MGS had funded 67 MSC Malaysia status companies with total amount of RM140.9 million between 1998 to 2005. Some of the outstanding successes emerging from this batch include Jobstreet.com, IRIS, Green Packet, Redtone International and the first recipient of STAR Grant, British Telecom's Asian Research Centre located in Cyberjaya.

- **Ninth Malaysia Plan (2006-2010):**

  The IRPA and the IGS grants were discontinued but new grants such as Technopreneurs Pre-Seed fund, Inno Fund and Science Fund were introduced. At the end of 2006, RM80 million was allocated for the Technopreneurs Pre-Seed fund, to boost up pre-commercialisation activities in R&D. There were around 20 R&D grants implemented under the Ninth Malaysia Plan.

- **Tenth Malaysia Plan (2011-2015):**

  The main R&D grants continued under the banner of the ScienceFund, InnoFund and TechnoFund. The highest amount of R&D grant was allocated to the TechnoFund with a total amount of RM492.37 million.

- **Eleventh Malaysia Plan (2016-2020):** In contrast, in 11th Malaysia Plan, Dana R&D, SMART-Fund and GO-Fund were the recipients of the highest MOSTI's R&D grants, with SMART-Fund getting the highest amount of RM116.77 million.

Additionally, private industries were also eligible to apply for grants under MOSTI which were solely intended for their development and business strengthening, namely the:

- Technology Acquisition Fund (TAF),
- Commercialisation of R&D Funds (CRDF),
- Demonstrator Application Grant Scheme (DAGS),
- Multimedia Super Corridor R&D Grant Scheme (MGS) and
- Industry Grant Scheme (IGS).

To attract global companies to join the Multimedia Super Corridor, many incentives were introduced for IT and multimedia companies, particularly in the form of tax breaks.

Apart from MOSTI, other ministries, private bodies, and government agencies such as Ministries of Health (MOH), Ministry of Higher Education (MOHE), CREST, MTDC, Bioeconomy Corp, PlatCOM Ventures also provide R&D grants to local researchers. MOHE provides grants to support basic and applied R&D among researcher in public and private HLIs. The main R&D grants by MOHE are Fundamental Research Grant Scheme (FRGS), Prototype Research Grant Scheme (PRGS), Long Term Research Grant Scheme (LRGS), Trans-disciplinary Research Grant Scheme (TRGS) and Malaysia Laboratories for Academia-Business Collaboration (MyLAB). MOHE's FRGS R&D initiative disbursed around

RM631.80 million in 10th Malaysia Plan and RM583.28 million in 11th Malaysia Plan. TRGS and MyLAB were two new grants introduced in 2016.

MOH also provides the MOH Research Grant (MRG), which focuses on MOH priorities and is open only to MOH staff and projects that involve collaboration with non-MOH researchers. During 2011-2020, MOH has disbursed RM188.67 million to 1,022 MRG projects through the MGS Grant. From a sectoral perspective, the NAFP and the Third National Agriculture Policy (NAP3) emphasised the importance of the private sector in driving the agriculture industry where incentives to the private sector are provided to ensure a good return on investment, especially in food production. The higher growth rate in the agriculture industry during the Ninth Malaysia Plan led to an increased involvement of the private sector in the industry, especially in large scale commercial food production and agro-based industries.

Table 6.5: Gaps in Incentives

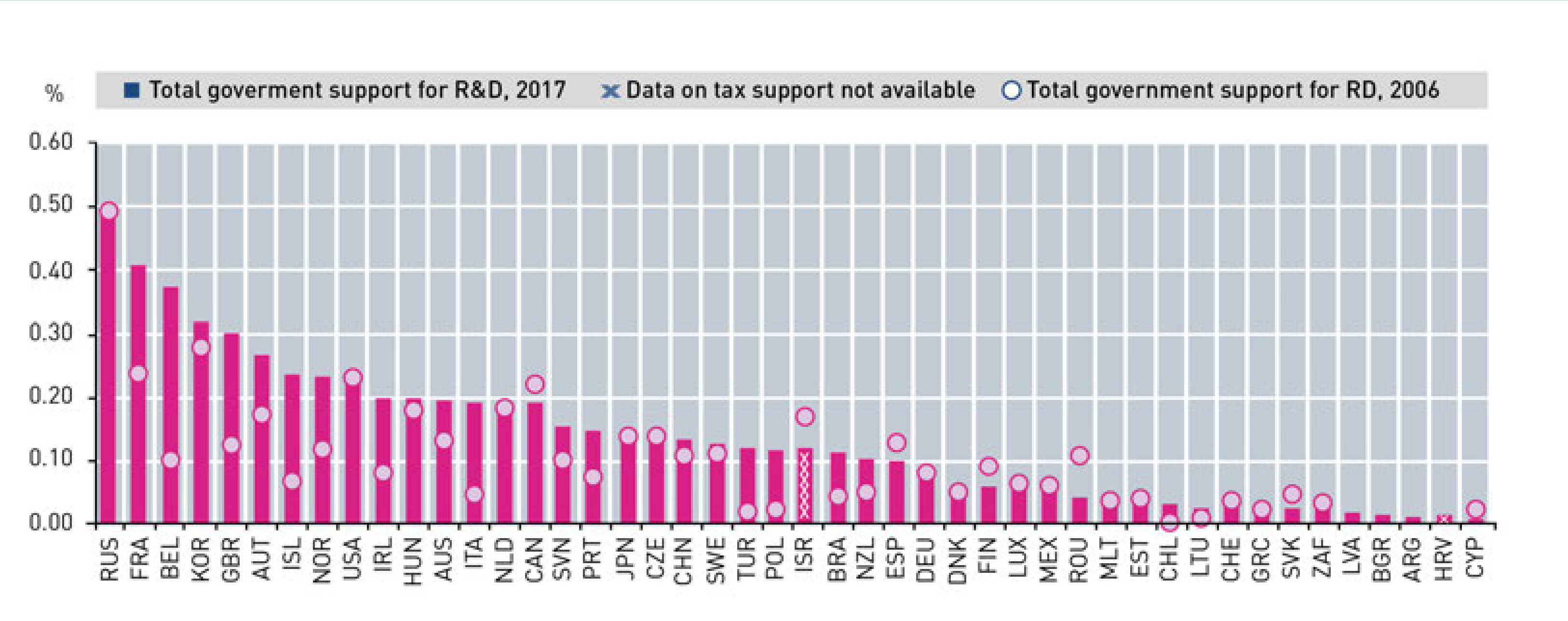
Economic Impact	Societal Impact	Environmental Impact
Fiscal and non-fiscal incentives are not focused and targeted in core sectors of the economy. Low funding for translational and experimental R&D and commercialization support. Lack of consistent and stable funding for large scale and long-term STI initiatives – constant policy changes. This hinders "blue-sky" and long-term R&D initiatives. Incentives for industries to substitute labour intensive jobs with automation is low in some sectors of the economy.	Fiscal and non-fiscal incentives to develop and use new technology in managing social programs and actual use among the B40 have a lot of room for improvement. While there are R&D funding available for undertaking various R&D in the S&T areas that can improve the quality of life of the Rakyat; many of these research initiatives lack development funds for achieving translational outcomes for the Rakyat (last mile problem). Many of the new technologies are not applicable, and if they are, they are not cost-effective. Hence, there is low utilization of locally developed STIs.	Fiscal and non-fiscal incentives to develop and use new technology to manage nation's natural resources and environmental ecosystem have a lot of room for improvement. There is a lack of holistic R&D funding & financial support (fundamental to applied, including support for green marketing and financing/sukuk) to ensure these investments lead to new applications that help manage and create better ROV from the natural infrastructure. The financial support system is fragmented. Greater incentives to use local technology should be in place, with the government leading the way to use local green technology.
Across the Pillars		
• Fiscal and non-fiscal incentives to develop and promote the use of indigenous technology lack focus and coordination in contributing to the strategic development and priorities of the country.		

Box Article 6.4: Incentives - The Road to Funding

The role of government is crucial to enable various stakeholders, such as companies and research institutions, in funding STI activities. However, it is imperative for government to shift from its role as an R&D funder that relies on traditional funding tools and look at innovative ways to fund STI activities. This is especially true as funding for STI is expected to become more difficult in the coming years given tightening public sector budgets and the challenging external global environment (e.g., economic downturns, global pandemics etc.).

Given these uncertainties, support for innovation must continue since it remains the fundamental platform for creating sustainable long-term socio-economic growth for the nation. Malaysia will need to explore new financial instruments that are complementary to traditional funding tools, such as grants, loans and fiscal incentives which are directed to ensure that innovative ideas and activities continue to be supported, following the innovative lead of other countries in developing novel financial and support instruments.

The global funding landscape for STI activities has become exceedingly competitive as innovative developed countries have looked to increase both the amount of funding for R&D as well as diversify the range of financial instruments for these activities. In 2019, 30 OECD countries offered tax relief for business R&D expenditures, up from 19 in 2000. This excludes the temporary introduction of R&D tax incentive by countries, such as Finland and New Zealand; the short-term provision of R&D tax relief in countries, such as Latvia; and the temporary suspension of the R&D tax credit in Portugal. The magnitude of total government support (both direct funding and tax credit) has also increased, whereby 31 out of 36 OECD members have seen an increase from 2006 to 2017.



Reference: Adapted from OECD (2019)

Figure 6.7: Changes in Government Support for Business R&D, 2006-2017 or Latest Year

Note: Total government support (direct and tax) for BERD as a percentage of GDP

Other innovative countries, like South Korea, have increased their percentage of tax incentive support for R&D compared to direct funding, between 2007 to 2017. The increase in tax incentive support also coincides with an increase in direct funding for R&D for businesses (from 0.11% of GDP in 2000 to 0.17% in 2017) showing a more targeted approach in encouraging R&D in the private sector.

Under the Special Tax Treatment Control Law (STTCL), the South Korean government provides tax incentives to stimulate R&D activities. These include a tax credit for research and manpower development expenses, a tax credit for technology transfer, and tax credits for merger or acquisition of a technology innovative SME. Of these tax incentives, South Korea is one of the few countries (e.g., Canada, China etc.) that have introduced a "Patent Box Article" regime where tax credit and reductions are provided for technology transfer among SMEs. These forms of incentives were introduced to facilitate transfer of technology between companies so as to enhance technical competencies and at the same time ensure the recovery of funds invested in technology more efficiently. The corporate income tax on income derived by local SMEs from the transfer of patents were reduced by up to 50%.

References:

OECD (2019), PwC (2020)

Box Article 6.5: Incentives - Islamic Finance and Research Funding

To expand the portfolio of financial instruments to support the development of the STI ecosystem, Malaysia could utilise its leadership in Islamic Finance, particularly Sukuk to spearhead indigenous technology and innovation. Sukuk refers to certificates of equal value which evidence undivided ownership or investment in the assets using Shariah principles and concepts endorsed by the Shariah Advisory Council Malaysia (SAC).

In 2002, Malaysia introduced the first USD600 million sovereign five-year global Sukuk, which made Malaysia a leader in the global Sukuk market development. The unprecedented growth since then and with 47% share of the total Sukuk outstanding, Malaysia has been corroborated as the largest Sukuk issuer in the world.

Sukuk played a key role in financing projects for infrastructure and renewable energy. In the 1980s, the Sukuk and conventional bond market had largely concentrated on public debt issues rather than involvement from the private debt market. The momentum started to pick up in 1990 with the participation from private entity where they realised that Sukuk could be used for various purposes; for example, financing healthcare, funding Waqf development, supporting humanitarian projects and projects aligned to UN SDGs.

Malaysia has created a conducive ecosystem for Islamic sustainable financing, as Malaysia is a well-known global Islamic finance hub. Under the Sustainable Responsible Investment Sukuk Framework released by the Securities Commission Malaysia (SC) in 2017, Green Sukuk fits into the clean energy and energy efficiency category. The main objectives of the green Sukuk and bonds issuance include: first, environmental preservation and conservation; second, the reduction of greenhouse gas emissions; and third, the creation of energy-efficient solutions. Recently, the Government has issued the Malaysian Sustainable Development Goals Sukuk Framework in April 2021 which aligned to global best practices such as the Sustainability Bond Guidelines 2018, Green Bond Principles 2018, Social Bond Principles 2020, and ASEAN Sustainability Bond Standards 2018. Despite the challenges due to the COVID-19 pandemic, the strong demand from the investors showed the market's confidence in Malaysia's economic recovery prospects for growth. This also signifies a clear acknowledgement of Malaysia's Islamic finance industry's innovative capabilities in structuring Sukuk to aid Malaysia's SDG-focused policies in the pursuit of the Shared Prosperity Vision 2030. Structuring Sukuk on a blockchain platform can enhance the transparency of underlying Sukuk assets and cash flows.

References:
Aassouli et al. (2018), Badeeu et al. (2019), Clapp and Pillay (2017), Islamic Financial Services Board (2019), Mohsin (2019), Securities Commission (2019), Shahida, S. and Sapiyi, S. (2013), Shukri et al. (2019), Sustainalytics (2021)

Institutions

Over the period spanning 1990 to 2000, from all the 8i-elements, institutions have had the most initiatives, with particular focus on services (ICT) and the manufacturing sectors. Many institutions were established during this period to drive the economy.

The Action Plan for Industrial Technology Development (APITD) launched in 1990 under IMP1 was aimed to strengthen the structural weaknesses in Malaysian technology development and support infrastructure for technological innovation. It focused on several key economic sectors, including automated manufacturing technology, advanced materials, biotechnology, electronics, and information technology, and these were later joined by energy, environmental and aerospace technology.

In 1992, MTDC was established to develop Malaysian technology-based companies via collaboration with the universities and research institutions to help facilitate the commercialisation of publicly funded research results. MTDC began its operations by investing mainly in electronic related start-ups and expansion stage companies. According to 20th MTDC Anniversary report, all these companies have been listed on the Kuala Lumpur Stock Exchange (Bursa Malaysia).

The Malaysian Industry-Government Group for High Technology (MiGHT) was launched in 1993 with the key role in building and driving partnerships in technology through a consensus building platform between the private and public sectors, as well as providing strategic advice. The initial focus of MiGHT was geared towards the aerospace industry based on the logic that this industry incorporates leading age technologies which can be utilised across many economic sectors. MiGHT has successfully formed a homegrown company, Composites Technology Research Malaysia (CRTM) as a supplier to global companies, such as BAE System.

By 2012, CRTM had grown very quickly and became a preferred tier two supplier for both Boeing and Airbus. Now, CRTM has established a strong presence as a preferred company in the global supply chain. It also helped create opportunities for more than 100 companies in Malaysia to become a part of the global supply chain. As a result, Malaysia has a very stable aerospace industry, from a manufacturing standpoint.

The Industrial Master Plan 2 (IMP2) was launched in 1996 as a continuation strategy of IMP1, but with the focus on building integrated industrial linkages and cluster development that encompassed both manufacturing processes and business support services. IMP2 tried to broaden nation's manufacturing capability through the strategy of cluster-based industrial development, such as the electronics and electrical (E&E) industry in Penang. Positive technology spill overs from the external sector to domestic demand began to materialize in the first half of IMP2, whereby Malaysian-based subsidiaries especially the electronic components sub-sector, which concentrated in Penang and Kuala Lumpur began upgrading their manufacturing process technology through automation - enabled by accumulation of process engineering capacities and technical and workforce skills. The output of Malaysian manufacturing increased from 8.9% in 1980 to 1990 to 13.2% per year in 1990 to 1995. Malaysia's product exports also grew from 11.5% annually during 1980 to 1990 to 17.8% from 1990 to 1995 (Jomo and Felker, 2007).

The Malaysian government was quick to recognize the importance of ICT early in the process. Later the ICT would go on to become the foundation of the drive towards a knowledge-based economy. Established institutions, such as the National Information Technology Council (NITC), Malaysia Digital Economy Corporation (MDEC) and Cybersecurity Malaysia remain relevant today. The National Information Technology Agenda (NITA) launched by NITC in 1996 became a major strategy for nation building through ICT. Various policy, regulatory and institutional reforms were subsequently initiated after NITA to promote the development of the new digital convergence industry, and the introduction of industry forums to promote a self-regulatory environment.

The Government of Malaysia established MDEC (previously known as Multimedia Development Corporation) as the lead government agency to implement the MSC Malaysia initiative, with an annual budget of RM30 million. MDEC under the Ministry of Communications and Multimedia Malaysia (KKMM) acts as a one-stop centre for all MSC companies to lead the ICT and digital economy growth in the country.

For agriculture, the Field Mechanisation Research Centre was commissioned in 2000 to modernize the agriculture sector. Institutional development in the agriculture industry has resolved many problems, such as uneconomic farm sizes, uneconomical crops, and low levels of productivity. However, it was mentioned in the NAFP that the role and function of agricultural institutions is to be streamlined to avoid functional overlap and increase the efficiency of the industry. For example, the role and function of Department of Fisheries (DOF) and Fisheries Development Authority of Malaysia (LKIM) will be coordinated to ensure the productivity of fisheries industry.

From 2001 to 2010, Malaysia established the National Science and Research Council (NSRC) to identify priority areas for the channelling of R&D funds. NSRC acts as a platform to provide long range scientific advice to improve the governance of R&D and drive the country's transformation into Knowledge and Innovation-led economy. The Malaysian Intellectual Property Organisation (MyIPO) was also formed to provide a strong legal infrastructure and effective administration regime to enhance greater creativity and exploitation of intellectual property. Malaysia Venture Capital Management Berhad (MAVCAP) was formed to help nurture infant ICT companies. SME Bank, Malaysian Debt Venture (MDV) and PEMUDAH were also established to facilitate businesses.

Malaysia Biotechnology Corporation (now known as Bioeconomy Corporation Berhad) was incorporated to coordinate implementation of National Biotechnology Policy in 2005 and to further develop three sectors, namely agriculture, healthcare and industrial manufacturing. After the Bioeconomy Transformation Programme (BTP) was introduced, Malaysia Biotechnology Corporation aggressively focused on promoting R&D and commercialization in agriculture.

In 2006, the government introduced a Malaysian Information, Communications and Multimedia Services 886 (MyICMS886) strategy to propel Malaysia in the delivery of advanced information, communication, and multimedia services towards improving the quality of life of Malaysians and at the same time boost Malaysia's global competitiveness. This strategy also aimed to enhance investment in the ICT infrastructure in the country. MyICMS886 had successfully expanded the High-Speed Broadband from 25% of household penetration in 2006 to total broadband penetration exceeding 75% of household as per targeted in the Tenth Malaysia Plan (2010-2015).

Yayasan Inovasi Malaysia (YIM) was established in 2008 to promote and champion grassroot innovation. Three main programs initiated by YIM are Mainstreaming Grassroots Innovations (MaGRIs), MESTECC/MOSTI Social Innovation (MSI) and High Impact Programme 6. By 2019, the combination of these programmes had benefitted approximately 4,400 local grassroot innovators comprising of smallholders, students, SMEs, people with disability, and single mothers.

From 2011 onwards, more institutions were created to harness innovation namely Agensi Inovasi Malaysia (AIM), PlaTCOM Ventures Sdn Bhd, MaGIC, NanoMalaysia etc. PlaTCOM was set up in 2014 by AIM and SME Corp to provide end-to-end facilitation services from concept to commercialisation and links to early-stage financing. According to Digital News Asia, 190 Intellectual Property Rights were transferred from various research organisations to industry in the form of technology licenses, 143 SMEs were admitted to the High Impact Programme 2 (HIP2) for commercialisation and 40 projects commercialised. A total fund of RM18 million was granted and the 40 SMEs generated a total sum of RM33 million in revenue which gave a return of investment of about 83% under the purview of PlaTCOM. NanoMalaysia is a business entity entrusted with nanotechnology commercialisation activities in the country. Through its various programs and initiatives, such as iNanovation, NANOVerify etc, this agency has supported local SMEs to grow their market share in nanotechnology industry. By the end of 2018, NanoMalaysia has developed 55 project Intellectual Property (IPs), 10 patents, 4 copyrights and one utility innovation, which have been filed with MyIPO.

In response to the Fourth Industrial Revolution (4IR), the Government of Malaysia launched the Industry4WRD: National Policy on Industry 4.0 in 2018 to drive digital transformation of the manufacturing and related services sectors, over the period 2018 to 2025. This national policy has four planned targets: Increase manufacturing productivity for every worker by 30% from RM106,647; Increase contribution of the manufacturing sector to the national economy from RM254.7 billion to RM392 billion; Strengthen innovation capacity and capability by improving Malaysia's ranking in the Global Innovation Index from 35 into the top 30; and increase in the number of skilled workers in the manufacturing sector from 18% to 35%.

Over 40 years' experience in machinery for research and technology development and improvement in the manufacturing and services sectors, SIRIM is seen as one of the leading agencies in implementing industry 4.0 initiatives. The SIRIM-Fraunhofer Programme is deemed as crucial initiative to drive productivity of SMES through advanced technology. This programme has benefited more than 2,700 SMEs and helped local industries to face the opportunities and challenges posed by industry 4.0 disruptive technologies. SIRIM Industrial Research (IR) is the leading applied research centre and technological innovation hub in Malaysia and plays a critical role in the development of key industrial sectors and helps drive the Industry4WRD initiatives by the government. It has helped to accelerate the government agenda in promoting industrial clusters, including smart manufacturing, medical technology, energy and environment, and machinery and equipment offered by the Technology and Innovation Centres.

Another major initiative to spur economic development in the country that had significant STI spill over impact is the five corridor programs. The corridor programs were a vehicle to promote inclusive economic development by attracting the best STI industries and high value-added jobs to these five corridor regions. The five corridors covered close to 70% of the country's landmass. The primary objective of the institutions that managed the corridor programs was to ensure that development in these regions uses some of the best technology to invigorate economic growth through the process of creating vibrant local STI ecosystems that will attract value-added jobs and industries. The initiative was introduced under the Ninth Malaysia Plan (2006-2010), where these following five corridors were announced:

- **Northern Corridor Economic Region (NCER)** in northern Peninsular Malaysia, where the main city that hosted the corridor was Georgetown. NCER was formed in 2007 to accelerate economic growth and social advantage of selected areas in the four northern states of Peninsular Malaysia. A number of new growth nodes emerged in this corridor, such as Chuping Valley, the Kedah Rubber City, the Kedah Science and Technology Park and Greater Kamunting include solar panel-driven SuriaKu initiative (MySuria), Estate Management Model for farmers, Community Innovation Centre, Bumiputra Micropreneur Development Programme (MCash), Modern Farming Training Programme using Fertigation, Nestle Paddy Club and Rapid Kamunting. In July 2020, cumulative investments surged to RM120.2 billion, which resulted in nearly 149,000 new jobs and around 30,000 entrepreneurs being developed in this corridor.

- **Iskandar Malaysia (IRDA)**, which was anchored in Johor Bahru. The Government allocated RM6.83 billion and a vast acreage to IRDA to boost the economic performance of the state of Johor. IRDA is the largest single development project in Johor which boasts the Coastal Highway and Eastern Dispersal Link, Legoland Malaysia, Puteri Harbour Family Theme Park and EduCity with Newcastle University, the University of Southampton and Marlborough College. A total investment of RM302.09 billion has been accumulated since its inception in 2006 until June 2019. This development project has created more than 700,000 jobs in various economic sectors, especially in services sector such as logistics, creative, tourism and education.

- **East Coast Economic Region (ECER)**, where Kuantan was the anchor city. ECER was launched two years later after IRDA in 2008. Among this corridor's existing economic drivers are manufacturing, bioeconomy, oil and gas, tourism, logistics and transportation. As of June 2019, total private investment in ECER stands at RM115.6 billion with 164,500 job opportunities created and around 38,000 entrepreneurs developed. The following are some of the main industries related infrastructure operating within ECER: Malaysia-China Kuantan Industrial Park, Pekan Automotive Park, Kuantan Integrated Industrial Park in Pahang, Kerteh Biopolymer Park in Terengganu and Pasir Mas Halal Park in Kelantan.

- **Sarawak Corridor of Renewable Energy (SCORE)** with Kuching as the main city for the corridor. SCORE was established in 2008 to harness the abundant energy potential of the central region of Sarawak, hence accelerating development in the central region, which until then happened to be the least developed region in Sarawak. There are three phases of development of SCORE projects. First phase (2008-2015) focussed on attracting high priority trigger projects and implementing high priority infrastructure projects. Second phase (2016-2020) was to ensure growth and development of Corridor by building industrial clusters and value chains, as well as to develop R&D capabilities. Third phase (2021-2030) is to fully focus on sustaining the economy through R&D. By 2018, SCORE had received RM80 billion in investments, with substantial investments in the power sector (RM29 billion) and other priority industries (RM33.6 billion). The government has also invested RM8.3 billion in physical infrastructure to develop SCORE. 17,828 jobs had been created as of the end 2018.
- **Sabah Development Corridor (SDC)**, with Kota Kinabalu as the main centre for this corridor. SDC was launched in 2008 to improve the *Rakyat's* quality of life by accelerating the economic development in Sabah. This was also to promote regional balance and bridge the rural-urban divide while ensuring sustainable management of resources in Sabah. Since the inception of SDC, the poverty rate in Sabah has been reduced significantly from 19.7% in 2009 to 2.9% in 2016. In addition, the development of infrastructure projects in Sabah grew rapidly developed, especially in logistic and transportation. For example, Pan Borneo and port trans-shipment hub in Sepanggar which will further improve the connectivity and logistical efficiency in Sabah.

Table 6.6: Gaps in STI-Institutions

Economic Impact	Societal Impact	Environmental Impact
Many Institutions of governance (federal, state, local council and institution of learning/R&D) are more suited to a production-based economy – have not kept pace with global STI developments. Too many players doing the same things – duplication of scarce resources, hence dissipating impact.	Institutions that manage many of the social programs (government agencies, NGOs and institutions of learning/R&D) have not kept pace with the STI developments. Hence, the delivery of services is ineffective, time consuming and often do not provide support to the intended target population. Many of these agencies do not have good community intelligence on the efficacy of the social programs in addressing the challenges of the diverse communities in the country. There is also significant duplication of services, which results in suboptimal use of resources.	There are many institutions that provide oversight to the management of the natural infrastructure in the country. Often there is duplication of services, and this reduces the efficiency off the limited resources available to manage the natural environment wealth of the country. Many institutions are not tech-savvy in managing the complex nature of the nation's natural infrastructure. Hence, much of the natural infrastructure continues to be poorly managed.
Across the Pillars		
• The quality of the institutions managing STI across the country have not kept pace with the global STI development. • Lack of advanced technologies and knowledge management systems to manage the complex relationships between the multiple players in the ecosystem results in many of them taking a functional approach instead of a strategic approach in the formulation and implementation of STI policies. • These lead to negative externalities such as duplication of scarce resources and turf wars.		

Interaction

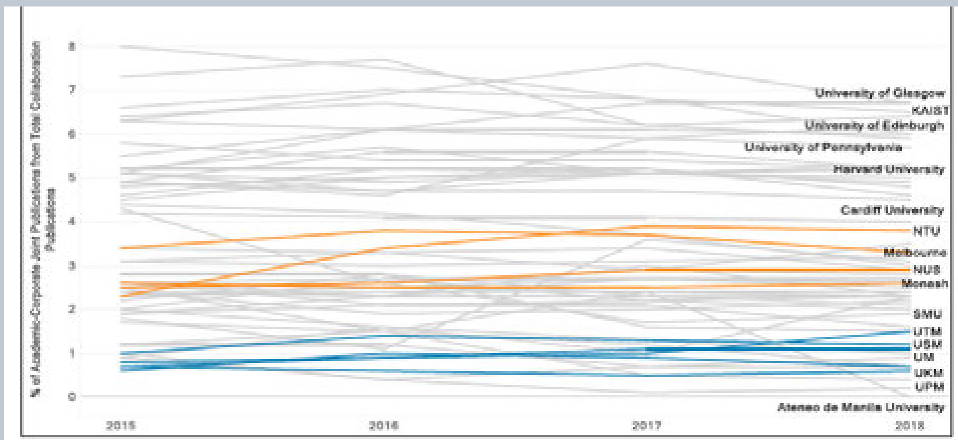
Numerous policies, strategies and incentives schemes have been implemented over the course of the last two decades. During the early years, the interaction was relatively weak in terms of knowledge transfer between companies and universities because there was no platform for the entities to interact with each other, resulting in organizational silos. However, awareness of the need to enhance collaboration between institutions is growing, and several platforms have been established to serve the purpose. An example of such agencies is the Technology Depository Agency Berhad (TDA), established in 2012 to foster and monitor all industrial collaboration programme (ICP) activities in Malaysia and globally. More platforms were established during the 2011-2020 period to foster and enhance collaboration between government, industry, and academia. Examples are CREST in 2012 and Steinbeis Malaysia in 2014. There are 156 electronic and electrical R&D projects approved within CREST and 70 of them are completed (CREST, 2020). CREST is a good exemplar of the importance of having strong public-private partnerships in technological development. While in the agriculture sector, the Agro-food Productivity Nexus is an interactive platform for the government agencies and key players in agriculture industries to plan, implement and monitor any programmes and initiatives in uplifting productivity.

Table 6.7: Gaps in Interaction

Economic Impact	Societal Impact	Environmental Impact
Interaction among key players is patchy at best – lots of turf wars. Hence, unable to capture the multiplier effect and optimal ROV.	Cooperation and collaboration among key players that manage the social programs are fragmented and patchy. There are a lot of turf wars and a lack of sharing of information among key agencies. Hence many of the programs are not implemented effectively and lack sustainability.	Cooperation and collaboration among key players that manage the natural infrastructure continues to be weak. There are a lot of turf wars among key agencies. Management and enforcement are not effective and hence prone to infringements.
Across the Pillars		
• Fragmentation is seen inter- and intra-members of the quadruple helix hindering cooperation and collaboration for sustainability as well as effective and optimal ROV.		

Box Article 6.6: Interaction - Industry-Academia Joint Publications

In developed economies, industry players jointly work with research universities to undertake cutting-edge fundamental research to spur translational research outcomes. In these countries it is common feature of research-intensive collaborations to have researchers from the corporate sector work hand in hand with academics to initiate and fund joint research programmes that lead to high impact outcomes as well as publications. The percentage of academic-industry joint publications from 2015 to 2018 (Figure 6.7) shows that the number of researchers from Malaysia's Research Universities that jointly published with the industry in the leading international journals is approximately 2% while it is 5% to 8% for some of the leading research-intensive universities from the more developed economies.



Analysed by Sunway University Research Team

Figure 6.8: Percentage of Academic-Industry Joint Publications (2015-2018)

Note: International collaborations are based on published journal collaborations with industry

Internationalisation

The Look East Policy introduced by the Malaysian government in 1981 continues to reverberate through the economy even after two decades, as the policy played a critical role in technology transfer from Japan and Korea and was the basis on which the electronics industry in Malaysia was built. The policy played a key role in transforming Malaysia from an agriculture economy to an industrial economy. Nonetheless, the policy has taken a back seat over the last decade, as Malaysia started to open its economy to other countries' STI, particularly from China, who was becoming a dominant player in many of ICT, artificial intelligence and business systems platforms.

Malaysia has also embarked on an ambitious internationalisation of STI through a variety of university and industry programs. Among the university programs was the opening up the education sector to several research-intensive international branch campuses from 1998 onwards. These saw major research-intensive universities from Australia and United Kingdom establish campuses in Malaysia, which has intensified STI and research training of local and international students, but also fostered strong research collaborations with counterparts in the foreign university home campuses. Local research universities, in particular the research universities have also reached outwards and nurtured strong research collaborations with leading international research universities, especially in STEM related areas. Several of the Malaysia Technical Universities (MTUN) have also intensified translational R&D and have established research collaborations with multinationals in key research priority areas, with strong industrial applications in the petroleum, chemicals, electrical and electronics and other manufacturing related areas. For instance, in 2019, the MTUN and Siemens Malaysia announced a landmark collaboration towards preparing university graduates for the world of systems integration.

There are also several STI global innovation networks, such as the UK-Malaysia Science and Innovation Network that was established to promote cooperation and collaboration between researchers in UK and Malaysia. As part of this initiative, the Newton-Ungku Omar Fund, which was established in 2014 and the Global Challenge Research Fund (GCRF), the European Union funded projects SEA-EU-NET and the UK-Southeast Asia Knowledge Partnerships were made available to support collaborations between researchers in Malaysia and UK. These initiatives were to support science and innovation that would contribute to the socioeconomic development of Malaysia. For example, collaborations on health research involving the UK Medical Research Council, Wellcome Trust, Ministry of Education Malaysia, and Academy of Sciences Malaysia. This fund also has held a £14 million 'Research and Innovation Bridges' programme on sustainable urbanisation, led by InnovateUK and Malaysian Industry-Government Group for High Technology (MiGHT).

As to Malaysia's aim to enhance its position in the global supply chain, several initiatives have been introduced by MATRADE to help Malaysian businesses equip themselves with expertise and skills to address global challenges, including the Malaysian Technical Cooperation Programmes (MTCP). These programmes reflect the Malaysian Government's commitment to promoting technical cooperation between developing countries, to strengthening regional and sub-regional cooperation and to fostering mutual self-reliance between developing countries. To date, Malaysia has extended trainings to 143 recipient countries and has trained more than 32,000 participants (MATRADE, 2020). The SMEs Go Global Programme initiative launched by SME Corporation Malaysia in 2015 aims for the internationalisation of local SMEs by facilitating their expansion into global markets. Spearheaded by the Malaysia Digital Economy Corporation (MDEC), the Digital Free Trade Zone (DFTZ) is a strategic national initiative to drive seamless cross-border trade through digitalisation and to promote local SMEs' access to vast opportunities in global markets through e-commerce. At the end of 2019, the DFTZ has impacted more than 13,000 local SMEs by helping them gain access to domestic and national e-Commerce markets, up from approximately 2,000 at the end of 2017 (MDEC, 2020). The establishment of the Food and Agro Council for Export (FACE) in 2014 was set up to facilitate the increase in exports of local agricultural products. This is reflected in the increment in GDP growth contributed by agriculture sector from RM98,177 million in 2014 to RM109,612 million in 2019, at current prices (DOSM, 2020).

Tun Abdul Razak Research Centre (TARRC) is a global centre of excellence by the Malaysian Rubber Board for rubber-related science and technology. This Centre of Excellence, founded in 1938, as the British Rubber Producers' Research Association (BRPRA) with the aim of carrying out fundamental research on natural rubber. It is based in Brickendonbury near Hertford, UK and is known as one of the world's leading rubber research and development establishments. TARRC's main role is to promote and assist the Malaysian manufacturers and rubber products industries penetrate world markets.

Table 6.8: Gaps in Internationalisation

Economic Impact	Societal Impact	Environmental Impact
Lack of understanding and awareness of international rules and competitive engagement, global best practices, global STI trends and directions. Low quantum of quality of high impact engagement with leading global players. Hence, low levels of technology and knowledge transfer. Many players are operating at the lower end or mid-level of the global knowledge and STI value chain. Highly dependent on foreign players for STI.	Many of the agencies that manage and administer the social programs lack the awareness and understanding on the global best practices related to social programs, especially the UN Sustainable Development Goals (UNSDGs); and how best to translate the UNSDGs into actionable polices and strategies that benefit the *Rakyat*. The interaction between local agencies and international agencies is relatively weak; hence the knowledge transfer is relatively low, especially in the use of STI to address social challenges.	The agencies that manage the nation's natural infrastructure lack awareness and understanding of the global environmental best practices and standards. Engagement between local agencies and international agencies is patchy; Knowledge transfer remains relatively low, especially in the use of STI, development of new regulatory architecture and incentives systems to ensure communities are able to get better ROV from the natural environment.
Across the Pillars		
• Lack of awareness and understanding on the global best practices and standards results in both a lower quantum as well as quality of engagement and collaboration. This hinders multi-lateral technology and knowledge transfers between local and foreign players. • In many instances Malaysia is unable to meet global best practices and standards. As such, Malaysian firms and institutions are operating at the lower end of the innovation value chain and supply networks.		

Box Article 6.7: Internationalisation - Global cooperation in clinical trials and vaccine procurement

Since 2020, the global health pandemic has grabbed the greatest of attention from the international community, overtaking issues such as climate change. History has shown that the international collaboration in managing global public health, such as HIV/AIDS, Ebola outbreak and Tuberculosis have sparked greater interest in cooperation. As the cost of inaction to eradicate infectious diseases is large, international collaboration in working to avoid the spread of an outbreak is crucial to minimise economic disruption. While all countries around the world are combating against a common enemy, there have been competitive efforts among certain states in securing the limited personal protective equipment, medical supplies and pharmaceutical products for themselves rather than consider global solidarity and equity. The inevitable pattern of vaccine nationalism arose when rich nations raced to protect themselves by securing more-than-enough stocks for their own needs leading to a spike in prices. Immunisation of the 'rich and elite' does not work well since the virus disregards economic status and ethnicity. If continued, vaccine nationalism is likely to eventually cause dire consequences for all.

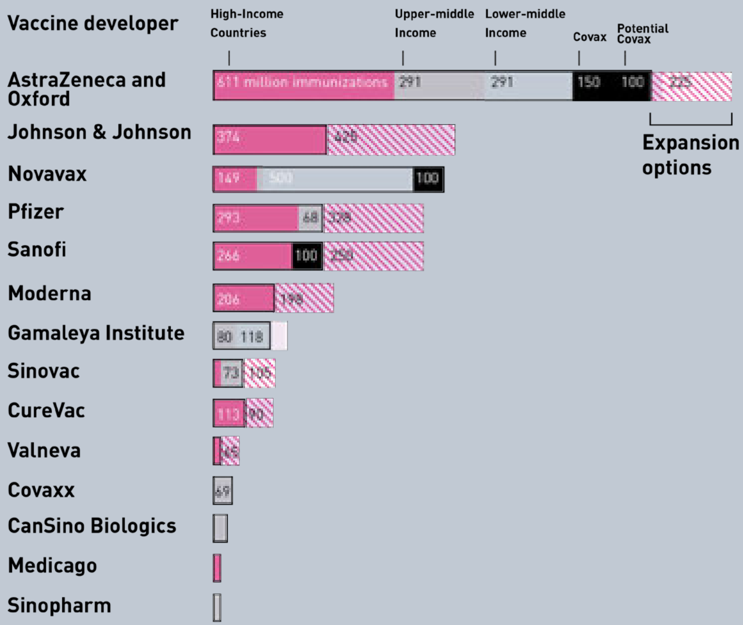


Figure 6.9: Immunisations Promised to Countries by Income Level

A Humanitarian Country Team has been formed with international partners to facilitate planning, information sharing and coordination of efforts to support Malaysia to strengthen its emergency risk management and response. This certainly served as an advantage for Malaysia in facing the COVID-19 pandemic. Prominent Malaysian virologist Emeritus Prof Datuk Dr Lam Sai Kit is a member of an international taskforce that is part of The Lancet COVID-19 Commission. The taskforce will investigate the origins of the virus, creating timeline from the end of the SARS outbreak in 2003 while analysing evidence and identify strategies to assist future pandemic preventions.

WHO Solidarity Trial

The "Solidarity Trial" coordinated by WHO is a worldwide trial to collect reliable data and compare the safety and effectiveness of four treatment protocols using different combinations of Remdesivir, Lopinavir/Ritonavir, Interferon beta, Chloroquine and Hydroxychloroquine. The MOH Institute for Clinical Research (ICR) and Clinical Research Malaysia (CRM) are involved in facilitating the implementation of the WHO-initiated trial in Malaysia. Nine government hospitals in eight states have been identified to participate and Malaysia was the first country in Asia to start enrolling patients to the Solidarity Trial on April 21.

The research is headed by Hospital Pulau Pinang infectious disease consultant Dr Chow Ting Soo with a team comprising 16 infectious disease physicians and pharmacists as co-investigators at the respective Health Ministry's hospitals. The use of the drugs would be evaluated by regulatory bodies the National Pharmaceutical Regulatory Agency and Medical Research and Ethics Committee.

COVID-19 Clinical Research Coalition

There are nearly 1500 COVID-19 clinical trials registered worldwide but very few are being conducted in resource-limited settings. The COVID-19 Clinical Research Coalition is hosted by Drugs for Neglected Diseases initiative involving multidisciplinary expertise from more than 50 countries. The coalition allows institutional and individual members to expedite COVID-19 research on prevention, diagnosis and case management in constrained settings. The coalition is committed to promoting and implementing open sharing of research data while advocating equitable and affordable access to available interventions.

Coalition members may adapt open access research protocols already developed for COVID-19 studies, such as the Solidarity trial, other trials in development, or they may develop new protocols according to their research priorities. Health director-general Datuk Dr Noor Hisham Abdullah is one of the 74 signatory members of the coalition.

Vaccine Procurement and Administration

Seeing the challenge of international inequities in access to the COVID-19 vaccine - in addition to its middle-income economic status and constrained funding resources, Malaysia has been actively involved in international alliances and discussions to facilitate their procurement. Malaysia is among 189 economies to join the COVAX Facility to expand access to COVID-19 vaccines and ensure adequate doses be administered to at least 10% of the population. The COVAX Facility offers an all-inclusive price of US$10.55 (RM43) per dose, or US$21.10 (RM86) per person for a two-dose regimen that would total up to more than RM94.08 million. In ensuring sufficient doses, Malaysia also inked a deal with Pfizer-BioNTech for another additional 20% of the population.

The procurement of approximately 14 million doses of Sinovac vaccine developed by China is expected to shield an additional 22% of the population. This procurement however will also encourage technology transfer and enhance local manufacturing capacity for the future.

Since the 2009 H1N1 pandemic, vaccines have become the latest tool in the global diplomacy agenda. In a post-COVID era, vaccines will become an alternative method to bolster diplomatic ties across nations. As an example of close bilateral relations, China has agreed to list Malaysia as a priority recipient of the China-developed COVID-19 vaccine once it is approved. With a well deliberated procurement strategy, Malaysia could create a beneficial vaccine diplomatic tie. By boosting its influence in the region, Malaysia could see a future on becoming a clinical trials hub for developing countries, as prescribed within the 30 national STIE niche areas.

References:
covid19crc (2021), CodeBlue (2020), Landau, E. (2021), Loh, F.F. (2020), Kretchmer, H. (2021), MOH (2020), NST (2020), Twohey, M., et al. (2020), WHO (2017), Twohey, M., et al. (2020)

THE STI ECOSYSTEM FROM THE PERSPECTIVES OF PUBLIC AND INDUSTRY

The Shared Prosperity Vision 2030 (SPV2030) emphasises the nation's holistic and inclusive development plans. Aligned to SPV 2030, the proposed framework should capture the inter-linkages between the economy, the social well-being of the people, and the country's environment and natural resources. Sustainable socio-economic development of a country is dependent on effective and efficient use of information, innovation and ideas. A sound STI ecosystem inevitably builds upon strong inter-relationships between the three pillars[3] -economic, societal and environmental. Adversely, lack of awareness and weaknesses in the enablers of the ecosystem negatively impacts the efficacy of the STI policies, strategies, and incentives to attain the desired outcomes of improving competitiveness of industry and quality of life of the *Rakyat*.

A survey was undertaken to examine the impact of STI ecosystem on dynamic capabilities and socio-economic and environmental impact from the perspective of the public at large and industry. These two key stakeholders (industry and the public) are impacted by STI initiatives since they are both recipients and utilisers of the support provided within the ecosystem to enhance the ROV for themselves and others in society. The public perspective senses how individuals observe the enabling ecosystem, and whether the fruits of innovation are observable by the layperson. For the second perspective, the role of STI in enabling enterprises to raise their dynamic capabilities and, by extension the avenues by which they can contribute to the country's economic, social and environmental sustainability was captured from industry participants.

Methodology

The mixed methods research used in this survey entails qualitative and quantitative research approaches to obtain a comprehensive understanding of industry, the public and the various perspectives of key stakeholders.

In the qualitative analysis, in-depth interviews with key stakeholders were conducted, guided by three main themes: the current STI ecosystem, present perceivable concerns and gaps, and suggestions for corrective measures and interventions.

As for the quantitative study, two sets of data (industry and public level) were analysed using descriptive analytics. Subsequently, the industry-level data were analysed using the impact analysis method. This step uncovers the complex relationship between the enablers, value creation, competitiveness and impact of the STI ecosystem.

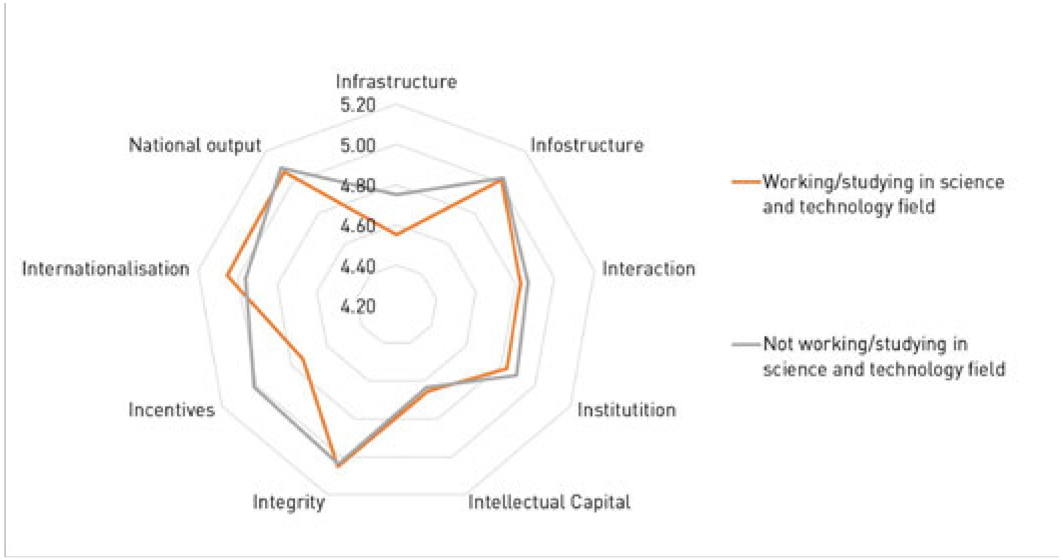
[3]See Appendix 6.4 and 6.5 for details on the measurement items for the three pillars. The economic pillar encompasses wealth, employment opportunities, income gap, poverty and overall economic well-being. Social pillar encompasses people's health, attitude and sense of security, access to basic amenities, openness and freedom, participation, sharing and national unity. Environmental pillar involves the sustainability of our environment-resources and reduction of waste.

Public level perspective

A structured survey was designed to capture the public (individual) perspective of Malaysia's STI ecosystem's state. The questionnaire was distributed to the public across Malaysia and 500 individuals responded. The demographic profile of the public is provided in Appendix, Table A6.3. Descriptive analysis of the STI enablers is discussed in this section.

As shown in Figure 6.10, individuals coming from STEM communities perceived a lower level of infrastructure, intellectual capital, and incentives while the communities outside STEM fields perceived a lower internationalisation level. The STEM communities perceived slightly lower level of national output compared to the rest. The above suggests that those in the STEM-related areas are of the view that there is a need to develop the nation's STI infrastructure and to provide more attractive incentives to enable the nation to move up the global innovation value chain and improve its socioeconomic output and outcomes. On the other hand, those in the non-STEM areas opined that Malaysia has a lot of room for improvement in building strong international knowledge networks that will enhance knowledge and technology transfer. Both groups of respondents agreed on the need to develop the intellectual capital.

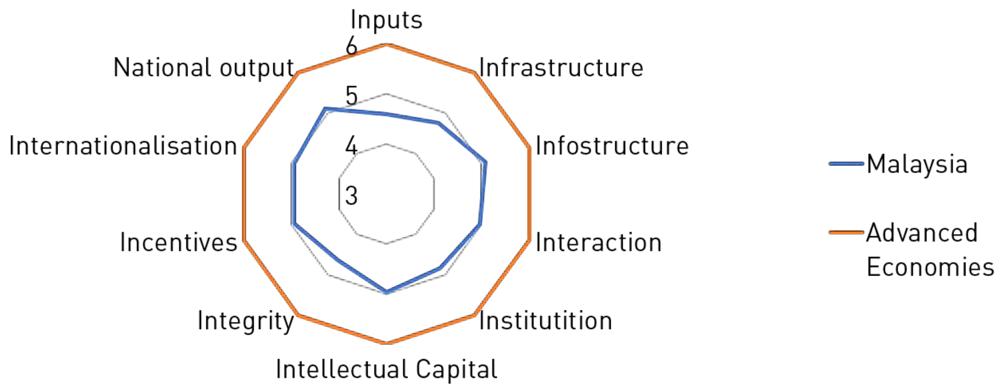
Figure 6.11 above shows that the public primarily perceives that all the enablers and national output within the STI ecosystem are weaker than advanced economies such as Singapore and Australia. Among Malaysia's STI enablers, the public perceive those inputs for STI development and integrity are much weaker while infrastructure and institutions are slightly weaker relative to the others. This suggests that the public believes there is room for improvement in terms of investments into strengthening the nation's STI ecosystem. The focus of such inputs should be targeted towards developing the nation's infrastructure and governance systems. Infrastructure and governance systems. Infrastructure and governance represent the most visible pillars of the STI ecosystem where there is a strong relevance and impact to the public's daily life. Institutional integrity is seen as critical to ensure trust and confidence in adherence to global best practices, which is the foundation for a sound ecosystem. These being perceived as stand-out weaknesses of the STI ecosystem needs immediate attention.



Analysed by Sunway University Research Team

Figure 6.10: Public – Enablers and National Output by STEM Communities

Note: The public data is filtered based on respondents' involvement in STEM (working/studying in a science & technology field), employment sector and state of residence. 63% of the respondents are from the non-STEM.



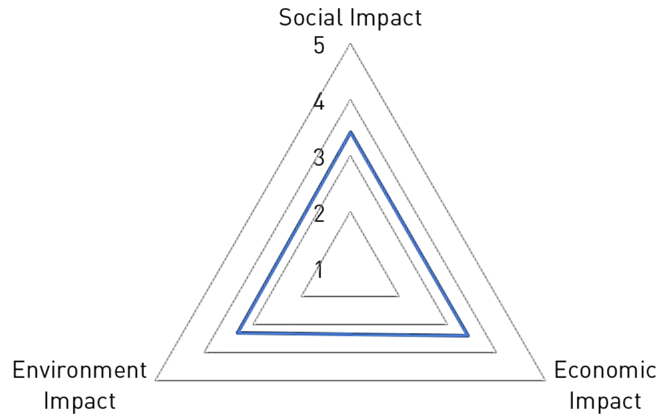
Analysed by Sunway University Research Team

Figure 6.11: Public – Enabler and National Output

Note: Respondents were asked to compare STI-related statements with that of advanced economies, where 1 = very far behind; 3 = weaker than; 6 = same as (Singapore & Australia); 8 = better than advanced economies

Figure 6.12 shows that Malaysia's STI ecosystem has achieved moderate impact across social, environmental, and economic pillars. This suggests that the public believes that the STI ecosystem has led to some, but not very significant improvements in the socio-economic and environmental well-being of the nation. This is not surprising, as this is congruent with the development of the enablers as shown in Figure 6.11, which are lagging behind developed countries.

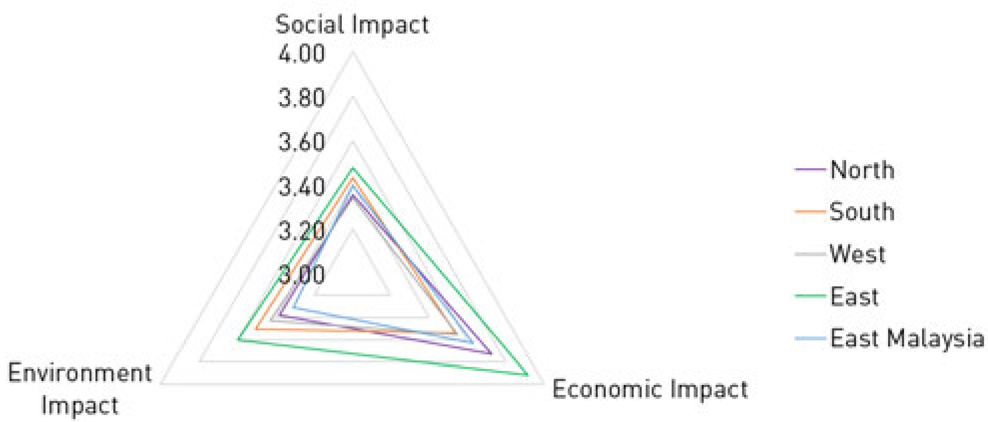
Figure 6.13 shows that the public are of the view that the regions with the most economic benefit from STI adoption are those from East and North of Peninsula Malaysia and from Sabah and Sarawak. In terms of social impact, the states in Eastern and Southern Peninsula and East Malaysia will benefit the most. For the Southern states, improvements in the STI will enable them to capture economic spill-overs from Singapore due to their close geographical proximity. In terms of environmental impact, Peninsula Malaysia (East, South and West) will have the most impact. Many of the respondents were of the view that the sectors in these states are major contributors to environmental degradation; and that STI will have the most positive impact in enabling them to adopt more environmentally friendly approaches. This is consistent with Conditional Convergence in the Solow-Swan Model (Solow, 1956; Swan, 1956) where regions that starts from a low base will initially experience a high growth rate with increased investments in STI in the early stages. However, the growth will gradually decline over time if investments are not complimented with structural adjustments of the ecosystem to respond to global changes.



Analysed by Sunway University Research Team

Figure 6.12: Public – STI Impact

Note: Respondents were asked to rate the degree of impact STI has had on the impact pillars, where 1 = No impact/ improvement and 5 = Very significant impact/improvement.



Analysed by Sunway University Research Team

Figure 6.13: Public – STI Impact

Note: Respondents were asked to rate the degree of impact STI has had on the impact pillars, where 1 = No impact/ improvement and 5 = Very significant impact/improvement.

The survey results show that the general public express the following views on the impact of STI on the economy, social development and environmental state of the country:

- Economic regions that have weaker STI ecosystem can benefit from more intensive development of the enablers of the STI ecosystem, these will enable them to generate greater knowledge spill-overs and technology transfer that will enhance their ROV to all stakeholders;

- Economic regions that are laggards in economic development can improve their economic outlook by adopting more advanced STI;

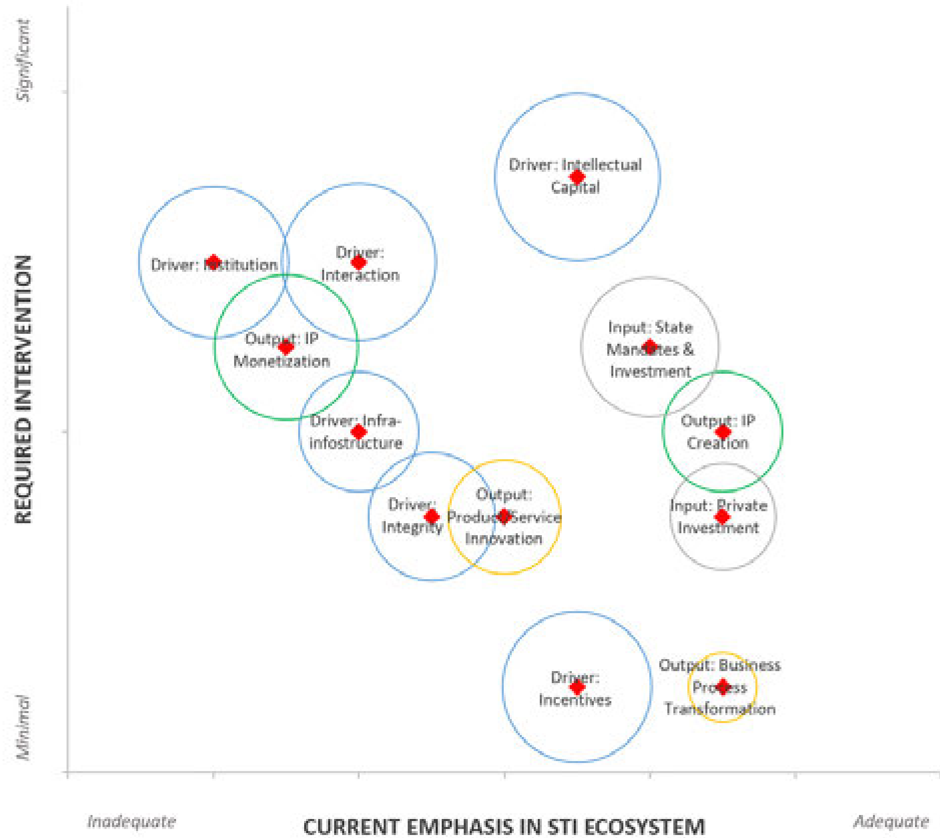
- Economic regions that are plagued with social problems can reduce these problems using better STI-driven programs and initiatives;

- Economic regions that contribute to environmental degradation can reduce these environmental challenges by adopting new STI-driven environmental management systems and technology to monitor and improve the local natural ecosystems in the country;

- Less developed regions in Malaysia can benefit from economic, technology and knowledge spill-overs by transforming their STI ecosystems into more advanced and sophisticated ecosystems to foster strong inter-linkages with their counterparts from more advanced regions.

Industry-level perspective

STI plays a key role in ensuring sustainability and competitiveness of local industries. Hence, it is important to gauge the sentiments of industry on the state of the STI ecosystem in supporting sustainable economic development and competitiveness of their industries. In this section, the state of the STI ecosystem from the perspective of the industry is examined. Two approaches - qualitative and quantitative approaches are used to examine the industry-level perspective. In the qualitative approach, in-depth interviews are undertaken to obtain firm level views on the STI ecosystem enablers. In the quantitative approach, descriptive analytics and impact study are used to analyse firm level data.



Analysed by Sunway University Research Team

Figure 6.14: Required Intervention vs Current Emphasis in STI Ecosystem

Note: In the analysis above, interaction and internationalisation were found to have large overlaps in respondents' sentiments and were thus coded as one item under interaction.

In-depth interviews were conducted among ten industry players and agencies to solicit industry -level perspectives on the state of the Malaysian STI ecosystem. Based on the interviews, the sentiments of the industry players on the STI ecosystem (enablers) were gauged on two dimensions of interest represented in Figure 6.14: (i) current emphasis in the STI ecosystem and (ii) required intervention to enable the industries to become globally competitive (refer to Appendix for full description of methodology and definitions).

The respondents believe that the subsidy programs in Malaysia have incentivised the creation of IP. However, there is a lot of room for improvements in these programs to deepen its impact on the economy. There needs to be adequate consideration of their quality and impact on the stakeholders' ability to sustain growth and competitiveness. Respondents believe that instead of spurring enterprises toward greater innovation outputs, policymakers should recalibrate subsidies and accelerator programs toward rewarding actual successful commercialisation of research. This would have the twofold impact of creating sought-after goods and services in the supply-chain while cultivating entrepreneurial mindsets among local innovators, researchers, and the workforce. The respondents opine that there is a lack of talent within the Malaysian workforce with the above-mentioned skill sets to transform the industries to be globally competitive and transition the economy to a higher socio-economic trajectory.

There is also a strong indication that policymakers and regulators' roles need to be expanded, culminating in more coherent directives for each industry. It appears that most industry practitioners prefer to respond to specific innovation mandates rather than pursue open-ended and self-directed avenues of transformation. Such a reactive decision-making culture is characteristic of developing nations, and Malaysia is no exception – core industries have historically been nurtured through significant, dedicated state intervention, which results in a co-dependence between industries and governing bodies. Industries rely on the state for information, exposure, and capital, while governing bodies become overspecialised in managing siloed industry segments. As such, both parties should begin cultivating change-oriented practices, moving away from an output-driven focus towards outcome driven initiatives.

Making a move from an output-centric operation toward an outcome or change/innovation-centric one requires a multidisciplinary and inter-disciplinary approach in managing STI. The result of a myopic approach to innovation has already been briefly discussed, where we learned that the creative endeavour must be strengthened by practicality (measured through commercial and societal benefits). A change in KPI formulation is necessary to motivate successful commercialisation instead of focussing on quantity. The agenda for collaboration has gained prominence over the years, with frameworks like DevOps and innovation centres-of-excellence being seeded in the most competitive industries to foster creative communities that span business and technical divisions. Respondents likewise recognised that the current efforts in knowledge exchange between industries, universities, and agencies need to be refined – each participant needs to be educated on the broader contexts and goals of the partnership, rather than be left to fixate on their solitary tasks.

Collaborations should extend beyond the operational aspects of the business and look to futureproofing the STI ecosystem This entails taking a strategic approach towards developing the enablers of the STI ecosystem.

A '***devops***' approach results in collaboration between two teams where they work with a shared passion to achieve a common goal.

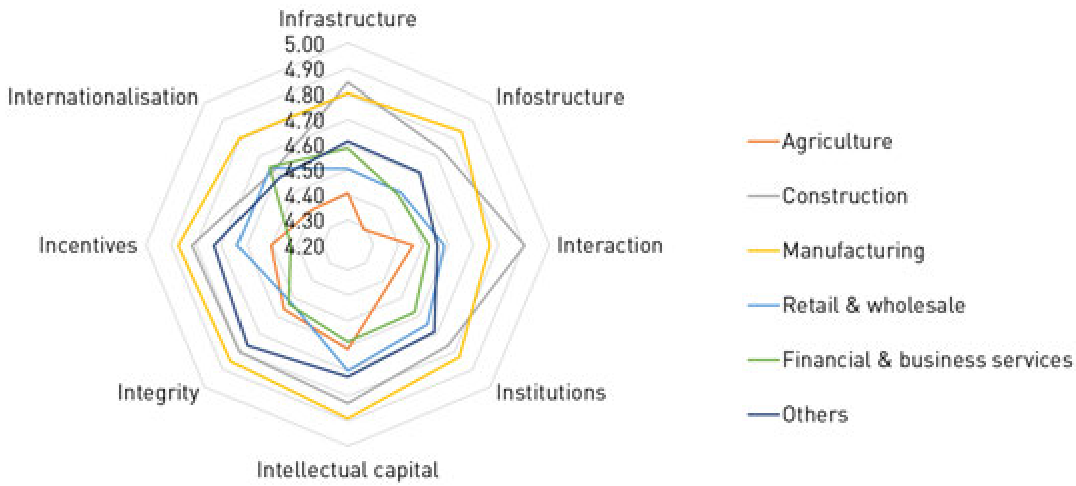
Industry-level: Descriptive Analytics

This section provides a brief description of the ecosystem enablers, outputs, and socio-economic and environmental outcomes as perceived by industry. The data collected from the questionnaire survey were then visualised to uncover patterns and trends in the data. The industry-level data are filtered based on the economic sectors, firm size, economic corridors and the location of headquarters (HQ).

The Malaysian manufacturing sector is perceived to possess the strongest level of enablers, with a generally well-distributed emphasis across all eight foundational and driver conditions (Figure 6.15). Nonetheless, Incentives, Integrity and Intellectual Capital are recognised as leading facilitating conditions for innovation.

The construction sector demonstrates the second-strongest positive perception of the STI enablers. Here, Infrastructure and Interaction are identified as leading constructs – unsurprising, given the role of physical logistics and materials supply-chains in the sector to provide vital competitive advantages at the industry-level. Internationalisation appears to be the weakest construct in this assessment, an indication of the sector's intrinsic focus on local markets as opposed to being global players.

The enablers are much weaker for the retail and wholesale sectors. Respondents particularly noted shortcomings in the Integrity driver, which is one of the least regarded across all sectors. The lack of transparency and accountability frameworks to regulate the management of resources is a gap that needs to be addressed urgently for innovation to flourish. Meanwhile, Internationalisation is perceived to be the strongest enabler – industry practitioners believe that participation in global distribution and collaboration networks will yield further knowledge transfers, organisational transformation, and enhance outputs.



Analysed by Sunway University Research Team

Figure 6.15: Enablers by Sectors

Note: Respondents were asked to compare STI-related statements with that of advanced economies, where 1 = very far behind; 3 = weaker than; 6 = same as (United States); 8 = better than advanced economies.

The financial and business services sector has a similar perception of Internationalisation and Infrastructure enablers. The perceived importance of these two drivers is an indication of how the sector tends to be more globally exposed than others – given that operational and innovative goals are shaped by competitive/regulatory standard beyond the local market. The visibility afforded by running the business against more stringent benchmarks (dictated by international best-practices) likely contributes to practitioners' overall low perception toward local innovative performance.

Finally, the agriculture sector possesses the weakest level of STI enablers. As a predominantly output-driven sector, introducing new technologies is viewed as less important than operationalising tried-and-trusted methods of production. In the cases where new intellectual property has been developed, industries lack the financial wherewithal for commercialising breakthroughs on a large-enough scale.

For outputs and STI impact (Economic, Environmental, and Social), manufacturing and construction sector seems to top the charts while agriculture seems to be the weakest, but it should be noted that the differences are relatively small (Figure 6.16).

Large industries are generally perceived to possess the strongest enablers, followed by small, medium, and micro industries. This visible size correlation is expected, as larger industries have access to larger transformative capital, talent, networks, and perhaps most importantly, visibility to new innovative frontiers (Figure 6.17).

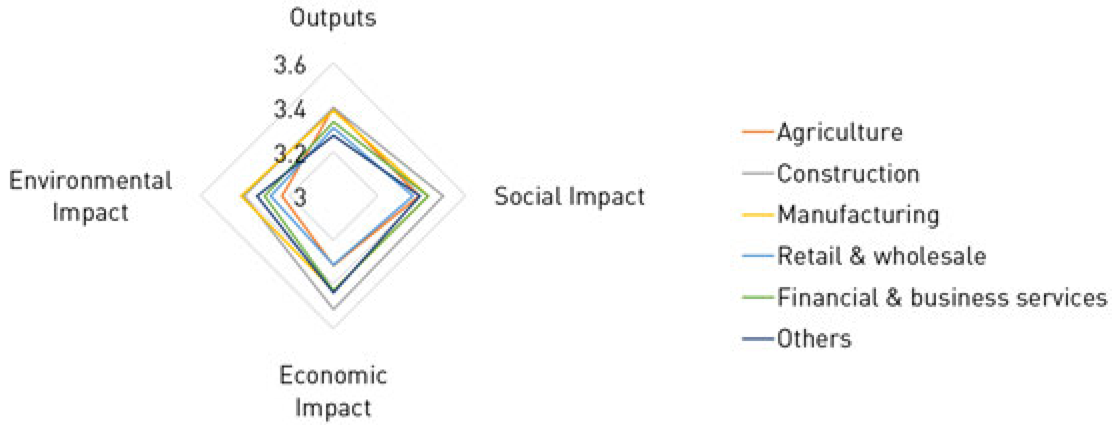


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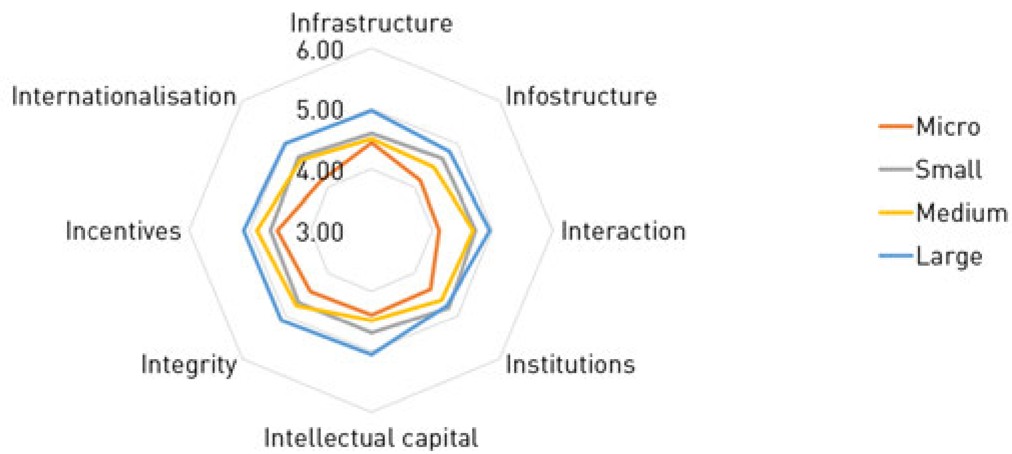
Figure 6.16: Outputs and STI Impact by Sectors

Note: Respondents were asked to rate the degree of impact STI has had on the impact pillars, where 1 = No impact / improvement and 5 = Very significant impact / improvement.



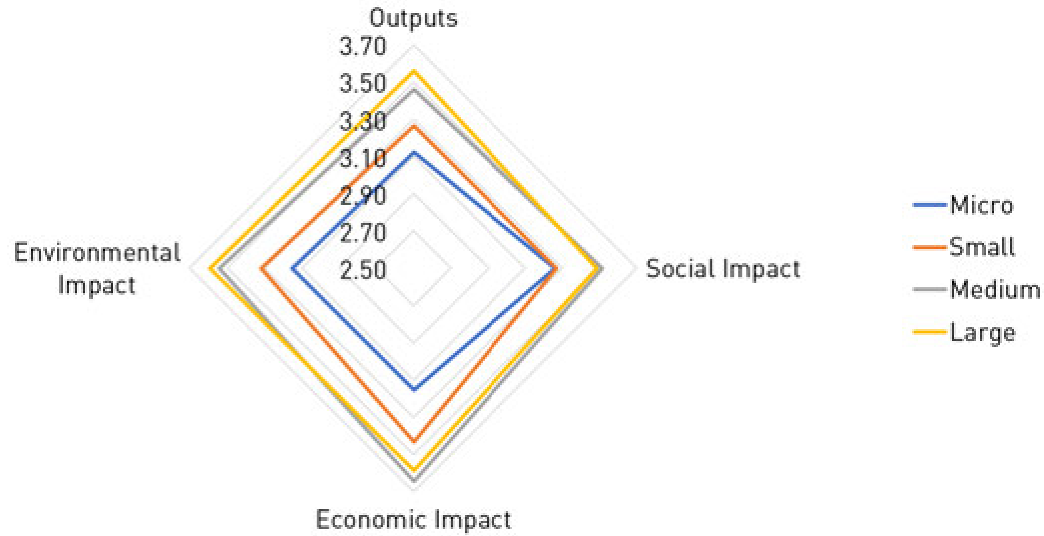
Analysed by Sunway University Research Team

Figure 6.17: Enablers by Size

Note: Respondents were asked to compare STI-related statements with that of advanced economies, where 1 = very far behind; 3 = weaker than; 6 = same as (United States); 8 = better than advanced economies.

Large and medium industries experienced the best output level from the STI ecosystem and showed the strongest impact from the STI ecosystem. Meanwhile, micro industries ranked the lowest in all aspects by firm size (Figure 6.18). This is a clear demonstration of the economies-of-scale come into play in fostering innovation. Larger industries can mobilise new knowledge to yield tangible results in a significantly more efficient and extensive manner.

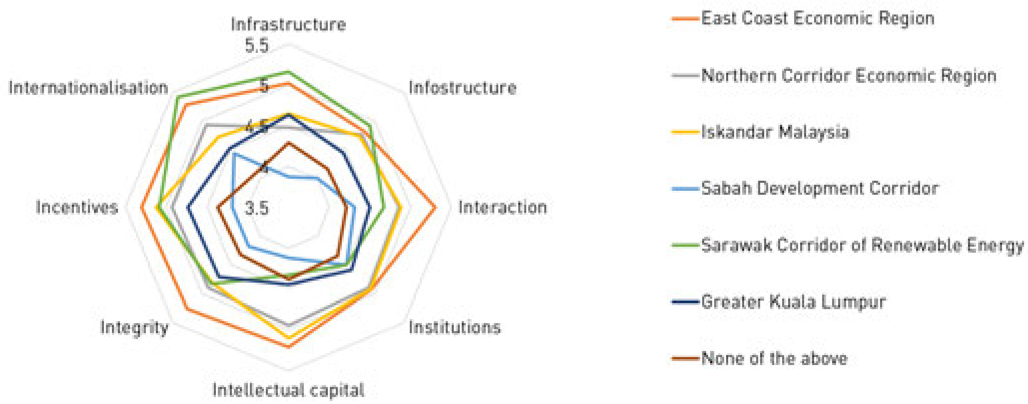
In terms of infrastructure development, Sarawak Corridor of Renewable Energy (SCORE), East Coast Economic Region (ECER), Iskandar Malaysia and Greater Kuala Lumpur are perceived by industries to have the highest development (Figure 6.19). While infostructure is relatively low, SCORE, ECER and Northern Corridor Economic Region (NCER) have made significant progress compared to the other regions. In terms of fostering strong interaction, the top three regions are ECER, Iskandar Malaysia and NCER. Generally, ECER, NCER and Iskandar Malaysia are perceived to possess the strongest level of enablers compared to the rest. SCORE is top for internationalisation, infrastructure and infostructure but weaker in the rest. The SDC and industries not in the above regions are perceived to have the weakest level of enablers.



Analysed by Sunway University Research Team

Figure 6.18: Outputs and STI Impact by Size

Note: Respondents were asked to rate the degree of impact STI has had on the impact pillars, where 1 = No impact/ improvement and 5 = Very significant impact/improvement.



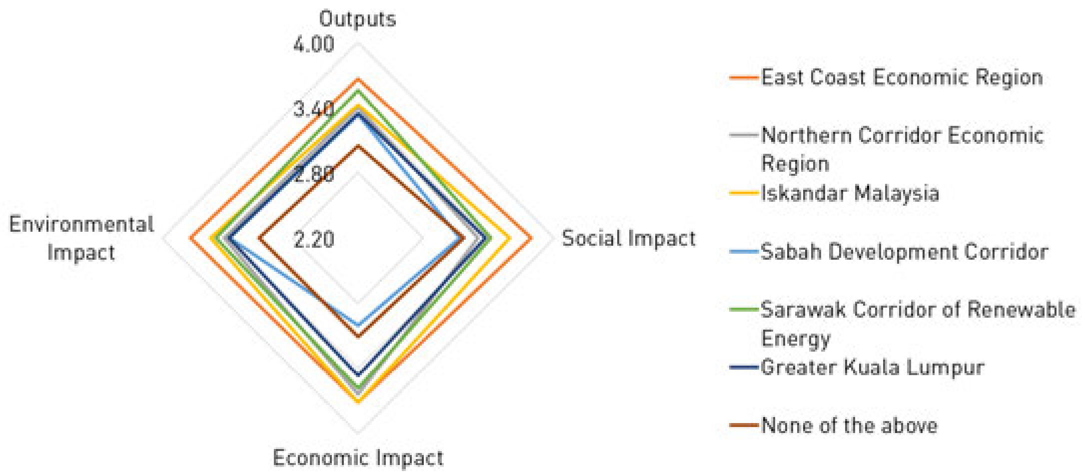
Analysed by Sunway University Research Team

Figure 6.19: Enablers by Region

Note: Respondents were asked to compare STI-related statements with that of advanced economies, where 1 = very far behind; 3 = weaker than; 6 = same as (United States); 8 = better than advanced economies.

The ECER, SCORE and Iskandar experienced the best outputs and are perceived to have received the strongest impact from the STI ecosystem on economic, societal and environmental outcomes (Figure 6.20). These results highlight that a focussed development strategy adopted by these regions has yielded higher outputs and outcomes than other regions. Industries not in any economic corridors, on the other hand, experienced the weakest outputs and STI impact.

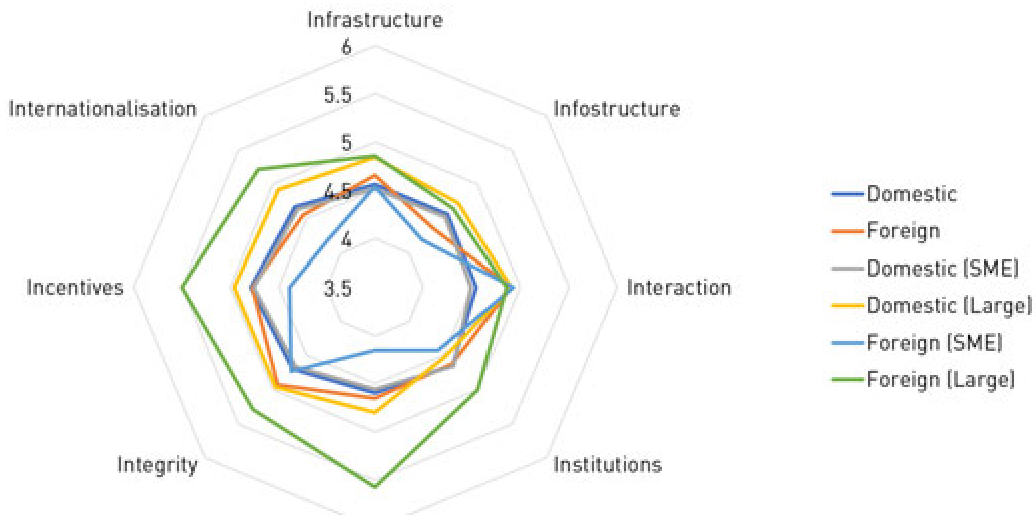
Foreign large industries are perceived to be the biggest beneficiaries of the STI ecosystem, relative to smaller domestic and foreign industries (Figure 6.21). Foreign larger industries appear to be in a better position to harness the STI ecosystem to create value compared to the smaller industries. Interestingly foreign SMEs tend to develop strong interaction (collaboration) within the ecosystem. The size effect seems to be stronger than nationality.



Analysed by Sunway University Research Team

Figure 6.20: Outputs and STI Impact by Region

Note: Respondents were asked to rate the degree of impact STI has had on the impact pillars, where 1 = No impact/ improvement and 5 = Very significant impact/improvement.



Analysed by Sunway University Research Team

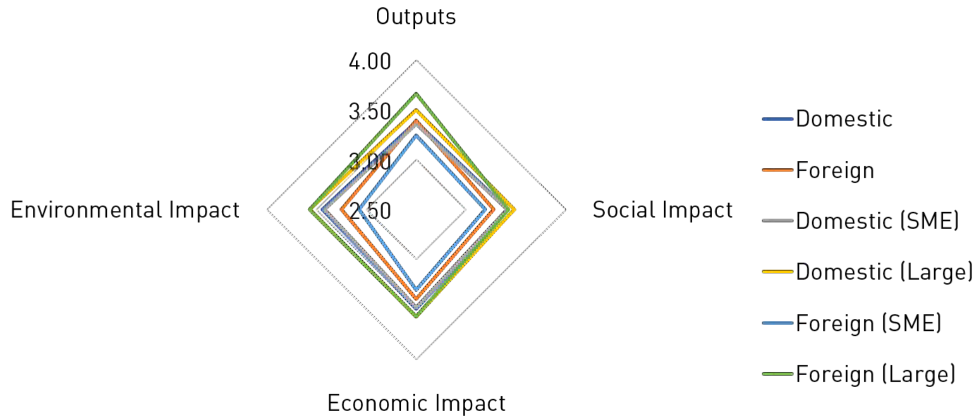
Figure 6.21: Enablers by Size and HQ Location

Note: Respondents were asked to compare STI-related statements with that of advanced economies, where 1 = very far behind; 3 = weaker than; 6 = same as (Untied States); 8 = better than advanced economies.

The effect of scale continues to be apparent in the dimensions of outputs and perceived STI impact. Large foreign and domestic industries outperform SMEs in all aspects, with foreign SMEs at the bottom of the rank (Figure 6.22). The latter could be attributed to the fact that foreign branches typically have specialised roles and have limited decisional autonomy. They are unlikely to undertake transformative projects on their own and are bound by parent entity directives.

Industry-level: Impact Analysis

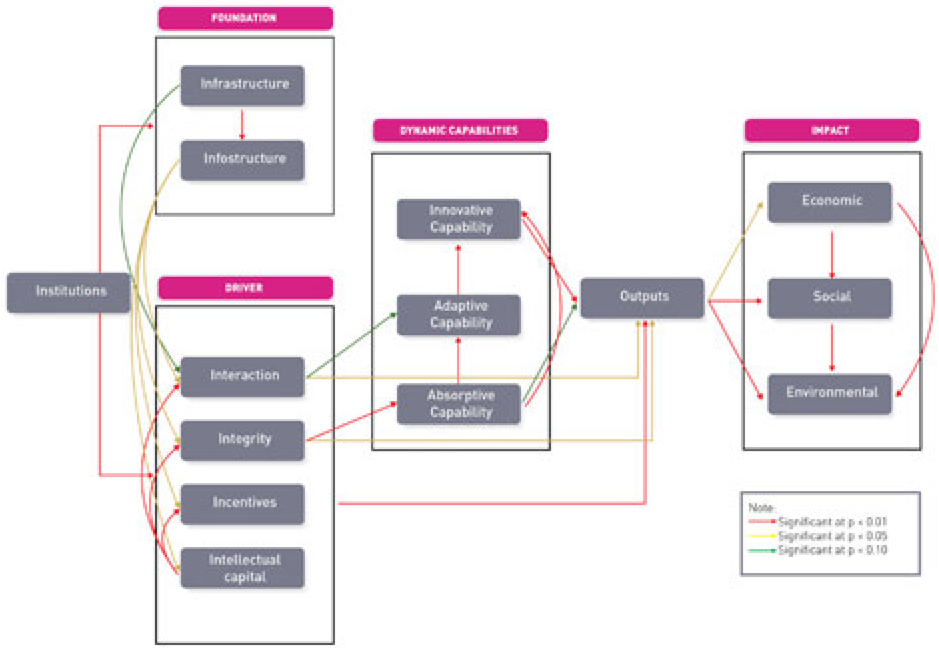
In this study, we used the quantitative survey methodology to uncover the complex relationships between the enablers (measured by the foundation and driver conditions), value creation (measured by the dynamic capabilities), competitiveness (measured by complexity and diversity) and impact (measured by socio-economic and environmental outcomes) (see conceptual model in Box Article 6.8, Figure 6.24). We conducted a quantitative survey at the industry-level to test the proposed model using a component-based Structural equation modelling methodology. The industry-level perspective on the role of the STI ecosystem on socio-economic and environmental impact is shown in Figure 6.23.



Analysed by Sunway University Research Team

Figure 6.22: Outputs, and STI Impact by Size and HQ Location

Note: Respondents were asked to rate the degree of impact STI has had on the impact pillars, where 1 = No impact/ improvement and 5 = Very significant impact/improvement.



Analysed by Sunway University Research Team

Figure 6.23: Results – Firm Perspective on the Role of STI Ecosystem on Socio-Economic and Environmental Impact

Note: In the analysis above, interaction and internationalisation were found to have large overlaps in respondents' sentiments and were thus considered as one factor (interaction) for the analysis.

The key finding from the empirical analysis is that industries believe institutions to be the underlying force for developing other enablers in Malaysia's STI ecosystem. This is a defining characteristic of Malaysia's developing ecosystem, and institutional effort in investing in infrastructure development and providing government support and incentives specifically has yielded results. Institutional linkages are observed to be formed with each driver condition as a centralised administration/decision-making. However, Institutions do not influence dynamic capability strengthening. This is since there is a lack of an integrated approach to ensure seamless flow of information and knowledge sharing among these institutions. The silo approach causes fragmentation of decision-making and hinders industries from strategic futureproofing against uncertainty and external shocks.

For Malaysia's industries, the digital infrastructure (Infostructure) plays a significantly broader role in enforcing the drivers for innovation compared to the physical Infrastructure. While the latter helps businesses to interact and foster collaboration– for instance, road and logistical networks, shared workspaces, labs – digital platforms play a much more central role in facilitating cross-industry partnerships, accountable resource management, subsidy distribution, and knowledge sharing.

Smart partnerships (Interaction) and accountability (Integrity) are identified as crucial contributors to effecting transformative change within the industry. This goes beyond simple business-as-usual functions and instead drives the business to learn new information (Absorptive capability) and employ it within the context of its operations (Adaptive capability).

For the impact study, discriminant validity analysis was undertaken, and it showed that some items for Internationalisation and interaction can be combined. This is not surprising as Malaysian industries have significant joint ventures and strategic partnerships.

However, most industries opine that the STI ecosystem lacks in-depth capability to enhance their learning through formally defined internal processes to redevelop/recombine existing knowledge to develop breakthrough innovations (Innovative capability). In many scientifically advanced countries, large investments in science and technology coupled with strong partnerships between industries and research institutions have led to radical and disruptive innovations that have transformed the competitive nature of global value chains. In the context of the recent COVID-19 pandemic, major vaccine development was undertaken by countries with strong STI ecosystems. In contrast developing countries, such as Malaysia, continue to be dependent on these advanced countries for accessing advanced innovation, technology and new scientific discoveries. The concern is that weaker STI ecosystems will result in developing countries, including Malaysia, to remain at the lower end of the global innovation value chain.

Industries expressed concern that the Intellectual capital (talent stock) does not significantly impact in helping them build strong dynamic capability and as such, the current talent capability fails to adequately influence the outputs of the industries. They opine that there is a need to realign education and research programs to meet the needs of industry[4].

For the most part, Malaysian industries remain largely output-driven rather than innovation-motivated and outcome-driven. Resources appear to be directed to fulfil established production KPIs, rather than improving the firm's dynamic capabilities. This results in a business culture that is inclined to preserve the operating status quo. There are some exceptions. Cross-entity collaborations and resource governance (interaction and Integrity drivers) appear to directly contribute to the industries' ability to learn, adapt, implement, and create innovations. These mostly take the form of strategic partnerships between local industries, universities and government bodies. In the future, this should be extended to include more multidisciplinary bodies to yield more sophisticated 'recombinant' innovation (Innovative capability). In summary, the dynamic capability components play a vital role in transposing resource inputs to outputs, and the level of these intrinsic to the firm dynamic capabilities features in the level and type of contributory impact on economic, social and environmental outcomes for the industry.

[4]This sentiment was expressed in the interviews conducted and also in the MyKE III (EPU, 2016a; EPU, 2016b)

A sound STI ecosystem will help strengthen the firm and industry level dynamic capabilities, which in turn will lead to market strength of economic activities. In turn economic prosperity has a knock-on effect on the social well-being of people as well as environment sustainability. For example, the recent announcement by the U.S. President Joe Biden on transitioning from fossil fuels to renewable energy resources where the technology is developed locally to create new jobs and spawn new industries will allow the US to lead in the green economy (St. John, J., et al., 2021). Increase in jobs in the green technology areas will lead to high paying jobs and a cleaner environment. Discoveries of new renewable and cost-effective energy sources based on scientific discoveries will give countries the competitive edge to expand their market reach globally and achieve sustainable economic growth.

The empirical evidence also shows that sound STI ecosystem will deepen the impact of social well-being on economic and environmental outcomes. The former linkage between social to economic outcomes is due to a sophisticated STI ecosystem will be able to provide people access to the necessary education and training to upskill themselves and thereby open up new employment and / or entrepreneurial opportunities. Education and awareness also have a spill over impact on adherence to environmental best practices. Strong STI enablers also raise industry-level accountability and transparency, thus contributing to greater economic efficiency and environmental sustainability.

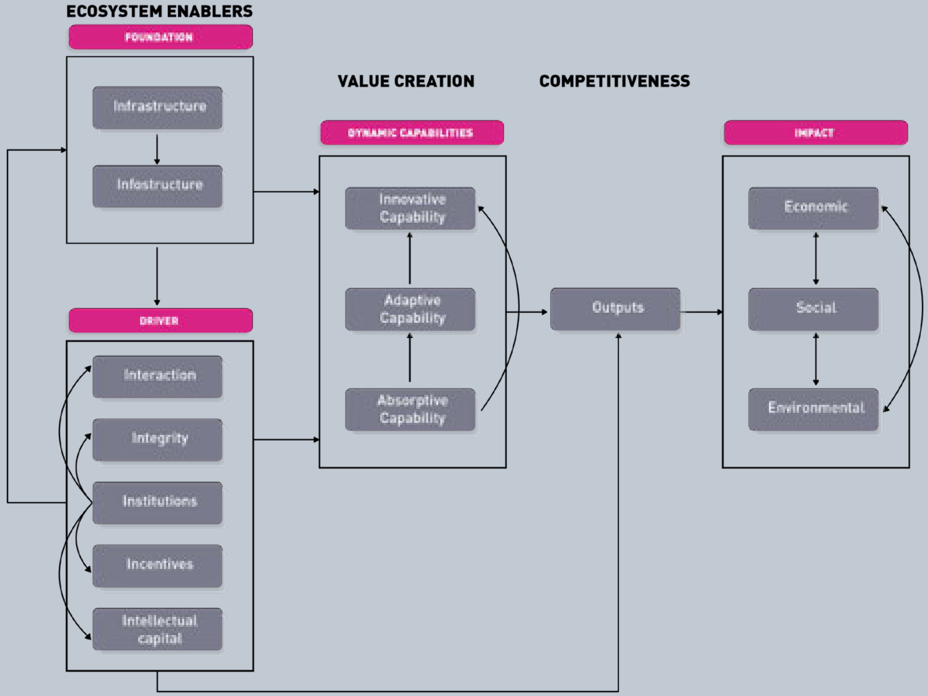
The industry-level respondents opine that the environmental factor influences economic and social factor. Malaysian industries believe that the current STI ecosystem has made some level of progress in identifying new operating synergies and competitive advantages through green innovation. They believe that an effective STI ecosystem contributes to sound environmental management practices thus leading to greater economic value and eco-friendly industries.

Given the strong interlinkages between the STI ecosystem enablers, dynamic capability and economic, societal and environmental outcomes and impact, policy makers must give careful consideration to co-development of policies pertaining to enhancing the STI enablers. This entails careful curation of policies that will initiate structural changes to reinforce the three pillars – economic, societal and environmental outcomes to generate sustainable wealth for the current and future generation of Malaysia.

In summary, effective STI policymaking can be devised, monitored, and implemented with a strong understanding of the capabilities of the country's STI players and their interactions within the ecosystem to create value and outcomes. In this context, both the industry-level and individual-level perceptions of the country's STI ecosystem were obtained. Their views and perception of the STI ecosystem enablers provided insights into existing STI policies and the gaps that need to be addressed to significantly in the three pillars. The long-term evolution of the STI structures requires the nation to recalibrate its developmental trajectory to ensure the three pillars reinforce one another.

Box Article 6.8: Relationship between the STI enablers, Dynamic Capabilities and Outcomes

The relationship between the 8i ecosystem enablers, dynamic capabilities, outputs and impact on socio-economic and environment is depicted in an overarching framework detailing these interactions as shown in Figure 6.24, where the ecosystem enablers for all three components of the dynamic capability feature strongly in advanced countries.



Analysed by Sunway University Research Team

Figure 6.24: Conceptual Framework for Developed Country

Note: In the analysis above, interaction and internationalisation were found to have large overlaps in respondents' sentiments and were thus considered as one factor (interaction) for the analysis.

In an ideal state, institutions (government agencies, trade associations and universities) would have a dual role of strengthening other STI enablers while encouraging the development of both firm- and individual-level dynamic capability components. In other words, the ecosystem enablers in advanced economies contribute to absorptive, adaptive and innovative capabilities. Sound absorptive, adaptive and innovative capabilities equip industries with tools to contribute to output, impacting the socio-economic and environmental outcomes.

Intuitively, a sound enabling environment is crucial to steer the organisation's culture, practices, and goals towards more meaningful outcomes. Such outcomes, in the form of the industry-level outputs, impact the nation's overall economic, social, and environmental well-being.
Strong interactions between the economic, social, and environmental pillars could come together to magnify outputs which will lead to positive spill-over to the economy, society and the environment. Strong collaborative networks among government agencies, industries, community organisations and other stakeholders go a long way in cultivating a knowledge culture, which deepens innovation and sustainable development.

CHAPTER SUMMARY

The global landscape over the last three decades has been transformed by major STI discoveries and developments that had major impact on the three pillars. STI has enabled economies to adopt new technologies that enhance their reach for higher quality inputs, information, knowledge and markets. These technological innovations also contributed to the richness of process improvement, product development, social transformation and improvement in environmental sustainability. While the diffusion of STI has been rapid over the last three decades, there is a concerning emerging trend in those countries there is a widening gap in the development of the STI ecosystem among developed countries and the rest of the world.

Those developed countries that have built strong STI ecosystem are linking these developments to their socio-economic imperatives that enhance global competitiveness and improve their citizens' quality of life. On the other hand, many countries are still lagging behind in curating a viable STI ecosystem that connects their STI initiatives to the socio-economic development and environmental sustainability for the country. Hence many of them are caught in the poverty trap or middle-income trap and are struggling with environmental degradation which has a knock-on effect on the quality of life of their citizens.

One of the major challenges that countries face is to characterise the STI ecosystem as much of the literature provides anecdotal or general characterisation of the STI ecosystem. This makes measuring, tracking, and putting in place effective STI policies that contribute to developing the three pillars challenging. In this section, the STI ecosystem is characterised by the 8i ecosystem framework that provides the enablers of the STI ecosystem with clear metrics at the macro level, community and firm level. This 8i ecosystem characterisation enables policy makers to ascertain the impact of the state of development of the STI enablers on the three pillars. This provides valuable insights on the type of STI policies and strategies that would help policymakers provide directions to move up the global innovation value chain improving both the global competitiveness of domestic industries and improving the quality of life of the citizens as outlined in SPV2030 and UNSDGs.

In this chapter, a review of the enablers of the STI ecosystem for Malaysia using the 8i approach was undertaken and its impact on the three pillars are provided. The analysis show that Malaysia has made significant progress in developing the STI ecosystem for a productive based economy, it still lags behind in transforming itself into a knowledge-based economy.

Appendix 6.1: Definitions of the constructs used in the SO2020 model

The questionnaire for both firm and general public level comprises of four sections. The first section pertains to investments, which evaluates the perception of investments and support for STI inputs in Malaysia. The second section measures the key STI ecosystem enablers - infrastructure, infostructure, interaction, internationalisation, institutions, intellectual capital, integrity, and incentives. The third section measures the value creation (the three components of dynamic capabilities), competitiveness (output) and the three pillars (societal, economic and environmental outcomes). The fourth section include questions on firm characteristics for the firm level survey and demographic characteristics for the public level survey. The final items used in the firm and public level analysis is outlined in Appendix 6.4. and Appendix 6.5.

Construct	Definition
Infrastructure	Quality of the physical infrastructure such as roads, railways, buildings, transportations and other public facilities to ensure seamless movement of people, good and services. The natural infrastructure entails the nation's natural environment, rivers, ponds, seas, oceans, estuaries, wetlands lakes, forests, mountains and natural resources in the country.
Infostructure	Digital communication network that connects people to the global community. These include telecommunication infrastructure and relevant software systems that fosters ICT connectivity, use of big data, and seamless integration of multiple digital and data analytic systems.
Interaction	Quality and depth of cooperation, collaboration and knowledge sharing between all stakeholders to create network externalities and multiplier effect within the economy.
Internationalisation	Participation in the development, formulation and adherence to international laws, treaties, regulations and engagements that ensure sustainable management of the country's STI ecosystem. These include the depth and breadth of engagement with global knowledge networks, institutions of governance, and supply chains.
Institutions	Quality of institutions of governance (federal, state and local council), including regulatory framework and standards bodies that ensures transparency and accountability for industry associations, community organisations, institutions of learning, and research institutes. These include the role of these institutions in ensuring effective formulation and implementation of economic, industrial, social, and other policies that will deepen the impact of STI on sustainable socioeconomic development.
Intellectual capital	Skill sets and entrepreneurial acumen for a knowledge society which include general and specialised knowledge, as well as technical, entrepreneurial, and leadership skills that can raise the ROV.
Integrity	Governance systems that manage resources efficiently and raise the ROV for all stakeholders in a transparent and accountable manner. These include policies, regulatory architecture, legislative framework, global best practices and standards that ensure rules of engagement are effectively developed, managed, implemented and outcome tracked.
Incentives	Grants, subsidies, tax incentives, cash transfers and other financial support. Non-fiscal incentives include access to R&D, testing centres and specialist facilities, mentorships and other support schemes to encourage the adoption of new technology, innovation and knowledge systems.
Absorptive capability	The ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends ... the ability to evaluate and utilise outside knowledge is largely a function of the level of prior knowledge.
Adaptive capability	A firm's ability to identify and capitalise on emerging market opportunities.
Innovative capability	A firm's ability to develop new products and/or markets, through aligning strategic innovative orientation with innovative behaviours and processes.
Outputs	Changes to products, services, operations, or knowledge that resulted from a vibrant, agile, and adaptive STI ecosystem
Social	The impact to the quality of people's lives, culture, and progressiveness.
Economic	The impact to the nation's economic competitiveness, inclusiveness, and resilience
Environmental	The impact to the nation's current and future environmental state.

Appendix 6.2: Study Design

Interview
A series of interviews have been conducted on ten respondents, each representing key Malaysian ministries, state-affiliated bodies, and high-tech private sector companies. This study's specific interview questions are provided in Appendix 6.3 to gauge industry experts' sentiments on the STI ecosystem.

Survey
As for the questionnaire survey, the sampling frame consists of 500 industries and 500 individuals across Malaysia. The profile of industries is provided in Table A6.1, Table A6.2 and Figure A6.1. The demographic profile of the public is provided in Table A6.3.

Table A6.1: Profile of Industries by Economic Sector

Business Activity	Total Sample	Size				Location of HQ		
		Micro	Small	Medium	Large	Domestic	Foreign	NA
1. Agriculture	20	8	8	2	2	14	2	4
2. Construction	21	5	3	9	4	14	1	6
3.Manufacturing	102	9	32	37	24	66	10	26
4.Retail & wholesale	121	51	30	35	5	79	5	37
5.Financial & business services	97	22	29	32	14	72	10	15
6.Others	139	32	45	39	23	105	12	22
Total Number of industries	**500**	**127**	**147**	**154**	**72**	**350**	**40**	**110**

Table A6.2: Ownership Structure of Industries by Economic Sector

Business Activity	Total Sample	Size				Location of HQ	
		Wholly Malaysian	Wholly Foreign	Malaysian Partnership	Foreign Partnership	Yes	No
1. Agriculture	20	17	0	3	0	12	8
2. Construction	21	15	2	4	0	10	11
3.Manufacturing	102	67	16	18	1	53	49
4.Retail & wholesale	121	94	6	20	1	50	71
5.Financial & business services	97	71	11	14	1	58	39
6.Others	139	106	5	28	0	75	64
Total Number of industries	**500**	**370**	**40**	**87**	**3**	**258**	**242**

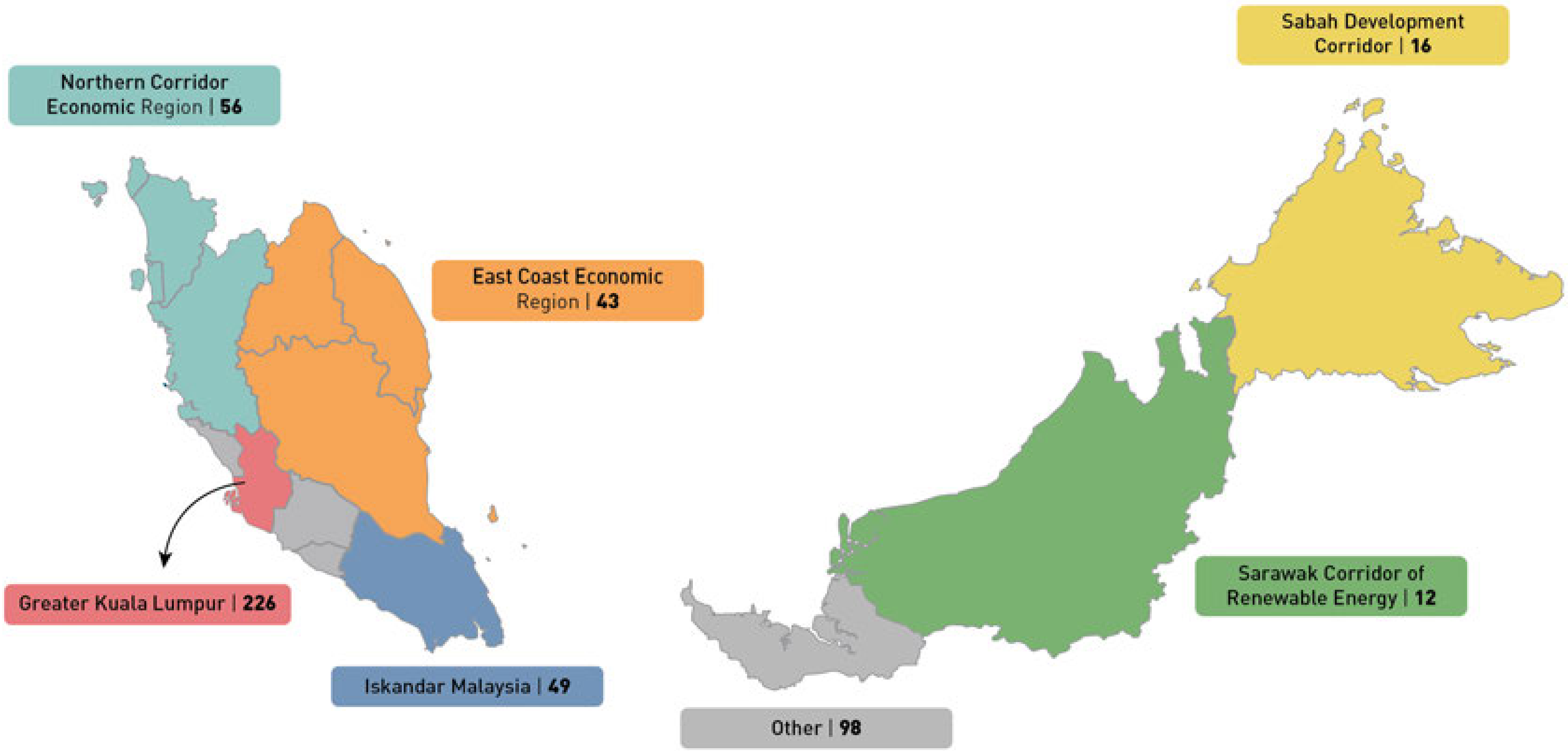


Figure A6.1: Total Industries by Region

Table A6.3: Demographic Characteristics of Public Respondents

	Frequency	%
State of Residence		
PENINSULAR MALAYSIA		
NORTH		
Kedah	26	5.2
Penang	34	6.8
Perak	41	8.2
Perlis	4	0.8
SOUTH		
Johor	68	13.6
Melaka	15	3
Negeri Sembilan	20	4
WEST		
Selangor/Petaling Jaya	113	22.6
Kuala Lumpur	32	6.4
Cyberjaya/Putrajaya	3	0.6
EAST		
Kelantan	23	4.6
Pahang	21	4.2
Terengganu	18	3.6
EAST MALAYSIA		
Sabah	45	9
Sarawak	37	7.4
Highest level of education		
Informal education (no schooling / self-learn).	3	0.6
Primary education.	3	0.6
Secondary education.	82	16.4
Pre-university (e.g. diploma, technical certificates).	142	28.4
Higher education / University education (e.g. bachelor's degree, professional qualification).	268	53.6
Don't know / Prefer not to answer.	2	0.4
Occupation		
White collar professionals (lawyer, doctor, etc.)	103	20.6
White collar non-professionals (Sec, admin, assist, etc.)	134	26.8
Skilled or semi-skilled (mechanics, technician, taxi driver, dispatch etc.)	38	7.6
Businessmen/Entrepreneurs (own business)	63	12.6
Blue collar (carpenter, painter, welder, etc.)	13	2.6
Unskilled labour	15	3

Retired	33	6.6
Unemployed	45	9
Student	30	6
Others	26	5.2
Working/studying in the STI field		
Yes	165	33
No	319	63.8
Not sure	16	3.2
Field of work		
Agriculture, Forestry, Mining	19	3.8
Manufacturing	57	11.4
Construction	34	6.8
Retail	38	7.6
Financial and business services	135	27.0
Others	217	43.4

Appendix 6.3: Key Interview Questions for Science Outlook 2020

1. What do you think of the current STI ecosystem in Malaysia in the context of your industry?
2. How strong is the current Malaysian STI ecosystem compared to regional and international comparators in your industry?
3. Are there any prominent outcomes (economic, societal, environmental) that have been achieved from past/current STI ecosystem(s) in your industry towards national priority areas?
4. What policies do we need, to ensure sufficient investments (public and/or private) and funding for STI R&D to create value for you and your stakeholders.
5. What are the enablers/drivers that will create value for your organisation and your key stakeholders?
6. What is the current state of play of these enablers?
7. What are the challenges with the current state of these enablers?
8. What can be done to enhance their value creation potential?
    i. Quick wins
    ii. Low hanging fruits
    iii. Medium term
    iv. Long term
9. If implemented, what would the impact be for the firm, industry, and country?

Table A6.4 presents the selected interview excerpts that were extracted from the interviews with industry experts. The respondents' perception of the current state of the STI ecosystem and their views on which factors require intervention is also highlighted in this table.

Table A6.4: Selected Interview Excerpts

Selected interview excerpts	Qualitative inference	Context
"SMEs in Malaysia has limited access to R&D facilities"	Malaysian SMEs lack proper infrastructure in terms of access to R&D facilities	Infrastructure
"Infrastructure and talent are the two main things which need to be in place"	Infrastructure is an important enabler to drive the STI ecosystem	
"recent industry forward policy highlighted the importance of infrastructure readiness ...to ensure the provision of high-speed broadband is sufficient for the industrial area"	Digital facilities such as high-speed broadband are essential to drive the STI ecosystem.	Infostructure
"Collaboration through triple helix approach (government entity, industry & public learning institutions) has successfully created 55 intellectual properties (IPs) in nanotechnology area for the past 5 years."	Collaboration is shown to be able to boost the STI ecosystem, and should therefore be encouraged amongst key stakeholders	Interaction
"Collaboration has become more widespread between the universities, research institutes and industries to drive innovation" *"The networking and interactions with other development agencies help to escalate the innovation into a meaningful solution so it can be used or adapted by other communities."*		
"relevant ministries should play the role together to encourage more collaborations from universities, research institutes and industries.		
"Programme where the researchers from universities will be attached to the industries...not all researchers understand the industries' need." *"local universities and local research centres are not business friendly as they cannot customise the test according to the industry's needs."*	Greater collaboration between research centres and universities should be encouraged to understand the needs of various industries better	
"Government should play the main role to make a major shift in nanotechnology innovation in Malaysia, including in drafting the nanotechnology policy." *"Malaysia needs a National R&D Blueprint to ensure the direction of the national interest in R&D is clear."*	Policies should be outlined clearly to establish a resilient STI ecosystem	Institutions
"Worried about the sustainability of intellectual capital to deliver the innovation" *SMEs could not achieve a certain productivity level because they lack skills and they still use manual labour instead of automation".* *"strong push by the government on STEM and TVET education which led to an increase in value of STI and raise the awareness of STEM among the students"* *"younger generation should be trained for analytical thinking especially in grassroots innovations."*	Companies lack people/employees with proper skillsets to drive innovative ideas within the industry	Intellectual capital
"To fit the industry requirements, the government have to spend further to upskill and reskill these graduates to fit them into the industry needs."		

Selected interview excerpts	Qualitative inference	Context
"research duplications among research institutes and the research universities."	Lack of integrity in research institutes and universities regarding research ideas	Integrity
"Malaysia is an incentive-driven country which has been announcing a lot of new incentives, but it is not working. There is a need for the country to look into an enforcement-based approach to develop more R&D activities in the country for the private sector." *"government had been… providing a variety of incentives to get them adapted to IR4.0 technologies."*	Industries are mainly incentive-driven rather than strategy-driven. industries are reliant on government incentives for them to invest in business activities.	Incentives
"Malaysian industries are incentives driven where they depend on incentives from the government to move their business forward." *Financial support should be provided to assist innovators to get international exposures*		
"Local Research Universities (RU) and Research Institutes (RI) created many home-grown products that are being commercialised, but low penetration rate of these products into the market." *"difficulties in getting the products to the market… partly attributed to the poor branding on local products."* *"Grassroot innovators are not getting enough support from the ground for the knowledge content development to facilitate them to the pre-commercialisation stage. "*	Some industries can create home-grown products, while others lack in that aspect. However, there is a gap in facilitating the commercialisation of the products that they have developed.	Outputs
"There has been a high volume of research being done in public and private universities, but the commercialisation rates are really low." *"need to focus on our strengths, build on our strength rather than copying other countries and compete with them"* *"Big gap between fundamental research to commercialisation"*		

Appendix 6.4: Measurement Items for SO2020 Public Perception On STI Ecosystem Enablers

No.	Construct	Items
1.	Infrastructure	Malaysia's physical infrastructure (roads, ports, public transportation, etc) is comparable to that found in advanced economies.
		Our information technology and telecommunications infrastructure (e,g. internet bandwidth speeds, 4G & 5G coverage) is comparable to that found in advanced economies.
		Malaysian infrastructure is of good quality and able to reliably deliver services that are comparable to that of advanced economies.
		The maintenance of our infrastructure is comparable to that of advanced economies.
		The pace of our infrastructure upgrade is comparable to that of advanced economies.
		The environmental sustainability (e.g. good balance of green zones in urban areas, preserving key green areas) of our infrastructure development is comparable to that of advanced economies.
2.	Infostructure	Government digital platforms are typically seamless, integrated, and easy to use for me (e.g. government websites, official service apps such as KWSP's i-akaun and MySejahtera).
		Private sector digital platforms are typically seamless, integrated, and easy to use for me (e.g. company websites, industry apps such as Grab, Lazada, banking apps).
		With seamlessly connected ICT technologies, I am fully aware of what new technological advances are taking place within the Malaysian STI ecosystem.
		In Malaysia, there is a clear catalogue of data and information that I can access easily.
		ICT platforms and services (e.g. fixed/mobile broadband packages) are affordable for me to access.
3.	Interaction	Our government agencies and universities work closely together to build a stronger STI ecosystem.
		Our government agencies are excellent in working with other international agencies to help promote our country's products and services.
		Our government agencies are excellent in working with or negotiating with other international agencies to help bring back key best practices to strengthen our STI ecosystem (i.e. adopting best technologies available instead of reinventing the wheel).
		Our companies and institutions are excellent at sharing knowledge between themselves (industry, government and universities) to catch up and compete with world leaders.

No.	Construct		Items
4.	Institutions	Policies, Programs & Regulations	Malaysia's STI policies and plans are linked in an effective manner to strengthen our STI ecosystem.
			STI policies and plans are designed and executed in a manner that strengthens our STI ecosystem.
			STI policies and plans are enforced in a manner that strengthens our STI ecosystem
			Our regulatory institutions contribute to the setting of global standards.
		Institutional sufficiency	Our institutions' effectiveness in managing constant improvements are comparable to advanced economies.
			Our institutions' effectiveness in managing uncertainties are comparable to advanced economies.
5.	Intellectual capital	Public sector skills & intellectual capital	Personnel in government agencies have the knowledge, skills and know-how to help move our country to a higher income level.
			Our public universities/labs are producing advances that are comparable to those found in advanced economies.
		Private sector skills & intellectual capital	Our private university graduates have the knowledge and skills to be globally competitive.
			Our private universities/labs are producing advances that are comparable to those found in advanced economies.
		Talent recruitment & retention	The technical skills of Malaysia's talent pool are comparable to advanced economies.
			The specialist skills of Malaysia's talent pool are comparable to advanced economies.
			The leadership skills of Malaysia's talent pool are comparable to advanced economies.
			The entrepreneurship skills of Malaysia's talent pool are comparable to advanced economies.
6.	Integrity		I know I can rely on rules of law to protect my personal rights and freedoms.
			When I enter into an agreement with any party, I know that it will highly likely be honoured.
			I can expect law enforcements to NOT participate in corrupt practices.
			I know I can be judged without discrimination under the rules of law.
			Corrupt practices that reduce the efficiencies of public services are rare in Malaysia.
7.	Incentives		I am provided with adequate levels of incentives for me to adopt new technologies to enhance my lifestyle (e.g. tax reliefs for IT goods and services, scientific knowledge subscriptions, etc.).
			Training and other non-financial support is sufficiently provided for me to develop and upgrade my capabilities in using advanced technologies.
			The Malaysian government sufficiently incentivises the move towards digitalisation through ICT adoption.
			There are adequate laws and regulations to ensure the credibility (i.e. certified or licensed by the relevant authorities) of technology goods and services providers.
			There are adequate consumer rights protection in place to keep consumers well informed and protected from fraudulent technology goods and services.

No.	Construct	Items
8.	Absorptive	I frequently keep an eye out for new technologies and innovations.
		I regularly attend talks/workshops to understand, learn and then use new knowledge and technologies.
		I keep track of science and technological knowledge for future reference.
9.	Adaptive	I constantly look at how I can adapt new knowledge and technologies into my daily life.
		I spend considerable time and effort in trying to understand how to use new knowledge and technologies for my own needs.
10.	Innovative	Using or combining existing technologies, I can create novel ways of solving problems.
		I can use existing technologies and innovations in new and original ways.
11.	Outputs	The Malaysian STI ecosystem has helped raise the quality of our local products to be comparable with advanced economies.
		The Malaysian STI ecosystem has helped raise the quality of our local services to be comparable with advanced economies.
		The Malaysian STI ecosystem has helped raise the quality of our local companies to be comparable with advanced economies.
12.	Societal impact	The STI ecosystem has helped improve people's health (physical and mental) & wellbeing?
		The STI ecosystem has helped to improve people's attitude and sense of security in life?
		The STI ecosystem has helped improve people's access to basic amenities (e.g. Water, sanitation, affordable homes, healthcare and other public utilities/services)?
		Advances in the STI ecosystem have helped improve society's openness and freedom (e.g. human rights, freedom of speech) of Malaysians.
		Advances in the STI ecosystem have helped improve the social inclusiveness (e.g. acceptance of minority groups, underprivileged communities, etc.).
		Advances in the STI ecosystem have helped improve the national unity of Malaysians.
		Advances in the STI ecosystem have helped communities and organisations to work collaboratively for societal improvement.
		Advances in the STI ecosystem have helped improve social justice and fairness.
		Advances in the STI ecosystem have helped improve Malaysian's access to education?
		Advances in the STI ecosystem have helped improve economic equality (reduce the wealth gap) amongst Malaysians?
		The advances in the STI ecosystem have helped to improve access to skills training for Malaysians to meet their future needs?

No.	Construct	Items
13.	Economic impact	The advances in the STI ecosystem has improved the overall economic outcomes of the people compared to ten years ago?
		The STI ecosystem has helped improve people's access to broader employment opportunities?
		The STI ecosystem has helped improve people's preparation for future jobs and industries?
		The STI ecosystem has helped create future industries that contribute wealth to the economy?
		The STI ecosystem helped increase the ability of the economy to withstand and recover from shocks? (e.g. COVID-19)
		The STI ecosystem has helped improve people's income?
		The STI ecosystem has helped provide improved opportunities for lifelong employment?
		The STI ecosystem has improved the country's ability to compete regionally (i.e. Asia-pacific)?
		The STI ecosystem has improved the country's ability to compete globally?
		The STI ecosystem has improved the country's ability to produce high-value goods and services?
		The STI ecosystem has helped to reduce the income gap between the bottom 40% and the top 20% of the population?
		The STI ecosystem has helped reduce the level of poverty in the country?
		The STI ecosystem has improved the overall economic well-being of the bottom 40% of the population
		The STI ecosystem has increased the people's ability to move from the bottom 40% of the population to the middle 40%/ top 20%.
14.	Environmental impact	Overall, advances in the STI ecosystem have helped improve preservation and conservation of the Malaysia's environment.
		Has the STI ecosystem improved the marine preservation and conservation outcomes in Malaysia?
		Has the STI ecosystem improved the air quality preservation and conservation outcomes of Malaysia?
		Has the STI ecosystem improved the flora & fauna (biodiversity of species) preservation and conservation outcomes of Malaysia?
		Has the STI ecosystem improved the natural habitats (forests, rivers, etc.) preservation and conservation outcomes of Malaysia?
		Has the STI ecosystem increased the sustainability of our environment?
		Has the STI ecosystem reduced the incidence of water-borne diseases?
		Has the STI ecosystem reduced the incidence of air-pollution related diseases?
		Has the STI ecosystem reduced the incidence of food-chain related diseases?
		Has the STI ecosystem helped produce knowledge and innovations to ensure the sustainability of resources and reduction of waste/pollutions?

Appendix 6.5: Measurement Items for SO2020 Industry-Level Impact Study

No.	Construct		Items
1.	Infrastructure		Malaysia's physical distribution infrastructure (roads, ports, transport, etc) is comparable to that found in advanced economies
			Malaysian STI infrastructure is in good functional order and able to reliably deliver the services that are required by my firm or industry sector.
			The maintenance of STI labs is comparable to that of advanced economies
			The pace of general infrastructure upgrade is comparable to that of advanced economies.
2.	Infostructure		We (I and/or people in my firm) find it easy to reach out to government agencies, institutes and universities in a seamless and integrated way using digital platforms
			Malaysian research labs/agencies, government agencies and universities are seamlessly integrated and digitally connected, and this helps build the STI and RD&C capabilities of my firm
			Similar to advanced economies, with seamlessly connected ICT technologies, I (and/or people in my firm) am fully aware of what new technological advances are taking place within the Malaysian STI ecosystem
3.	Interaction		Our government agencies are excellent in working with other international agencies to help promote our country's products and services
			Malaysian STI Labs/Government agencies work hand in hand with us to understand our industry (or firm) needs
			Malaysian companies, such as my firm, are well connected to the global knowledge network and able to easily access and acquire cutting edge market intelligence and STI knowledge.
			Government Linked Companies (GLCs) present within Malaysia help nurture and build the local supply network/talent
4.	Institutions	Policies, Programs & Regulations	Malaysia's STI policies and programs dovetail together in a coherent and effective manner to nurture and develop our industry/sectors skills and competencies
			STI policies and plans are designed and executed in manner that helps us to reach our RD&C objectives
			Malaysia has business-friendly policies that encourage industries in this industry to conduct RD&C and thereby contribute to the development of robust STI ecosystem
			Malaysian regulatory institutions contribute to the setting of global standards and because of this they can help us develop our competitive capabilities to succeed in markets
			Industry associations can effectively contribute and influence policy formulation for our sector
			Community organisations can effectively contribute and influence policy formulation for our sector
		Institutional sufficiency	Our institutions' effectiveness and efficiencies in managing change for improvement are comparable to advanced economies
			Our government's effectiveness and efficiencies in managing change for improvement are comparable to advanced economies
			Our industry associations' effectiveness and efficiencies in managing change for improvement are comparable to advanced economies
			Our universities' effectiveness and efficiencies in managing change for improvement are comparable to advanced economies.
			Our community organisations' effectiveness and efficiencies in managing change for improvement are comparable to advanced economies

No.	Construct	Items
5.	Intellectual capital	Personnel in government agencies have the knowledge, skills and know-how to help move our country to a higher income level
		Personnel in the private sector have the knowledge, skills and know-how to help move our country to a higher income level
		The technical skills of Malaysia's talent pool are comparable to advanced economies
		The specialist skills of Malaysia's talent pool are comparable to advanced economies
		The leadership skills of Malaysia's talent pool are comparable to advanced economies
		The entrepreneurship skills of Malaysia's talent pool are comparable to advanced economies
6.	Integrity	My company can share its knowledge/IP with government organisations and feel confident that our knowledge is well protected
		My company can share its knowledge/IP with universities and feel confident that our knowledge is well protected
		Industries in my industry sector know we can rely on rules of law to protect our R&D investment and advances
		When my company enters an agreement with any organisation/company we know that it will highly likely be honoured
		We can expect competitors to NOT recourse to corrupt practices, or use backdoors to further their ends
		I believe others (competitors, universities and government agencies) will NOT seek any way (legal or foul) to try and steal our RD&C knowledge
		There is high level of research integrity training amongst STI researchers and government agents to ensure people behave to the highest ethical standards
7.	Incentives	We are provided with adequate levels of tax incentives for us to be able to ramp up investment in RD&C activities
		We find there is enough direct financial support from the variety of government programs that we can tap in to help us develop our industry sector to strengthen and upgrade our RD&C capabilities
		Training and other non-financial support is sufficiently provided for us to develop and upgrade our capabilities to deliver high-value add products and services
		The Malaysian government sufficiently incentivises the move towards digitalisation through ICT adoption
		The Malaysian regulatory system encourages grass root STI developments through provision of appropriate (financial and non-financial) incentives
8.	Absorptive	We frequently scan the market environment for new customer insights and opportunities
		We frequently acquire technologies from external sources
		We systematically store market and technological knowledge for future reference

No.	Construct	Items
9.	Adaptive	We have sufficient resources (employees, finances, R & D know-how) to be able to respond quickly to new opportunities
		We have sufficient resources (employees, finances, R & D know-how) to be able to respond quickly to economic uncertainties
10.	Innovative	We quickly analyse and interpret changing market demands for our technologies
		We can successfully reconfigure our resources to come up with new productive assets
11.	Outputs	Has the Malaysian STI ecosystem helped you enhance the level of product innovations in your company?
		Has the Malaysian STI ecosystem helped you enhance the level of service innovations in your company?
		Has the STI ecosystem in Malaysia helped you enhance the level of process innovations in your company?
		Has the STI ecosystem in Malaysia helped you enhance the level of business model innovations in your company?
		How has the STI ecosystem in Malaysia helped you increase the number of patents, copyright and other IP granted to your company?
		Has the STI ecosystem in Malaysia helped you enhance the level of commercialisation successes by your company?
		Has the STI ecosystem in Malaysia helped you increase the number STI peer-reviewed publications in your company?
12.	Societal impact	The STI ecosystem has helped improve people's health (physical and mental) & wellbeing?
		The STI ecosystem has helped to improve people's attitude and sense of security in life?
		The STI ecosystem has helped improve people's access to basic amenities (e.g. Water, sanitation, affordable homes, healthcare and other public utilities/services)?
		Advances in the STI ecosystem have helped improve society's openness and freedom (e.g. human rights, freedom of speech) of Malaysians.
		Advances in the STI ecosystem have helped improve the national unity of Malaysians.
		Advances in the STI ecosystem have helped communities and organisations to work collaboratively for societal improvement.
13.	Economic impact	The STI ecosystem has helped create future industries that contribute wealth to the economy?
		The STI ecosystem helped increase the ability of the economy to withstand and recover from shocks? (e.g. COVID-19)
		The STI ecosystem has helped improve people's income?
		The STI ecosystem has helped provide improved opportunities for lifelong employment?
		The STI ecosystem has improved the country's ability to compete regionally (i.e. Asia-pacific)?
		The STI ecosystem has helped to reduce the income gap between the bottom 40% and the top 20% of the population?
		The STI ecosystem has helped reduce the level of poverty in the country?
		The STI ecosystem has improved the overall economic well-being of the bottom 40% of the population?

No.	Construct	Items
14.	Environmental impact	Has the STI ecosystem improved the marine preservation and conservation outcomes in Malaysia?
		Has the STI ecosystem improved the air quality preservation and conservation outcomes of Malaysia?
		Has the STI ecosystem improved the flora & fauna (biodiversity of species) preservation and conservation outcomes of Malaysia?
		Has the STI ecosystem improved the natural habitats (forests, rivers, etc.) preservation and conservation outcomes of Malaysia?
		Has the STI ecosystem increased the sustainability of our environment?
		Has the STI ecosystem reduced the incidence of water-borne diseases?
		Has the STI ecosystem reduced the incidence of air-pollution related diseases?
		Has the STI ecosystem reduced the incidence of food-chain related diseases?
		Has the STI ecosystem has helped produce knowledge and innovations to aid your organisation in ensuring the sustainability of resources and reduction of waste/pollutions?

Appendix 6.6: Indicators for Composite Index

Pillars	Sub-pillars	Indicators	Description
STI Index	Input	Business expenditure on R&D (%)	Percentage of GDP
		Funding for technological development	Funding for technological development is readily available
		Gros fixed capital formation (%)	Percentage of GDP
		Investment in Telecommunications	Percentage of GDP
		Total expenditure on R&D per capital ($)	
	Incentives	Corporate tax rate on profit	Max tax rate, calculated on profit before tax
		Government subsidies	To provide and public companies as a percentage of GDP
		Intellectual property rights	Intellectual property rights are adequately enforced
		Investment insentives	Investment incentives are attractive to foreign investors
		Protectionism	Protectionism of your government does not impair the conduct of your business
		Subsidies	Subsidies do not distort fair competition and economic development
	Infostructure	Communications technology	Communications technology (voice and data) meets business requirements
		Digital transformation in companies	Digital transformation in companies is generally well implemented
		Use of big data and analytics	Companies are very good at using big data and analytics to support decision-making
		Use of digital tools and technologies	Companies are very good at using digital tools and technologies to improve performance
		Broadband subscribers	Number of subscriptions per 1000 inhabitants
		Computers per capita	Number of computers per 1000 people
		Internet bandwith speed	Average speed
		Internet users	Number of internet users per 1000 people
		Mobile broadband subscribers	3G & 4G market, % of mobile market

Pillars	Sub-pillars	Indicators	Description
STI Index	Institutions	Adaptability of government pollcy	Adaptability of government pollcy to changes in the economy is high
		Development and application of technology	Development and application of technology are supported by the legal environment
		Government decisions	Government decisions are effectively implemented
		Labor regulations	Labor regulations (hiring/firing practices,mininum wages,etc) do not hinder business activitites
		Legal and regulatory framework	The legal and regulatory framework encourages the competitiveness of enterprises
		Scientific reserach legislation	Laws relating to scientific research do encourage Innovation
		State ownership of enterprises	State of enterprises is not a threat to business activitites
	Integrity	Bribery and corruption	Bribery and corruption do not exist
		Bureaucracy	Bureaucracy does not hinder business activity
		Rule of law	Rule of law index
		Social responsibility	Social responsibility of business leasders is high
		Transparency	Transparency of government policy is satisfactory
	Intellectual Capital	Attracting and retaining talents	Attracting and retaining talents is a priority in companies
		Brain drain	Brain drain (well-educated and skilled people) does not hinder competitiveness in your economy
		Digital / Technological skills	Digital / Technological skills are readily available
		Educational assessment- PISA / Mathematics	PISA survey of 15-year olds
		Educational assessment- PISA / Reading	PISA survey of 15-year olds
		Educational assessment- PISA / Sciences	PISA survey of 15-year olds
		Foreign highly-skilled personnel	Foreign highly-skilled personnel are attracted to your country's business environment
		Innovative capacity	Innovative capacity of firms (to generate new products, processes and /or services) is high in your economy
		Primary and secondary education	Primary and secondary education meets the needs of a competitive economy
		Qualified engineers	Qualified engineers are available in your labor market
		Researchers in R&D per capita	Full-time work equivalent (FTE) per 1000 people
		Sciences degrees	Percentage of total first university degrees in science and engineering
		Skilled labor	Skilled labor is readily available
		Total R&D personnel in business per capita	Full-time work equivalent (FTE) per 1000 people
		Total R&D personnel in per capita	Full-time work equivalent (FTE) per 1000 people
		University education	University education meets the needs of competitive economy

Pillars	Sub-pillars	Indicators	Description
STI Index	Infrastructure	Air transportation	Number of passengers carried by main companies, thousands
		Distribution infrastructure	The distribution infastructure of goods and services is generally efficient
		Energy infrastructure	Energy infrastructure is adequate and efficient
		Maintenance and development	Maintenance and development of infrastructure are adequately planned and financed
		Quality of air transportation	Quality of air transportation encourages business development
		Railroads	Density of the network, km per square km
		Roads	Density of the network, km per roads/square km land area
		Water transportation	Number of passengers carried by main companies, thousands
	Interaction	Knowledge transfer	Knowledge transfer is highly developed between companies and universities
		Public-private partnerships	Public and private sector ventures are supporting technological development
		Technological cooperation	Technological cooperation between companies is developed
	Internationalisation	Attitudes toward globalization	Attitudes toward globalization are generally positive in your society
		Image abroad or branding	The image abroad of your country encourages business development
		National culture	The national culture is open to foreign ideas
	Output	Export of commercial services(%)	Percentage of GDP
		Export of goods per capita	US$ per capita
		High-tech exports (%)	Percentage of manufactured exports
		ICT service exports	Percentage of service exports
		Medium and high-tech value added	Proportion of total manufacturing value added, expressed as a percentage
		Nobel prizes per capita	Awarded in physics, chemistry, physiology or medicine and economics since 1950 per million people
		Number of patents in force	by applicant's origin, per 100,00 inhabitants
		Patent applications per capita	Number of applications filed by applicant's origin, per 100,00 inhabitants
		Scientific articles	Scientific articles published by origin of author

Pillars	Sub-pillars	Indicators	Description
Impact	Economic Impact	Diversification of the economy	Diversification of the economy (industries, export markets, etc) is extensive
		GDP (PPP) per capita	Estimates; US$ per capita at purchasing power parity
		Overall productivity (PPP)	Estimates; GDP (PPP) per person employed, US$
		Resillience of the economy	Resillience of the economy to economic cycles is strong
	Environmental Impact	CO2 emissions	Metric tons of carbon dioxide from fuel combustion
		Ecological footprint	Global hectares per person
		Exposure to particle pollution	Mean population exposure to PM2.5, Micrograms per cubic metre
		Forest area growth	Five-year percentage change of hectares
		Pollution problems	Pollution problems do not seriously affect your economy
		Renewable energies (%)	Share of renewables in total energy requirements, %
		Total biocapacity	Global hectares per capita of biologically productive space
		Water resources	Total internal renewable per capita in cubic meters
		Access to water	Access to water is adequately ensured and managed
	Societal Impact	Cost-of-living index	Index of a basket of goods & services in the main city, inclusing housing (New York CIty-100)
		Democracy index	EIU Overall Democracy Index, ©The Economist Intelligence Unit Limited 2020
		Equal opportunity	Equal opportunity legislation in your economy encourages economic development
		Freedom of the Press	Reporters Without Borders: World Press Freedom Score
		Gender Inequality	Gender Inequality Index (UNDP)
		Gini coefficient	Equal distribution of income scale: 0 (absolute equality) to 100(absolute inequality)
		Justice	Justice is fairly administered
		Personal security and private property rights	Personal security and private property rights are adequately protected
		Quality of life	Quality of life is high
		Risk of political instability	The risk of political instability is very low
		Social cohesion	Social cohesion is high

Appendix 6.7: List of Megaprojects

No.	Megaproject	Established (completed)
1.	Federal Land Development Authority Settlement (FELDA settlement)	1956
2.	Stadium Merdeka	1957
3.	Klang Gates Dam- The first dam in Malaysia for water supply	1958
4.	Stadium Negara	1962
5.	Malaysian Houses of Parliament	1963
6.	National Museum	1963
7.	Masjid Negara	1965
8.	Subang International Airport	1965
9.	Tugu Negara	1966
10.	Angkasapuri	1968
11.	East-West Highway	1970
12.	Karak Highway	1974
13.	Petroliam Nasional Berhad (PETRONAS)	1974
14.	Perusahaan Otomobil Nasional (PROTON)	1983
15.	Dayabumi Complex	1984
16.	Kenyir Dam	1985
17.	Penang Bridge	1985
18	Kompleks Tun Abdul Razak (KOMTAR Tower)	1986
19.	Sultan Ismail Power Station (SIPS)	1988
20.	North South Expressway (PLUS)	1994
21.	Stadium – Shah Alam	1994
22.	Putrajaya	1995
23.	Kuala Lumpur Tower (KL Tower)	1996
24.	Malaysia Super Corridor (MSC)	1996
25.	Cyberjaya	1997
26.	Alor Setar Tower	1997
27.	Kompleks Sukan Negara (KSN)	1998
28.	Malaysia-Singapore Second Link (Linkedua)	1998
29.	Kuala Lumpur International Airport (KLIA)	1998
30.	PETRONAS Twin Tower	1999
31.	Kuala Lumpur Sentral Station (KL Sentral)	2001
32.	Express Rail Link (ERL)	2002
33.	East Coast Expressway (ECE)	2005
34.	East Coast Economic Region (ECER)	2005
35.	Iskandar Malaysia	2006
36.	Stormwater Management and Road Tunnel (SMART Tunnel)	2007
37.	Northern Corridor Economic Region (NCER)	2007
38.	Sabah Development Corridor (SDC)	2008
39.	Sarawak Corridor of Renewable Energy (SCORE)	2008
40.	Southern Integrated Gateway	2008
41.	Bakun Dam	2011
42	Sultan Abdul Halim Muadzam Shah Bridge (Penang Second Bridge)	2014
43	Merdeka 118	2014
44	Pan Borneo Highway	2016
45	Mass Rail Transit (MRT)	2017
46	Pengerang Integrated Petroleum Complex (PIPC)	2018
47	Penang Central	2018
48	Tun Razak Exchange (TRX)	2019

Qualitative Analysis

In-depth interview sessions with multi-stakeholders were conducted in two ways. Initially, face-to-face interviews were conducted with the respondents. The subsequent interviews had to be conducted using the online platform, such as Zoom or Microsoft Teams as deemed appropriate with the respondents during the COVID-19 pandemic with the Movement control order (MCO) and the Conditional MCO (CMCO) in place. The discussion was guided with a semi-structured set of discussion points by an expert moderator from the study team (See Appendix 6.3 for interview questions). Figure A6.2 shows the key themes of the discussion.

Analysis of the in-depth interview data proceeded to identify key themes that correspond to the STI ecosystem enablers. Each respondent is questioned on their views on the Malaysian STI ecosystem – and their responses are mapped to the inputs, drivers and outputs as defined in Appendices 6.1 – A6.5. These responses will be further split into how each interviewee views the current state of the ecosystem as well as the trajectory and future outlook of the market.

The interviews have yielded responses that can be organised into 12 key categories/constructs, each representing a specific topic or concern that respondent have discussed in their sessions. To keep count of the sentiment behind each response, every affirmative and negative statement concerning a topic is assigned a value of +1 or -1, respectively. When a single respondent makes multiple statements on a single topic, his/her ultimate position on the topic will be discerned and assigned the corresponding numerical indicator. Hence, each respondent will contribute a maximum/minimum of +1 or -1 to each of the 12 topics discussed.

Neutral statements (such as facts and observations) are assigned a value of 0, while non-responses are not assigned any value. This ensures that the frequency of a topic being discussed is also tracked. Additionally, each response will then be categorised by present view ('Current State of STI Ecosystem') or a forward-looking view ('Required Intervention').

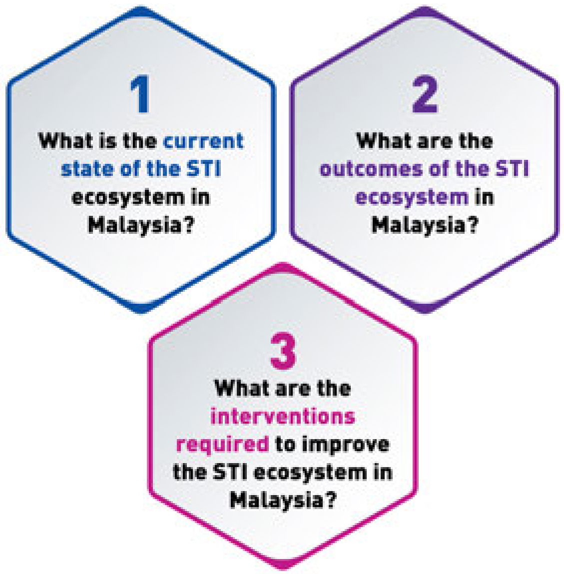


Figure A6.2: Key Themes of the Qualitative Discussion

Concerning the present views, the sum of assigned values from all respondents on each topic represents how much the construct is perceived to be emphasised in the nation's current innovation agendas. Higher values indicate emphases are **Adequate**; lower values indicate emphases are **Inadequate**.

Concerning the forward-looking views, the sum of assigned values from all respondents on each topic represents how much the construct is perceived to be in need of improvement/change. Higher values indicate **Significant** intervention is required; lower values indicate **Mild Intervention** is required.

By plotting the outcomes along two axes, we can create a quadrant of priority areas of innovation. The frequency of topics being mentioned is also represented by a bubble. This will provide an indication of the level of recognition given to a particular topic or issue, and how well of the final plot represents the market's view. Larger bubbles indicate more contributing views and are thus more representative/robust; smaller bubbles indicate fewer contributing views and maybe skewed by extreme opinions.

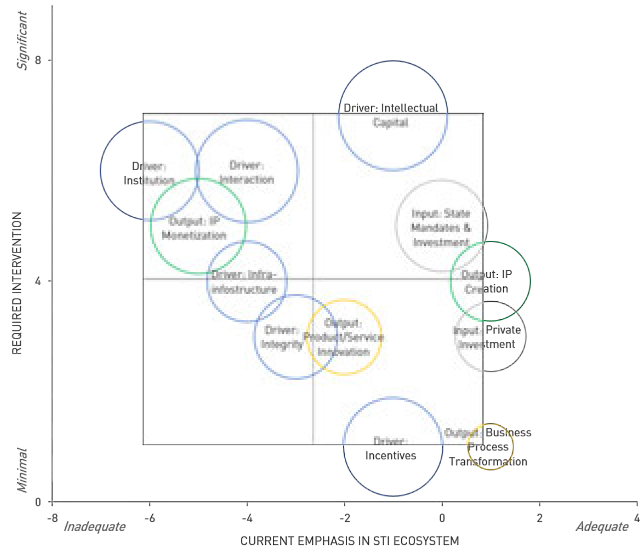
By introducing a quadrant bounded by the extreme values assigned to all topics (Figure A6.3), we can visualise four major interpretations of the data for decision making and future actions:

- Top-left: Presently overlooked issues/ themes that require significant overhauls
- Top-right: Actively pursued issues/themes that require course-correction
- Bottom-left: Issues/themes perceived to be minor, with few recognised means of proceeding
- Bottom-right: Actively pursued issues/ themes that should not be directly intensified but need to be employed as facilitators for developing other themes.

From Figure A6.4, the upper-left quadrant characterises presently overlooked issues/ themes that require significant overhauls comprising of:

- **Driver: Institutions**
  There are too many institutions with overlapping/conflicting mandates that result in fragmented directives which increases bureaucracy. This can lead to uncoordinated strategies; this tends to create a high level of bureaucracy.

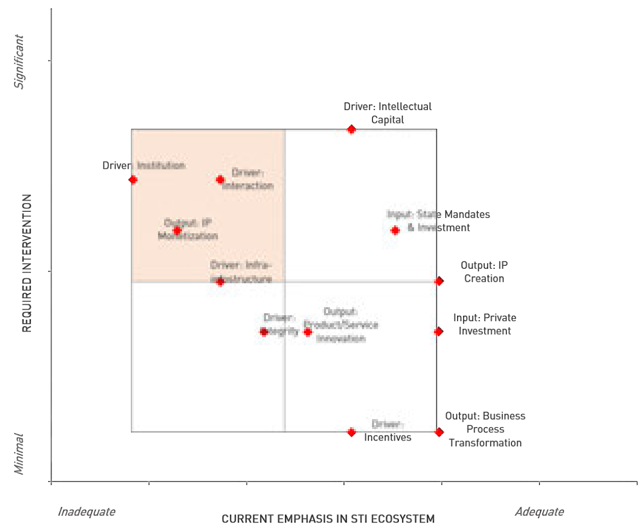
  Better oversight, framework standardisation, and potentially consolidation of institutions will be required to support an increasingly complex, multidisciplinary ecosystem.



Analysed by Sunway University Research Team

Figure A6.3: Current Emphasis in the STI Ecosystem

Note: In the analysis above, interaction and internationalisation were found to have large overlaps in respondents' sentiments and were thus coded as one item under interaction.



Analysed by Sunway University Research Team

Figure A6.4: Current Emphasis in the STI Ecosystem (upper-left quadrant)

Note: In the analysis above, interaction and internationalisation were found to have large overlaps in respondents' sentiments and were thus coded as one item under interaction.

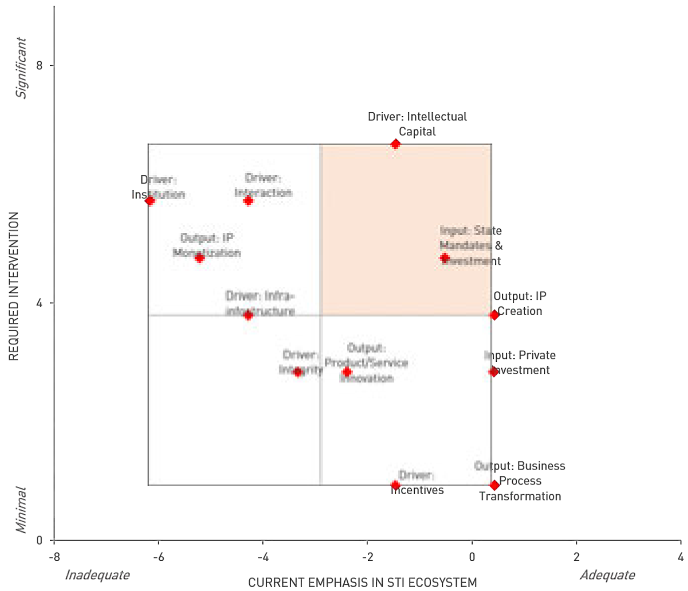
- **Driver: Interaction**
  Limited avenues and instances of collaboration among organisations across different sectors inhibit cross-germination of knowledge and the development of Dynamic Capabilities.

  Partnerships need to be pursued for intentions beyond what is defined by day-to-day operations. This cultural shift from pro-output toward pro-learning requires fundamental changes in corporate priorities on an industry-level.

- **Output: IP Monetisation**
  Lack of entrepreneurial acumen among technical/R&D talent to generate commercially viable innovation assets has resulted in much investment capital being expended on economically impractical IPs.

  Improved KPI formulation is necessary to motivate successful commercialisation instead of development volume. Meanwhile, business and technical practitioners should also be bridged through collaborative frameworks such as DevOps to generate hybrid strategic competencies.

> A ***'devops'*** approach results in collaboration between two teams where they work with a shared passion to achieve a common goal.



Analysed by Sunway University Research Team

Figure A6.5: Current Emphasis in the STI Ecosystem (upper-right quadrant)

Note: In the analysis above, interaction and internationalisation were found to have large overlaps in respondents' sentiments and were thus coded as one item under interaction.

The upper-right quadrant (Figure A6.5) represents factors of STI ecosystem that are already set along the right trajectory and require course-correction. This comprises of:

- **Driver: Intellectual Capital**
  Widening gaps between labour force availability and the need for talent continues to be reiterated by industry practitioners. While there has been adequate cultivation of knowledge workers owing to curricular improvements and occupational reskilling/upskilling, industries struggle to retain such employees. In particular, the growing SME sector suffers from both limited capital and limited prospects to attract new, sophisticated talent into its ranks.

- **Input: State Mandates & Investment**
  While historical developmental agendas have succeeded in laying the economic foundation for key industries, there is a rising demand for targeted policies to accelerate technological adoption.

The bottom-right quadrant (as shown in Figure A6.6) presents actively pursued issues/themes that need not be directly intensified but need to be employed as facilitators for developing other themes. This comprises of:

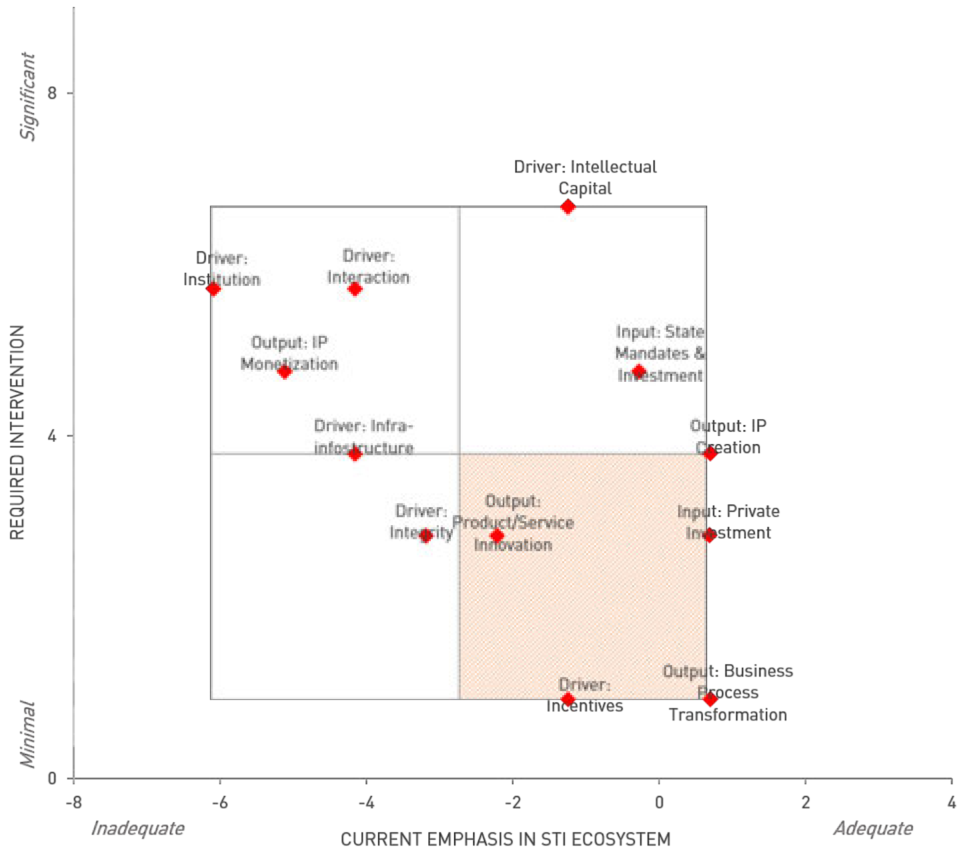
- **Input: Private Investment**
  The activeness of multinational corporations in Malaysian is recognised as both a boon and bane to the local STI ecosystem. On the one hand, they are a continuing source of capital, knowledge, and global networking; on the other, they significantly outcompete emergent local industries as producers and as job prospects.

- **Driver: Incentives**
  Over the years, Malaysia has continued to earmark substantial budgets for industrial subsidies and tax benefits. However, the overall economic and innovative impact has been far from adequate. Many respondents believe such monetary inducements have wrongly encouraged quantity of outputs when it should have emphasised (commercial) quality. Moving forward, performance-based Incentives may prove to better suited for steering the nation toward a sustainable STI ecosystem.

- **Output: IP Creation**
  As indicated above, industries have historically been encouraged to generate high output without due consideration of quality of outcomes. This narrow output-centricity suggests that for the STIE ecosystem to progress, greater effort needs to be made to translate research and creative endeavours to tangible commercially viable outcomes.

- **Output: Product/Service Innovation**
  Malaysian industries are perceived to be ultimate consumers rather than creators of innovation. Local industries have excelled at adopting and adapting external knowledge into their operations. However, this has also bred a measure of complacency and change aversion – most industries are given to stagnation, entrenching themselves in 'tried-and-true' models of operation without considering new avenues of transformation.

- **Output: Business Process Transformation**
  Very few respondents recognise the need for transforming and overhauling current business norms – those that do perceive the current observable performance to require minimal follow-up action.



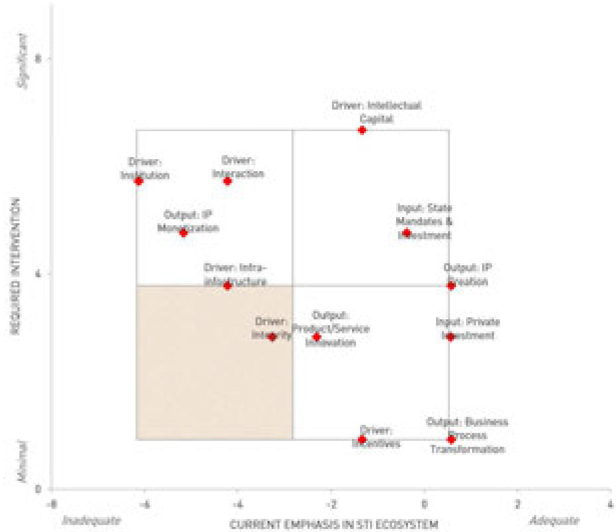
Analysed by Sunway University Research Team

Figure A6.6: Current Emphasis in the STI Ecosystem (bottom-right quadrant)

Note: In the analysis above, interaction and internationalisation were found to have large overlaps in respondents' sentiments and were thus coded as one item under interaction.

The bottom-left quadrant (Figure A6.7) are issues/themes perceived to be minor, with few recognised means of proceeding and progressing. These comprise of:

- **Driver: Integrity**
  There is a moderate perception of accountability frameworks among Malaysian industries, though somewhat skewed toward inadequacy. While many recognise the need to empower social and environmental outcomes of innovation, the few solutions put forward all converge on centralised governance and an assumption of institutional efficacy.



Analysed by Sunway University Research Team

Figure A6.7: Current Emphasis in the STI Ecosystem (bottom-left quadrant)

Note: In the analysis above, interaction and internationalisation were found to have large overlaps in respondents' sentiments and were thus coded as one item under interaction.

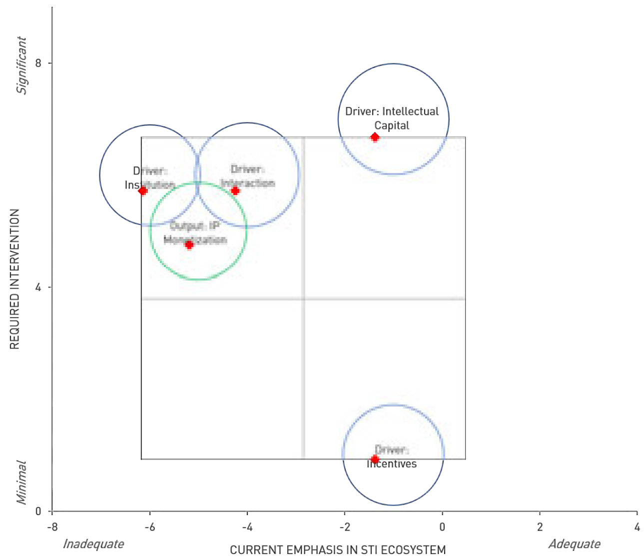
SCENARIO

Through the entire series of interviews, several notable constructs were frequently deliberated by respondents. As identified by the largest bubble-sizes, these topics are:

Driver: *Incentives; Institution; Interaction; Intellectual Capital*

Output: *IP Monetisation*

These indicate likely leverage points for policymakers to strengthen the STIE ecosystem. It is vital to observe the linkages between these constructs, and leverage of existing 'strengths' to close the largest gaps in capability (Figure A6.8).

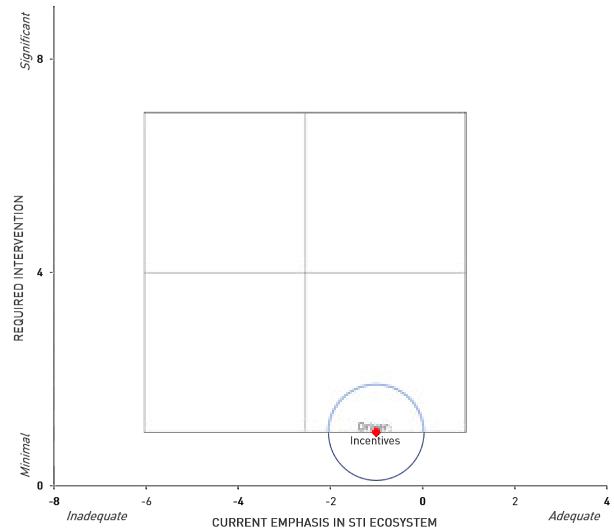


Analysed by Sunway University Research Team

Figure A6.8: Illustrative Scenario 1

In this scenario (Figure A6.9), constructs occupying the bottom-right quadrant are considered as entry-points for intervention. Principal among them is the Drivers: incentives, which currently represents a substantial and 'adequate' catalyst for economic activity.
As discussed in the analysis of the interviews, a course-correction is required to ensure future programs promote the right outcomes and market behaviour for long-term innovative sustainability.

The most common criticism of the current innovation subsidy programs is that they are too centered on outputs (resulting in industries prioritising on generating high volumes of innovative assets, but with little regard for their actual impact to economic, societal and/or environmental outcomes), and in some cases, are geared to attract MNCs in favour of developing sustainable local enterprises (Figure A6.10).



Analysed by Sunway University Research Team

Figure A6.9: Illustrative Scenario 2

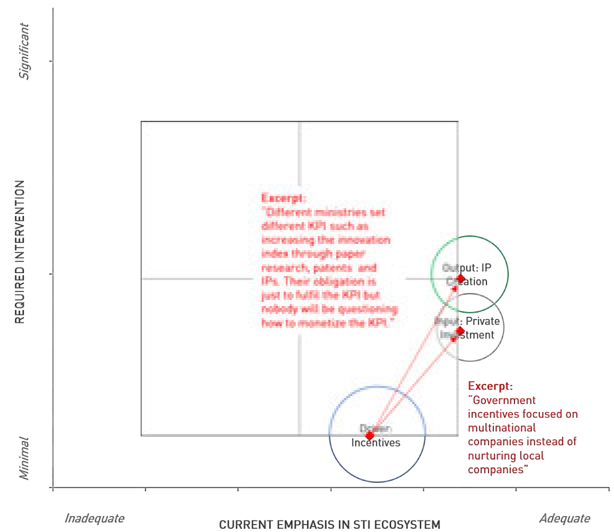


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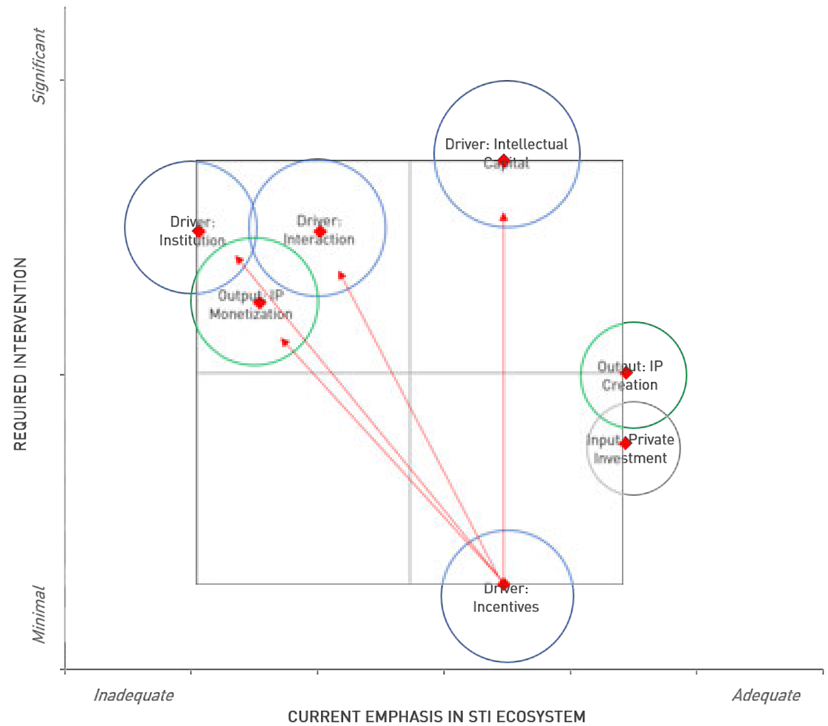
Figure A6.10: Illustrative Scenario 3



Analysed by Sunway University Research Team

Figure A6.11: Illustrative Scenario 4

In Figure A6.11, these relationships are denoted as an intra-quadrant relationship that suggests redundancies in ecosystem initiatives. The ideal process of strengthening and progressing the STIE agenda is to build stronger linkages between factors across different quadrants – specifically from bottom-right to top-left. In the case of Driver:incentives, there is a broad consensus that ministries and economic committees should overhaul the KPIs for existing incentive programs, such that industry participants are rewarded for IP monetisation, be it local commercial success or international.

Such efforts can also be extended to interactions, rewarding collaboration between multidisciplinary entities to create hybrid business and technical competencies across industries. The lynchpin of these efforts would be consolidated governing authorities that have better visibility over the many facets of the STI ecosystem, serving to direct and orchestrate transformations instead of reactively executing outdated industrial KPIs.

Overall developing a vibrant STI ecosystem in Malaysia is a complex, multi-stage process. The many divergent attempts by industries, regulators, and market participants to utilise knowledge and resources need to be reined in under a unifying framework.

The most immediate priority is to wean the economy off its dependence on governance and policy-making, which has mainly been silo in nature. Such fragmented directives stem from how developing countries naturally conceive and structure their economies, in general. Emphasis on specific, strategically important industries during the early stages of development leads to creating regulatory/executive bodies that are very industry- and functionally focussed. Hence, it is not uncommon for individual industries to have many lines of reporting, audit, and approval to several governing institutions that minimally interact with each other.

For the STI ecosystem to progress, the impetus for change needs to be twofold; first, industries have to be gradually empowered toward more self-directed innovation, and second, the administrative sprawl among governing institutions needs to be eliminated to minimise conflict among policies and the enforcement of increasingly outdated KPIs. In short, all participants have to cultivate practices and goals that foster exploratory initiatives, rather than entrench the industry in its present developing stage.

Such measures should be subsequently followed up by effective incentivisation and facilitation of multilateral feedback between regulators and enterprises, such that economic participants can validate policies and help evolve them when necessary.

The proliferation of multidisciplinary competencies trickling down from governing institutions to industries would help drive business digitalisation/transformation on an industry-level. Ultimately this would lead to the successful, widespread operationalisation of new innovative competencies.

Index Methodology

The dataset was obtained from the IMD World Competitiveness Yearbook database. The index indicators were selected using the Delphi method with iterative expert consultations and focus group discussions. The selection criteria were based on the 8i framework and indicators that were most relevant and appropriate for the framework were selected.

Missing data was imputed using a combination of the following methods as described by Engels and Diehr (2003):

1. Next observation carried backwards (NOCB) where there were no last known observations:

   $$\widehat{y_{q,c}^{t}} = y_{q,c}^{t+1}$$

   where, $\hat{y}$ is the estimated imputation for indicator q for country c at time t.

2. Interpolation where there were last known and next known observations, the average of the last and next known observations were assigned as the imputed estimate.

3. Last observation carried forwards (LOCF) where there were no next known observations:

   $$\widehat{y_{q,c}^{t}} = y_{q,c}^{t-1}$$

   where, $\hat{y}$ is the estimated imputation for indicator q for country c at time t.

The imputed dataset was then normalised using distance to a reference country (United States of America in the year 2000) as described in the OECD Handbook on Constructing Composite Indicators (2008):

$$x_{q,c}^{t} = \frac{y_{q,c}^{t}}{y_{q,c=\bar{c}}^{t=\bar{t}}}$$

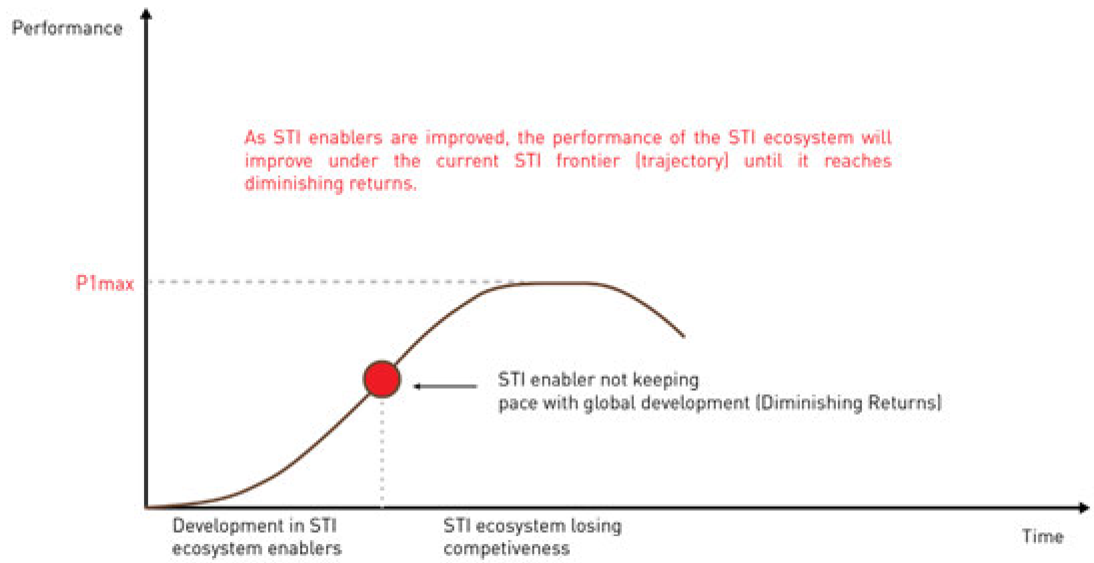
where, x is the normalised value for indicator q for country c at time t. $\bar{t}$ is the reference year and $\bar{c}$ is the reference country.

The overall STI Ecosystem score was then additively aggregated, where the average value of the indicators forms the value of the sub-pillars, the average value of the sub-pillars forms the value of the pillars, and the average value of the pillars form the overall STI Ecosystem score for each country and year.

Future Proofing Malaysia

Future Proofing Malaysia

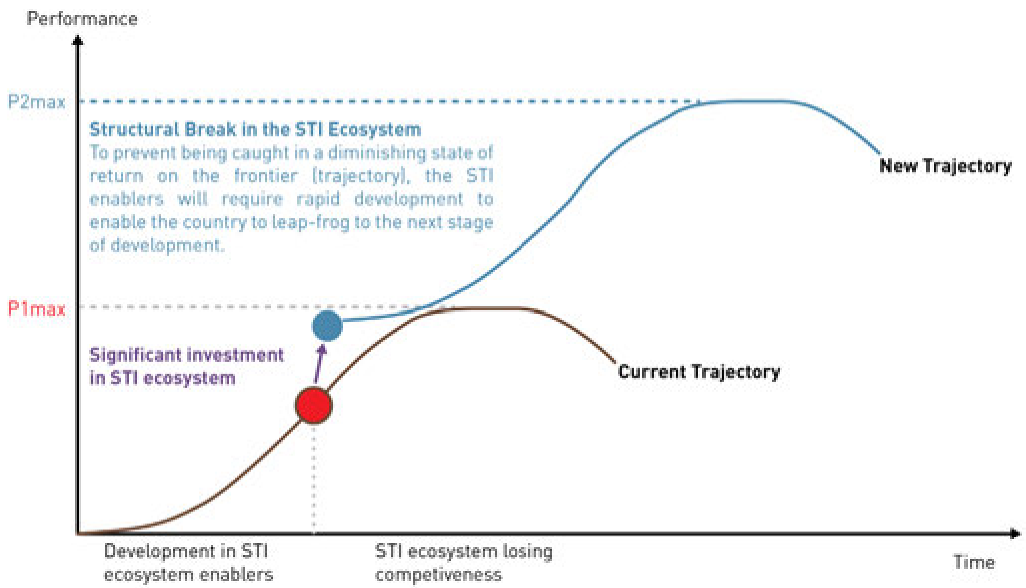
The global socioeconomic landscape has changed dramatically over the last three decades and it is predicted to undergo considerable structural changes. Advanced countries are expected to continue to develop their STI ecosystem at a rapid pace, which will have a significant economic, societal and environmental impact on the global community and Malaysia. To ensure that Malaysia keeps pace with the advanced countries, the STI ecosystem needs to be agile and responsive to internal and external shocks. A sound STI ecosystem will increase the Return on Value (ROV) of the nation's resources and transform challenges into new opportunities to move up the value chain for all stakeholders in the country.



Analysed by Sunway University Research Team

Figure S2.1: Evolution of STI Ecosystem

STI ecosystems evolve rapidly proportional to the investments channeled to strengthen the enablers of the ecosystem. If these enablers do not keep pace with global developments, economic performance will start to show diminishing returns as competition intensifies. This will eventually lead to a decline in economic performance, as shown in Figure S2.1



Analysed by Sunway University Research Team

Figure S2.2: Initiating "Structural Change" in the STI Ecosystem

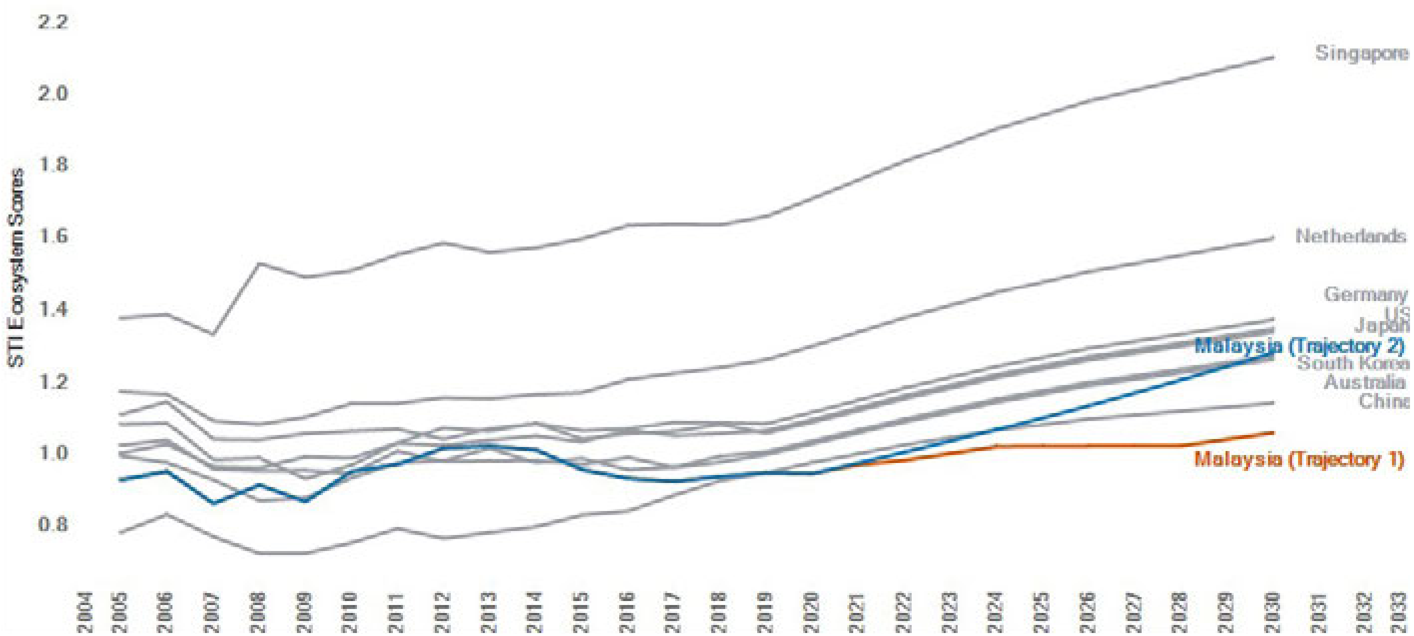
Countries that continuously invest in strengthening their STI environment will propel innovations and frontier technologies. This will result in their economic performance transitioning onto a higher trajectory as shown in Figure S2.2

Growth theory suggests that improvements in STI will contribute to economic performance. However, countries need to continually develop their ecosystem to ensure that they are not caught in a state of diminishing returns. To break away from this state, countries need to invest in strengthening the enablers of the STI ecosystem and ensure that it deepens the positive spill-over impact to key industry and economic sectors of the country as shown in Figures S2.1 and S2.2.

State of Play of the STI ecosystem

The Malaysian STI ecosystem has developed into a strong production-based economy which has served as the nation's engine of growth. However, technological innovation continues to evolve at speed, moving the world towards a hyper-converged knowledge economy. Malaysia's competitive edge is slowly being eroded because the historical levers of economic growth have not kept pace with the transformation in the global knowledge economy. Consequently, Malaysia is caught in the ***Middle-Income Country trap.***

While there are a number of pace-setter sectors in Malaysia, many of them have low utilisation of STI. They operate at the lower end of the economic value chain and the STI ecosystem across the country is fragmented. As a result, the full potential of the economic wealth, social development, and environmental sustainability continues to be unrealised. To overcome this middle-income trap will require major structural changes to the STI ecosystem so as to ensure that it deepens the impact on the assets of the country to generate sustainable and equitable development. If Malaysia makes no changes in the STI plans while developed and developing countries continue to pursue their STI development trajectories,

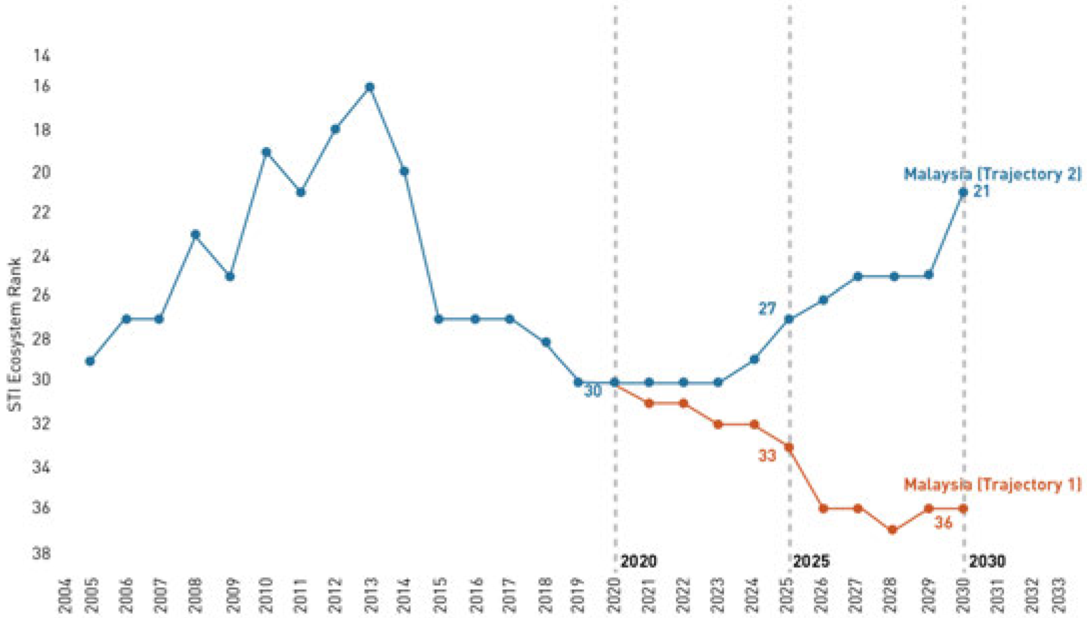


Analysed by Sunway University Research Team

Figure S2.3: Trajectories of Selected STI Ecosystems, 2005-2030

Note: The STI scores were computed using the values of indicators relative to that of USA in 2000

Malaysia's STI scores and rankings (Trajectory 1: Status Quo Position) are forecasted to fall significantly behind these countries as shown in Figure S2.3 and Figure S2.4. An alternative trajectory (Trajectory 2: Enhance STI Ecosystem) is to invest in developing the STI ecosystem at the level comparable to that of more advanced countries; i.e. increasing the allocation for STI programmes, strengthening the 8i-enablers of the STI ecosystem, and deepening the impact of STI on the country's socio-economic drivers. This will enable the socioeconomic drivers to move up the value chain and enhance their ROV to Malaysia. Under this trajectory, the STI scores are expected to catch up with more developed economies, such as South Korea and Australia. In tandem, the STI ecosystem ranking is projected to improve from 30 in 2020 to 21 by 2030 (Figure S2.4).



Analysed by Sunway University Research Team

Figure S2.4: Trajectories Based on Rankings of Selected STI Ecosystems, 2005 – 2030

Note: Actual data obtained is from 2005 to 2020. The global country ranks in 2020 were split into 3 categories. Based on historical data, we assumed that the countries (with the exception of Malaysia) will follow a similar growth rate. The top one-third of the 2020 cohort were the pace-setter countries with a compound annual growth rate (CAGR) of 2.1% from 2020 to 2030; the second one-third of the cohort were the emerging economies with a CAGR of 1.6% from 2020 to 2030; and the final third of the cohort were the laggard economies with a CAGR of 1.3% from 2020 to 2030. The annual ranks were calculated according to the projected scores.

Trajectory 1 represents the status quo where the impact of COVID-19 was accounted for by calculating the per day MCO cost to GDP and there are no additional exogenous interventions.

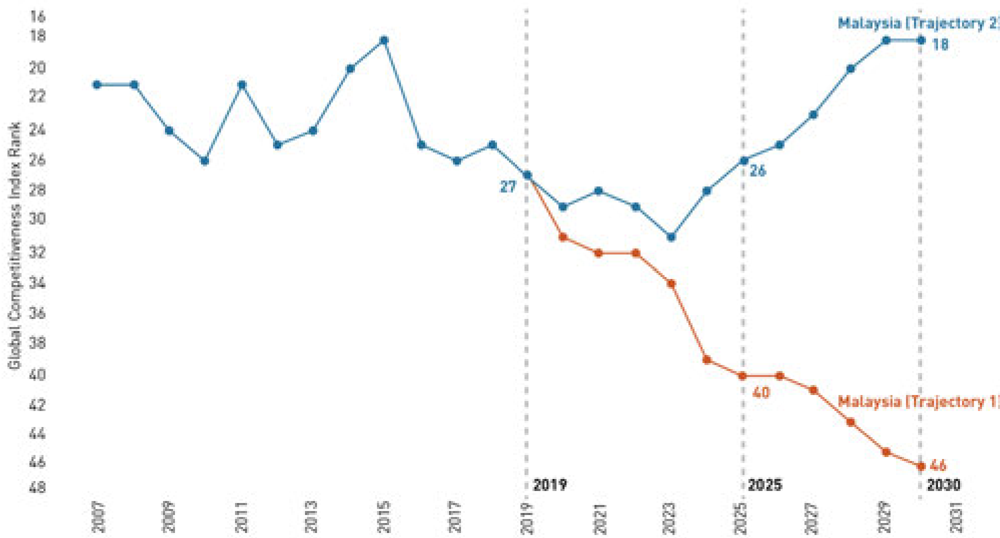
Trajectory 2 represents the ramp-up scenario where nominal GDP is targeted to be RM3 trillion by 2030. The necessary capital, labour, and technology growth rates to achieve this target was then computed.

The Impact of STI Ecosystem on Global Competitiveness

Every country's global competitiveness is closely tied to the development of the nation's STI ecosystem. As the STI ecosystem improves, the economic environment will be able to attract increasing investments for the nurturance of a competitive workforce, organisational capabilities, and strategic cooperation among economic agents. The two trajectories below examine the impact of STI ecosystem on global competitiveness scores and ranking of Malaysia. These projections are based on the STI trajectories in Figure S2.3.

Trajectory 1: Status Quo Position: At this position, Malaysia's global competitiveness is expected to decline over time. In terms of ranking, Malaysia is expected to fall five places from 27 in 2019 to 46 by 2030 as shown in Figure S2.5.

Trajectory 2: Enhance STI Ecosystem: Malaysia's global competitiveness is expected to improve from the current position of 27 in 2019 to 18 in 2030 as shown in Figure S2.5.



Note: Actual data is obtained from 2007 to 2019. The 2020 to 2030 projections were calculated using the respective countries' CAGR from existing data. It is assumed that the growth rates will remain constant from 2020 and 2030 and final scores were projected, and ranks calculated accordingly.

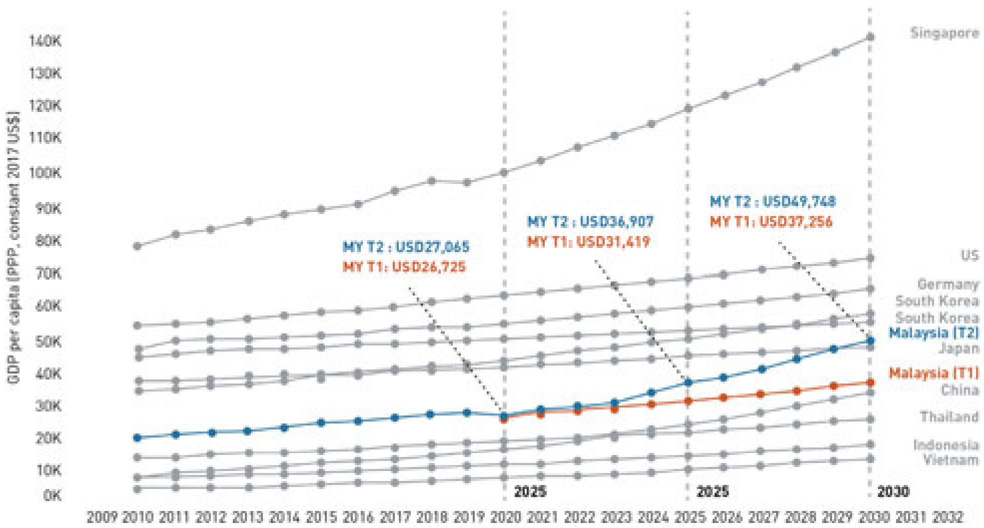
Analysed by Sunway University Research Team

Figure S2.5: Trajectories for Global Competitiveness Index Rankings, 2007 – 2030

The Impact of STI Ecosystem on the Economy

The economic wealth of a country is closely tied to the state of the STI ecosystem and global competitiveness of the country. A strong STI ecosystem can increase the productivity of industries and the workforce, enabling firms to strengthen their process improvements and product development. The ecosystem will also allow firms to pursue economies of scale and broaden their economies of scope. More importantly, it will create spill-over impacts that spawn next-generation sources of economic wealth, as shown in Figure S2.6. Here, the wealth of Malaysia is depicted under the two different STI trajectories from Figure S2.5.

Trajectory 1 (T1): Status Quo Position: Malaysia's per-capita GDP is growing at a **CAGR of 3.4%** from 2021 to 2030. The income is expected to increase from USD26,725 in 2020 to USD37,256 in 2030.
Trajectory 2 (T2): Enhance STI Ecosystem: Malaysia's per-capita GDP is expected to grow at a **CAGR of 6.3%** from 2021 to 2030. The income is expected to increase from USD27,065 in 2020 to USD49,748 in 2030. This translates to approximately RM3 trillion in nominal GDP by 2030.



Analysed by Sunway University Research Team

Figure S2.6: Trajectories for Economic Wealth using GDP per Capita, Purchasing Power Parity, 2010 -2030

Note: Global 2020 to 2030 projections were calculated using the respective countries' CAGR from existing data. It is assumed that the growth rates will remain constant from 2020 and 2030.

Trajectory 1 (T1) represents the status quo where the impact of COVID-19 was accounted for by calculating the per day MCO cost to GDP and there are no additional exogenous interventions.

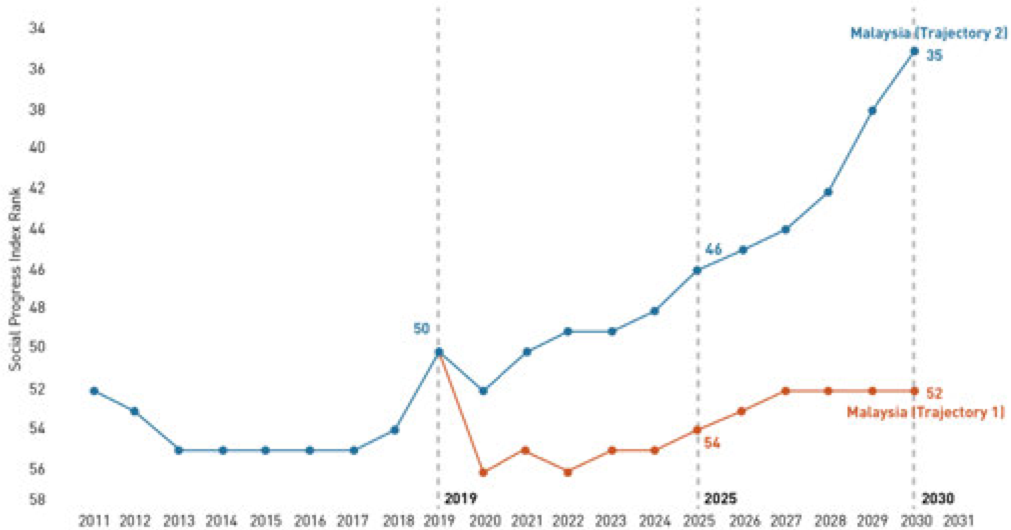
Trajectory 2 (T2) represents the enhanced STI scenario where nominal GDP is targeted to be RM3 trillion by 2030. The GDP was then divided by population of Malaysia projected by the Department of Statistics (DOSM) and controlled for purchasing power parity using World Bank's PPP conversion factor.

The Impact of STI Ecosystem on Society

STI development has a transformative impact on society by providing population access to quality education, appropriate infrastructure, and other services that improves their quality of life. In this context, the impact of the two STI Ecosystem trajectories on societal development are shown in Figure S2.7

Trajectory 1: Status Quo Position: Malaysia's societal development ranking is expected to fall from 50 in 2019 to 56 in 2020 due to the COVID-19 pandemic. Projections show that there will be a gradual improvement in the rankings from 56 in 2020 to 52 in 2030. However, the overall change is still lower than the pre-COVID rankings, as shown in Figure S2.7.

Trajectory 2: Enhance STI Ecosystem: Malaysia's societal development ranking is expected to fall in 2020 due to the COVID-19 pandemic. However, if the country had a stronger STI ecosystem, it would have been better able to absorb the shock of COVID-19 on society (ranking would have fallen from 50 to 52 instead of 56). It is envisaged that a strong STI will enable the societal development rankings to move from 52 in 2020 to 35 by 2030, catching-up with more developed countries as shown in Figure S2.7.



Analysed by Sunway University Research Team

Figure S2.7: Trajectories for the Social Progress Index Rankings, 2011 – 2030

Note: Actual data is obtained from 2011 to 2019. Global 2020 to 2030 projections were calculated using the respective countries' CAGR from existing data. It is assumed that the growth rates will remain constant from 2020 and 2030 and final scores were projected, and ranks calculated accordingly.

Trajectory 1 represents the status quo where the impact of COVID-19 was accounted for by calculating the per day MCO cost to GDP and there are no additional exogenous interventions.

Trajectory 2 represents the enhanced STI scenario where nominal GDP is targeted to be RM3 trillion by 2030.

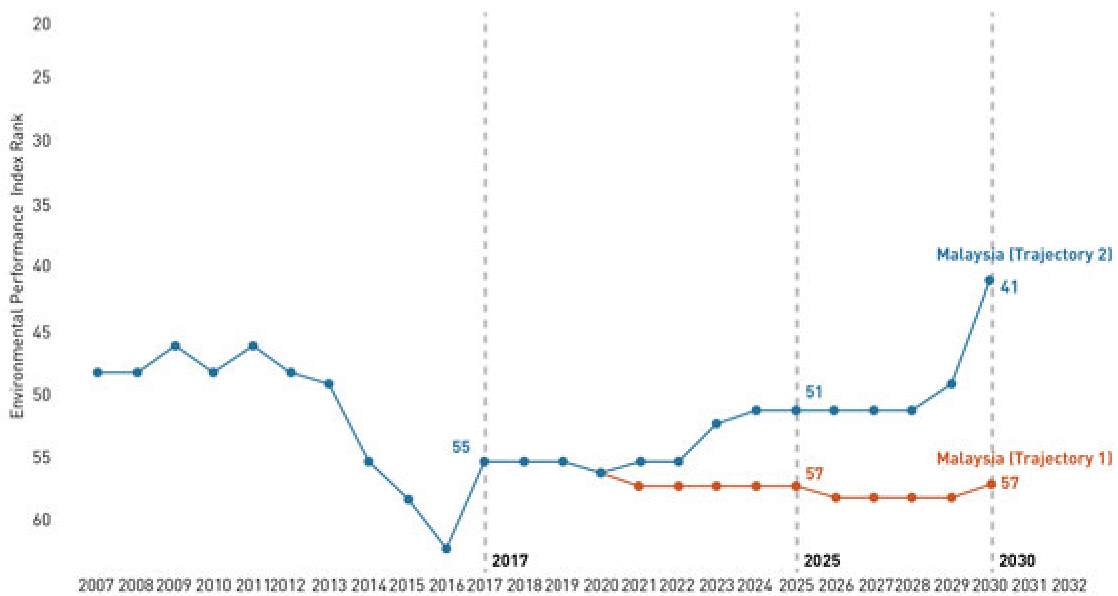
[1]Societal development is measured by the Social Progress Index. The Social Progress Index covers the following metrics: nutrition and basic medical care; water and sanitation; shelter; personal safety; access to basic knowledge; access to information and communications; health and wellness; environmental quality; personal rights; person freedom and choice; inclusiveness; and access to advanced education.

The Impact of STI Ecosystem on the Environment

The strong nexus between the STI ecosystem and the environment has been established in earlier discussions. This section examines the impact of STI ecosystem development on the Environment .

Trajectory 1: Status Quo Position: Due to a fragmented STI ecosystem, the environment is expected to not improve over the next decade. Malaysia's environmental performance ranking will hover around the 55th to 57th position from 2017 to 2030 as shown in Figure S2.8.

Trajectory 2: Enhance STI Ecosystem: An enhanced STI ecosystem will result in significant improvement in the environment, where the environmental performance trajectory is forecasted to improve. Improvements in the environment are expected to accelerate the performance ranking from 55th position in 2017 to 41st position in 2030, catching-up with more developed countries as shown in Figure S2.8



Analysed by Sunway University Research Team

Figure S2.8: Trajectories for Environmental Performance Index Rankings, 2007 - 2030

Note: Trajectory 1 represents the status quo where the impact of COVID-19 was accounted for by calculating the per day MCO cost to GDP and there are no additional exogenous interventions.

Trajectory 2 represents the ramp-up scenario where nominal GDP is targeted to be RM3 trillion by 2030. The necessary capital, labour, and technology growth rates to achieve this target was then computed.

[2]Environment is measured by The Environmental Performance Index from Yale, https://epi.yale.edu/. It consists of the following indicators:

Environmental Health (40%): Sanitation & drinking water; heavy metals; and waste management.

Ecosystem Vitality (60%): Biodiversity & habitat (terrestrial biome protection both national and global; marine protected areas; protective areas representativeness index; species habitat index; species protect index; biodiversity index); ecosystem services (tree cover loss; grassland loss; and wetland loss); fisheries (fish stock status; marine trophic index and fish caught by trawling); climate change (CO_2 growth rates; CH_4 growth rate, F-gas growth rate; N_2O growth rate; black carbon growth rate; CO_2 from land cover; GHG intensity trend; and GHG per capita); pollution emissions (SO_2 growth rate and NO_2 growth rate); agriculture (sustainable nitrogen management index); and water resources (wastewater treatment).

Dynamics between the STI Ecosystem and the Economic, Societal and Environmental Pillars

The development of STI ecosystem is critical to enable Malaysia to be a globally competitive developed country by 2030, aligned to the aspirations of SPV 2030. It is the catalyst for creating wealth that can support social safety nets and ensure that the natural ecosystem is sustainable. Development of a strong and dynamic STI ecosystem will require strategic investments to deepen its impact on the three pillars. This holistic and targeted approach in linking STI to socioeconomic drivers of the country will spur Malaysia's move up the societal, economic, and environmental value chains.

These goals demand a Whole-of-Government and Whole-of-Society approach to foster committed participation from all stakeholders (industry, industry associations, academic institutions, R&D institutions, and community organisations). This will promote greater efficacy in policy formulation, implementation and monitoring of STI outcomes. Successful implementation will spark a strong multiplier effect across the different sectors of the economy, society, and the environment. Strong partnerships among industries and other stakeholders will build absorptive and adaptive capabilities, as well as innovative capabilities. As the economy moves up the value chain, it will nurture niche economic areas that are globally competitive, creating high-value-added jobs, reverse the brain drain, and increase equitable economic development.

A sound STI ecosystem will also address present structural inequalities through improving access to life-long learning, affordable homes, healthcare services, social protection, and other resources that are fundamental to a high quality of life. The nation's national resources can also be conserved, as well as administered in a responsible and sustainable manner with the support of a robust STI ecosystem. Malaysia's global competitiveness will be bolstered through the convergence of economic development, social transformation, and environmental sustainability initiatives. This will create an STI ecosystem with powerful "shock-absorbers" to mitigate risks associated with global uncertainties and volatilities. Thus, fostering a resilient and innovative socioeconomic system. The simulation analysis above shows that it is possible for Malaysia to escape the middle-income trap and future proof the nation from global shocks and uncertainties by nurturing a sound and agile STI ecosystem.

07

Recommendations

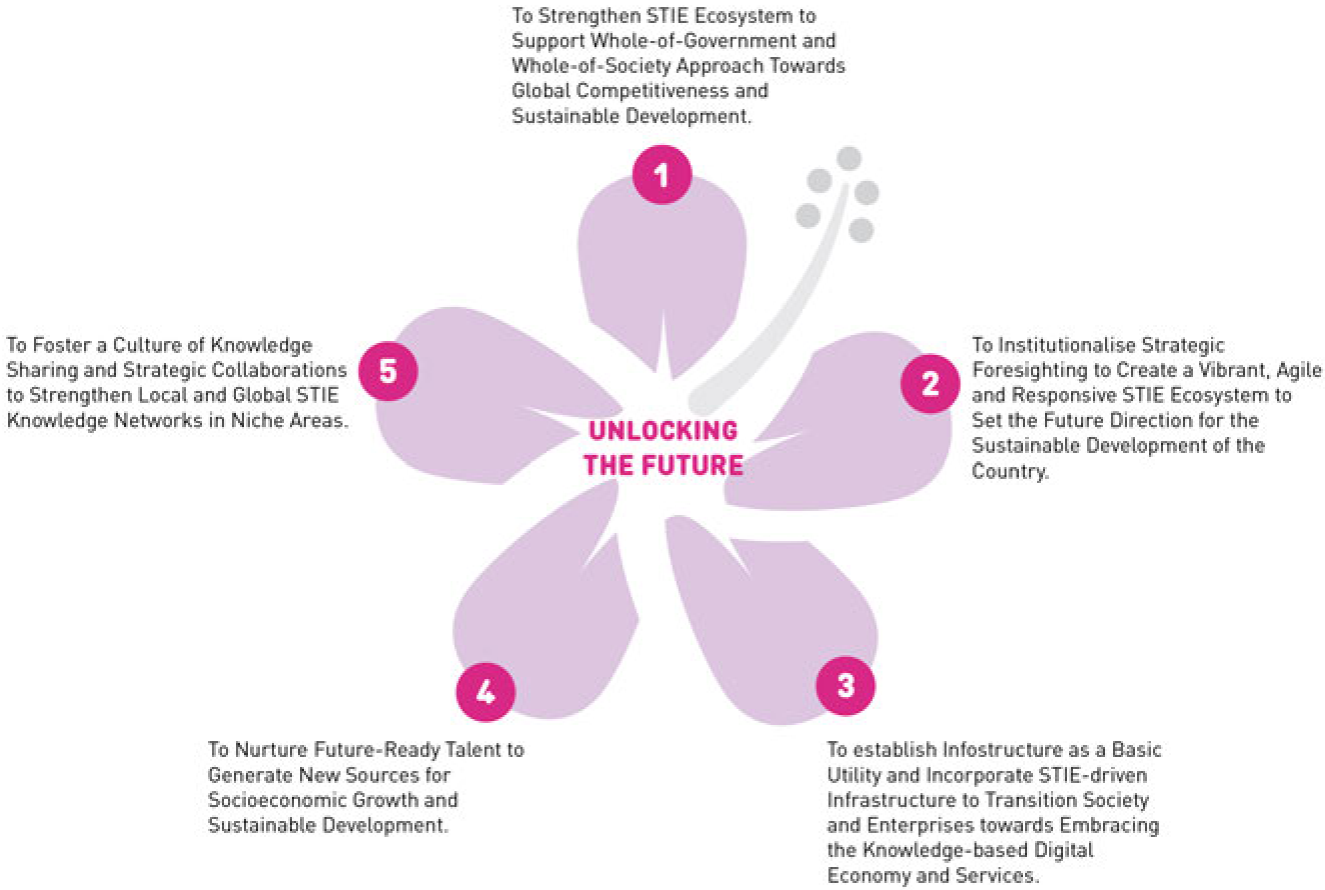
The Science Outlook 2020 study explores the nature and progress of Malaysia's Science, Technology and Innovation (STI) ecosystem across a period of thirty years. It connects the shifts in the socioeconomic and environmental landscape to the development of the STI ecosystem through the mid- and long-term plans.

Our analyses led to the identification of several gaps in Malaysia's STI ecosystem that continue to hamper and constrain the level of Return on Value (ROV) being realised within Malaysia. Full potential of the STI initiatives has not been realised to drive the nation to become an innovation- and knowledge-driven economy as numerous STI initiatives are not aligned to the socioeconomic and environmental development of the country.

A focused approach in setting the priorities and direction for strengthening the STI ecosystem to enable the nation's socioeconomic development across multiple agencies, economic sectors, and jurisdictions is imperative. The planning process for STI and socioeconomic development can no longer remain fragmented.

A more holistic and dynamic Science, Technology, Innovation and Economic (STIE) ecosystem needs to be nurtured, as outlined in the National Science, Technology & Innovation Policy 2021-2030 (NPSTI 2021-2030) and the Shared Prosperity Vision 2030 (SPV2030) for Malaysia to step out of the middle-income trap.

The recommendations set out below are proposed to address the gaps identified in the earlier chapters and cut across all three Impact Pillars of this study.



RECOMMENDATION 1

To Strengthen STIE Ecosystem to Support Whole-of-Government and Whole-of-Society Approach Towards Global Competitiveness and Sustainable Development.

GAPS

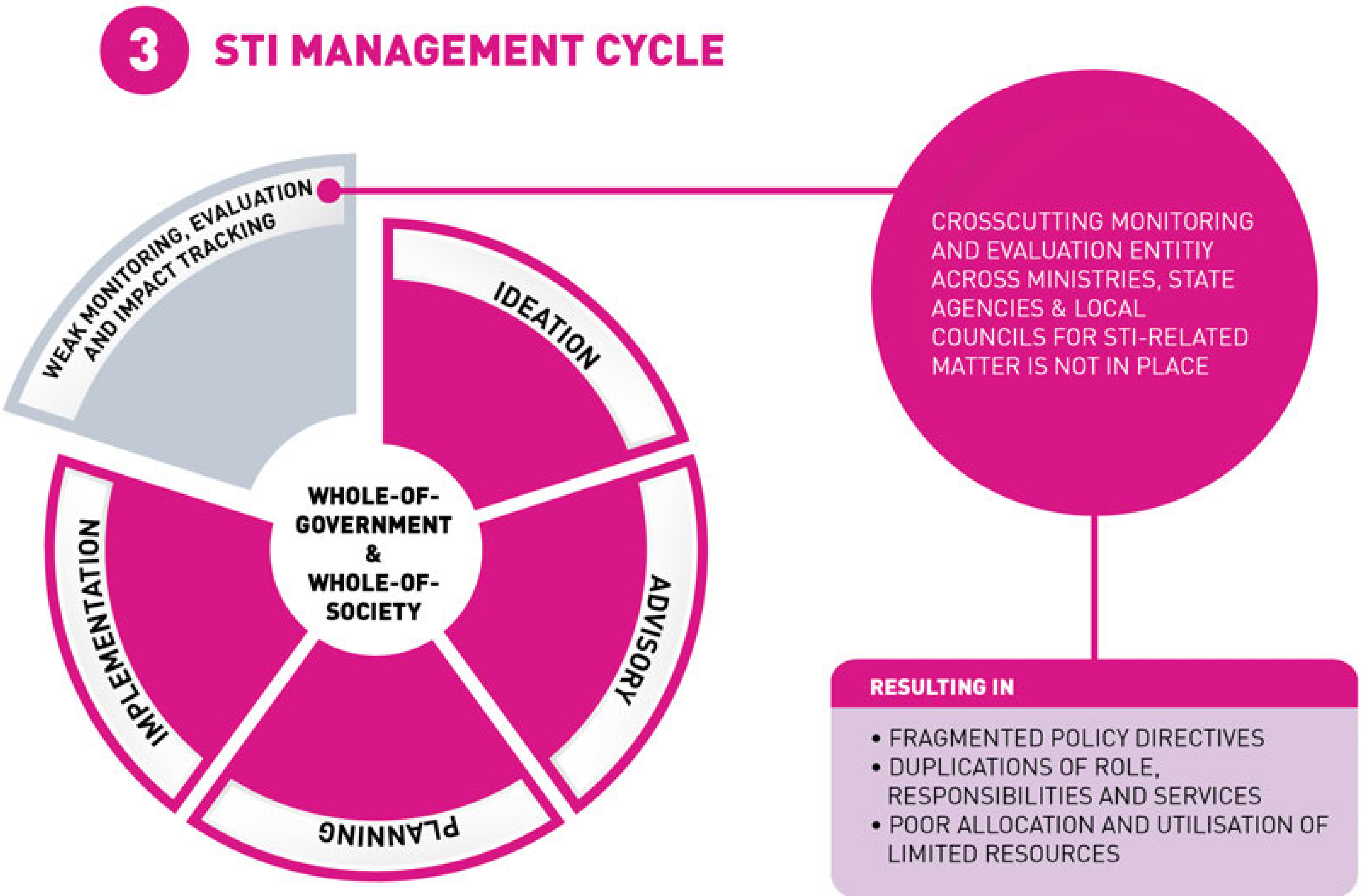
- Many **institutions of governance** (federal and state agencies, local councils, institutions of higher learning, research institutions, and NGOs) have **not kept pace** with STI development as most of these institutions are **not tech-savvy** in managing the complex nature of interactions, such as managing the natural and physical infrastructure and delivering social services to target groups.
- These weaknesses in oversight and coordination towards a unified all-encompassing goal often result in **fragmented policy directives leading to ineffective and time-consuming implementation** of strategies, programmes and initiatives.
- The danger of having many institutions, often with **duplications of role**, responsibilities and services dampens the efficacy of effort due to the multiplicity of differently directed initiatives resulting in **poor utilisation of limited resources**.
- Fiscal and non-fiscal incentives are **not focused and targeted** to core sectors of the economy due to constant policy changes, coupled with inconsistent funding for large scale and long-term STI initiatives
- There is **no clear institutional champion** to monitor, evaluate, track impact and put in place a continuous improvement cycle (Figure 7.1).

THE WAY FORWARD

The STIE ecosystem management should be strengthened, streamlined and transformed through a Whole-of-Government (WOG) and Whole-of-Society (WOS) approach to ensure formulation and implementation of evidence based STIE policies. This will allow greater economic efficiency, more effective delivery of social services and effective management of environmental issues that cut across multiple jurisdictions of government and society. Achieving this will require the government to implement seamless planning, coordination, and monitoring of STIE-related issues by nurturing a high level of transparency and integration of interdependency across ministries and agencies with different portfolios and jurisdictions. Collaboration with society groups, by including them at the decision-making level of STIE would enhance the process of getting science input from community and industry-based groups who are conduits to the final users of the products and services. The WOG-WOS approach would nurture a collaborative platform to generate and promote new ideas, as well as democratise STIE planning, implementation, monitoring and refining policies and strategies.

ACTIONABLE STRATEGY

1. Create a **robust STIE management and monitoring system** for impact tracking and e-governance through establishment of a national digital governance ledger.
2. Create specific **national digital registries** for healthcare, environmental and natural assets (physical & non-physical) and intellectual capital to name a few, for better management, monitoring, analyses and decision making.



Reference: Modified from ASM, (2018)

Figure 7.1: STI Management Cycle

RECOMMENDATION 2

To Institutionalise Strategic Foresighting to Create a Vibrant, Agile and Responsive STIE Ecosystem to Set the Future Direction for the Sustainable Development of the Country.

GAPS

- **Lack of integrated and coordinated national foresighting** plan to ensure sustainable socioeconomic development across the country despite the various national plans and visions such as the National Economic Policy and Vision 2020.

THE WAY FORWARD

To ensure Malaysia remains competitive and adaptive to future challenges, foresight capacity needs to be institutionalised within government bringing together the relevant players. This structure should take an ecosystem approach to produce insights for carefully designed interventions and follow throughs to the highest levels of government. Formalising a cross-cutting platform to enable strategic foresight allows for a greater impact tracking role of harmonising the strategic planning of all ministries.

ACTIONABLE STRATEGY

1. Formation of an independent **"Foresight entity"** to develop Malaysia's overall STIE ecosystem to be agile, adaptive and responsive to address global challenges and provide global leadership in key strategic areas of importance, especially from the perspective of the four Ministerial clusters namely, Infrastructure, Defence, Education and Economy.

RECOMMENDATION 3

To establish Infostructure as a Basic Utility and Incorporate STIE-driven Infrastructure to Transition Society and Enterprises towards Embracing the Knowledge-based Digital Economy and Services.

GAPS

- **Access** to the wealth of information from the World Wide Web does not reach across the length and breadth of Malaysia due to inadequate digital infrastructure as telecommunication service providers do not expect to see significant Return on Investment (ROI) despite the existence of underutilised fibre cables (dark fibre) in some regional areas.
- **Connectivity and quality** in many parts of the country remain weak, particularly in localities where the poor and marginalised communities live despite the availability of sufficient capacity to supply these communities with the necessary digital infrastructure services.

THE WAY FORWARD

The global economy has been transformed by the information revolution and this is changing every facet of the nation. Information and digital technology are a key catalyst to enhance the reach, richness and access for knowledge and services to all segments of society, aligned to the SPV2030.

ACTIONABLE STRATEGY

1. To include the fixed **broadband infostructure services as a basic utility**, from deployment, management and maintenance of high-quality services in all future mid- to low-level real estate development projects. The process should involve **democratisation of infostructure services** by breaking up extant monopolies held by any single party to a system that involves an open market in the supply and maintenance of infrastructures and infostructure services.
2. To ensure the physical and natural ecosystems **adopt advanced digital technologies** to pre-empt, manage and mitigate man-made and natural disasters and risks. Ensuring that our valuable natural resources continue to yield to the needs of our national development in a sustainable manner requires that protection, preservation and enhancement of natural infrastructure is accorded high priority since the wellbeing of society and the planet is at stake.

RECOMMENDATION 4

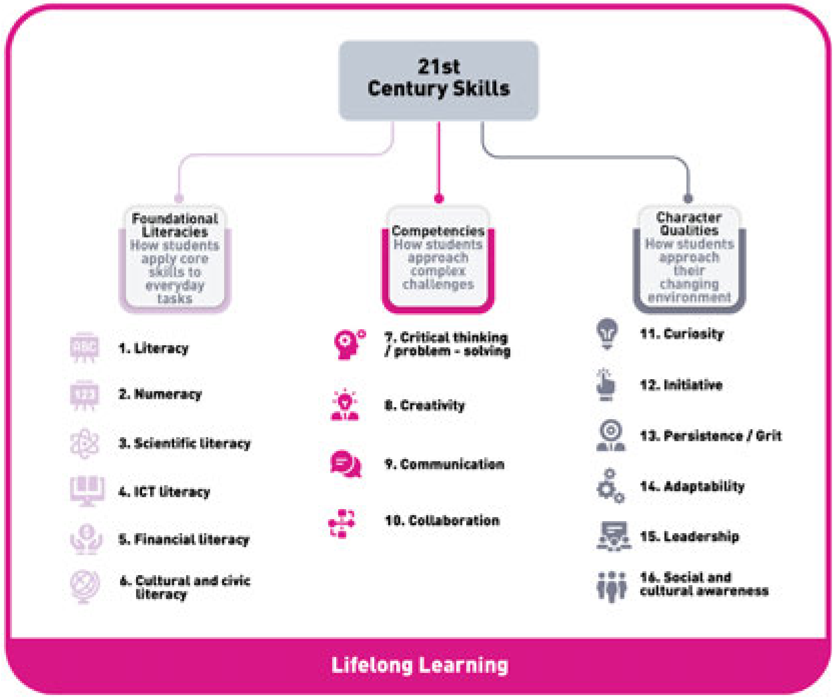
To Nurture Future-Ready Talent to Generate New Sources for Socioeconomic Growth and Sustainable Development.

GAPS

- Knowledge and intellectual capital growth are **not keeping up** with the demands of the world in critical areas.
- Talent in Malaysia is characterised as possessing high general skills but **lacking in multidisciplinary and specialised skills** as well as leadership skills and entrepreneurial acumen.
- Industry relies heavily on **foreign technology and know-how** to upgrade its operations.
- **Opportunities** to acquire and upgrade to appropriate skills for the future via online platforms are **scarce among marginalised communities.**

THE WAY FORWARD

The talent of the future must be equipped with depth of knowledge and specialist industry competencies, resilient and multi-versed to be able to communicate and work across disciplinary areas and be ready to constantly upgrade and re-skill over their lifetime. They also need to be well- schooled in societal values such as ethics and morality to tackle today's problems in ways that ensure they do not deplete and sacrifice the physical and natural endowments needed by future generations (Figure 7.2).



Reference: Adapted from Soffel, J. (2016)

Figure 7.2: Skills Required for the 21st Century

ACTIONABLE STRATEGY

1. To formulate and institutionalise a **Talent Masterplan** based on the 10-10 *My*STIE Framework and develop a **clear competency framework** that is co-developed by government, academia, industry players and civil society groups for future-ready talent.
2. To establish an **occupation tracking mechanism** to monitor technical school leavers and graduates as they enter the workforce and monitor their career trajectories over time. This system would identify and project STIE-related jobs, the needed supply and skills of the future for Malaysia and adjust training and learning to meet the evolving needs of the economic, societal and environmental sectors.
3. To **enhance the curriculum** of local training institutes for policy and diplomacy (i.e. Institute of Diplomacy and Foreign Relations (IDFR) and National Institute of Public Administration (INTAN)) to incorporate STIE-knowledge as part of existing curriculum and provide training to nurture civil servants who will then graduate as multi-versatile citizens and, respond to market intelligence with appropriate knowledge of global standards and best practices that advocate sustainable development. There is a need to acculturate civil servants to be good advocates and ambassadors of our rich biodiversity, natural ecosystem, and environmentally friendly industries and keep abreast with key emerging issues of interest to Malaysia.

RECOMMENDATION 5

To Foster a Culture of Knowledge Sharing and Strategic Collaborations to Strengthen Local and Global STIE Knowledge Networks in Niche Areas.

GAPS

- Lack of **knowledge sharing** between intermediaries' and inter- and intra-members of the quadruple helix for sustainable development of communities and enterprises.
- Lack of **collaboration** among implementing agencies due to uncoordinated top-down planning leading to an overlap of roles and responsibilities.
- The **level and depth of international cooperation and collaboration** among institutions of learning, industries, government agencies and community organisations are not deep and extensive.

THE WAY FORWARD

A strong STIE ecosystem to nurture a knowledge sharing culture that will enable marginalised communities to access information, knowledge, technology, innovation and other resources to improve their quality of life must be in place. A vibrant STIE ecosystem will enable micro- and SMEs to build strong dynamic capabilities from the technology and knowledge transfer to support a strong global supply chain.

ACTIONABLE STRATEGY

1. Strengthen **regional innovation centers** in the localities across the country to drive multi-stakeholders' collaboration such as between regional Corridors, Science/Technology Parks, technology incubators, universities, institutions of learning/training research institutes, industry and community organisations to strengthen and enable technology-based start-ups, communities and, micro and SMEs to develop the local economy with a global outlook while upholding the sustainability of the physical environment and natural resources. (Figure 7.3a- Figure 7.3f).

Northern Corridor Potential STIE Ecosystems

Manufacturing Projects:
Top 5 areas in Perlis
1. Plastic Products
2. Electronics & Electrical Products, Food Manufacturing
3. Rubber Products
4. Textile & Textile Products
5. Transport Equipment

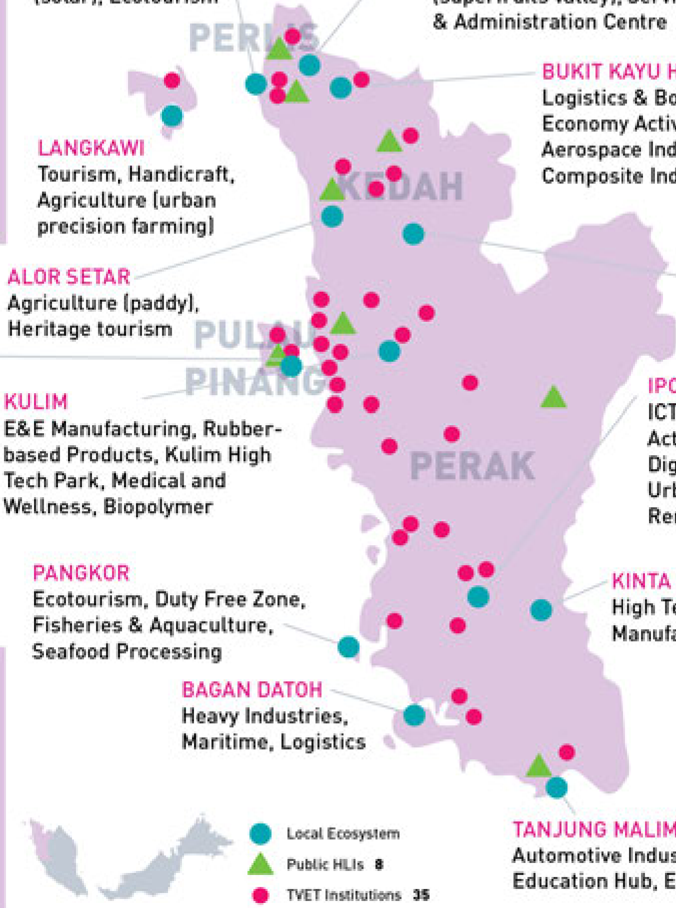
KUALA PERLIS
Fisheries, Transportation & Logistics, Renewable Energy (solar), Ecotourism

KANGAR
Halal Industries, Green Manufacturing, Agrobusiness (superfruits valley), Service & Administration Centre

Manufacturing Projects:
Top 5 areas in Kedah
1. Electronics & Electrical Products
2. Transport Equipment
3. Fabricated Metal Products
4. Plastic Products
5. Rubber Products

BUKIT KAYU HITAM
Logistics & Border Economy Activities, Aerospace Industry, Composite Industry

LANGKAWI
Tourism, Handicraft, Agriculture (urban precision farming)



PULAU PINANG
Manufacturing (electrical & electronics, medical devices, high tech manufacturing hub, R&D and commercial & industrial activities), Medical & Healthcare Tourism, Digital Economy (global business services, e-commerce), Financial Services, Logistics Hub, Agriculture (seed centre-aquaculture), Education Hub, Agrotourism, Halal Port

ALOR SETAR
Agriculture (paddy), Heritage tourism

PENDANG
Modern Agriculture & Livestock

KULIM
E&E Manufacturing, Rubber-based Products, Kulim High Tech Park, Medical and Wellness, Biopolymer

IPOH
ICT, Mining, Sustainable Mining & Downstream Activities, Eco & Heritage Tourism, Agriculture, Digital Economy, Financial Administrative Centre, Urban Revitalisation, Education, Manufacturing, Renewable Energy Generation

PANGKOR
Ecotourism, Duty Free Zone, Fisheries & Aquaculture, Seafood Processing

KINTA
High Tech Manufacturing, ICT

BAGAN DATOH
Heavy Industries, Maritime, Logistics

Manufacturing Projects:
Top 5 areas in Pulau Pinang
1. Electronics & Electrical Products
2. Machinery & Equipment
3. Fabricated Metal Products
4. Plastic Products
5. Basic Metal Products, Food Manufacturing

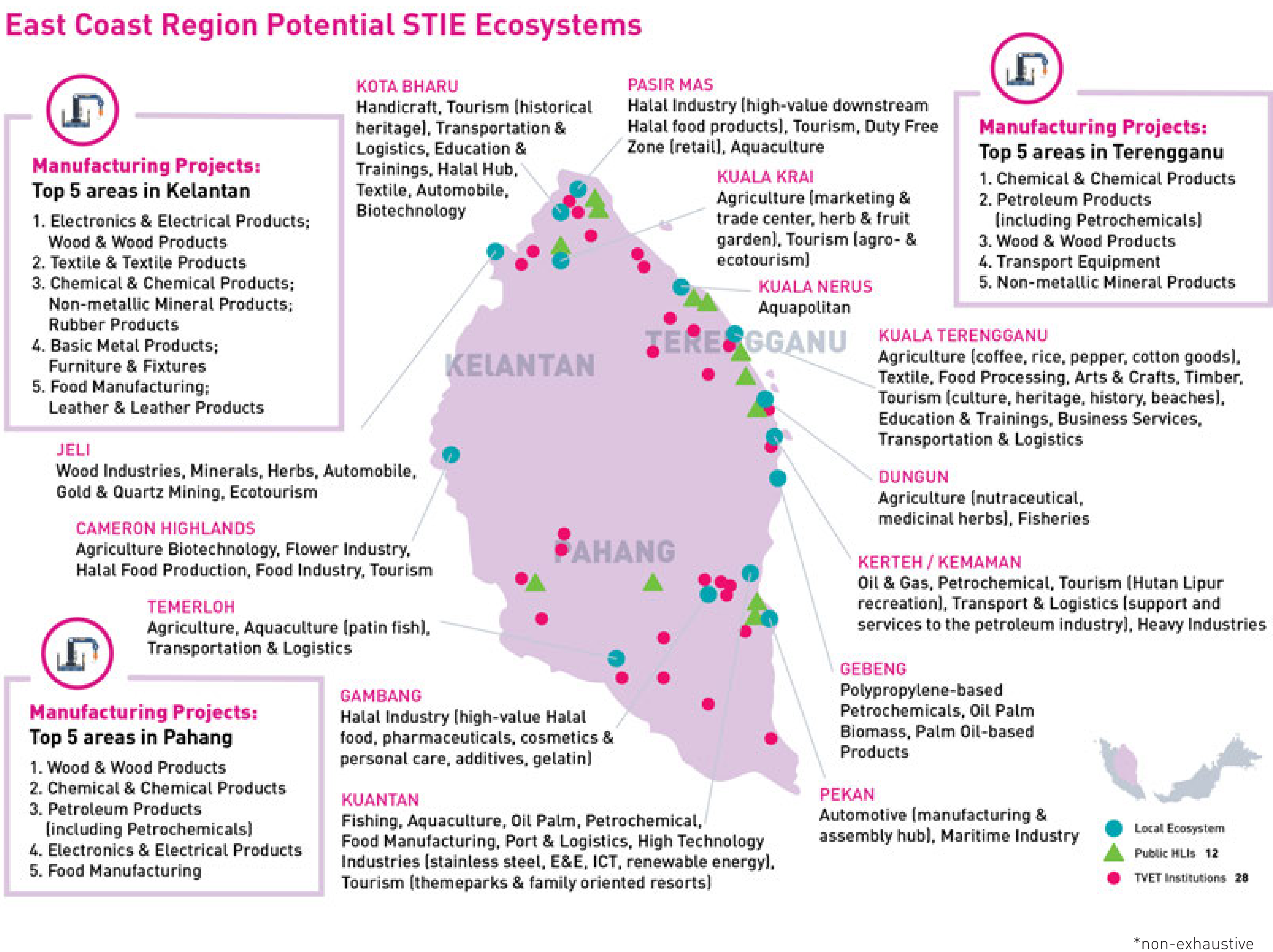
TANJUNG MALIM
Automotive Industry, Education Hub, Ecotourism

Manufacturing Projects:
Top 5 areas in Perak
1. Electronics & Electrical Products
2. Non-metallic Mineral Products
3. Rubber Products
4. Food Manufacturing
5. Plastic Products

*non-exhaustive

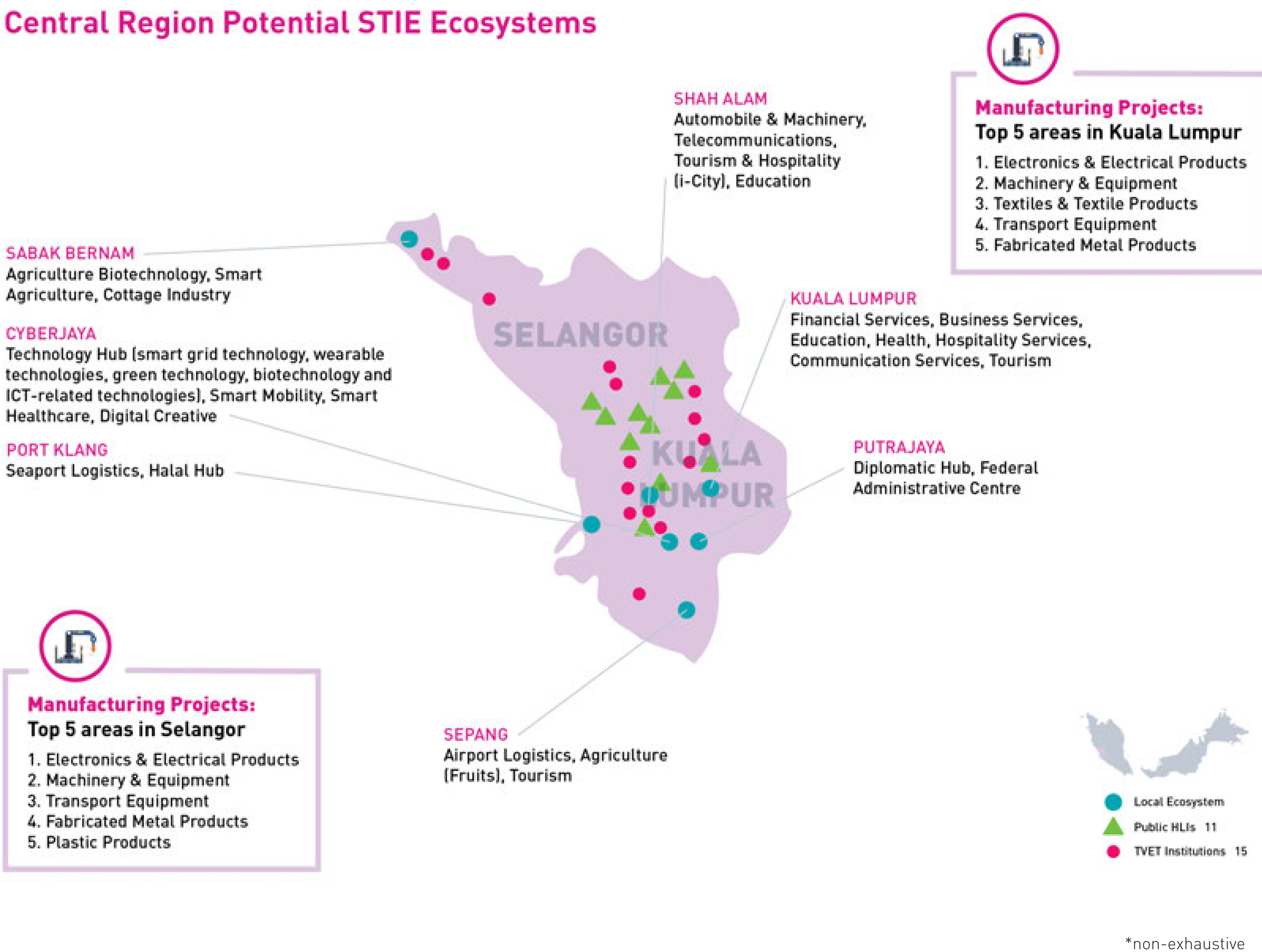
Reference: Adapted from ASM (2020) and Nair (2011)

Figure 7.3a: Mapping of Potential STIE Ecosystems across Localities in Malaysia



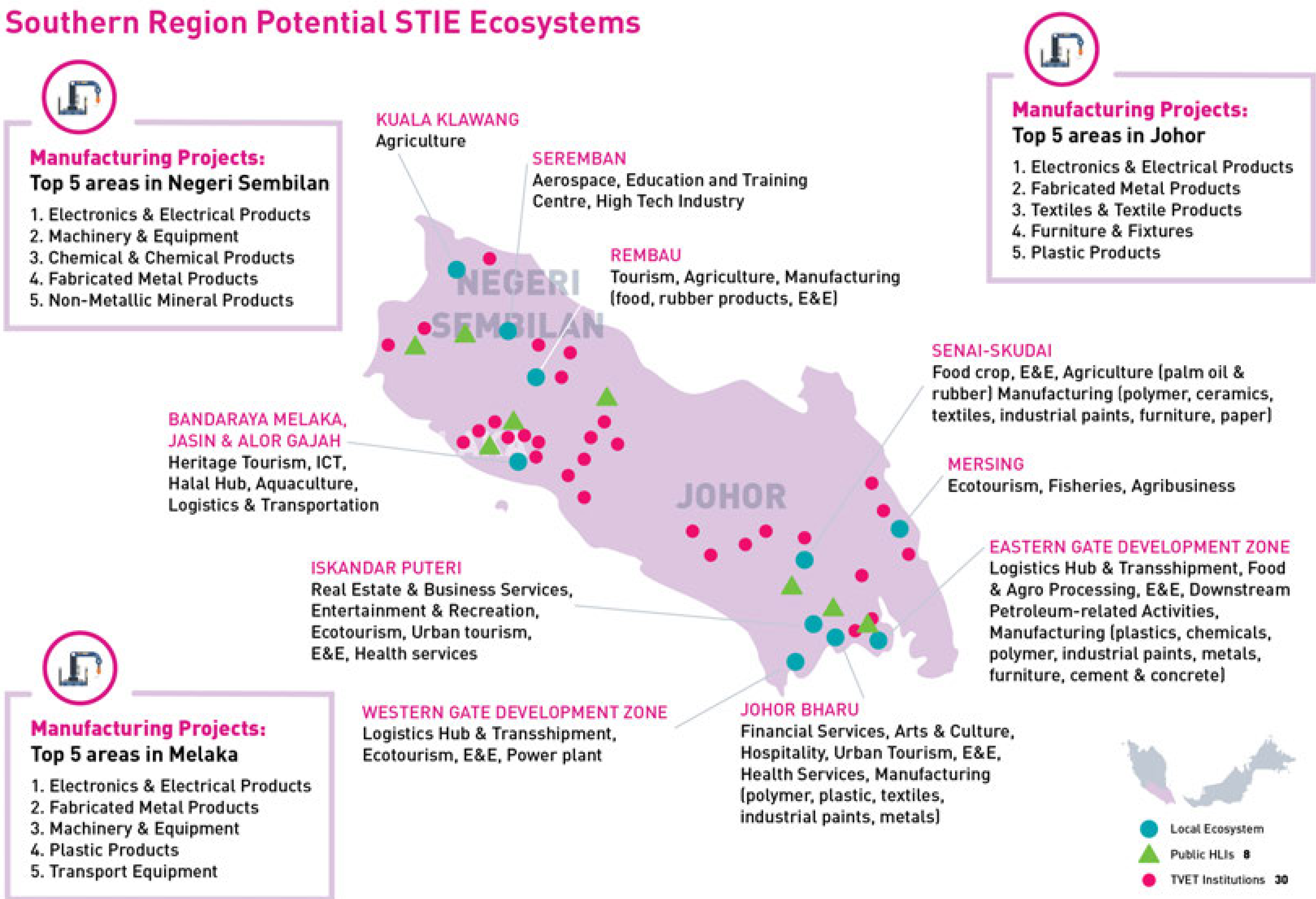
Reference: Adapted from ASM (2020) and Nair (2011)

Figure 7.3b: Mapping of Potential STIE Ecosystems across Localities in Malaysia



Reference: Adapted from ASM (2020) and Nair (2011)

Figure 7.3c: Mapping of Potential STIE Ecosystems across Localities in Malaysia

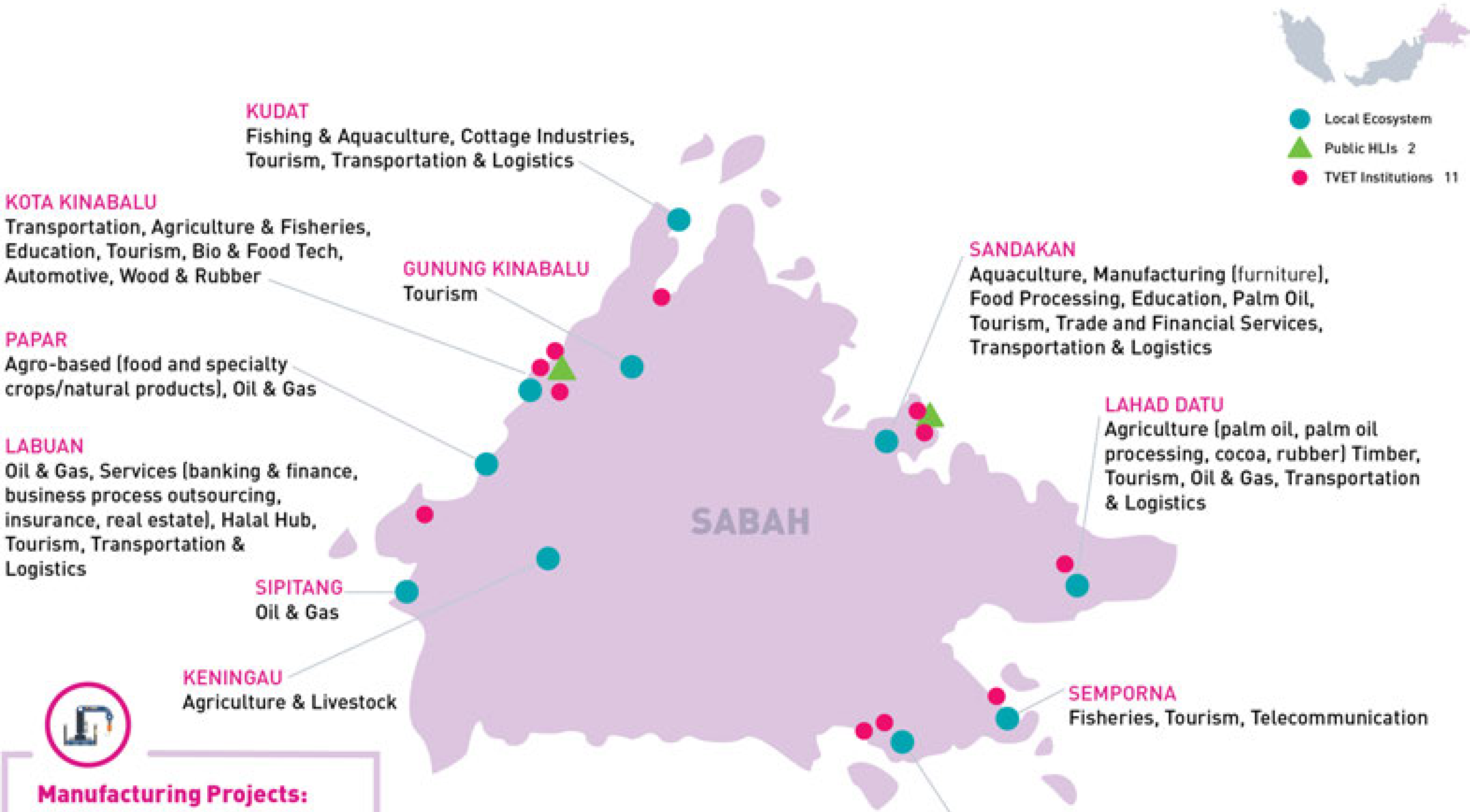


*non-exhaustive

Reference: Adapted from ASM (2020) and Nair (2011)

Figure 7.3d: Mapping of Potential STIE Ecosystems across Localities in Malaysia

Sabah Potential STIE Ecosystems



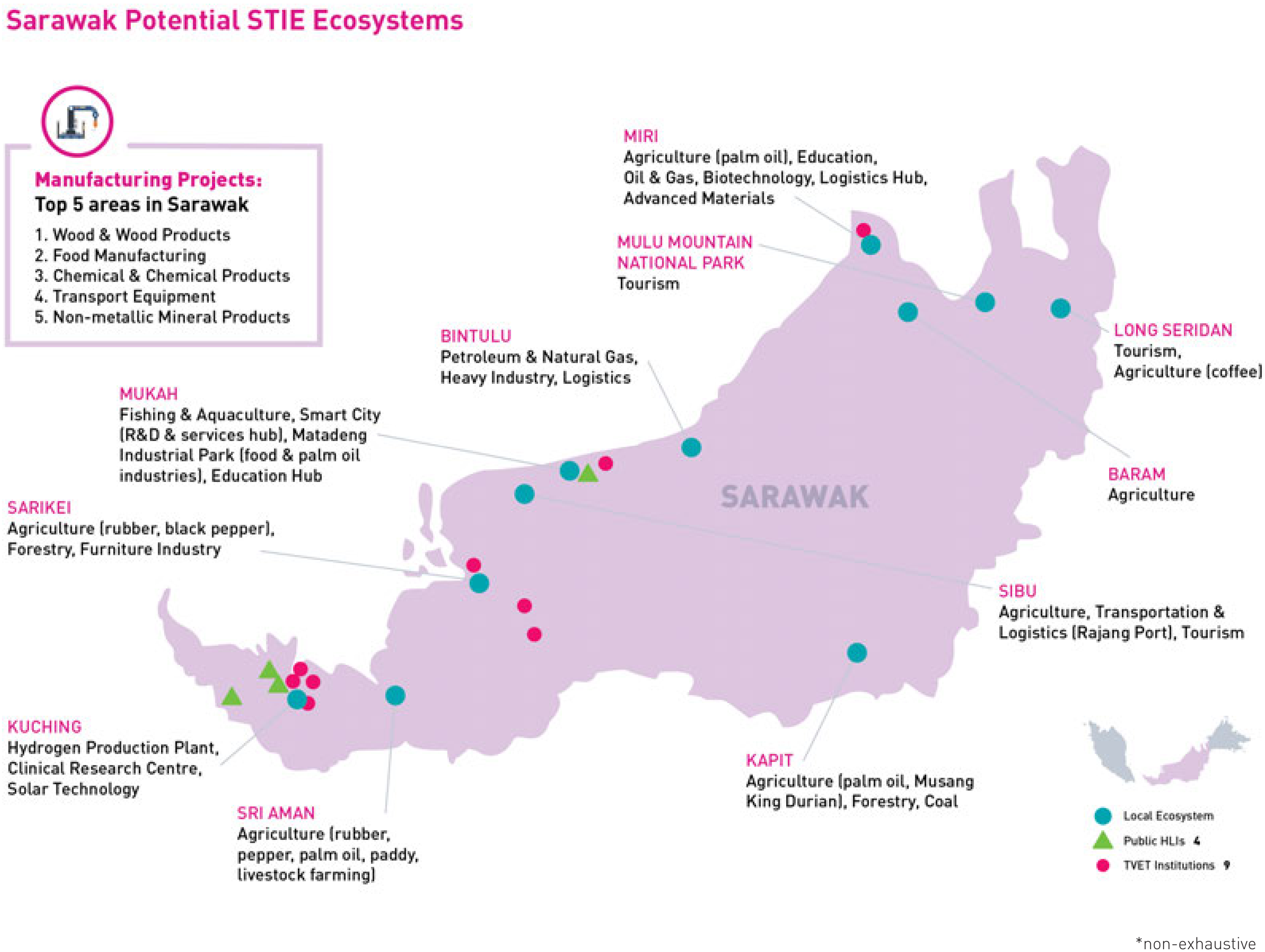
Manufacturing Projects:
Top 5 areas in Sabah

1. Wood & Wood Products
2. Food Manufacturing
3. Chemical & Chemical Products
4. Non-metallic Mineral Products
5. Transport Equipment

*non-exhaustive

Reference: Adapted from ASM (2020) and Nair (2011)

Figure 7.3e: Mapping of Potential STIE Ecosystems across Localities in Malaysia



Reference: Adapted from ASM (2020) and Nair (2011)

Figure 7.3f: Mapping of Potential STIE Ecosystems across Localities in Malaysia

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References

1. Ahmad, M. H., Selamat R., Salleh, R., Majid, N. L. A., Zainuddin, A. A., Bakar W. A. M. A., Aris, T. (2020), 'Food Insecurity Situation in Malaysia: Findings from Malaysian Adult Nutrition Survey (MANS) 2014', *Malaysian Journal of Public Health Medicine*, 20(1), pp. 167-174. doi: 10.37268/mjphm/vol.20/no.1/art.553.

2. Bank Negara Malaysia (BNM) (2019), 'Bank Negara Malaysia Annual Report 2018'. Available from: https://www.bnm.gov.my/documents/20124/791626/ar2018_book.pdf

3. Centre for Research on the Epidemiology of Disasters (CRED) (2009), 'Disaster General Classification'. Available from: https://www.emdat.be/classification

4. Chua S.N. (2020), 'The economic cost of mental disorders in Malaysia', *The Lancet*, vol 7. E23.

5. Economic Planning Unit (EPU) (2021), 'Malaysia Digital Economy Blueprint', Putrajaya, EPU. Available from: https://www.epu.gov.my/sites/default/files/2021-02/malaysia-digital-economy-blueprint.pdf

6. Ganeshwaran (2021), 'Reversing the decline among M40', *The Star*, 18 June 2021. [online] Available from: https://www.thestar.com.my/business/business-news/2021/06/18/reversing-the-decline-among-m40

7. Huawei Technologies (2021), 'Global Connectivity Index 2020 - Shaping the New Normal with Intelligent Connectivity'. [online] Available from: https://www.huawei.com/minisite/gci/en/ [Accessed on 12 June 2021].

8. Institute for Public Health (2020), 'Non-communicable diseases, healthcare demand, and health literacy: Key Findings', *National Health and Morbidity Survey (NHMS) 2019*, vol. 1, Ministry of Health Malaysia.

9. Organisation for Economic Co-operation and Development (OECD) (2018), 'Digital Government Review of Brazil: Towards the Digital Transformation of the Public Sector', OECD Digital Government Studies, OECD Publishing, Paris, https://doi.org/10.1787/9789264307636-en

10. United Nations Children's Fund (UNICEF) (2018), 'Children Without: A Study of Urban Child Poverty and Deprivation in Low-Cost Flats in Kuala Lumpur', Kuala Lumpur, United Nations Childrens' Fund.

11. United Nations Children's Fund (UNICEF) (2019), 'Children, Food and Nutrition: State of the World's Children 2019. A look at child malnutrition in Malaysia and beyond'. Available from: https://www.unicef.org/malaysia/children-food-and-nutrition-state-worlds-children-2019

12. United Nations (UN) (2021), 'UN E-Government Survey in Media'. Available from https://publicadministration.un.org/egovkb/Data-Center [Accessed on 17 June 2021].

13. World Intellectual Property Organization (WIPO) (2016&2020), 'Global Innovation Index Report, 2016 & 2020', Cornell University, INSEAD.

14. World Bank (2021), 'Malaysia Literacy Rate 1991-2021'. Available from: https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?end=2018&locations=MY&start=1980&view=chart [Accessed on 5 April 2021].

References for Figures

Figure 1.6 (a) Malaysian Science and Technology Information Centre (MASTIC) (2020), 'Gross Expenditure on R&D (GERD), 1992-2018', National Survey of Research and Development (R&D) in Malaysia. Data requested from MASTIC (2020).

Ministry of Science, Technology and Innovation (MOSTI) (2020), 'Dasar Sains, Teknologi dan Inovasi Negara 2021-2030', Putrajaya, MOSTI.

Figure 1.6 (b) UNESCO Institute for Statistics (2020), 'GERD as a percentage of GDP, 1996-2018'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 2 November 2020].

Figure 1.7 UNESCO Institute for Statistics (2020), 'Researchers per thousand labour force (FTE), 1996-2018'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 26 November 2020].

Figure 1.8 UNESCO Institute for Statistics (2020), Total Full Time Equivalent (FTE) Researchers by Sectors, 1996-2018'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 3 November 2020].

Figure 1.9 Scimago Journal and Country Rank (2020), 'Published Documents by Year, 1996-2019'. [online] Available from: https://www.scimagojr.com/countryrank.php [Accessed on 9 November 2020].

WIPO Statistics database (2020), 'Patent Applications, 1996-2018'. [online] Available from https://www3.wipo.int/ipstats/index.htm?tab=patent [Accessed on 16 December 2020].

UNESCO Institute for Statistics (2020), 'Average GERD per Researcher (FTE), 1996-2018'. [online] Available from http://data.uis.unesco.org/ [Accessed on 16 December 2020].

Figure 1.10 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure 1.11 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure 1.12 Ministry of Science, Technology and Innovation (MOSTI) (2018), 'Pelan Strategik MOSTI 2016-2020', Putrajaya, MOSTI. Available from: https://www.mosti.gov.my/wp-content/uploads/repository/penerbitan/2018/Pelan-Strategik-Kementerian-Sains-Teknologi-Dan-Inovasi-MOSTI-2016-2020.pdf [Accessed on 29 December 2020].

Figure 1.14 Respective websites of State Governments

Figure 1.15 MAMPU (2017), 'Digital Government Transformation Action Plan 2017-2018', Available from: https://www.malaysia.gov.my/media/uploads/1d510df1-a212-4e36-9c29-ef477daca172.pdf

Figure 1.17 Speedtest Global Index (2021). Available from: https://www.speedtest.net/global-index [Accessed on 3 July 2021].

Figure 1.18 Department of Statistics Malaysia (2020), 'ICT Use and Access by Individuals and Households Survey Report', Malaysia, DOSM.

Figure 1.19 International Monetary Fund (IMF) (2021), 'World Economic Outlook Database, April 2021'. [online] Available from: https://www.imf.org/en/Publications/WEO/weo-database/2021/April

Maddison Project Database (2020), 'Maddison Project Working Paper', nr. 10. [online] Available from: www.ggdc.net/maddison.

World Bank (2020), 'GDP (constant 2010 US$) – Malaysia', World Bank national accounts data, and OECD National Accounts data files. [online] Available from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=MY

Figure 1.20 International Monetary Fund (IMF) (2021), 'World Economic Outlook Database, April 2021'. [online] Available from: https://www.imf.org/en/Publications/WEO/weo-database/2021/April

World Bank (2020), 'GDP (constant 2010 US$) – Malaysia', World Bank national accounts data, and OECD National Accounts data files. [online] Available from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=MY

Figure 1.21 Economic Planning Unit (EPU) (2016), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

Figure 1.22 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure 1.23 Economic Planning Unit (EPU) (2016), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

Figure 1.25 Academy of Sciences Malaysia (ASM) (2017), 'ASM S&T Foresight Malaysia 2050 Report'.

Figure 1.26 Department of Statistics Malaysia (DOSM) (2020), 'Labour Force Survey Report 2019'.

Figure 1.28 Department of Statistics Malaysia (DOSM) (2019), 'Labour Force Survey (LFS) Time Series Statistics by State, 1982-2019'.

Figure 1.29 World Intellectual Property Organization (WIPO) (2016&2020), 'Global Innovation Index Report, 2016 & 2020', Cornell University, INSEAD.

Figure 1.30 Economic Planning Unit (EPU) (2016), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

Figure 1.31 Department of Statistics Malaysia (DOSM) (2020), 'Household Income & Basic Amenities Survey Report 2019'.

Figure 1.32 Department of Statistics Malaysia (DOSM) (2020), 'Household Income & Basic Amenities Survey Report 2019'.

Figure 1.33 World Bank (2021), 'Human Capital Index (HCI) (scale 0-1) - Malaysia, World, Singapore, Thailand, Korea, Rep., Vietnam, Philippines, Japan'. [Online] Available from: https://data.worldbank.org/indicator/HD.HCI.OVRL?cid=GGH_e_hcpexternal_en_ext&end=2020&locations=MY-1W-SG-TH-KR-VN-PH-JP&start=2010&view=chart [Accessed on 10 July 2021].

Figure 1.34 Yale University (2006-2020), 'Environmental Performance Index, 2006-2020', Yale Center for Environmental Law & Policy.

Figure 1.35 OECD Statistics (N.D.), 'Welfare Cost of Premature Deaths' [Accessed on May 2021]

The International Disaster Database (EM-DAT) (N.D), 'Damage Costs from Disasters' [Accessed on May 2021]

Conduct of Study

1. Academy of Sciences Malaysia (ASM), (2016), Science Outlook 2015: Action towards vision, Kuala Lumpur, Academy of Sciences Malaysia.

2. Academy of Sciences Malaysia (ASM), (2018), Science Outlook 2017: Converging Towards Progressive Malaysia 2050, Kuala Lumpur, Academy of Sciences Malaysia.

3. Mahathir Mohamad (1991), 'Malaysian: The Way Forward (Vision2020)', Economic Planning Unit.

4. Ministry of Economic Affairs (MEA) (2019), 'Shared Prosperity Vision 2030', Putrajaya, Ministry of Economic Affairs.

5. Nair, M. (2011), 'Inclusive innovation and sustainable development: leap-frogging strategies to a high-income economy', *ICT Strategic Review 2011/2012*, PIKOM and MOSTI, Malaysia.

6. 6. Tashakkori, A., and Teddlie, C. (2010), 'Indicators of Quality in Mixed Methods and Their Relevance to Evaluation Quality', *American Evaluation Association*, Panel presented at the Presidential Strand Panel, San Antonio, Texas.

7. Venkatesh, V., Brown, S.A., Sullivan, Y.W. (2016), 'Guidelines for Conducting Mixed-methods Research: An Extension and Illustration', *Journal of the Association for Information Systems*, vol. 17, Issue 7, pp. 435 – 494. Available from: https://core.ac.uk/download/pdf/301380447.pdf

8. Wang, C.L., and Ahmed, P. (2007), 'Dynamic capabilities: A review and research agenda', *International Journal of Management Reviews*, vol. 9, no. 1, pp. 31–51. doi:10.1111/j.1468-2370.2007.00201.x

Figure 3 Nair, M. (2011), 'Inclusive Innovation and Sustainable Development: Leap-Frogging Strategies to a High-Income Economy', *ICT Strategic Review 2011/2012*, PIKOM and MOSTI, Malaysia.

Figure 4 Nair, M. (2011), 'Inclusive Innovation and Sustainable Development: Leap-Frogging Strategies to a High-Income Economy', *ICT Strategic Review 2011/2012*, PIKOM and MOSTI, Malaysia.

Wang, C.L., and Ahmed, P. (2007), 'Dynamic capabilities: A Review and Research Agenda', *International Journal of Management Reviews*, vol. 9, no. 1, pp. 31–51. doi:10.1111/j.1468-2370.2007.00201.x

Spreadsheet 1 – Assessment of Vision 2020

1. Fleming, D. and Søborg, H. (2019), 'Can Vision 2020 be Far Away? Malaysia's Transformation Problems to a High-income Economy', *Global Policy*, vol. 10, no.4, pp. 512-526.

2. Hamid, A.S., Ahmad Marzuki, N., Ahmad, N.A., and Ishak, M.S. (2016), 'Social Capital and Community Cohesion: The Constitution of Community Social Capital In Malaysia', *International Review of Management and Marketing*, vol. 6, no. 8S. Available from: https://www.econjournals.com/index.php/irmm/article/view/3918

3. Institute for Public Health (2015), 'Non-Communicable Diseases, Risk Factors & other Health Problems', *National Health and Morbidity Survey (NHMS) 2015*, vol. 2, Ministry of Health Malaysia.

4. Institute for Public Health (2020), 'Non-communicable diseases, healthcare demand, and health literacy: Key Findings', *National Health and Morbidity Survey (NHMS) 2019*, vol. 1, Ministry of Health Malaysia.

5. Legatum Institute (2020), 'The Legatum Prosperity Index 2020'. [online] Available from: https://www.prosperity.com/all-countries [Accessed on 25 January 2021].

6. Mahathir Mohamad (1991), 'Malaysian: The Way Forward (Vision2020)', Economic Planning Unit (EPU).

7. The Edge Markets (2020), 'Millennials are the most stressed-out generation at work'. [online] Available from: https://www.theedgemarkets.com/content/advertise/millennials-are-most-stressed-out-generation-work [Accessed on February 2021].

Figure S1.1 Legatum Institute (2020), 'The Legatum Prosperity Index 2020'. [Online] Available from: https://www.prosperity.com/all-countries [Accessed on 25 January 2021].

Figure S1.2 Institute for Public Health (2020), 'Non-Communicable Diseases, Healthcare Demand, And Health Literacy: Key Findings', *National Health and Morbidity Survey (NHMS) 2019*, vol. 1, Ministry of Health Malaysia.

Figure S1.3 Institute for Public Health (2020), 'Non-Communicable Diseases, Healthcare Demand, And Health Literacy: Key Findings', *National Health and Morbidity Survey (NHMS) 2019*, vol. 1, Ministry of Health Malaysia.

Figure S1.4 Institute for Public Health (2020), 'Non-Communicable Diseases, Healthcare Demand, And Health Literacy: Key Findings', *National Health and Morbidity Survey (NHMS) 2019*, vol. 1, Ministry of Health Malaysia.

Figure S1.5 Institute for Public Health (2020), 'Non-Communicable Diseases, Healthcare Demand, And Health Literacy: Key Findings', *National Health and Morbidity Survey (NHMS) 2019*, vol. 1, Ministry of Health Malaysia.

Figure S1.6 The Edge Markets (2020), 'Millennials are The Most Stressed-Out Generation at Work', AIA Vitality 2019. [Online] Available from: https://www.theedgemarkets.com/content/advertise/millennials-are-most-stressedout-generation-work [Accessed on February 2021].

Figure S1.7 Department of Statistics Malaysia (DOSM) (2020), 'Malaysian Well-Being Index (MyWI) 2000-2019', Economic Planning Unit.

Figure S1.8 World Bank (2020), 'Worldwide Governance Indicators - Voice and Accountability and the Political Stability & Absence of Violence/Terrorism', *Data Catalog*. [Online] Available from: https://datacatalog.worldbank.org/dataset/worldwide-governance-indicators

Figure S1.9 World Bank (2020), 'Worldwide Governance Indicators - Rule of Law and Control of Corruption', *Data Catalog*. [Online] Available from: https://datacatalog.worldbank.org/dataset/worldwide-governance-indicators

Figure S1.10 Legatum Institute (2020), 'The Legatum Prosperity Index 2020'. [Online] Available from: https://www.prosperity.com/all-countries [Accessed on 25 January 2021].

Figure S1.11 Malaysian Science and Technology Information Centre (MASTIC) (2020a), 'Gross Expenditure on R&D (GERD), 1992-2018', *National Survey of Research and Development (R&D) in Malaysia*. Data requested from MASTIC (2020).

Malaysian Science and Technology Information Centre (MASTIC) (2020b), 'Gross Expenditure on R&D by Sectors, 1992-2018', *National Survey of Research and Development (R&D) in Malaysia*. Data requested from MASTIC (2020).

Malaysian Science and Technology Information Centre (MASTIC) (2020c), 'Percentage of GERD by Type of R&D Activities in Malaysia, 1992-2018', *National Survey of Research and Development (R&D) in Malaysia*. Data requested from MASTIC (2020).

Malaysian Science and Technology Information Centre (MASTIC) (2020d), 'Total Full Time Equivalent (FTE) Researchers by Sectors, 1992-2018', *National Survey of Research and Development (R&D) in Malaysia*. Data requested from MASTIC (2020).

Figure S1.11 UNESCO Institute for Statistics (2020a), 'GERD as a Percentage of GDP, 1996-2018'. [Online] Available from: http://data.uis.unesco.org/ [Accessed on 2 November 2020].

UNESCO Institute for Statistics (2020b), 'GERD by Sector Performance, 1996-2018'. [Online] Available from: http://data.uis.unesco.org/ [Accessed on 3 November 2020].

UNESCO Institute for Statistics (2020c), 'GERD by Type of R&D Activities, 1996-2018'. [Online] Available from: http://data.uis.unesco.org/ [Accessed on 3 November 2020].

UNESCO Institute for Statistics (2020d), 'Researchers per Thousand Labour Force (FTE), 1996-2018'. [Online] Available from: http://data.uis.unesco.org/ [Accessed on 26 November 2020].

UNESCO Institute for Statistics (2020e), Total Full Time Equivalent (FTE) Researchers by Sectors, 1996-2018'. [Online] Available from: http://data.uis.unesco.org/ [Accessed on 3 November 2020].

Figure S1.12 Legatum Institute (2020), 'The Legatum Prosperity Index 2020'. [Online] Available from: https://www.prosperity.com/all-countries [Accessed on 25 January 2021].

Figure S1.13 Department of Statistics Malaysia (DOSM) (2020), 'Household Income & Basic Amenities Survey Report 2019'. [Online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=120&bul_id=TU00TmRhQ1N5TUxHVWN0T2VjbXJYZz09&menu_id=amVoWU54UTl0a21NWmdhMjFMMWcyZz09

Figure S1.14 Ida Lim, (2020), 'Statistics Dept: Malaysia's New Poverty Line Income is RM2,208, Over 400k Households Considered Poor', *Malay Mail*.

Figure S1.15 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure S1.16 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure S1.17 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure S1.18 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure S1.19 Knoema (N.D.), 'Malaysia - Gross National Income Per Capita In Current Prices', National Accounts. [Online] Available from: https://knoema.com/atlas/Malaysia/topics/Economy/National-Accounts-Gross-National-Income/GNI-per-capita [Accessed on 7 January 2021].

Figure S1.20 World Bank (2020a), 'Data Bank – Wealth Account'. Available from: https://databank.worldbank.org/source/wealth-accounts# [Accessed on 17 November 2020].

Chapter 2 – Three Decades of STI Evolution

1. Academy of Sciences Malaysia (ASM), (2018), Science Outlook 2017: Converging Towards Progressive Malaysia 2050, Kuala Lumpur, Academy of Sciences Malaysia.

2. Alamgir, M., Campbell, M.J., Sloan, S., Engert, J., Word, J. and Laurance, W.F., (2020), 'Emerging challenges for sustainable development and forest conservation in Sarawak, Borneo', *PloS one*, vol. 15, no. 3, p.e 0229614.

3. ASEAN Trade Repository (.), MFN Tariffs (WTO). [online] Available from: https://atr.asean.org/read/mfn-tariffs-wto/50#:~:text=MFN%20tariffs%20are%20specific%20tariff,are%20transposed%20into%20domestic%20legislation [Accessed on 13 April 2021].

4. Asian Development Bank (ADB), (1998), ADB Annual Report 1998, ADB. Available from: https://www.adb.org/sites/default/files/institutional-document/31333/ar1998.pdf

5. Borneo Today (2016), 'Sabah Fisheries Department Willing to Develop Tagal System in Sarawak', 12 October [online]. Available from: https://www.borneotoday.net/sabah-fisheries-department-willing-to-develop-tagal-system-in-sarawak/ [Accessed on 13 April 2021].

6. D. Lathrop and L. Ruma (2010), 'Open Government: Collaboration, Transparency, and Participation in Practice', *O'Reilly Media*, 1st edition, ISBN: 978-0-596-80435-0.

7. DoctorOnCall (2021), 'About Us'. [online] Available from: https://www.doctoroncall.com.my/ [Accessed on 13 April 2021].

8. Dosi, G., Freeman, C., Nelson, R., Silverberg, G., and Soete, L. (1988), 'Technical Change and Economic Theory', *Laboratory of Economics and Management*, Sant'Anna School of Advanced Studies, Pisa, Italy. Available from: http://www.lem.sssup.it/WPLem/files/dosietal_1988_outline.pdf

9. e-estonia (2021), 'KSI Blockchain - e-Estonia'. [online] Available from: https://e-estonia.com/solutions/security-and-safety/ksi-blockchain/ [Accessed on 6 April 2021].

10. Ellwanger and Chies (2021), 'Zoonotic spillover: Understanding basic aspects for better prevention', *Genetics and molecular biology*, 44(1 Suppl 1), e20200355. https://doi.org/10.1590/1678-4685-GMB-2020-0355.

11. Halim, A.A., Othman, N., Ismail, S.R., Jawan, J.A. and Ibrahim, N.N. (2012), 'Indigenous knowledge and biodiversity conservation in Sabah, Malaysia', *International Journal of Social Science and Humanity*, vol. 2, No. 2, pp. 159-163.

12. Human Resource Development Corporation (HRD Corp) (2021), 'e-LATiH'. [online] Available from: https://elatih.hrdcorp.gov.my/ [Accessed on 13 April 2021].

13. International Work Group for Indigenous Affairs (IWGIA) (2020), 'Indigenous People 2020: Malaysia'. [online] Available from: https://www.iwgia.org/en/malaysia/3605-iw-2020-malaysia.html [Accessed on 10 April 2021].

14. Jacinta Tangil, Asmiaty Amat (2020), 'Kearifan Tempatan dalam Sistem Bombon oleh Masyarakat Kadazandusun di Kiulu, Tuara, Sabah', *Malaysian Journal of Social Sciences and Humanities* (MJSSH), vol. 5, No. 2, pp. 77–86.

15. Jephrin Z.W, Seiichi E., Arthur B.S. (2009), 'Towards Sustainable Community-based Fishery Resource Management: The Tagal System of Sabah, Malaysia', *Fish for the People*, Vol. 07, No. 2.

16. Keesing and Ostfeld (2021), 'Impacts of biodiversity and biodiversity loss on zoonotic diseases', *National Academy of Sciences*, vol. 118, no. 17.

17. Kementerian Tenaga dan Sumber Asli (KeTSA) (2020), 'Malaysia Biodiversity Information System (MyBIS) – About'. [online] Available from: https://www.mybis.gov.my/one/articledetail.php?menu=10&art=15 [Accessed on 12 April 2020].

18. King, A. and Schneider, B. (1991), 'The First Global Revolution: A Report by the Council of The Club of Rome Paperback', 1st edition, *Pantheon Books.*

19. Knowledge Resources for Science Technology Excellence Malaysia (KRSTEMY) (2021), 'Modules'. [online] Available from: https://krste.my/ [Accessed on 13 April 2021].

20. Macháček, V. and Srholec, M. (2021), 'Predatory publishing in Scopus: Evidence on cross-country differences', *Scientometrics*, 126, 1897–1921. https://doi.org/10.1007/s11192-020-03852-4

21. Malaysian Administrative Modernisation and Management Planning Unit (MAMPU), (2021), 'Whole of Government'. [Accessed on April 2021]

22. Malaysia Automotive Robotics and IoT Institute (MARii) (2021a), 'MARii introduces MARiiKERJA – A digital platform for youth employment in industry'. [online] Available from: http://www.marii.my/post/marii-introduces-mariikerja-a-digital-platform-for-youth-employment-in-industry [Accessed on 9 April 2021].

23. Malaysia Automotive Robotics and IoT Institute (MARii) (2021b), 'Program Industry-Led Professional Certificate (IPC)'. [online] Available from: https://www.mariikerja.my/ [Accessed on 13 April 2021].

24. Malaysia Digital Economy Corporation (MDEC) (2021a), 'About Us'. [online] Available from: https://mdec.my/go-ecommerce/about/ [Accessed on 13 April 2021].

25. Malaysia Digital Economy Corporation (MDEC) (2021b), 'eRezeki'. [online] Available from: https://mdec.my/erezeki [Accessed on 13 April 2021].

26. Malaysia Digital Economy Corporation (MDEC) (2021c), 'Global Online Workforce'. [online] Available from: https://mdec.my/glowmalaysia [Accessed on 13 April 2021].

27. Malaysia External Trade Development Corporation (MATRADE) (2021), 'MyExport'. [online] Available from: https://myexport.matrade.gov.my/ [Accessed on 13 April 2021].

28. Malaysia National Trade Repository (2021), 'About MNTR'. [online] Available from: http://mytraderepository.customs.gov.my/en/Pages/an_pg.aspx [Accessed on 9 April 2021].

29. Meadows, D.H., Meadows, D.L., Randers, J. and Behrans, W.W. (1972), 'The Limits to Growth', *Universe Books*, N.Y.

30. Mesarovic, Mihajlo and Pestel, Eduard (1975), 'Mankind at the turning point: the second report to the Club of Rome', *Research and Documentation Papers: Economic Series* No. 1, Hutchinson, London.

31. Minah Sintian (2013), 'Kepercayaan dan Amalan Masyarakat Kadazandusun dalam Pemeliharaan Alam Sekitar'. *Persidangan Intelektual Kebangsaan Malaysia*, pp. 631-642.

32. Ministry of Health (MOH) (2021), 'COVIDNOW in Malaysia'. [online] Available from: https://covidnow.moh.gov.my/ [Accessed on 10 September 2021].

33. Ministry of Science, Technology and Innovation (MOSTI) (2018), 'Pelan Strategik MOSTI 2016-2020', Putrajaya, MOSTI. Available from: https://www.mosti.gov.my/wp-content/uploads/repository/penerbitan/2018/Pelan-Strategik-Kementerian-Sains-Teknologi-Dan-Inovasi-MOSTI-2016-2020.pdf [Accessed on 29 December 2020].

34. Myers, S.S., Gaffikinc, L., Golden, C.D., Ostfeldd, R.S., Redford, K.H., Ricketts, T.H., Turner, W.R., and Osofsky, S.A. (2013), 'Human health impacts of ecosystem alternation', *Proceedings of the National Academic of Sciences of the United States of America (PNAS)*, November, Vol. 110, No. 47, pp. 18753-18760.

35. National Council of Women's Organization (NCWO) (2019), 'The Beijing +25 CSO Parallel Report Malaysia 2019'. [online] Available from: https://ngocsw.org/wp-content/uploads/2019/11/Malaysia-CSO-report.pdf

36. National Institute of Public Administration (INTAN) (2021), 'E-Pembelajaran Sektor Awam (EPSA)'. [online] Available from: https://www.epsa.gov.my/?language=en [Accessed on 13 April 2021].

37. Organisation for Economic Co-operation and Development (OECD) (2018), 'Digital Government Review of Brazil: Towards the Digital Transformation of the Public Sector', *OECD Digital Government Studies*, OECD Publishing, Paris, https://doi.org/10.1787/9789264307636-en

38. O'Reilly, T. (2010), 'Government as a Platform', *innovations*, vol. 6, no. 1, O'Reilly Media, Inc., United States.

39. Porter, M.E. (1991), 'Competition and Strategy', *Harvard Business School Press*.

40. School of International Futures (SOIF) (2021), 'Features of effective systemic foresight in governments around the world', United Kingdom. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/985279/effective-systemic-foresight-governments-report.pdf

41. Schumpeter, J. (1942), 'Capitalism, Socialism, and Democracy', New York, Harper & Bros.

42. Schwab, K. (2016), 'The Fourth Industrial Revolution: what it means, how to respond', World Economic Forum, UK, Penguin. Available from: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

43. Shahriar, S., Chamhuri, S., Ghazali, R. and Chamhuri, N. (2014), 'Prospects of Rural Transformation Centre (RTC) of Malaysia from the Perspective of Inclusive Rural Development', *Current World Environment*, vol. 9, No. 3. Available from: http://www.cwejournal.org/pdf/vol9no3/vol9_no3_639-645.pdf [Accessed on 13 April 2021].

44. Sivanandam, H., Rahim, R., Carvalho, M. and Tan, T. (2020), 'Ministry: Reinstate MyBrain programme', *The Star,* 15 December 2020. [online] Available from: https://www.thestar.com.my/news/nation/2020/12/15/ministry-reinstate-mybrain-programme [Accessed on 23 December 2020].

45. Stern, P.N (2020), 'The Industrial Revolution in World History', 5th Edition, Routledge, New York.

46. The Sentral (2021), 'Sistem e-LATiH HRDF, lebih 5,000 rakyat mendaftar dalam tempoh 24 jam'. [online] Available from: https://www.thesentral.my/2021/02/07/sistem-e-latih-hrdf-lebih-5000-rakyat-mendaftar-dalam-tempoh-24-jam/ [Accessed on 13 April 2021].

47. UN Environmental Programme (2021), 'GOAL 12: Sustainable consumption and production', . [online] Available from: https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-12

References for Figures

Figure 2.3 Academy of Sciences Malaysia (ASM), (2019), 'Malaysia Policy & Master Plan on STI 2021–2030 Study'.

Figure 2.4 Respective websites of State Governments

Figure 2.5 (a) Ministry of Finance Malaysia (MoF) (2018), 'Statistik jumlah pelanggan di UTC seluruh Malaysia mengikut UTC dari tahun 2013 sehingga 2017'. [online] Available from: https://www.data.gov.my/data/ms_MY/dataset/statistik-jumlah-pelanggan-utc-seluruh-malaysia-2013-2017 [Accessed on 12 April 2021].

Kementerian Pembangunan Luar Bandar (KPLB) (2021), 'Pusat Komuniti Desa' Available from: https://www.rurallink.gov.my/pusat-komuniti-desa-pkd/ [Accessed on 12 April 2021].

Figure 2.5 (b) Ministry of Finance Malaysia (MoF) (2018), 'Statistik jumlah pelanggan di UTC seluruh Malaysia mengikut UTC dari tahun 2013 sehingga 2017'. [online] Available from: https://www.data.gov.my/data/ms_MY/dataset/statistik-jumlah-pelanggan-utc-seluruh-malaysia-2013-2017 [Accessed on 12 April 2021].

Figure 2.6 United Nations (UN) (2021), 'E-Government Development Index'. Available from: https://publicadministration.un.org/egovkb/en-us/About/Overview/-E-Government-Development-Index [Accessed on 17 June 2021].

Figure 2.7 Organisation for Economic Co-operation and Development (OECD) (2019), 'Strengthening digital government', *OECD Going Digital Policy Note*, OECD, Paris.

Ojo, A. and Millard, J. (2017), 'Government 3.0 – Next Generation Government Technology Infrastructure and Services', *Public Administration and Information Technology*, vol. 32, Springer International Publishing.

Figure 2.8 (a) Malaysian Science and Technology Information Centre (MASTIC) (2020), 'Gross Expenditure on R&D (GERD), 1992-2018', *National Survey of Research and Development (R&D) in Malaysia*. Data requested from MASTIC (2020).

Ministry of Science, Technology and Innovation (MOSTI) (2020), 'Dasar Sains, Teknologi dan Inovasi Negara 2021-2030', Putrajaya, MOSTI.

Figure 2.8 (b) UNESCO Institute for Statistics (2020), 'GERD as a percentage of GDP, 1996-2018'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 2 November 2020].

Figure 2.9 (a) Malaysian Science and Technology Information Centre (MASTIC) (2020), 'Gross Expenditure on R&D by Sectors, 1992-2018', *National Survey of Research and Development (R&D) in Malaysia*. Data requested from MASTIC (2020).

Figure 2.9 (b) UNESCO Institute for Statistics (2020), 'GERD by Sector Performance, 1996-2018'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 3 November 2020].

Figure 2.10 (a) Malaysian Science and Technology Information Centre (MASTIC) (2020), 'Percentage of GERD by Type of R&D Activities in Malaysia, 1992-2018',*National Survey of Research and Development (R&D) in Malaysia*. Data requested from MASTIC (2020).

Figure 2.10 (b) UNESCO Institute for Statistics (2020), 'GERD by Type of R&D Activities, 1996-2018'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 3 November 2020].

Figure 2.11 UNESCO Institute for Statistics (2020), 'Researchers per thousand labour force (FTE), 1996-2018'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 26 November 2020].

Figure 2.12 (a) Malaysian Science and Technology Information Centre (MASTIC) (2020), 'Total Full Time Equivalent (FTE) Researchers by Sectors, 1992-2018', *National Survey of Research and Development (R&D) in Malaysia*. Data requested from MASTIC (2020).

Figure 2.12 (b) UNESCO Institute for Statistics (2020), Total Full Time Equivalent (FTE) Researchers by Sectors, 1996-2018'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 3 November 2020].

Figure 2.13 Scimago Journal and Country Rank (2020), 'Published Documents by Year, 1996-2019'. [online] Available from: https://www.scimagojr.com/countryrank.php [Accessed on 9 November 2020].

Figure 2.14 SciVal (2020), 'Percentage of Quality Publications in Malaysia and OECD Countries 1996-2019'. [online] Available from: https://www.scival.com/ [Accessed on 29 December 2020].

Figure 2.15 MyIPO Statistics (2021), 'Application and Granted Patents and Utility Innovations, 1986–2020'. [online] Available from: https://www.myipo.gov.my/en/Statistics-application-registration/#toggle-id-1 [Accessed on 1 February 2021].

Figure 2.16 Knowledge Resources for Science Technology Excellence Malaysia (KRSTEMY) (2021), 'Product & Technology Percentage by Organization Type'. [online] Available from: https://krste.my/Statistics/5 [Accessed on 5 March 2021].

Figure 2.17 Scimago Journal and Country Rank (2020), 'Published Documents by Year, 1996-2019'. [online] Available from: https://www.scimagojr.com/countryrank.php [Accessed on 9 November 2020].

WIPO Statistics database (2020), 'Patent Applications, 1996-2018'. [online] Available from https://www3.wipo.int/ipstats/index.htm?tab=patent [Accessed on 16 December 2020].

UNESCO Institute for Statistics (2020f), 'Average GERD per Researcher (FTE), 1996-2018'. [online] Available from http://data.uis.unesco.org/ [Accessed on 16 December 2020].

Figure 2.18 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure 2.19 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

1. Academy of Sciences Malaysia (ASM) (2018), Science Outlook 2017: Converging Towards Progressive Malaysia 2050, Kuala Lumpur, Academy of Sciences Malaysia.

2. Academy of Sciences Malaysia (ASM) (2020), 10-10 Malaysian Science, Technology, Innovation and Economy (MySTIE) Framework: Trailblazing the Way for Prosperity, Societal Well-Being & Global Competitiveness, Kuala Lumpur, Academy of Sciences Malaysia.

3. Academy of Sciences Malaysia (ASM) (2020b), (Embargoed) An Impact Study on National Biotechnology Policy (DBN 2005-2020), Kuala Lumpur, Academy of Sciences Malaysia.

4. Ahmed, P. and Shepherd, C.D. (2010), 'Innovation Management: Context, Strategies, Systems and Processes', *Prentice Hall*, Essex UK, Pearson, 1st edition.

5. Ariff, M. (2008), 'Comment on Income Inequality in Malaysia', *Asian Economic Policy Review*, vol. 3 no. 1, pp. 133–134.

6. Arujanan, M., and Singaram, M. (2018), 'The biotechnology and bioeconomy landscape in Malaysia', *New biotechnology*, 40(Pt A), pp. 52–59. Available from: https://pubmed.ncbi.nlm.nih.gov/28668584/ [Accessed on 22 August 2021].

7. BBC Research (2020), 'Agricultural Biotechnology: Emerging Technologies and Global Markets'. Available from: https://www.bccresearch.com/market-research/biotechnology/agricultural-biotechnology-markets-report.html [Accessed on 2 September 2021].

8. Britannica, T. Editors of Encyclopaedia (2021), 'Biotechnology', *Encyclopaedia Britannica*. Available from: https://www.britannica.com/technology/biotechnology [Accessed on 22 August 2021].

9. Chang, J. (2021), '40 Gig Economy Statistics You Must Learn: 2021 Market Share & Data Analysis', *Finances Online*. Available from: https://financesonline.com/gig-economy-Statistics/ [Accessed on 18 August 2021].

10. Ciera, X., Mason, A.D., de Nicola, F., Kuriakose, S., Mare, D.S., Tran, T.T. (2021), 'The Innovation Imperative for Developing East Asia', The World Bank, Washington, D.C. [online] Available from: https://openknowledge.worldbank.org/handle/10986/35139

11. Dardak, R.A. (2020), 'Addressing Food Security in Challenging Times', *Food and Fertilizer Technology Center for the Asian and Pacific Region*. [online] Available from: https://ap.fftc.org.tw/article/2634 [Accessed on 25 July 2021].

12. Dawood, S.R.S., Ghazali, S. and Samat, N. (2019), 'Digital Divide and Poverty Eradication in the Rural region of the Northern Peninsular Malaysia', *Indonesian Journal of Geography*, vol. 51 no. 2, pp. 172-182.

13. De Stefano, V. (2016), 'The Rise of the "Just-in-Time Workforce": On-Demand Work, Crowdwork, and Labour Protection in the "Gig Economy"', Geneva, International Labour Organization.

14. Department of Commerce, USA (2020a), 'Malaysia Commercial Guide – Agriculture Sector'. [online] Available from: https://www.trade.gov/knowledge-product/malaysia-agricultural-sector [Accessed on 25 July 2021].

15. Department of Commerce, USA (2020b), 'South Korean – Information and Communication Technology'. [online] Available from: https://www.trade.gov/country-commercial-guides/south-korea-information-and-communication-technology [Accessed on 25 July 2021].

16. Department of Commerce, USA (2020c), 'Taiwan – Information and Telecommunication Technology'. [online] Available from: https://www.trade.gov/country-commercial-guides/taiwan-information-and-telecommunications-technology [Accessed on 25 July 2021].

17. Department of Statistics Malaysia (DOSM) (2019b), 'Malaysia Digital Economy 2018'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/pdfPrev&id=UERrcjExbnRKd3NwQ0Y3V011RngyQT09#:~:text=In%202018%2C%20contribution%20of%20digital,cent%20(2017%3A%209.8%25) [Accessed on 11 July 2021].

18. Department of Statistics Malaysia (DOSM) (2020a), 'Information and Communication Technology Satellite Account 2019'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=319&bul_id=cHBrejFuMlVMdFZzc2VrNjlIZEZQUT09&menu_id=TE5CRUZCblh4ZTZMODZIbmk2aWRRQT09 [Accessed on 25 July 2021].

19. Department of Statistics Malaysia (DOSM) (2020b), 'Household Income & Basic Amenities Survey Report 2019'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=120&bul_id=TU00TmRhQ1N5TUxHVWN0T2VjbXJYZz09&menu_id=amVoWU54UTl0a21NWmdhMjFMMWcyZz09 [Accessed on 25 July 2021].

20. Department of Statistics Malaysia (DOSM) (2021b), 'Key Statistics of Labour Force in Malaysia', March 2021. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=124&bul_id=Ty9BVWN6cUtkYnhrK0ZpMCtCL2NPQT09&menu_id=Tm8zcnRjdVRNWWlpWjRlbmtlaDk1UT09 [Accessed on 25 July 2021].

21. Economic Planning Unit (EPU) (2016a), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

22. Economic Planning Unit (EPU) (2016b), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 2)', Putrajaya, Prime Minister's Department.

23. Eden, A.H., Moor, J.H., Soraker, J.H. and Steinhart, E. (Editors) (2012), 'Singularity Hypothesis: A Scientific and Philosophical Assessment', Springer-Verlag Berlin Heidelberg.

24. Fortune Business Insight (N.D.), 'Bioenergy Market Size, Share & COVID-19 Impact Analysis, By Product Type (Solid Biomass, Liquid Biofuel, Biogas, and Others), By FeedStock (Agriculture Waste, Wood and Woody Biomass, Solid Waste and Others), By Application (Power Generation, Heat Generation, Transportation, and Others), and Regional Forecast, 2020-2027'. Available from: https://www.fortunebusinessinsights.com/bioenergy-market-103296 [Accessed on 2 September 2021].

25. Gauri, P. and Eerden, J.V. (2019), 'What the Fifth Industrial Revolution is and why it matters'. World Economic Forum, The European Sting. [online] Available from: https://europeansting.com/2019/05/16/what-the-fifth-industrial-revolution-is-and-why-it-matters/

26. Harris, R. (2021), 'Malaysia's Multimedia Super Corridor an IFIP WG 9.4 Position Paper'. IFIP WG 9.4 and Faculty of Information Technology UNIMAS. [Online] Available from: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.202.5101&rep=rep1&type=pdf

27. Hassan, A.A., Ngah, I., and Applanaidu, S.D. (2018), 'Agricultural Transformation in Malaysia: The Role of Smallholders and Area Development', *Conference: Agricultural Transformation and Inclusive Growth: The Malaysian Experience*, World Bank. Available from: https://documents1.worldbank.org/curated/en/617611574179512389/pdf/Agricultural-Transformation-and-Inclusive-Growth-The-Malaysian-Experience.pdf

28. Ida Lim (2020), 'Despite CMCO 2.0, BNM keeps Malaysia's 2020 economic growth at -3.5pc to -5.5pc as restrictions less strict than MCO', *Malay Mail*, 13 November [online]. Available from: https://www.malaymail.com/news/malaysia/2020/11/13/despite-cmco-2.0-bnm-keeps-malaysias-2020-economic-growth-at-3.5pc-to-5.5pc/1922323 [Accessed on 25 July 2021].

29. International Labour Organization (ILO) (2020a), 'TRIANGLE in ASEAN Quarterly Briefing Note, Malaysia, July–December 2020'. [online] Available from: https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/genericdocument/wcms_614381.pdf [Accessed on 25 July 2021].

30. Invest Selangor (2015), 'Selangor Industrial Master Plan', Selangor, *Monash University Malaysia*. [online] Available from: https://www.investselangor.my/Selangor-Industrial-Master-Plan-Study/

31. Ishak, S. (2000), 'Economic Growth and Income Inequality in Malaysia, 1971–95', *Journal of the Asia-Pacific Economy*, vol. 5(1/2), pp. 112–124.

32. Jobstreet.com (2021), 'Gig economy: The rise of freelancers & its impact on HR'. [online] Available from: https://www.jobstreet.com.my/en/cms/employer/gig-economy-rise-freelancers-impact-hr/ [Accessed on 21 July 2021].

33. Last, C. (2018), 'Cosmic Evolutionary Philosophy and a Dialectical Approach to Technological Singularity', *Information*, vol. 9, no. 78, doi:10.3390//info9040078.

34. Lee, H.A., and Khalid, M.A. (2020), 'Is Inequality Really Declining in Malaysia', *Journal of Contemporary Asia*, Vol. 50, no. 1, pp. 14–35.

35. Lee, M.N.N. (2004), 'Global Trends, National Policies and Institutional Responses: Restructuring Higher Education in Malaysia', *Educational Research for Policy and Practice*, vol. 3, no. 1, pp. 31–46, doi:10.1007/s10671-004-6034-y.

36. Liew, E.J.Y., Vaithilingam, S. and Nair, M. (2014), 'Social Network Technology and Socioeconomic Behaviour', *ICT Strategic Review 2014/2015*, PIKOM and MOSTI, Malaysia.

37. Liu, K.C., and Racherla, U.S. (2019), 'Innovation, Economic Development and Intellectual Property in Indian and China', *Springer Open*. [online] Available from: https://library.oapen.org/bitstream/id/5a9553c0-77b1-422d-98c1-cce8c47079fd/1006887.pdf

38. Ministry of Finance Malaysia (MoF) (2021a), 'Tightened MCO 3.0 to have 1.0 pct impact on GDP – Tengku Zafrul'. [online] Available from: https://www.mof.gov.my/en/news/press-citations/tightened-mco-3-0-to-have-1-0-pct-impact-on-gdp-tengku-zafrul

39. Ministry of Finance Malaysia (MoF) (2021b), '2021 Fiscal Outlook and Federal Government Revenue Estimates'. [online] Available from: http://belanjawan2021.treasury.gov.my/pdf/revenue/2021/fiscal-outlook-2021.pdf [Accessed on 25 July 2021].

40. Ministry of International Trade and Industry (MITI) (1986), 'First Industrial Master Plan for National Industrial Policy 1986–1994', Kuala Lumpur, MITI.

41. Ministry of International Trade and Industry (MITI) (1995), 'Second Industrial Master Plan for National Industrial Policy 1995–2005', Kuala Lumpur, MITI.

42. Ministry of International Trade and Industry (MITI) (2006), 'Third Industrial Master Plan for National Industrial Policy 2006-2020', Kuala Lumpur, MITI.

43. Nair, M. (2009), 'Language proficiency and affinity to the information society: challenges and opportunities for rural society', *ICT Strategic Review 2009/2010: Innovation, the way forward*, PIKOM and MOSTI, Malaysia, Chapter 10, pp. 141-160.

44. Nair, M. (2010), 'The E-Commerce Ecology: Leapfrogging Strategies for Malaysia', *ICT Strategic Review 2010/2011*, PIKOM and MOSTI, Malaysia, Chapter 12, pp. 193-211.

45. Nair, M. (2011), 'Inclusive innovation and sustainable development: leap-frogging strategies to a high-income economy', *ICT Strategic Review 2011/2012*, PIKOM and MOSTI, Malaysia.

46. Nair, M. and Vaithilingam, S. (2012), 'Innovative use of ICT among urban-poor communities: challenges and opportunities', *ICT Strategic Review 2012/2013*, PIKOM and MOSTI, Malaysia, pp. 181-191.

47. Nair, M. and Vaithilingam, S. (2013a), 'Broadband diffusion, innovative capacity and sustainable development: lesson for Malaysia', *ICT Strategic Review 2013/2014*, PIKOM and MOSTI, Malaysia.

48. Nair, M. and Vaithilingam, S. (2013b), 'Leap-frogging the urban-poor to a high-income economy: a case study from a developing country', *Journal of Emerging Economies and Islamic Research*, Vol. 1, no. 2, pp. 1-24.

49. Nair, M., Ahmed, P., Lee, D.L.L.W. (2019), 'Malaysian Business Sentiment 2019/2020: A Perspective from Malaysian Executives', Monash University Malaysia. [online] Available from: https://mon.clients.squiz.net/__data/assets/pdf_file/0005/2078033/Monash-Business-Sentiment-Report-2019-2020.pdf

50. Nair, M., Ahmed, P., Vaithilingam, S., Narayanan, P., Chan, A.W., Lee, D.L.L.W., Qing, Y.H., Lim, C.C., Lee, W.J., and Tang, S. (2020), 'Malaysian Business Sentiment 2020/2021: A Perspective from Malaysian Executives', Monash University Malaysia. [online] Available from: https://www.monash.edu.my/__data/assets/pdf_file/0009/2432277/MSH-343-Monash-Business-Sentiment-Brochure-2020-FA-161220-For-Web.pdf

51. Nair, M., Han, G.-S., Lee, H., Goon, P., Lee, P.A., Muda, R. (2009), 'Affinity of rural society to the information economy: an exploratory analysis from Malaysia', *Economic Bulletin*, Vol. 10, December, pp. 101-133.

52. Nair, M., Han, G.-S., Lee, H., Goon, P., Muda, R. (2010), 'Determinants of the digital-divide in rural communities of a developing country: the case of Malaysia', *Development and Society*, pp. 139-162.

53. Popkova, Elena G., Ragulina, Julia V., and Bogoviz, Aleksei Vl. (2019), 'Industry 4.0: Industrial Revolution of the 21st Century', *Studies in Systems, Decision and Control*, Springer International Publishing, vol. 169, no. 1, doi:10.1007/978-3-319-94310-7.

54. Portulans Institute (2019), 'Network Readiness Index 2019: Towards a Future-Ready Society', Washington D.C., USA. [online] Available from: https://networkreadinessindex.org/wp-content/uploads/2020/03/The-Network-Readiness-Index-2019-New-version-March-2020.pdf [Accessed on 25 July 2021].

55. Potapov, A. (2018), 'Technological Singularity: What Do We Really Know?' *Information*, vol. 9, no. 82, doi:10.3390/info9040082.

56. Prime Minister's Office (PMO) (2021), 'Speech by The Prime Minister'. [online] Available from: https://www.pmo.gov.my/speech/

57. Prime Minister's Office of Malaysia (1981), Look East Policy.

58. PwC, Rabobank and Temasek (2019), 'The Asian Food Challenge: Harvesting the Future', *Asia-Pacific Agri-Food Innovation Week*, Singapore. [online] Available from: https://www.pwc.co.nz/industry-expertise/global-food-supply-and-integrity/afc-report-112019.pdf

59. Ragayah, H. (2008), 'Income Inequality in Malaysia', *Asian Economic Policy Review*, vol. 3 (1), pp. 114–132.

60. REFSA (2020), 'Conceptualizing the Gig Economy in Malaysia'. [online] Available from https://refsa.org/wp-content/uploads/2020/06/REFSA-Brief-Conceptualising-the-Gig-Economy-in-Malaysia.pdf [Accessed on 21 July 2021].

61. Schwab, K. (2016), 'The Fourth Industrial Revolution: what it means, how to respond', World Economic Forum, UK, Penguin. Available from: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

62. Statista (2021), 'Import Value of Food in Malaysia from 2012 to 2019'. [online] Available from: https://www.statista.com/Statistics/795515/import-value-of-food-malaysia/ [Accessed on 25 July 2021].

63. Verified Market Research (2019), 'Global Red Biotechnology Market By Product Type, By Application, By End User, Competitive Landscape, Geographic Scope And Forecast'. Available from: https://www.verifiedmarketresearch.com/product/red [Accessed on 7 September 2021].

64. World Bank (2019), 'Agriculture Transformation and Inclusive Growth: The Malaysian Experience, November 2019'. [online] Available from: https://documents1.worldbank.org/curated/en/617611574179512389/pdf/Agricultural-Transformation-and-Inclusive-Growth-The-Malaysian-Experience.pdf

References for Figures

Figure 3.2 Maddison Project Database (2020), 'Maddison Project Working Paper', nr. 10. [online] Available from: www.ggdc.net/maddison.

World Bank (2020), 'GDP (constant 2010 US$) – Malaysia', *World Bank national accounts data, and OECD National Accounts data files*. [online] Available from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=MY

International Monetary Fund (IMF) (2021), 'World Economic Outlook Database, April 2021'. [online] Available from: https://www.imf.org/en/Publications/WEO/weo-database/2021/April

Figure 3.3 World Bank (2020), 'GDP (constant 2010 US$) – Malaysia', *World Bank national accounts data, and OECD National Accounts data files*. [online] Available from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=MY

International Monetary Fund (IMF) (2021), 'World Economic Outlook Database, April 2021'. [online] Available from: https://www.imf.org/en/Publications/WEO/weo-database/2021/April

Figure 3.4 Department of Statistics Malaysia (DOSM) (2021a), 'National Accounts: GDP by Kind of Economic Activity at Constant Prices (Various Issues) 1990-2020'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09 [Accessed on 25 July 2021].

Figure 3.5 National Graduate Institute for Policy Studies (GRIPS) (2006), 'Industrial Policy Formulation in Thailand, Malaysia and Japan', *Vietnam Development Forum*, Chapter 4, pp. 45-60. [online] Available from: https://www.grips.ac.jp/vietnam/VDFTokyo/Doc/TMJreportEN.pdf [Accessed on 18 April 2021].

Figure 3.6 Feenstra, R., Robert I. and Marcel P. T. (2015), 'The Next Generation of the Penn World Table', American Economic Review 2015, vol. 105(10), pp. 3150-3182. [Online] Available from: https://www.rug.nl/ggdc/productivity/pwt/?lang=en [Accessed on 25 July 2021].

Figure 3.7 - Figure 3.8 Department of Statistics Malaysia (DOSM) (2021), 'Key Statistics of Labour Force in Malaysia, May 2021', Table 6. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=124&bul_id=a09WTHNBQVpVcHFiZkNTaEZnTHF3UT09&menu_id=Tm8zcnRjdVRNWWlpWjRlbmtlaDk1UT09 [Accessed on 25 July 2021].

Figure 3.9 International Labour Organization (ILO) (2020), 'ILO Modelled Estimates, November 2020', *ILOSTAT Statistics on Labour Productivity*. [online] Available from: https://ilostat.ilo.org/topics/labour-productivity/ [Accessed on 25 July 2021].

Figure 3.10 Feenstra, R., Robert I. and Marcel P. T. (2015), 'The Next Generation of the Penn World Table', *American Economic Review 2015*, vol. 105(10), pp. 3150-3182. [Online] Available from: https://www.rug.nl/ggdc/productivity/pwt/?lang=en [Accessed on 25 July 2021].

Figure 3.11 UNESCO Institute for Statistics (2021), 'GERD performed by Business Enterprise (in '000 PPP$, constant prices - 2005), Researchers (FTE) in Business Enterprise % and GERD in '000 PPP$ (in constant prices - 2005)'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 7 August 2021].

Figure 3.12 UNESCO Institute for Statistics (2020), 'GERD as a percentage of GDP, 1996-2018'. [online] Available from: http://data.uis.unesco.org/ [Accessed on 2 November 2020].

WIPO Statistics database (2020), 'Patent Applications, 1996-2018'. [online] Available from https://www3.wipo.int/ipstats/index.htm?tab=patent [Accessed on 16 December 2020].

Figure 3.13 - Figure 3.14 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure 3.15 - Figure 3.16 Economic Planning Unit (EPU) (2016), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

Figure 3.17 - Figure 3.19 Department of Statistics Malaysia (DOSM) (2021), 'Selected Agricultural Indicators, Malaysia (Various Issues) 2000-2020'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=72&bul_id=RXVKUVJ5TitHM0cwYWxlOHcxU3dKdz09&menu_id=Z0VTZGU1UHBUT1VJMFlpaXRRR0xpdz09 [Accessed on 25 July 2021].

Figure 3.20 Economic Planning Unit (EPU) (2016), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

Figure 3.21 Economic Planning Unit (EPU) (2016), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

Figure 3.22 - Figure 3.23 Economic Planning Unit (EPU) (2016), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

Figure 3.24 Department of Statistics Malaysia (DOSM) (2021), 'National Accounts: GDP by Kind of Economic Activity at Constant Prices (Various Issues) 1990-2020'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09 [Accessed on 25 July 2021].

Figure 3.25 - Figure 3.29 Economic Planning Unit (EPU) (2016), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)'

Figure 3.30 Department of Statistics Malaysia (DOSM) (2021), 'National Accounts: GDP by Kind of Economic Activity at Constant Prices (Various Issues) 1990-2020'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09 [Accessed on 25 July 2021].

Figure 3.31 - Figure 3.35 Economic Planning Unit (EPU) (2016), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

Figure 3.36 - Figure 3.40 Department of Statistics Malaysia (DOSM) (2020), 'Household Income & Basic Amenities Survey Report 2019'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=120&bul_id=TU00TmRhQ1N5TUxHVWN0T2VjbXJYZz09&menu_id=amVoWU54UTl0a21NWmdhMjFMMWcyZz09 [Accessed on 25 July 2021].

Figure 3.41 - Figure 3.43 Department of Statistics Malaysia (DOSM) (2021), 'Salaries & Wages Survey Report, Malaysia, 2020'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=157&bul_id=VDRDc0pGZHpieEUwMDNFWHVHSnpkdz09&menu_id=Tm8zcnRjdVRNWWlpWjRlbmtlaDk1UT09 [Accessed on 25 July 2021].

Figure 3.44 Nair, M. (2011), 'Inclusive innovation and sustainable development: leap-frogging strategies to a high-income economy', *ICT Strategic Review 2011/2012*, PIKOM and MOSTI, Malaysia.

Figure 3.45 - Figure 3.46 Department of Statistics Malaysia (DOSM) (2021), 'National Accounts: GDP by Kind of Economic Activity at Constant Prices (Various Issues) 1990-2020'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09 [Accessed on 25 July 2021].

Figure 3.47 - Figure 3.48 Department of Statistics Malaysia (DOSM) (2020), 'Main Findings of Special Survey 'Effects of COVID-19 on the Economies and Companies/Business Firms' - Round 1'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cone&menu_id=RkJtOThJSlBJNStOV1liM1JsKzdZUT09 [Accessed on 25 July 2021].

Figure 3.49 - Figure 3.50 Department of Statistics Malaysia (DOSM) (2021), 'Key Statistics of Labour Force in Malaysia', May 2021. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=124&bul_id=a09WTHNBQVpVcHFiZkNTaEZnTHF3UT09&menu_id=Tm8zcnRjdVRNWWlpWjRlbmtlaDk1UT09 [Accessed on 25 July 2021].

1. Ali Salman (2018), 'Create or Nurture? Lessons from Cyberjaya: Malaysia's Promised Silicon Valley', *Institute for Democracy and Economic Affairs*, Policy Ideas No. 50, July 2018. Available from: http://ideas.org.my/wp-content/uploads/2018/07/PI50-Lessons-from-Cyberjaya-v3.pdf [Accessed on 18 April 2021].

2. Awang, A. (2001), 'The Cyber Cities of Malaysia: Realising the Vision', *CTBUH 2001 6th World Congress*, Melbourne, Council on Tall Buildings and Urban Habitat (CTBUH). Available from: https://global.ctbuh.org/resources/papers/download/1675-the-cyber-cities-of-malaysia-realising-the-vision.pdf

3. Barrock, J. (2021), 'Cabinet may discuss cabotage policy this week', *The Edge Markets Malaysia*, 2 August [online]. Available from: https://www.theedgemarkets.com/article/cabinet-may-discuss-cabotage-policy-week [Accessed on 19 August 2021].

4. Chooi, J.T.K. (2009), 'Multimedia Super Corridor Malaysia: Public-private R&D collaboration', *Tech Monitor*. Available from http://www.techmonitor.net/tm/images/7/73/09sep_oct_sf4.pdf [Accessed on 18 April 2021].

5. Department of Statistics Malaysia (DOSM) (2016), 'Economic Census 2016', DOSM.

6. Economic Planning Unit (EPU) (1996), 7th Malaysia Plan 1996-2000, pp. 467, Putrajaya, Economic Planning Unit.

7. Economic Planning Unit (EPU) (2001), 8th Malaysia Plan 2001-2005, Putrajaya, Economic Planning Unit.

8. Economic Planning Unit (EPU) (2011), 10th Malaysia Plan 2011-2015, Putrajaya, Economic Planning Unit.

9. Economic Planning Unit (EPU) (2021), 'Malaysia Digital Economy Blueprint', Putrajaya, Economic Planning Unit.

10. Edna Reid (1998), 'Malaysia's Multimedia Super Corridor and Roles of Information Professionals', *Purdue University Library Services E-Pubs*. [online] Available from: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.990.7710&rep=rep1&type=pdf#:~:text=Some%20mega%2D%20projects%20in%20Asia,India's%20Bangalore%20Information%20Technology%20Park [Accessed on 18 April 2021].

11. Federation of Malaysian Manufacturers (FMM) (2016), 'ICT Adoption Survey'.

12. Huff, Toby E. (2002), 'Malaysia's Multimedia Super Corridor and Its First Crisis of Confidence', *Asian Journal of Social Science*, Leiden, Koninklijke Brill NV. Available from: https://brill.com/view/journals/ajss/30/2/article-p248_5.xml?language=en [Accessed on 18 April 2021].

13. Malaysia Communication and Multimedia Commission (MCMC) (2007), 'Industry Performance Report 2006', pp. 46. [online] Available from: https://www.mcmc.gov.my/skmmgovmy/files/65/6554169b-4a31-426b-8112-f6002e86eab4/files/assets/basic-html/page-46.html# [Accessed on 18 April 2021].

14. Ministry of International Trade and Industry (MITI) (2019), 'Cabotage Policy', *Glossary*. Available from: https://www.miti.gov.my/index.php/glossary/term/184 [Accessed on 19 August 2021].

15. Multimedia Development Corporation (MDEC) (2011), 'MSC Malaysia Annual Industry Report 2010-2011'.

16. Multimedia Development Corporation (MDEC) (2021), 'MSC Malaysia Status'. [online] Available from https://mdec.my/what-we-offer/msc-malaysia/ [Accessed on 15 June 2021].

17. Tufail, A. (2006), 'Factors Leading to Decentralization of Office Firms: The Case of Multimedia Super Corridor', Universiti Teknologi Malaysia. [online] Available from: http://eprints.utm.my/id/eprint/3203/1/MuhammadAsimTufailMFAB2006.pdf [Accessed on 18 April 2021].

18. TwentyTwo13 (2019), 'Over 10,000 schools in limbo over Internet connection in 2020'. [online] Available from: https://twentytwo13.my/issues/over-10000-schools-in-limbo-over-internet-connection-in-2020/ [Accessed on 18 April 2021].

1. Abadzi, H (2003), 'Adult Literacy: A Review of Implementation Experience (English)', *Operations Evaluation Department (OED) Working Paper Series*, Washington, D.C.: World Bank Group. Available from: http://documents.worldbank.org/curated/en/111821468330039348/Adult-literacy-a-review-of-implementation-experience.

2. Academy of Sciences Malaysia (2017), 'Addressing the Global Health Challenge of Obesity in Malaysia Workshop Report', Kuala Lumpur.

3. Agensi Inovasi Malaysia (2017), 'Innovating Malaysia's Social Sector', *Social Progress Assessment*, Malaysia.

4. Ahmad, M. H., Selamat R., Salleh, R., Majid, N. L. A., Zainuddin, A. A., Bakar W. A. M. A., and Aris, T. (2020), 'Food Insecurity Situation in Malaysia: Findings from Malaysian Adult Nutrition Survey (MANS) 2014', *Malaysian Journal of Public Health Medicine*, vol. 20, no. 1, pp. 167-174. doi: 10.37268/mjphm/vol.20/no.1/art.553.

5. AIA Malaysia (2020), 'Malaysia's Healthiest Workplace by AIA Vitality 2018 Survey'. Available from: https://healthiestworkplace.aia.com/malaysia/eng/ Accessed on 10 Sep 2020]

6. Alamgir, M., Campbell, M.J., Sloan, S., Engert, J., Word, J. and Laurance, W.F., (2020), 'Emerging Challenges for Sustainable Development and Forest Conservation in Sarawak, Borneo', PloS one, vol. 15, no. 3, pp. 0229614.

7. Ali, J. M. (2019), 'Unlocking the Economy through Technical & Vocational Education & Training', *Proceeding of The Malaysian TVET Forum 2019*, Kingsley Strategic Institute.

8. American Psychiatric Association Official Website. Available from: https://www.psychiatry.org/ [Accessed on 10 Sep 2020]

9. Amin, M and Zarka, A. (2018), 'Female Top Managers in Malaysia', *Enterprise Note*, vol. 36, The World Bank.

10. Amin, M.M., Abas, N.H., Shahidan, S., Rahmat, M.H., Suhaini, N.A., Nagapan, S. and Rahim, R.A. (2017), 'A Review on The Current Issues and Barriers of Industrialised Building System (IBS) Adoption in Malaysia's Construction Industry', *In IOP Conference Series: Materials Science and Engineering*, vol. 271, no. 1, pp. 012031, IOP Publishing.

11. Aun, L. H. (2020), 'Work and Wages of Malaysia's Youth: Structural Trends and Current Challenges. ISEAS Perspective', 2020, vol. 98. Available from: https://www.iseas.edu.sg/wp-content/uploads/2020/08/ISEAS_Perspective_2020_98.pdf

12. Australian Academy of Science (2021), 'Impact of COVID-19 on Women in the STEM Workforce', Asia-Pacific.

13. Azreen H. (2021), '468 Suicide Cases In The First Five Months of 2021', *The Malaysian Reserve*, 1 July [Online]. Available from: https://themalaysianreserve.com/2021/07/01/468-suicide-cases-in-the-first-five-months-of-2021/ [Accessed on 1/7/2021]

14. Bank Negara Malaysia (BNM) (2018), 'Annual Report 2018'.

15. Bank Negara Malaysia (BNM) (2019a), 'Food Import and the Exchange Rate: More Than Meets the Eye', *3rd Quarter 2019 Bulletin*.

16. Bank Negara Malaysia (BNM) (2019b), 'Annual Report 2019'.

17. BERNAMA (2020), 'Changing Consumer Attitudes Towards Water'. Available from: https://bernama.com/en/features/news.php?id=1816022#:~:text=Based%20on%20statistics%20from%20the,1.5%2Dlitre%20capacity%20each)

18. Berry, C., Michelson, D., Othman, E., Tan, J. C., Gee, B., Hodgekins, J., Byrne, R.E., Ng, A.L.O., Marsh, N.V., Coker, S. and Fowler, D. (2018), 'Views of Young People in Malaysia on Mental Health, Help-Seeking And Unusual Psychological Experiences'. *Early Intervention in Psychiatry*, vol. 14, no. 1, pp. 115-123. Available from: https://doi.org/10.1111/eip.12832

19. Bloomberg Tax (2021), 'Recovering from Covid-19: Tax Measures and Incentives in Malaysia', 1 Jul 2021 [Online]. Available from: https://news.bloombergtax.com/daily-tax-report-international/recovering-from-covid-19-tax-measures-and-incentives-in-malaysia-1 [Accessed on 2 Jul 2021]

20. Chen, S. (1989), 'Impact of a School Milk Programme on the Nutritional Status of School Children'. *Asia Pacific Journal of Public Health*, vol. 3, no. 1, pp. 19-25.

21. Choon, J. (2021), 'Covid-19: On Average, Almost Four Suicide Cases Reported to Police Every Day in First Quarter of 2021, Says Dr Noor Hisham', *The Malay Mail*, 29 June [Online]. Available from: https://www.malaymail.com/news/malaysia/2021/06/29/covid-19-on-average-almost-four-suicide-cases-reported-to-police-every-day/1985906 [Accessed on 1/7/2021]

22. Chua S.N. (2020), 'The Economic Cost of Mental Disorders In Malaysia', *The Lancet*, vol 7, ed. 23.

23. Company Histories (2021), 'Telekom Malaysia History'. Available from: https://www.companieshistory.com/telekom-malaysia/ [Accessed on 8 April 2021]

24. Construction Industry Development Board (CIDB) (2021), 'Construction from A New Angle'. *HEIGHT*. Available from: https://www.cidb.gov.my/sites/default/files/2021-04/Heights%20Jan-Mar%202021.pdf

25. Critical Skills Monitoring Committee (2020), 'Critical Occupations List 2019/2020 Technical Report', TalentCorp.

26. Daily Express (2018), 'Sabah Still Has the Most Blackouts'. Available from: https://www.dailyexpress.com.my/news/128199/sabah-still-has-the-most-blackouts/ [Accessed on 13 April 2021].

27. Data Terbuka Malaysia (2021), 'Number of Students in Higher Education Institutions by Type of Institutions and Sex, Malaysia'. Available from: https://www.data.gov.my/data/ms_MY/dataset/number-of-students-in-higher-education-institutions-by-type-of-institutions-and-sex-malaysia [Accessed on 10 July 2021]

28. Department of Statistics Malaysia (DOSM) (2019), 'Labour Force Survey (LFS) Time Series Statistics by State, 1982-2019'.

29. Department of Statistics Malaysia (DOSM) (2020a), 'Malaysian Well-Being Index Report 2019'.

30. Department of Statistics Malaysia (DOSM) (2020b), 'ICT Use and Access by Individuals and Households Survey Report, Malaysia'.

31. Department of Statistics Malaysia (DOSM) (2020c), 'Statistic Yearbook 2019, Malaysia'.

32. Department of Statistics Malaysia (DOSM) (2020d), 'Household Income & Basic Amenities Survey Report 2019'.

33. Department of Statistics Malaysia (DOSM) (2020e), 'Statistic on Causes of Death, Malaysia'.

34. Department of Statistics Malaysia (DOSM) (2020f), 'Key Statistics of Labour Force in Malaysia May 2020'.

35. Department of Statistics Malaysia (DOSM) (2020g), 'Labour Force Survey Report 2019'.

36. Department of Statistics Malaysia (DOSM) (2021a), 'Key Statistics of Labour Force in Malaysia May 2021'.

37. Department of Statistics Malaysia (DOSM) (2021b), 'Labour Market Review. First Quarter 2021'.

38. Department of Statistics Malaysia (DOSM) (2021c), 'Key Statistics of Labour Force in Malaysia February 2021'.

39. Department of Statistics Malaysia (DOSM) (2021d), 'Salaries and Wages Survey Report 2020'.

40. Derichs, C. (1999) Nation building in Malaysia under conditions of globalization. Duisburg Working Papers on East Asian Studies, No. 25/1999, Gerhard-Mercator-Universität Duisburg, Institut für Ostasienwissenschaften, Duisburg. Available at: http://hdl.handle.net/10419/41027

41. Dinsmore, A., Allen, L. and Dolby, K., (2014), 'Alternative Perspectives on Impact: The Potential of ALMs and Altmetrics to Inform Funders about Research Impact'. PLoS Biol, vol. 12, no. 11, pp. e1002003. Available from: https://doi.org/10.1371/journal.pbio.1002003

42. Economic and Social Research Council (ESRC) (2020), 'Defining Impact'. Available from: https://esrc.ukri.org/research/impact-toolkit/what-is-impact/ [Accessed on 11 September 2020]

43. Economic and Social Research Council UK. (2020), 'What is impact?'. Available from: https://esrc.ukri.org/research/impact-toolkit/what-is-impact/ [Accessed on 11 September 2020]

44. Economic Planning Unit (EPU) (2018), 'Mid-term Review of the 11th Malaysia Plan 2016-2020'.

45. Economic Planning Unit (EPU) (2021a), 'Malaysia Voluntary National Review (VNR) 2021'.

46. Economic Planning Unit (EPU) (2021b), 'Malaysia Digital Economy Blueprint', Putrajaya, Malaysia.

47. Education Performance and Delivery Unit (PADU) (2018), 'Malaysia Education Blueprint 2013-2025'

48. Employees Provident Fund (EPF) (2019), 'Annual Report 2018', pp. 341.

49. Energy Commission (2017), 'Energy in Malaysia: Towards a Brighter Future', vol. 12.

50. FAO, IFAD, UNICEF, WFP and WHO. (2019), 'The State of Food Security and Nutrition in the World 2019', *Safeguarding Against Economic Slowdowns and Downturns*. Rome, FAO.

51. FAOSTAT (2020). Available from: http://www.fao.org/faostat/en/#-data

52. Fappi, A., and Mittendorfer, B. (2020), 'Different Physiological Mechanisms Underlie an Adverse Cardiovascular Disease Risk Profile in Men and Women', *The Proceedings of the Nutrition Society*, vol. 79, no.2, pp.210–218. Available from: https://doi.org/10.1017/S0029665119001022

53. Fitch (2019), 'Vietnam Records Highest Rise in Obesity in Southeast Asia'. Available from: https://en.vcci.com.vn/vietnam-records-highest-rise-in-obesity-in-southeast-asia [Accessed on 24 April 2020]

54. Foo, C.H. (2020), '2019 Household Income Survey: What It Tells Us About Malaysia's Property Oversupply'. Available from: https://www.iproperty.com.my/news/malaysia-household-income-survey-property-oversupply/ [Accessed on 18 November 2020]

55. Freedenthal, S. (2018), 'When Suicidal Thoughts Do Not Go Away', 3 Jan [Online]. Available from: https://www.speakingofsuicide.com/2018/01/03/chronic-suicidality/ [Accessed on 13 Nov 2020]

56. Galen Centre. (2020), 'MOH Gets Tiny Mental Health 2020 Budget Raise', 25 Oct 2019 [Online]. Available from: https://codeblue.galencentre.org/2019/10/25/moh-gets-tiny-mental-health-2020-budget-raise/ [Accessed on 13 Nov 2020]

57. Global Nutrition Report. (2020), 'Asia: The Burden of Malnutrition at A Glance'. Available from: https://globalnutritionreport.org/resources/nutrition-profiles/asia/#:~:text=The%20Asia%20region%20experiences%20a,the%20global%20average%20of%2021.3%25 [Accessed on 16 Apr 2021]

58. Government of the Federation of Malaya (1960). Report of the Education Review Committee 1960 (Rahman Talib Report). Kuala Lumpur. Government Press.

59. Gupta, S., Hawk, T., Aggarwal, A., and Drewnowski, A. (2019), 'Characterizing Ultra-Processed Foods by Energy Density, Nutrient Density, and Cost'. *Frontiers in Nutrition*, vol. 6, no. 70. Available from: https://doi.org/10.3389/fnut.2019.00070

60. Hafizi Md Lani, N., Yusop, Z., and Syafiuddin, A. (2018), 'A Review of Rainwater Harvesting in Malaysia: Prospects and Challenges'. *Water*, vol. 10, no.4, pp. 506. doi: 10.3390/w10040506

61. Halili, S. Hajar. and Sulaiman, H. (2018), 'Factors Influencing the Rural Students' Acceptance of Using ICT For Educational Purposes'. *Kasetsart Journal of Social Sciences*. doi: 10.1016/j.kjss.2017.12.022

62. Hamid, A.H.A., Kamar, Z., Zain, K.A.M., Ghani and Rahim (2008), 'Industrialized Building System (IBS) in Malaysia: The Current State and R&D Initiatives', *Malaysia Constr. Res. J*, vol. 2, pp. 1–13.

63. Hamzah, N., Perera, P.N. and Rannan-Eliya, R.P. (2020), 'How Well Does Malaysia Achieve Value for Money in Public Sector Purchasing of Medicines? Evidence From Medicines Procurement Prices From 2010 To 2014', *BMC Health Serv Res*, vol. 20, no. 509. Available at: https://doi.org/10.1186/s12913-020-05362-8 [Accessed on 25 May 2021]

64. Holmberg, K., Bowman, S., Bowman, T., Didegah, F. and Kortelainen, T. (2019), 'What Is Societal Impact and Where Do Altmetrics Fit into the Equation?', *Journal of Altmetrics*, vol. 2, no. 1, pp. 6. Available from: https://doi.org/10.29024/joa.21

65. Human Resources Development Fund (HRDF) (2019), 'HRDF Human Capital Report', Issue: Feb 2019/1, Kuala Lumpur, Malaysia.

66. Human Rights Commission of Malaysia (SUHAKAM) (2013), 'Report on Access to Education in Malaysia'. Available from: http://www.suhakam.org.my/wp-content/uploads/2013/11/Research-Report.pdf [Accessed on 20 May 2020]

67. Huyer, S. (2015), 'UNESCO Science Report: Towards 2030'. Available from: https://en.unesco.org/sites/default/files/usr15_is_the_gender_gap_narrowing_in_science_and_engineering.pdf

68. Inquirer.net (2019), '5.1% Of Filipinos Obese Due to Affluence, Unhealthy Diet'. Available from https://newsinfo.inquirer.net/1144410/5-1-of-filipinos-obese-due-to-affluence-unhealthy-diet [Accessed on 24 April 2020]

69. International Telecommunication Union (2021), 'Digital Dashboard'. Available from: https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx [Accessed on 16 September 2021]

70. Jackson Nicholas (2011), 'United Nations Declares Internet Access a Basic Human Right'. Available from: https://www.theatlantic.com/technology/archive/2011/06/united-nations-declares-internet-access-a-basic-human-right/239911/ [Accessed on 14 April 2021]

71. Jeffrey Hays (2015), 'Internet in Malaysia'. Available from: http://factsanddetails.com/southeast-asia/Malaysia/sub5_4f/entry-3665.html [Accessed on 14 April 2021]

72. Kandiah, M., and Tee, E. (1990), 'Evaluation of the Nutritional Impact of the School Supplementary Feeding Programme', Seventh ASEAN Workshop on Food Habits. Pulau Pinang, Malaysia.

73. Khalib, A. M. and See, J. (2018), 'Innovate for Health: Earmarking Sin Tax to Support Malaysia's NCD Response'. *Policy For Action (1/2018)*. Galen Centre.

74. Khazanah Research Institute (KRI) (2018), 'The State of Households 2018 Different Realities'.

75. Khazanah Research Institute (KRI) (2021), 'Navigating Challenges, Realising Opportunities of Digital Transformation'.

76. Khor, S. K. (2019), 'Cut the Queue: A Basket of Solutions for Malaysian Hospitals', *Issues*, Penang Institute, Malaysia.

77. Kinder, C. (1998), 'The population explosion: Causes and Consequences'. Yale - New Haven institute.

78. Lee, R. (2020), 'Cover Story: The disparity between income and house prices', *The Edge Markets*. Available from: https://www.theedgemarkets.com/article/cover-story-disparity-between-income-and-house-prices [Accessed on 16 September 2021].

79. Leo, H. (2018), 'Recommendations of The Special Rapporteur On The Human Rights To Water And Sanitation', *Report Of The Official Country Visit to Malaysia 14-27 November 2018*.

80. Li, Y. O. and Komarek, A. R., (2017), 'Dietary Fibre Basics: Health, Nutrition, Analysis and Applications', *Food Quality and Safety*, vol. 1, no. 1, pp. 47-59.

81. Lim, S. L. (2018), 'Bridging Barriers: A Report on Improving Access to Mental Healthcare in Malaysia', Penang Institute, Malaysia

82. Lind, M. V., Larnkjær, A., Mølgaard, C., and Michaelsen, K. F. (2017), 'Dietary Protein Intake and Quality in Early Life: Impact on Growth and Obesity', *Current Opinion in Clinical Nutrition and Metabolic Care*, vol. 20, no. 1, pp. 71–76. Available from: https://doi.org/10.1097/MCO.0000000000000338

83. Malay Mail (2020), 'Handover of Sabah Electricity to State Government to Take Five Years, Says Deputy Minister'. Available from: https://www.malaymail.com/news/malaysia/2020/12/07/handover-of-sabah-electricity-to-state-govt-to-take-five-years-says-deputy/1929685 [Accessed 13 April 2021].

84. Malay Mail (2021), 'Report: Fresh Grad Salaries Fell to Minimum Wage Level In 2020, Says Stats Dept'. https://www.malaymail.com/news/malaysia/2021/04/01/report-fresh-grad-salaries-fell-to-minimum-wage-level-in-2020-says-stats-de/1962896 [Accessed on 1 April 2021].

85. Malaysian Communications and Multimedia Commission (MCMC) (2018), 'Statistical Brief Number Twenty-Three', *Internet Users Survey 2018*, Selangor.

86. Malaysian Communications and Multimedia Commission (MCMC) (2020), 'National Digital Network (JENDELA)'. Available from: https://myjendela.my [Accessed 14 April 2021]

87. MAMPU (2020), 'Jumlah Jajaran Landasan Keretapi Yang Dimiliki Oleh Perbadanan Aset Keretapi'. Available from: https://www.data.gov.my/data/ms_MY/dataset/jumlah-jajaran-landasan-keretapi-yang-dimiliki-oleh-perbadanan-aset-keretapi [Accessed on 6 April 2021]

88. Manca, A.R. (2014) Social Cohesion. In: Michalos A.C. (eds) Encyclopedia of Quality of Life and Well-Being Research. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0753-5_2739

89. Meynagh, M. H. Z., Marsono, M. M., Kama, A. K. and Isaabadi. (2014), 'Main Factors of Contractor Reluctancy to Adopt IBS Projects In Malaysia', *Aust. J. Basic Appl. Sciences*, vol. 8, pp. 251–254.

90. Ministry of Economic Affairs (MEA) (2019), 'Shared Prosperity Vision 2030 (SPV2030)'.

91. Ministry of Education (MOE) (2013), 'Malaysia Education Blueprint 2013-2025 (Preschool to Post-Secondary Education)'.

92. Ministry of Education Malaysia (MOE) (2017), 'Program Mengatasi Keciciran Mulai Tahun 2018'.

93. Ministry of Education Malaysia (MOE) (2020), 'Quick Facts 2020 Malaysia Educational Statistics'.

94. Ministry of Education Malaysia (MOE) (N.D.) 'Annual Report 2018'.

95. Ministry of Finance (MOF) (2019), 'Federal Government Expenditure', *Fiscal Updates 2019*.

96. Ministry of Foreign Affairs (MOFA) (2021), 'Kenyataan Media YB Datuk Seri Hishammuddin Tun Hussein', 21 Apr 2021. Available from: https://www.kln.gov.my/web/guest/speeches-statements/-/asset_publisher/mN2jZPwqWjGA/content/kenyataan-media-yb-dato-seri-hishammuddin-tun-hussein-inter-ministerial-collaboration-cluster-on-covid-19-vaccine-and-medication-development-through-i?redirect=%2Fweb%2Fguest%2Fspeeches-statements&inheritRedirect=true [Accessed on 19 Jul 2021]

97. Ministry of Health Malaysia (MOH) (2011, 2016, 2019a), '*National Health Morbidity Survey 2011*, 2016, 2019'.

98. Ministry of Health Malaysia (MOH) (2012), 'Healthcare Demand and Out-of-Pocket Expenditure', National Health Morbidity Survey 2011, vol. 3.

99. Ministry of Health Malaysia (MOH) (2016), 'National Strategic Plan for Non-Communicable Disease 2016-2025'.

100. Ministry of Health Malaysia (MOH) (2017), 'Malaysian Mental Healthcare Performance Technical Report 2016'. Putrajaya: Malaysian Healthcare Performance Unit, National Health Institute.

101. Ministry of Health Malaysia (MOH) (2019b), 'Malaysia National Health Accounts: Health Expenditure Report 1997-2017', Putrajaya.

102. Ministry of Health Malaysia (MOH) (2020a), 'COVID-19 Pandemic in Malaysia: The Journey', Putrajaya.

103. Ministry of Health Malaysia (MOH) (2020b), 'COVID-19 Mental Health Kit in Hospital Setting & Quarantine Centre'.

104. Ministry of Health Malaysia (MOH) (2020c), 'COVID-19: Primary Healthcare Initiatives in Malaysia'.

105. Ministry of Health Malaysia (MOH) (N.D..), 'MyHEALTH Portal', Available from: http://denggi.myhealth.gov.my/history-and-epidemiology-of-dengue/?lang=en, [Accessed on 4 Sep 2020]

106. Ministry of Health Malaysia (MOH), 'Health Facts 2014-2018'.

107. Ministry of Health Malaysia (MOH), 'Health Indicator 2015-2019'.

108. Ministry of Health Malaysia (N.D.), 'Annual Report 2011, 2017, 2018'.

109. Ministry of Health Malaysia (N.D.), 'National Strategic Plan for Tuberculosis Control 2016 – 2020', Putrajaya: Disease Control Division (TB/Leprosy Sector).

110. Ministry of Health Malaysia, (N.D.), 'The Implementation of Taxation on Sugar-Sweetened Beverages (SSBS) in Malaysia'. Available from: https://nutrition.moh.gov.my/en/the-implemention-of-taxation-on-sugar-sweetened-beverages-ssbs-in-malaysia/

111. Ministry of Housing and Local Government (KPKT) (2019), 'National Housing Policy 2018'.

112. Ministry of Human Resources (MOHR) (2020), 'Malaysia Standard Classification of Occupations (MASCO 2013)', Putrajaya, Malaysia.

113. Ministry of Rural Development (KKLW) (2016), 'Rural Electricity Supply (BELB)'. Kementerian Pembangunan Luar Bandar. Available from: https://policy.asiapacificenergy.org/sites/default/files/BELB%20Programme.pdf [Accessed on 13 April 2021]

114. Ministry of Transport (MOT) (2019), 'Transport Statistic Malaysia', Malaysia.

115. Muhammad, A., D'Souza, A., Meade, B., Micha, R. and Mozaffarian D. (2017), 'How Income and Food Prices Influence Global Dietary Intakes by Age and Sex: Evidence From 164 Countries', B*MJ Global Health*, vol. 2, no. 3. Available from: http://dx.doi.org/10.1136/bmjgh-2016-000184

116. Nasrun, M., Nawi, M. and Utara, U. (2015), 'Suitability of IBS Formwork System in Malaysian Construction Industry', *Australian Journal of Basic and Applied Sciences*, vol. 9, pp. 89-91.

117. New Straits Times (2020a), 'Almost 40% of Students Can't Study at Home as They Lack Electronic Devices'. Available from: https://www.nst.com.my/news/nation/2020/04/584641/almost-40pct-students-cant-study-home-they-lack-electronic-devices [Accessed on 5 August 2020]

118. New Straits Times (2020b), 'Education Ministry Gets Largest Allocation of RM50.4b in 2021 Budget'. Available from: https://www.nst.com.my/news/government-public-policy/2020/11/638830/education-ministry-gets-largest-allocation-rm504b-2021 [Accessed on 5 December 2020]

119. New Straits Times (2020c), 'Factors Hindering Vaccine Research'. Available from: https://www.nst.com.my/news/nation/2020/02/565765/factors-hindering-vaccine-research [Accessed on 9 Jul 2021]

120. Noor I. M. (2002), 'The Nutrition and Health Transition in Malaysia', *Public Health Nutrition*, vol. 5, no. 1A, pp. 191–195.

121. Pandian, A. (1997), 'Reading in Malaysia', Universiti Kebangsaan Malaysia, Bangi, Selangor.

122. Partap, U., Young, E.H., Allotey, P., Sandhu, M. S., and Reidpath, D. D. (2019), 'Characterisation and Correlates of Stunting Among Malaysian Children and Adolescents Aged 6–19 Years'. *Global Health, Epidemiology and Genomics*, vol. 4, no. 2, pp. 1–11. Available from: https://doi.org/10.1017/gheg.2019.1 [Accessed on 25 June 2021]

123.Penfield, T., Baker, M. J., Scoble, R., and Wykes, M. C. (2014), 'Assessment, Evaluations and Definitions of Research Impact: A Review'. *Research Evaluation*, vol. 23, no. 1, pp. 21–32.

124.Phillips, C (2021), 'Malaysia's Internet Speed Improve Even Before 5G is Launched' Available from: https://www.speedtest.net/insights/blog/malaysia-internet-speeds-march-2020/ . [Accessed on 27 June 2021]

125.Prime Minister's Office (PMO) (2021), 'Program Strategik Memperkasa Rakyat dan Ekonomi (PEMERKASA)'. Available from: https://www.pmo.gov.my/ms/2021/03/teks-ucapan-program-strategik-memperkasa-rakyat-dan-ekonomi-pemerkasa-2/ [Accessed on March 2021]

126.Puteri,M.M.M., and Theebalakshmi, K., (2021), 'Median Multiple Affordability: Use and considerations', *Khazanah Research Institute*. Available from: http://www.krinstitute.org/assets/contentMS/img/template/editor/Views%20-%20Median%20Multiple.pdf [Accessed on 16 September 2021]

127.Rancangan Malaysia ke-10, 2011 - 2015, Percetakan Ker. Malaysia

128.Real Estate (2019), 'Singapore Has a Property Glut That Could Take Years to Clear'. Available from: https://www.businesstimes.com.sg/real-estate/singapore-has-a-property-glut-that-could-take-years-to-clear [Accessed on 14 April 2021].

129.Rodman, S., (2019), 'How Financial Issues Impact Your Mental Health', 22 Feb [Online]. Available from: https://www.talkspace.com/blog/financial-issues-impact-mental-health/ [Accessed on 4 Nov 2020]

130.Saad, S. (2012) Re-building the Concept of Nation Building in Malaysia. Asian Social Science. Canadian Centre of Science and Education. Available at: 10.5539/ass.v8n4p115

131.Sabah Electricity Sdn. Bhd (SESB) (N.D.), 'Corporate Profile'. Available from: https://www.sesb.com.my/?q=content/corporate-profile [Accessed on 7 April 2021]

132.Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G., and Woelm, F. (2020), 'The Sustainable Development Goals and COVID-19. Sustainable Development Report 2020', Cambridge: Cambridge University Press.

133.Sashitharan, S., Jusoh, M.S., Amlus, M.H., Rahimi, A., Ibrahim, A., and Ismail, M.S. (2014), 'Industrialized Building System (IBS) Performance in Malaysian Construction Industry: Analysing the Cost, Training And Construction Policies', *J. Appl. Sci. Agric*, vol.9, pp.6–11.

134.Shahrir, S. N., Abdul Manaf, M. R., Mustapha, F. I. and Md Isa, Z. (2019), 'Critical Review on Dietary Sodium Reduction Policies in Malaysia', *International Food Research Journal*, vol. 26, no. 1, pp. 33 - 40

135.Shakhshir, G. N. (2017), 'Association Between Water Supply and Early Childhood Development In Palestine: A Descriptive Analysis Of Demographic And Health Survey Data', *The Lancet*, vol. 390, no. Supplement 2, pp. S25. [Online]. Available from: https://doi.org/10.1016/S0140-6736(17)32076-7 [Accessed on 25 June 2021]

136.Soboksa, N. E., Gari, S.R., Hailu, A.B. and Alemu, B.M. (2021) 'Childhood Malnutrition and the Association with Diarrhea, Water supply, Sanitation, and Hygiene Practices in Kersa and Omo Nada Districts of Jimma Zone, Ethiopia', *Environmental Health Insights*. Available from: https://journals.sagepub.com/doi/10.1177/1178630221999635 [Accessed on 25 June 2021]

137.Social Progress Imperative (2019), 'Calibrating the 1028 Social Progress Index to the Sustainable Development Goals: Methodology Note'.

138.Social Progress Imperative Official Website. Available from: https://www.socialprogress.org/index/global/methodology [Accessed on 20 Apr 2020]

139.Speedtest Global Index (2021). Available from: https://www.speedtest.net/global-index [Accessed on 3 July 2021]

140.Sundaram, J. K. and Tan, Z. G. (2019), 'Achieving Food Security for all Malaysians', Khazanah Research Institute, Kuala Lumpur.

141.Suraya, I., Christopher, C.W.W., Hawati, A.H., Nur Fareza, M., Gregory, H., Tan, T.T., Muhammad, N.K., and Adam Manaf, M.F. (2019), 'Rethinking Housing: Between State, Market and Society: A special Report for the Formulation of the National Housing Policy (2018-2025)', Khazanah Research Institute, Malaysia.

142.Telecom Review (2020), 'The Evolution of Malaysia's Telecom Industry'. Available from: https://www.telecomreviewasia.com/index.php/news/featured-articles/1841-the-evolution-of-malaysia-s-telecom-industry [Accessed on 13 April 2021].

143.Telekom Malaysia Berhad (TM) (N.D.), 'Annual Report 2014, Malaysia', Telekom Malaysia Berhad.

144.Tenaga Nasional Berhad (TNB) (2021), 'History'. (Online). Available from: https://www.tnb.com.my/about-tnb/history/ . [Accessed on 7 April 2021]

145.The Star (2021), 'Reversing the Decline among M40'. Available from: https://www.thestar.com.my/business/business-news/2021/06/18/reversing-the-decline-among-m40 [Accessed on 15 July 2021]

146.The Straits Time (2019), 'New Rules for Buying Malaysian Property: Concern Over Foreign Invasion, Real Estate Bubble'. Available from: https://www.straitstimes.com/asia/se-asia/concern-over-foreign-invasion-real-estate-bubble [Accessed on 14 April 2021].

147.United Nations Children's Fund (UNICEF) (2018), 'Children Without: A Study of Urban Child Poverty and Deprivation in Low-Cost Flats in Kuala Lumpur'. UNICEF, Malaysia.

148.United Nations Children's Fund (UNICEF) (2019a), 'Children, Food and Nutrition: State of the World's Children 2019', *A Look at Child Malnutrition in Malaysia and Beyond*. Available from https://www.unicef.org/malaysia/children-food-and-nutrition-state-worlds-children-2019

149.United Nations Children's Fund (UNICEF) (2019b), 'The State of the World's Children 2019'. *Children, Food and Nutrition: Growing Well in A Changing World*, UNICEF, New York.

150.United Nations Children's Fund (UNICEF) (2019c), 'Children Out of School Malaysia (The Sabah Context)', UNICEF, Malaysia.

151.United Nations Children's Fund (UNICEF) and United Nations Population Fund (UNFPA) (2020), 'Families on the Edge'. Available from: https://www.unicef.org/malaysia/media/1576/file/Families%20on%20edge%20part%202.pdf [Accessed on 23 July 2021]

152.United Nations Conference on Trade and Development (2020), 'Maritime Key Figure For 2019'. Available from: https://unctadstat.unctad.org/countryprofile/maritimeprofile/en-gb/458/index.html [Accessed on 6 April 2021]

153.United Nations Educational, Scientific and Cultural Organization (UNESCO) (2017), 'Literacy Rates Continue to Rise from One Generation to the Next'. Available from: http://uis.unesco.org/sites/default/files/documents/fs45-literacy-rates-continue-rise-generation-to-next-en-2017_0.pdf

154.UTM Official Website (N.D.). Available from: https://www.utm.my/about/ [Accessed on 3 Nov 2020]

155.Walter, A. I., Helgeberger, S., Wiek, A., and Scholz, R. W. (2007), 'Measuring Societal Effects of Transdisciplinary Research Projects: Design and Application of An Evaluation Method', *Evaluation and Program Planning*, vol. 30, no. 4, pp. 325–338.

156.Wan Muda, W. M., Sundaram J.K. and Tan, Z. G. (2019), 'Discussion Paper 7/19 Addressing Malnutrition in Malaysia', Khazanah Research Institute, Kuala Lumpur.

157.Wang, J., & Wen, S. (2010), 'Examining Reflective Thinking: A Study of Changes in Methods Students' Conceptions and Understandings of Inquiry Teaching', *International Journal of Science and Mathematics Education*, pp. 1-21.

158.Whiting, K. (2021), 'These 8 women in STEM are at the Forefront of the World's Response to COVID-19', World Economic Forum.

159.Wolf, B., Lindenthal, T., Szerencsits, J. M., Holbrook , J. B., and Heß, J. (2013), 'Evaluating Research beyond Scientific Impact: How to Include Criteria for Productive Interactions and Impact on Practice and Society', *Gaia*, vol. 22, no. 2, pp. 11.

160.Wolf, B., Szerencsits, M., Gaus, H., Müller, C. E., & Heß, J. (2014), 'Developing a Documentation System for Evaluating the Societal Impact of Science', *Procedia Computer Science*, vol. 33, pp. 289–296.

161.World Bank (2019), 'Making Ends Meet', Malaysia Economic Monitor (December), World Bank, Washington DC.

162.World Bank (2020a), 'Assessing the Effectiveness of Public Research Institutions in Fostering Knowledge Linkages and Transferring Technology in Malaysia', Washington, DC: The World Bank.

163.World Bank (2020b), 'School Enrolment, Tertiary (% gross Malaysia)'. Available from: https://data.worldbank.org/indicator/SE.TER.ENRR?locations=MY [Accessed on 2 February 2021].

164.World Bank (2021a), 'Malaysia Literacy Rate 1991-2021'. Available from: https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?end=2018&locations=MY&start=1980&view=chart.

165.World Bank (2021b), 'Unemployment, youth total (% of total labor force ages 15-24) (modeled ILO estimate)-Singapore, Malaysia'. Available from: https://data.worldbank.org/indicator/SL.UEM.1524.ZS?locations=SG-MY [Accessed on 10 July 2021].

166.World Bank Blogs (2020), 'How water impacts early childhood nutrition: An integrated water and nutrition framework'. Available from https://blogs.worldbank.org/water/how-water-impacts-early-childhood-nutrition-integrated-water-and-nutrition-framework [Accessed on 25 June 2021]

167.World Bank Open Data (N.D.) Available from: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=MY

168. World Data Atlas (N.D.), 'Malaysia-Total Rail Lines'. Available from: https://knoema.com/atlas/Malaysia/Length-of-rail-lines. [Accessed on 6 April 2021]

169.World Economic Forum (WEF) (2020), 'The Global Social Mobility Report 2020'. *Equality, Opportunity and a New Economic Imperative*, Geneva, Switzerland.

170.World Health Organisation (WHO) (2011), 'Global Health and Ageing', National Institutes of Health. US Department of Health and Human Services.

171.World Health Organisation (WHO) (2018), 'Malaysia Eliminates Mother-To-Child Transmission of HIV and Syphilis. Available from https://www.who.int/westernpacific/news/detail/08-10-2018-malaysia-eliminates-mother-to-child-transmission-of-hiv-and-syphilis [Accessed on 20 June 2020]

172.World Health Organisation (WHO) (2019), 'Global Spending on Health: A World in Transition?'.

173.World Health Organisation (WHO) (2021a), 'Factsheets: Malnutrition'. Available from https://www.who.int/news-room/fact-sheets/detail/malnutrition [Accessed on 20 June 2021]

174.World Health Organisation (WHO) (2021b), 'Factsheets: Suicide'. Available from https://www.who.int/news-room/fact-sheets/detail/suicide [Accessed on 20 June 2020]

175.World Population Review (2019), 'Obesity Rates by Country'. Available from https://worldpopulationreview.com/country-rankings/obesity-rates-by-country

176.Zaki, N, F. M & Ahmad, N. A., and 'Ashri, M. I. M. (2019), 'Exploring the Factors Affecting the Gap on Literacy Skills among Students with Learning Disabilities: A Case Study', *International Journal of Academic Research in Progressive Education and Development*, no. 8, pp. 2226-6348. Available from: http://dx.doi.org/10.6007/IJARPED/v8-i3/6389

177.Zukki, A. H. M., Ying, J. T. R., and Rahuman, M. R. H. (2018), 'Divergence of Economic Performance and Public Sentiments'. *BNM Quarterly Buletin*. Available from: https://www.bnm.gov.my/documents/20124/767010/p3ba1.pdf

Reference for Figures

Figure 4.1 Department of Statistics Malaysia (DOSM) (2020), 'Malaysian Well-Being Index (MyWI) 2000-2019', Economic Planning Unit, Prime Minister's Department.

Figure 4.2 Speedtest Global Index (2021). Available from: https://www.speedtest.net/global-index [Accessed on 3 July 2021]

Figure 4.3 Department of Statistics Malaysia (2020). ICT Use and Access by Individuals and Households Survey Report, Malaysia, DOSM.

Figure 4.4(a) i) Suraya, I., Christopher, C.W.W., Hawati, A.H., Nur Fareza, M., Gregory, H., Tan, T.T., Muhammad, N.K., and Adam Manaf, M.F. (2019). Rethinking Housing: Between State, Market and Society: A special Report for the Formulation of the National Housing Policy (2018-2025), Malaysia, Khazanah Research Institute (KRI).

ii) Puteri,M.M.M., & Theebalakshmi, K., (2021). 'Median Multiple Affordability: Use and considerations''. Khazanah research Institute. Available from: http://www.krinstitute.org/assets/contentMS/img/template/editor/Views%20-%20Median%20Multiple.pdf [Accessed on 16 September 2021]

Figure 4.4(b) Global Property Guide (2021). Square Metre Prices in Asia. Available from: https://www.globalpropertyguide.com/Asia/square-meter-prices. [Accessed on 8 June 2021]

Figure 4.5 Our World in Data Official Website, https://ourworldindata.org/ [Accessed on 6 Aug 2020]

Figure 4.6 Statista (2020), 'Consumer Price Index (CPI) for Vegetables in Malaysia from 2013 To 2019'. Available from: https://www.statista.com/statistics/961181/cpi-vegetables-malaysia/ [Accessed on 6 Aug 2020]

Statista (2020), 'Consumer Price Index (CPI) for Fruits in Malaysia from 2013 to 2019'. Available from: https://www.statista.com/statistics/961173/cpi-fruits-malaysia/ [Accessed on 6 Aug 2020]

Figure 4.7 i) World Bank Open Data, Prevalence of stunting, https://data.worldbank.org/indicator/SH.STA.STNT.ZS?locations=MY&view=chart [Accessed on 5 Aug 2020]

ii) World Bank Open Data, Prevalence of underweight, https://data.worldbank.org/indicator/SH.STA.MALN.ZS?locations=MY&view=chart [Accessed on 5 Aug 2020]

Figure 4.8 i) Wan Muda, W. M., Sundaram J.K. & Tan, Z. G. (2019). Discussion Paper 7/19 Addressing Malnutrition in Malaysia, Kuala Lumpur: Khazanah Research Institute.

ii) Khalidi J. R. & Tan Z. G. (2020). Understanding School Feeding in Malaysia. Kuala Lumpur: Khazanah Research Institute.

iii) Rancangan Malaysia ke-2 1971 – 1975, Percetakan Kerajaan Malaysia

iv)Rancangan Malaysia ke-3 1976 - 1980, Percetakan Kerajaan Malaysia

v) Ministry of Health Malaysia Official Portal. (N.D.). Community Feeding Programme http://nutrition.moh.gov.my/en/program-community-feeding/ [Accessed on 8 Jun 2020]

vi) Budget 2021 Announcement by Minister of Finance on 6 Nov 2020

Figure 4.9 World Bank Open Data, Current health expenditure per capita, https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD?locations=MY&view=chart [Accessed on 1 Mar 2021]

Figure 4.10 Data courtesy of Ministry of Health, 2020

Figure 4.11 World Bank (2021), 'Malaysia Literacy Rate 1991-2021'. Available from: https://data.worldbank.org/indicator/SE.ADR.LITR.ZS?end=2018&locations=MY&start=1980&view=chart [Accessed on 5 April 2021].

Figure 4.12 International Telecommunication Union (ITU) (2021), 'Digital Dashboard'. Available from: https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx [Accessed on 16 September 2021]

Figure 4.13 Khazanah Research Institute (KRI) (2016), 'Climbing the Ladder: Socio-economic Mobility in Malaysia', Khazanah Research Institute, Kuala Lumpur.

Figure 4.14 Ministry of Higher Education Malaysia (MOHE) (2014-2019), 'Laporan Kajian Pengesanan Graduan, 2014-2019'.

Figure 4.15 Department of Statistics Malaysia (2019). Labour Force Survey (LFS) Time Series Statistics by State, 1982-2019. DOSM.

Figure 4.16 Department of Statistics Malaysia. (2020). Labour Force Survey Report 2019. DOSM.

Figure 4.17 Amin, M & Zarka, A. (2018). Female Top Managers in Malaysia. *Enterprise Note* (36). The World Bank.

Figure 4.18 Amin, M & Zarka, A. (2018). Female Top Managers in Malaysia. *Enterprise Note* (36). The World Bank.

Figure 4.19 Amin, M & Zarka, A. (2018). Female Top Managers in Malaysia. *Enterprise Note* (36). The World Bank.

Figure 4.20 Bank Negara Malaysia (2018). Annual Report 2018. Bank Negara Malaysia

Figure 4.21 Department of Statistics Malaysia (2020). Household Income & Basic Amenities Survey Report 2019. DOSM.

Figure 4.22 Department of Statistics Malaysia (2020). Household Income & Basic Amenities Survey Report 2019. DOSM.

Figure 4.23 Ministry of Education Malaysia (MOE) (2015-2019), Quick Facts 2015-2019 Malaysia Educational Statistics'.

Figure 4.24 UNESCO (UIS) Official Website. Researchers (HC)-% Female. Available from: `http://data.uis.unesco.org/index.aspx?queryid=3402 [Accessed on 11th January 2020]

Figure 4.25 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

1. Academy of Sciences Malaysia (2021). Special Interest Group on COVID-19.

2. Academy of Sciences Malaysia (2021). Special Interest Group on Zoonosis.

3. American College of Emergency Physicians Website, Health Care System Surge Capacity Recognition, Preparedness, and Response. Available at: https://www.acep.org/patient-care/policy-statements/health-care-system-surge-capacity-recognition-preparedness-and-response/ [Accessed on 3 Nov 2020]

4. Centres for Disease Control and Prevention, One Health Basics, Available at: https://www.cdc.gov/onehealth/basics/index.html [Accessed on 16 Apr 2021]

5. Clavier, F and Ghesquiere, F. (2021). Leveraging Digital Solutions to Fight COVID-19: Lessons from ASEAN Countries, Research and Policy Brief, No. 41. World Bank, Washington, DC.

6. Code Blue (2021). Vaccination Challenges in Rural Sabah and Sarawak, 1 Mar 2021 [online]. Available at: https://codeblue.galencentre.org/2021/03/01/vaccination-challenges-in-rural-sabah-and-sarawak-amanda-yeo/ [Accessed on 9 July 2021].

7. Consultative Group to Assist the Poor (2020). Social Assistance Payments in Response to COVID-19: The Role of Donors, Washington DC. CGAP.

8. Human Rights Watch (2021). Malaysia: Raids on Migrants Hinder Vaccine Access, 16 Aug 2021, Available at: https://www.hrw.org/news/2021/06/30/malaysia-raids-migrants-hinder-vaccine-access [Accessed on 9 Jul 2021].

9. Looi, L-M. & Chua, K-B. (2007). Lessons from the Nipah virus outbreak in Malaysia, Malaysian Journal of Pathology, 29(2), pg 63-67

10. Medina, A. F. (2020). Malaysia's Healthcare Sector: A Rising Giant in ASEAN. Retrieved from https://www.aseanbriefing.com/news/malaysias-healthcare-sector-a-rising-giant-in-asean/ [Accessed on 25 May 2021]

11. Ministry of Health Malaysia. From the Desk of the Director-General of Health Malaysia The Malaysian Response to COVID-19: Building Preparedness for 'Surge Capacity', Testing Efficiency, and Containment, https://kpkesihatan.com/2020/06/16/the-malaysian-response-to-covid-19-building-preparedness-for-surge-capacity-testing-efficiency-and-containment/ [Accessed on 11 Feb 2021]

12. Ministry of Women, Family and Community Development. (2020). Talian Kasih Statistics during MCO.

13. Ng C. W., Choo, W. Y., Chong, H. T., Dahlui, M., Goh, K. J. & Tan, C. T. (2009). Long-term socioeconomic impact of the Nipah Virus encephalitis outbreak in Bukit Pelanduk, Negeri

Sembilan, Malaysia: A mixed methods approach, Neurology Asia, 14(2): 101 – 107

14. Tee, K. K., Takebe, Y. and Kamarulzaman, A. (2009). Emerging and Re-emerging Viruses in Malaysia, 1997-2007, International Journal of Infectious Diseases, Vol 13, 3, pg 307-318

15. The Star (2019) Eight H1N1 flu cases detected in Sabah. (https://www.thestar.com.my/news/nation/2019/12/29/eight-h1n1-flu-cases-detected-in-sabah [Accessed on 20 Nov 2020]

16. The Star (2021). Health DG Dr Noor Hisham joins coalition of global scientists fighting Covid-19. https://www.thestar.com.my/news/nation/2020/04/03/health-dg-dr-noor-hisham-joins-coalition-of-global-scientists-fighting-covid-19 [Accessed on 16 Feb 2021].

17. The Straits Times (2020). Malaysia asking for nearly 1900 more healthcare workers. Available at: http://uat.straitstimes.com/asia/se-asia/malaysia-requests-for-nearly-1900-more-healthcare-workers-as-covid-19-infections-surge [Accessed on 11/2/2021]

18. UN Women (2020). Violence against women and girls: the shadow pandemic: Statement by Phumzile Mlambo-Ngcuka, Executive Director of UN Women, Available at: https://www.unwomen.org/en/news/stories/2020/4/statement-ed-phumzile-violence-against-women-during-pandemic, [Accessed on 5 Dec 2020]

19. UNFAO (2002). Manual on the Diagnosis of Nipah Virus Infection in Animals, F Food and Agriculture Organization of the United Nations & Animal Production and Health Commission for Asia and the Pacific (APHCA)

20. UNICEF (2020). Families on the Edge: Issue 1. Kuala Lumpur, Malaysia.

Reference for Figure

Figure 4.26 Ministry of Women, Family and Community Development (KPWKM) (2020). Domestic Violence and Seeking for Social Assistance Related Calls Made to *Talian Kasih* from 18 March to 13 August 2020.

1. Abdullah, F., Mohammad, S., Mohamad, J. and & Ahmad, M. (2019), 'The Economic Model for Flood Damage Cost in Retailing Business in Malaysia', *Proceedings of the Second International Conference on the Future of ASEAN (ICoFA) 2017*, vol. 1, pp. 509-518.

2. Academy of Sciences Malaysia (ASM) (2014), 'Blueprint for The Establishment of Rare Earth-Based Industries in Malaysia Full Report'.

3. Academy of Sciences Malaysia (ASM) (2017a), 'ASM S&T Foresight Malaysia 2050 Report'.

4. Academy of Sciences Malaysia (ASM) (2017b), 'Strategic Plan for Integrated River Basin Management in Malaysia', vol 1.

5. Academy of Sciences Malaysia (ASM) (2018), 'Integrated Urban Water Management in Peninsular Malaysia', Malaysia.

6. Academy of Sciences Malaysia (ASM) (2019), 'Final Report ASM Task Force on Sungai Kim Kim and Pasir Gudang Incidents'.

7. Agamuthu Periathamby, Fauziah Shahul Hamid and Khalil Khidzir (2009), 'Evolution of Solid Waste Management in Malaysia: Impacts and Implications Of The Solid Waste Bill, 2007', *Journal of Material Cycles and Waste Management*, vol. 11, pp. 96-103.

8. Agamuthu, P. and Victor D. (2011), 'Policy Trends of Extended Producer Responsibility in Malaysia. Waste Management & Research', *Journal of the International Solid Waste Management Waste and Public Cleansing Association*, vol. 29, no. 9, pp. 945 – 953.

9. Agroz (2016), 'Building Asia's Largest Indoor Vertical Farms'. [Accessed on 19 Feb 2021]

10. Aldrie Amir, (2018), 'On Our Love Affair with Malaysian mangroves', *New Straits Times*. [Accessed on 30 September 2020]

11. Ali Neh (2020), 'Agricultural Waste Management System [AWMS] in Malaysian', *Journal of Waste Management & Xenobiotics*, vol. 3, no.2.

12. ASEAN Peatland Forests Project (2020), 'Threats related to Peatlands in Malaysia'. [Accessed on: 18 December 2020]

13. Association of Southeast Asian Nations (ASEAN) (2017), '5th ASEAN State of The Environment Report', Jakarta, Indonesia.

14. Balaram, V. (2019), 'Rare Earth Elements: A Review of Applications, Occurrence, Exploration, Analysis, Recycling, and Environmental Impact', *Geoscience Frontiers*, vol. 10, no. 4, pp. 1285-1303.

15. Cazzolla, G. R., and Velichevskaya, A. (2020), 'Certified "Sustainable" Palm Oil Took the Place of Endangered Bornean and Sumatran Large Mammals Habitat and Tropical Forests in The Last 30 Years', *Science of The Total Environment*, vol. 742, no. 140712.

16. Chandini, Kumar, R., Kumar, R., & Prakash, O. (2019), 'The Impact of Chemical Fertilizers on our Environment and Ecosystem', pp.69-86.

17. Che Ros F., Shahrin M.F., and Chuan D.L.Y. (2019), 'Estimation of Infrastructure Demand for Flood Control in Malaysia' [Accessed on 15 May 2021]

18. Chun, J.A., Lim, C., Kim, D. and Kim, J.S. (2018), 'Assessing Impacts of Climate Change and Sea-Level Rise on Seawater Intrusion in a Coastal Aquifer', Water, vol. 10, pp. 357.

19. CNN Travel (2016), '10 of the World's Greatest Tunnels'. [Accessed on 19 May 2021]

20. Cooper, H., Evers, S., Aplin, P., Crout, N., Dahalan, M., and Sjogersten, S. (2020), 'Greenhouse Gas Emissions Resulting from Conversion of Peat Swamp Forest to Oil Palm Plantation'. *Nature Communications*, vol. 11, no. 1, pp. 407.

21. Dasgupta, P. (2021), 'The Economics of Biodiversity: The Dasgupta Review'.

22. Dave, S. and Priyanshu, K. (2021), 'Growing Champions: Malaysia's Renewable Energy Opportunity', *The Edge Malaysia Daily*. [Accessed on 17 March 2021]

23. Department of Environment (DOE) (2005-2019), 'Environmental Quality Report 2005-2019'.

24. Department of Environment (DOE) (2009), 'Environmental Quality (Industrial Effluents) Regulations 2009'.

25. Department of Environment (DOE) (2020) 'Best Available Techniques Guidance Document on Waste Incinerator'.

26. Department of Fisheries (DOF) (2012-2019), 'Annual Fisheries Statistics 2012-2019'.

27. Department of Irrigation and Drainage (DID) (2019), 'Pusat Kawalan Smart'. [Accessed on 19 May 2021]

28. Department of Statistics Malaysia (DOSM) (2009-2020), 'Compendium of Environment Statistic 2009-2020'.

29. Department of Statistics Malaysia (DOSM) (2012-2019), 'Statistic Yearbook 2011-2019'.

30. Department of Statistics Malaysia (DOSM) (2020a), 'Selected Agriculture Indicators'.

31. Department of Statistics Malaysia (DOSM) (2020b), 'Labour Productivity: Selected'.

32. Department of Statistics Malaysia (DOSM) (2020c), 'Supply and Utilisation Accounts Selected Agricultural Commodities 2015 -2019'.

33. Ellen Macarthur Foundation (2017), 'A New Textiles Economy: Redesigning Fashion's Future'.

34. Energy Commission (2020), 'Malaysia Energy Statistics Handbook 2020'.

35. Environmental Science (N.D.), 'Sources of Water Pollution'. [Accessed on 25 June 2021]

36. Esposito, B., Sessa, M., Sica, D. and Malandrino, O. (2020), 'Towards Circular Economy in the Agri-Food Sector: A Systematic Literature Review', *Sustainability*, vol. 12, no. 18, pp. 7401.

37. European Parliament (2019), 'Briefing: Environmental Impact of The Textile and Clothing Industry. What Consumers Need to Know'. [Accessed on 13 October 2020]

38. FAO Fisheries Division (2020), 'FishSTAT'. [Accessed on 2 March 2021]

39. Fernando, Y. and Hor, W. (2017), 'Impacts of Energy Management Practices on Energy Efficiency and Carbon Emissions Reduction: A Survey of Malaysian Manufacturing Firms', *Resources Conservation and Recycling*. Forthcoming.

40. Fibre2Fashion.com (2011), Malaysia Launches Clean Batik Initiative. [Accessed on 15 November 2020]

41. Food and Agriculture Organization (FAO) (2020), 'Climate-Smart Agriculture'. [Accessed on 20 November 2020]

42. Food and Agriculture Organization (FAO) (N.D) 'REDD+ Reducing Emissions from Deforestation and Forest Degradation'. [Accessed on 19 August 2021]

43. Forest Carbon Partnership (N.D) 'What is REDD+?' [Accessed on 19 August 2021]

44. Forestry Department of Peninsular Malaysia (FDPM) (2007-2018), 'FDPM Annual Report 2007-2018'.

45. Gazzola, P., Pavione, E., Pezzetti, R. and Grechi, D. (2020), 'Trends in the Fashion Industry. The Perception of Sustainability and Circular Economy: A Gender/Generation Quantitative Approach', *Sustainability*, vol. 12, pp. 2809.

46. Gibb, R., Redding, D.W., and Chin, K.Q. (2020), 'Zoonotic Host Diversity Increases in Human-Dominated Ecosystems', *Nature*, vol. 584, pp. 398–402.

47. Grace, C and Sarban S. (2019), 'Inaction Over Effluents Affecting Locals' Livelihood'. *The Star*. [Accessed on 24 November 2020]

48. Haliza, A. R. (2018), 'Climate Change Scenarios in Malaysia: Engaging the Public', vol. 1, no. 2, pp. 55-77

49. Hamid, A. I., Din, A. H., Hwang, C., Khalid, N. F., Tugi, A., and Omar, K. M. (2018), Contemporary Sea Level Rise Rates Around Malaysia: Altimeter Data Optimization for ASSESSING Coastal Impact', *Journal of Asian Earth Sciences*, vol. 166, pp. 247–259.

50. Hamzah, N., Tokimatsu, K. and Yoshikawa, K. (2019), 'Solid Fuel from Oil Palm Biomass Residues and Municipal Solid Waste by Hydrothermal Treatment for Electrical Power Generation in Malaysia: A Review', *Sustainability*, vol. 11, no. 4, pp. 1060.

51. Himanshu Purandare, Niranjan Ketkar, Shreyas Pansare, Prathamesh Padhye and Archana Ghotkar. (2016), 'Analysis of Post-Harvest Losses: An Internet of Things and Machine Learning Approach', *2016 International Conference on Automatic Control and Dynamic Optimization Techniques (ICACDOT)*, Pune, pp. 222-226,

52. Institute for Global Environmental Strategies (IGES) (2019), 'Water Environment Partnership in Asia (WEPA) Third Phase Final Report'. [Accessed on 13 November 2020]

53. Intergovernmental Panel on Climate Change (IPCC) (2021), 'Summary for Policymakers: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change', Cambridge University Press.

54. Iskandar, N. L. (2018), 'Organic Farming: Producing Safe and Healthy Food and Environment', MARDI.

55. Jessie Lim, (2018), 'Flood control the priority'. *The Star*. [Accessed on 19 May 2021]

56. Jiang, S. (2017), 'Overview of Pesticide Management in Malaysia'. [Accessed on 10 November 2020]

57. Joy Lee (2021), 'Farming goes indoors', The Star. [Accessed on 6 Feb 2021]

58. Karuppuchamy, Amutha. (2017), 'Environmental Impacts of Denim'.

59. Keizrul, A., Tan K.S. and Ghazali N.H.M (2005), 'No More in The Comfort Zone – Malaysia's Response to the December 2004 Tsunami.', International Hydrography and Oceanography Conference and Exhibition, 3-7 July 2005, Kuala Lumpur, Department of Irrigation and Drainage.

60. Kuan, S. H., Ghorbani, Y. S., and Bernard, L. H. (2016), 'A Review of Rare Earths Processing In Malaysia', Universiti Malaysia Terengganu International Annual Symposium on Sustainability Science and Management 2016, Kuala Terengganu

61. Latif, M. T., Othman, M., Idris, N., Juneng, L., Abdullah, A., Hamzah, W., Khan, M., Nik Sulaiman, N. M., Laxmi, J.,Aghamohammadi, N., Sahani, M., Chung, J. X., Ahamad, F., Amil, N., Darus, M., Varkkey, H., Tangang, F. and Jaafar, A. B. (2018), 'Impact of Regional Haze Towards Air Quality in Malaysia: A Review', *Atmospheric Environment*, vol. 177, pp. 28-44.

62. Law Insider (2021) 'Environmental Credits Definition'. [Accessed on 8 August 2021]

63. Lee Goi, C. (2020), 'The River Water Quality Before and During the Movement Control Order (MCO) in Malaysia', *Case Studies in Chemical and Environmental Engineering*, vol.2, pp. 100027.

64. Lembaga Lebuhraya Malaysia (LLM) (2008-2019), 'Annual Reports 2008-2019'.

65. Levi Strauss & Co. (2016), 'Open Source: Water Innovation',

66. Loren Bell (2014), 'What Is Peat Swamp and Why Should I Care', *Mongabay*. [Accessed on 10 June 2021]

67. Malaysian Investment Development Authority (MIDA) (2018), 'Textile and Textile Products'. [Accessed on 27 October 2020]

68. Marc Humphries (2012), 'Rare Earth Elements: The Global Supply Chain'.

69. Mariani Ariffin and Siti Norhafizah M. Sulaiman (2015), 'Regulating Sewage Pollution of Malaysian Rivers and its Challenges'. *Procedia Environmental Sciences,* vol. 30, pp, 168-173.

70. Market Research (2019), 'Prospects for the Textile and Clothing Industry in Malaysia, 2019'. [Accessed on 27 October 2020]

71. Mei Mei Chu (2019), 'Huge Amount of Fabric Waste Dumped'. *The Star*. [Accessed on 27 October 2020]

72. Mei Mei Chu, Lo Tern Chern and Rena Lim (2019), 'Clean-up to Cost Over RM10mil', *The Star*.

73. Miettinen, J., Shi, C., and Liew, S. C. (2011), 'Two Decades of Destruction in Southeast ASIA'S Peat Swamp Forests', *Frontiers in Ecology and the Environment*, vol. 10, no. 3, pp. 124–128.

74. Ministry of Energy and Natural Resources (KETSA) (2021), 'Malaysia's Energy Transition Plan 2021-2040 Featured at The Special Meeting of ASEAN Ministers on Energy and the Minister of Economy Trade and Industry of Japan'. [Accessed on 5 July 2021]

75. Ministry of Energy, Green Technology and Water (KeTTHA) (2017), 'Malaysia's Green Technology Master Plan 2017-2030'

76. Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) (2018a), 'Malaysia's Third National Communication and Second Biennial Update Report'.

77. Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) (2018b), 'Malaysia Roadmap Towards Zero Single-use Plastics 2018-2030'.

78. Ministry of Environment and Water (KASA) (2020a), 'Malaysia's Third Biennial Update Report to UNFCC in December 2020'.

79. Ministry of Environment and Water (KASA) (2020b), 'Environmental Sustainability in Malaysia 2020-2030 Roadmap'.

80. Ministry of Industry and Trade (MITI) (2019), 'MITI Report 2018'.

81. Ministry of Natural Resources and Environment (NRE) (2015), '5th National Report of Malaysia to Convention Biological Diversity'.

82. Ministry of Water, Land and Water Resources (KATS) (2019), '6th National Report of Malaysia to Convention Biological Diversity'.

83. MMC-GAMUDA (N.D.a), 'SMART – Flood and Traffic Congestion Solutions for KL City Centre'. [Accessed on 19 May 2021]

84. MMC-GAMUDA (N.D.b), 'SMART Project - A Solution for the City of Kuala Lumpur'. [Accessed on 19 May 2021]

85. Mustaffa, R. (2016), 'Reducing Food Loss and Waste Along Value Chain in Malaysia, 2016', *APEC Expert Consultation on Food Loss and Waste at Retail and Consumer Levels*, Taipei City, Taiwan

86. National Disaster Management Agency (NADMA) (2018), 'Annual Report NADMA 2018'.

87. New Straits Times (2020), 'Sabah Incurs Over RM456 Million Losses in Power and Water Theft'. [Accessed on 13 April 2021]

88. Niinimäki, K., Peters, G., Dahlbo, H. (2020), 'The Environmental Price of Fast Fashion', *Nat Rev Earth Environ*, vol. 1, pp. 189–200.

89. Norhidayah, A., Chia-Kuang, L., Azhar, M. K., and Nurulwahida, S. (2013), 'Indoor Air Quality and Sick Building Syndrome in Three Selected Buildings', *Procedia Engineering*, vol, 53, pp. 93–98.

90. Nur Hanani Azman (2020), 'KPKT: Six WTE Plants Planned Towards 2025'. *The Malaysia Reserve*. [Accessed on 15 January 2021]

91. Nuraziatul Aida Ismail (2019), 'Importation of Plastic Waste to Malaysia', *IMPEL Waste and TFS Conference 16-17 October 2019*, Bucharest, Romania

92. Omar, H., Misman, M. A., & Linggok, V. (2018), 'Characterizing and Monitoring of Mangroves in Malaysia Using Landsat-Based Spatial-Spectral Variability', *IOP Conference Series: Earth and Environmental Science*, no. 169, pp. 012037.

93. Osman, A., Saari, N., Saleh, R., Bakar, J., Zainal, N.D., Yacob., M. (2009). 'Post-Harvest Handling Practices on Selected Local Fruits and Vegetables at Different Levels Of The Distribution Chain' *Journal of Agribusiness Marketing*, vol. 2, pp. 39-53.

94. Overland, I., Bazilian, M., Ilimbek Uulu, T., Vakulchuk, R., & Westphal, K. (2019), 'The Gegalo Index: Geopolitical Gains and Losses After Energy Transition' *Energy Strategy Reviews*, vol. 26, pp. 100406.

95. Rashvinjeet S. B. (2018), 'Latest Tapir Killed by Van Pushes Roadkill of Iconic Species to Over 70', *The Star*. [Accessed on 19 December 2021]

96. Razali, A., Syed Ismail, S., Awang, S., Praveena, S., & Zainal Abidin, E. (2018), 'Land Use Change in Highland Area and Its Impact on River Water Quality: A Review of Case Studies in Malaysia'. *Ecological Processes*, vol. 7, no. 1.

97. Reef Check Malaysia (RCM), (2019), '2019 Annual Report Survey'.

98. Sean Fleming, (2020), 'These Scientists Are Listening to The Borneo Rainforest to Protect Biodiversity', World Economic Forum. [Accessed on 20 August 2020]

99. Sheila Sri Priya, (2020), 'Tech-Forward Waste Transformation', *The Star*. [Accessed on 30 November 2020]

100. Shuhada, S. N., Salim, S., Nobilly, F., Lechner A. M., and Azhar, B. (2020) 'Conversion of Peat Swamp Forest to Oil Palm Cultivation Reduces the Diversity and Abundance of Macrofungi'. *Global Ecology and Conservation*, vol. 23.

101. Siti Indati Mustapa, Waznatol Widad Mohamad Ishak, Gasim Hayder and Azlina Mohammad Jais (2020), 'Circular Economy: Life Cycle Cost Analysis of Management Alternatives for Sewage Sludge in Malaysia', *Global Business and Management Research: An International Journal*, vol. 12, no. 4, pp. 484-496.

102. Somasundram, C., Razali, Z., & Santhirasegaram, V., (2016), 'A Review on Organic Food Production in Malaysia', *Horticulture*, vol. 2, no. 3, pp. 12.

103. SWCorp (2019), 'Huge Amount of Fabric Waste Dumped', *The Star.* [Accessed on 27 October 2020]

104. Switch Asia Project, (2009a), 'Clean Batik Initiatives'. [Accessed on 15 November 2020]

105. Switch Asia Project, (2009b), 'Impact Sheet Clean Batik Initiative -Promoting Resource Efficiency and Natural Dyes for A Greener Batik Industry'. [Accessed on 15 November 2020]

106. The Conversation Fund (N.D) 'Environmental Credit Markets: An Investment Primer' [Accessed on 8 August 2021]

107. The Economist Group (2020), 'The Global Food Security Index 2020'.

108. The Guardian (2012), 'How Can We Stop Water from Becoming a Fashion Victim?'. [Accessed on 13 October 2020]

109. The Malaysian Reserve (2019), 'The Malaysian Reserve Article: Food Import Bill Hits RM34.2b as of August', Ministry of Agriculture and Agro-based Industry (MOA) (2019). [Accessed on 18 December 2020]

110. The Star (2015), 'UN Praises Malaysia's Novel SMART Tunnel'. [Accessed on 19 May 2021]

111. Thomas Publishing Company (2020), 'The H&M Supply Chain Could Be the Model to Follow in Making Fast Fashion Sustainable'. [Accessed on 06 October 2020]

112. Tonks, A., Aplin, P., Beriro, D., Cooper, H., Evers, S., Vane, C., Sjögersten, S. (2017), "Impacts of Conversion of Tropical Peat Swamp Forest To Oil Palm Plantation On Peat Organic Chemistry, Physical Properties And Carbon Stocks', *Geoderma*, vol. 289, pp. 36-45.

113. TRX City (N.D), 'SMART Tunnel Stands the Test of Time'. [Accessed on 19 May 2021]

114. Ulya, N. A., Nurlia, A., & Waluyo, E. A. (2020), 'The Application of Economics in The Policy Formulation to Manage Peat Swamp Forests as Important Ecosystems In Climate Change', *IOP Conference Series: Earth and Environmental Science*, pp. 487.

115. United Nation Environment Programme (UNEP) (2005), 'Annotated Guiding Principles for Post-Tsunami Rehabilitation and Reconstruction'.

116. United Nation Environment Programme (UNEP) (2016), 'GEO-6 Regional Assessment for Asia and the Pacific', Nairobi, Kenya.

117. United Nations Educational, Scientific and Cultural Organization (UNESCO) (2020), '2020 World Water Development Report'.

118. United States Food and Drug Administration (USFDA) (2019), 'Malaysia Cotton and Products Annual 2019'

119. Usmani, R. S. A., Saeed, A., Abdullahi, A., Ramiah P., Thulasyammal., Zaman, N. and Hashem, I. (2020), 'Air Pollution and Its Health Impacts in Malaysia: A Review', *Air Quality, Atmosphere & Health*, vol. 13.

120. UTM OTEC, (2019), 'What is OTEC?'. [Accessed on 15 September 2020]

121. Vanda Felbab-Brown (2021), 'Preventing Pandemics Through Biodiversity Conservation and Smart Wildlife Trade Regulation'. [Accessed on 31 January 2021]

122. World Bank (2018), 'Regulatory Indicators for Sustainable Energy'.

123. World Bank (2019), 'How Much Do Our Wardrobes Cost to the Environment?'. [Accessed on 6 October 2020]

124. World Bank (2020), 'Nutrition smart agriculture: When Good Nutrition is Good Business'. [Accessed on 9 November 2020]

125. World Bank (2021), 'Market Study for Malaysia: Plastics Circularity Opportunities and Barriers'. [Accessed on 30 April 2021]

126. World Economic Forum (WEF), (2021), 'The Global Risks Report 2021 16th Edition'.

127. World Health Organisation (WHO), (2018a), 'Ambient (*Outdoor*) Air Pollution'. [Accessed on 30 July 2020]

128. World Health Organisation (WHO), (2018b), 'Nipah Virus'. [Accessed on 3 January 2021]

129. World Wide Fund for Nature (WWF) (2020), '68% Average Decline in Species Population Sizes Since 1970, Says New WWF Report'. [Accessed on October 2020]

130. WWF Malaysia (2020), 'Study on EPR Scheme Assessment for Packaging Waste in Malaysia'. [Accessed on 2 November 2020]

131. WWF Malaysia (N.D), 'Mangrove Forests'. [Accessed on 25 June 2020]

132. Yang Farina (2016), 'Pesticides Residues in Agricultural Soils and Its Health Assessment for Humans in Cameron Highlands, Malaysia', *Malaysian Journal of Analytical Science*, vol. 20, no. 6, pp. 1346-1358.

133. Zaini Ujang, Rakmi Abd Rahman, Aznah Nor Anuar., (2008), 'Current Trends in Water Quality and Resource Management', *In 1st Technical Meeting of Muslim Water Researchers Cooperation (MUWAREC)* pp. 62-80. Malaysia.

134. Zhang, M. H. and Malhotra, V. (1996), 'High Performance Concrete Incorporating Rice Husk Ash as a Supplementary Cementing Material', *Aci Materials Journal*, vol. 93, pp. 629-636.

1. Abd Rahim Shuib, Mohd Ramdhan Khalid, & Mohd Solah Deraman, (2011), 'Innovation and Technologies for Oil Palm Mechanization [Paper presentation]', *Further Advances in Oil Research (2000-2010)*, Kuala Lumpur.

2. Alam, A. S. A. F., Er, A. C. and Begum, H. (2015), 'Malaysian Oil Palm Industry: Prospect and Problem', *Journal of Food, Agriculture and Environment*. vol. 1313, no. 22, pp. 143-148.

3. Ananthalakshmi, A. (2019), 'Malaysia says palm oil industry challenged to meet green standards by 2020', *Reuters*.

4. Balu Nambiappan, Azman Ismail, Norfadilah Hashim, Nazlin Ismail, Dayang Nazrima Shahari, Nik Badullah Nik Idris, Noraida Omar, Kamalrudin Mohamed Salleh, Nur Ain Mohd Hassan and Kushairi, A. (2018) 'Malaysia: 100 Years of Resilient Palm Oil Economic Performance', *Journal of Oil Palm Research*, vol. 30, no.1 pp. 13-23

5. Hamzah, N., Tokimatsu, K. and Yoshikawa, K. (2019), 'Solid Fuel from Oil Palm Biomass Residues and Municipal Solid Waste by Hydrothermal Treatment for Electrical Power Generation in Malaysia: A Review', *Sustainability*, vol. 11, no. 4, pp. 1060. doi: 10.3390/su11041060

6. Loh, S. K., Nasrin, A. B., Mohamad., A. S., Nurul, A., Muzzammil, N., Daryl, J. T., and Stasha E. R. A. (2017), 'Biogas Capture – A Means of Reducing Greenhouse Gas Emissions from Palm Oil Mill Effluent', *Oil Palm Bulletin*, vol. 75, pp. 27-36.

7. Loh, S. K., Nasrin, A. B., Sukiran, M. A., Bukhari, N. A., Muzzammil, N. and Stasha, E. R. A., and Astimar, A. A. (2020), 'The Future of Biogas in the Malaysian Palm Oil Industry: Why Need Methane Capture?', *Oil Palm Bulletin*, no. 72. 75, pp. 1-7

8. Malaysian Agricultural Research and Development Institute (MARDI) (2018), 'MARDI's Innovations Towards Building a Better Tomorrow Five-Year Achievement Report (2011 – 2015)'.

9. Malaysian Palm Oil Board (MPOB) (2020), 'Technology of Transfer'. [Accessed on September 2020]

10. Malaysian Palm Oil Council (MPOC) (2017), 'Palm International Nutra-Cosmeceutical Conference, 2017'

11. Malaysian Palm Oil Council (MPOC) (2020), '96.04% Of Oil Palm Estates Have Achieved MSPO Certification — MPOB'. [Accessed on March 2020]

12. Malaysian Palm Oil Council (MPOC) (2020), 'Malaysian Palm Oil Industry'. [Accessed on March 2020]

13. Malaysian Palm Oil Council (MPOC) (N.D.), 'Palm Oil and the Environment'. [Accessed on 7 March 2020]

14. Michael Ng (2019), 'Malaysian Sustainable Palm Oil (MSPO) To Be Made Mandatory By 2019', MPOC. [Accessed on September 2020]

15. MIMOS Berhad (2019), 'Tracking the Palm Oil Value Chain'. [Accessed on 1 March 2020]

16. Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) (2018), 'Malaysia's Third National Communication and Second Biennial Update Report'.

17. Sime Darby (2016), 'A Quantum Leap with Genome Select'. [Accessed on March 2020]

18. Unit Peneraju Agenda Bumiputera (TERAJU) (2010), 'A Roadmap for Malaysia. Chapter 9: Deepening Malaysia's Palm Oil Advantage', pp. 281-341. [Accessed on 7 March 2020]

19. Wan Hasamudin Wan Hassan, Rosnah Mat Soom and Anis Mokhtar (2005), 'Disintegrable Plastics from Oil Palma and Its Products'.

20. Yuleng Khor, Johan Saravanamuttu, and Deborah Augustin (2015), 'The Felda Case Study, 2015'.

Reference for Figures

Figure 5.1 World Bank, (2020), 'Data Bank – Wealth Account'. [Accessed on 17 November 2020]

Figure 5.2 Yale University, (2006-2020), 'Environmental Performance Index, 2006-2020', Yale Center for Environmental Law & Policy.

Figure 5.3 International Energy Agency (IEA), (2020), 'World Energy Balances Highlights 2020'. [Accessed on 12 January 2021]

Figure 5.4 International Energy Agency (IEA), (2020), 'Data & Statistics'. [Accessed on 12 January 2021]

Figure 5.5 Sustainable Energy Development Authority (SEDA), (2018), 'SEDA 2018 Annual Report'.

Figure 5.6 Ministry of Natural Resources and Environment (NRE) (2011), 'Malaysia's Second National Communication'.

Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) (2018), 'Malaysia's Third National Communication and Second Biennial Update Report'.

Ministry of Energy, Green Technology and Water (KeTTHA) (2017), 'Malaysia's Green Technology Master Plan 2017-2030'.

Figure 5.7 Energy Commission, (2019), 'Malaysia Energy Statistics Handbook 2019'.

Figure 5.8 ASEAN-German Energy Programme (AGEP) (2020), 'Country Profile – RE Target'. [Accessed on 30 September 2021]

Ministry of Energy and Natural Resources (KeTSA) (2021), 'Malaysia's Energy Transition Plan 2021-2040 Featured at The Special Meeting of ASEAN Ministers on Energy and the Minister of Economy Trade and Industry of Japan'. [Accessed on 5 July 2021]

Figure 5.10 Department of Statistics Malaysia (DOSM) (2015-2020), 'Compendium of Environment Statistics 2015-2020'.

Figure 5.13 World Bank, (2020), 'Cereal yield, kg per hectare'. [Accessed on: 13 November 2020]

Figure 5.14 Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC), (2018), 'Malaysia's Third National Communication and Second Biennial Update Report'.

Department of Fisheries (DOF) (2012-2019), 'Annual Fisheries Statistics 2012-2019'

Figure 5.16 Department of Environment (DOE) (2005-2019), 'Environmental Quality Report 2005-2019'.

Figure 5.17 Department of Environment (DOE) (2012-2019), 'Environmental Quality Report 2012-2019'.

Figure 5.18 OECD iLibrary (2020), 'Air pollution exposure', [Accessed on 15 January 2021]

Department of Environment (DOE) (2018), 'Environmental Quality Report 2018'.

Figure 5.20 Department of Statistics Malaysia (DOSM) (2020), 'Annual minimum and maximum air pollutant index for selected stations, Malaysia, 2000 – 2017'. Open Data – Environment.

Figure 5.21 Unites Nation Statistics Division (UNSD) (2020), 'UN Data – Solid Waste Management'. [Accessed: 2 November 2020]

Figure 5.22 Agamuthu Periathamby, Fauziah Shahul Hamid and Khalil Khidzir. (2009), 'Evolution of solid waste management in Malaysia: Impacts and implications of the solid waste bill, 2007', *Journal of Material Cycles and Waste Management*, vol. 11, pp. 96-103.

Agamuthu. P & Fauziah S. (2012), 'Trends in sustainable landfilling in Malaysia, a developing country', *Waste Management & Research*, vol. 30, no. 7, pp. 656-663.

Figure 5.25 Ministry of Natural Resources and Energy (NRE) (2021), 'Kawasan Berhutan Di Malaysia (1990-2018)'. [Accessed on 22 January 2021]

Figure 5.26 Department of Statistics Malaysia (DOSM) (2019), 'Compendium of Environment Statistics 2019.

Figure 5.27 UNEP-WCMC and IUCN, (2020), 'Protected Planet: The World Database on Protected Areas (WDPA)', Cambridge. [Accessed in October 2020]

Figure 5.28 International Union for Conservation of Nature (IUCN) (2014 & 2020), 'Red List of Threatened Species 2014 & 2020'. [Accessed on 18 December 2020]

Figure 5.29 Reef Check Malaysia (RCM) (2007-2020), '2007-2020 Annual Report Survey'.

Figure 5.30 International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure 5.31 OECD Statistics (N.D.), 'Welfare cost of premature deaths' [Accessed on May 2021]

The International Disaster Database (EM-DAT), (N.D.), 'Damage costs from disasters' [Accessed on May 2021]

1. Aassouli, D., Asutay, M., Mohieldin, M., Nwokike, T.C. (2018), 'Green Sukuk, Energy Poverty, and Climate Change: A Roadmap for Sub-Saharan Africa', *Policy Research working paper*, No. WPS 8680, Washington, D.C., World Bank Group [Accessed on 16 February 2021].

2. Aminudin, R., Jamaiuddin N., Hamid, R.A., Shukri, S. and Lee, P.M. (2020), 'Need to address digital divide', The Star. [online] Available from: https://www.thestar.com.my/opinion/letters/2020/07/31/need-to-address-digital-divide [Accessed on 12 June 2021].

3. Badeeu, F.N., Nafiz, A.R. and Muneeza, A. (2019), 'Developing Regional Healthcare Facilities in Maldives through Mudharabah Perpetual Sukuk', *International Journal of Management and Applied Research*, Vol. 6, No. 2, pp. 81-96. https://doi.org/10.18646/2056.62.19-006 [Accessed on 16 February 2021].

4. Barrett, P., Treves, A., Shmis, T., Ambasz, D., Ustinova, M. (2019), 'The Impact of School Infrastructure on Learning: A Synthesis of the Evidence', Washington DC, The World Bank.

5. Christa Clapp and Kamleshan Pillay (2017), 'Chapter 5: Green Bonds and Climate Finance', *Climate Finance: Theory and Practice*, pp. 79-105.

6. CodeBlue (2020), 'Gavi Welcomes Malaysia After Signing COVAX Vaccine Plan', Galen Centre. [online] Available from: https://codeblue.galencentre.org/2020/11/25/gavi-welcomes-malaysia-after-signing-covax-vaccine-plan/ [Accessed on 17 February 2021].

7. Collaborative Research in Engineering, Science & Technology (CREST) (2020), 'Key Statistics at a glance'. [online] Available from: https://crest.my/ [Accessed on 23 December 2020].

8. COVID-19 Clinical Research Coalition (2021), 'Purpose and principles guiding the COVID-19 Clinical Research Coalition'. [online] Available from: https://covid19crc.org/ [Accessed on 15 February 2021].

9. Department of Statistics Malaysia (DOSM) (2015), 'Information and Communication Technology Satellite Account 2010-2014'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=319&bul_id=aHBPSStGSU9LUU5VMzVHa29OT1Ewdz09&menu_id=TE5CRUZCblh4ZTZMODZIbmk2aWRRQT09 [Accessed on 12 June 2021].

10. Department of Statistics Malaysia (DOSM) (2019), 'Information and Communication Technology Satellite Account 2018'. [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=319&bul_id=UWpOUFBQSjk2TDhJNXFwUFhJZHNEUT09&menu_id=TE5CRUZCblh4ZTZMODZIbmk2aWRRQT09 [Accessed on 12 June 2021].

11. Department of Statistics Malaysia (DOSM) (2020), 'National Accounts'. [Accessed on December 2020].

12. Department of Statistics Malaysia (DOSM) (2021), 'National Accounts Time Series Data', [online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09 [Accessed on 20 December 2020].

13. Economic Planning Unit (EPU) (2016a), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 1)', Putrajaya, Prime Minister's Department.

14. Economic Planning Unit (EPU) (2016b), 'A Study on Knowledge Content in Key Economic Sectors in Malaysia Phase III (MYKE III, Phase 2)', Putrajaya, Prime Minister's Department.

15. Education Performance and Delivery Unit (PADU) (2016), 'Malaysia Education Blueprint 2013-2025 Annual Report 2016', Putrajaya, Kementerian Pendidikan Malaysia.

16. Education Performance and Delivery Unit (PADU) (2017), 'Malaysia Education Blueprint 2013-2025 Annual Report 2017', Putrajaya, Kementerian Pendidikan Malaysia.

17. Engels, J., and Diehr, P. (2003), 'Imputation of missing longitudinal data: a comparison of methods', *Journal of Clinical Epidemiology*, vol. 56, No. 10, pp. 968-976. doi: 10.1016/s0895-4356(03)00170-7

18. Esther Landau (2021), 'Cheaper Covid-19 vaccine from China via Pharmaniaga', *New Straits Time*. [online] Available from: https://www.nst.com.my/business/2021/01/656732/cheaper-covid-19-vaccine-china-pharmaniaga [Accessed on 17 February 2021].

19. Harry Kretchmer (2021), 'Vaccine nationalism – and how it could affect us all', World Economic Forum. [online] Available from: https://www.weforum.org/agenda/2021/01/what-is-vaccine-nationalism-coronavirus-its-affects-covid-19-pandemic/ [Accessed on 17 February 2021].

20. Huawei Technologies, (2021), 'Global Connectivity Index 2020 - Shaping the New Normal with Intelligent Connectivity'. [online] Available from: https://www.huawei.com/minisite/gci/en/ [Accessed on 12 June 2021].

21. International Institute for Management Development (IMD) (2000-2019), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

22. Islamic Financial Service Board (IFSB) (2019), 'Islamic Financial Services Industry Stability Report 2019', Kuala Lumpur, IFSB.

23. Jomo, K.S. and Felker, G. (2007), 'Technology Policy in Malaysia', *International Journal of Technological Learning, Innovation and Development,* Inderscience Enterprises Ltd, vol. 1, no. 2. Available from: http://www.inderscience.com/link.php?id=15402

24. Kahaner, D.K. (1995), 'Developing Science Parks in Asia', *Asian Technology Information Programme*.

25. Loh Foon Fong (2020), 'Covid-19: M'sia enrols first patient in WHO trial to find cure', *The Star*. [online] Available from: https://www.thestar.com.my/news/nation/2020/04/22/covid-19-m039sia-enrols-first-patient-in-who-trial-to-find-cure [Accessed on 16 February 2021].

26. Malaysia Digital Economy Corporation (MDEC) (2020), 'Key Milestones – Digital Free Trade Zone (DFTZ)'. [online] Available from: https://mdec.my/digital-economy-initiatives/for-the-industry/entrepreneurs/dftz/ [Accessed on 23 December 2020].

27. Malaysia External Trade Development Corporation (MATRADE) (2020), 'Malaysian Technical Cooperation Programme (MTCP)'. Available from: https://www.matrade.gov.my/en/about-matrade/achievements/matrade-success-stories/malaysian-technical-cooperation-programme-mtcp [Accessed on December 2020].

28. Ministry of Education (MOE) (2013), 'Malaysia Education Blueprint 2013-2025 (Preschool to Post-Secondary Education)', Putrajaya, Kementerian Pendidikan Malaysia.

29. Ministry of Education (MOE) (2020), 'Dashboard awam sekolah-sekolah yang dinaik taraf dibawah program pembaikan sekolah daif'. [online] Available from: https://projekdaif.moe.gov.my/ [Accessed on 25 May 2020].

30. Ministry of Health (MOH) (2020), 'Joint Press Release MOH-WHO 6 April 2020 – Malaysia starts global "Solidarity Trial" – a research effort to test possible treatments for COVID-19'. [online] Available from: https://kpkesihatan.com/2020/04/06/joint-press-release-moh-who-6-april-2020-malaysia-starts-global-solidarity-trial-a-research-effort-to-test-possible-treatments-for-covid-19/ [Accessed on February 2021].

31. Mohsin, M.M.A. (2019), 'Waqfintech and Sustainable Socio-Economic Development', *International Journal of Management and Applied Research*, Vol. 6, No. 3, pp. 130-141. https://doi.org/10.18646/2056.63.19-009 [Accessed on 16 February 2021].

32. Nair, M. (2011), 'Inclusive innovation and sustainable development: leap-frogging strategies to a high-income economy', *ICT Strategic Review 2011/2012*, PIKOM and MOSTI, Malaysia.

33. Nair, M., Ahmed, P., Vaithilingam, S., Narayanan, P., Chan, A.W., Lee, D.L.L.W., Qing, Y.H., Lim, C.C., Lee, W.J., and Lee, K.F. (2018) 'Malaysian Business Sentiment 2018: A Perspective from Malaysian Executives', Monash University Malaysia. [online]

34. Nair, M., Ahmed, P., Vaithilingam, S., Narayanan, P., Chan, A.W., Lee, D.L.L.W., Qing, Y.H., Lim, C.C., Lee, W.J., and Ong, C.S. (2019), 'Malaysian Business Sentiment 2019/2020: A Perspective from Malaysian Executives', Monash University Malaysia. [online] Available from: https://mon.clients.squiz.net/__data/assets/pdf_file/0005/2078033/Monash-Business-Sentiment-Report-2019-2020.pdf

35. Nair, M., Ahmed, P., Vaithilingam, S., Narayanan, P., Chan, A.W., Lee, D.L.L.W., Qing, Y.H., Lim, C.C., Lee, W.J., and Tang, S. (2020), 'Malaysian Business Sentiment 2020/2021: A Perspective from Malaysian Executives', Monash University Malaysia. [online] Available from: https://www.monash.edu.my/__data/assets/pdf_file/0009/2432277/MSH-343-Monash-Business-Sentiment-Brochure-2020-FA-161220-For-Web.pdf

36. New Straits Time (2020), 'Malaysian virologist joins commission probing origin of Covid-19'. [online] Available from: https://www.nst.com.my/news/nation/2020/11/643708/malaysian-virologist-joins-commission-probing-origin-covid-19 [Accessed on 17 February 2021].

37. OECD (2008), 'Handbook on Constructing Composite Indicators: Methodology and User Guide', France, OECD Publications. Available from: https://www.oecd.org/sdd/42495745.pdf

38. OECD (2019), 'OECD Time-Series Estimates of Government Tax Relief for Business R&D', *Horizon 2020 Programme of the European Commission*. [online] Available from: https://www.oecd.org/sti/rd-tax-stats-tax-expenditures.pdf [Accessed on 17 February 2021].

39. PwC (2020), 'Korea, Republic of: Corporate - Tax credits and Incentives', *Worldwide Tax Summaries*. [online] Available from: https://taxsummaries.pwc.com/republic-of-korea/corporate/tax-credits-and-incentives [Accessed on 17 February 2021].

40. Shahida, S. and Saharah, S. (2013), 'Why Do Firms Issue Sukuk Over Bonds? Malaysian Evidence ', *Prosiding Perkem VIII*, vol.2, pp. 551-573.

41. Securities Commission Malaysia (SC) (2019), 'Sustainable and Responsible Investment Sukuk Framework: An Overview'. [online] Available from: https://www.sc.com.my/api/documentms/download.ashx?id=84491531-2b7e-4362-bafb-83bb33b07416 [Accessed on 16 February 2021].

42. Shukri, N., Zamri, S., Muneeza, A. and Ghulam, H. (2019), 'Waqf Development in Marawi City via Issuance of Perpetual Waqf Sukuk', *International Journal of Management and Applied Research*, Vol. 6, No. 2, pp. 68-80. https://doi.org/10.18646/2056.62.19-005 [Accessed on 17 February 2021].

43. Solow, Robert M. (1956), 'A Contribution to the Theory of Economic Growth', Quarterly Journal of Economics, 70.1:65-94.

44. St. John, J., Spector, J. and Merchant, E.F. (2021), 'Inauguration of President Biden Kicks Energy and Climate Agenda into Action', Greentech Media. [online] Available from: https://www.greentechmedia.com/articles/read/inauguration-of-president-biden-kicks-energy-and-climate-agenda-into-action [Accessed on February 2021].

45. Sustainalytics (2021), 'The Government of Malaysia SDG Sukuk Framework', *Second-Party Opinion*, Putrajaya. Available from: https://www.mof.gov.my/pdf/ekonomi/sustainability/The-Government-of-Malaysia-Second-Party-Opinion.pdf [Accessed on 1 May 2021].

46. Swan, Trevor W. (1956), 'Economic Growth and Capital Accumulation', *Economic Record* 32.63: 334-361.

47. The Growth Lab at Harvard University (2019), 'Growth Projections and Complexity Rankings, V2' [Data set]. https://doi.org/10.7910/dvn/xtaqmc

48. United Nations (2004), 'Asia-Pacific Development Journal', *Economic and Social Commission for Asia and the Pacific*, Thailand, United Nations Publication. Available from: https://www.unescap.org/sites/default/d8files/knowledge-products/apdj11-2-full_0.pdf

49. Wang, C.L., and Ahmed, P. (2007), 'Dynamic capabilities: A review and research agenda', *International Journal of Management Reviews*, 9(1), 31–51. doi:10.1111/j.1468-2370.2007.00201.x

50. World Bank (2020), 'GDP (constant 2010 US$) – Malaysia (1950 – 1970)', *World Bank national accounts data, and OECD National Accounts data files*, The World Bank.

51. World Economic Forum (WEF) (2020a), 'Global Competitiveness Report Special Edition 2020: How Countries are Performing on the Road to Recovery', Geneva, Switzerland, World Economic Forum.

52. World Economic Forum (WEF) (2020b), 'The Future of job report 2020', Geneva, Switzerland, World Economic Forum. Available from: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf

53. World Economic Forum (WEF) (2021), 'Tech for Integrity - Shaping the Future of Trust and Integrity'. [online] Available from: https://widgets.weforum.org/tech4integrity/index.html [Accessed on 12 June 2021].

54. World Health Organization (WHO) (2017), 'Malaysia–WHO Country Cooperation Strategy 2016–2020', Manila, Philippines, World Health Organization, Regional Office for the Western Pacific.

Reference for Figures

Figure 6.1 Academy of Sciences Malaysia (ASM) (2017), 'ASM S&T Foresight Malaysia 2050 Report'.

Figure 6.2 Construction Industry Development Board (CIDB) (2018), 'CIDB Quick Facts'. [online] Available from: https://www.cidb.gov.my/sites/default/files/2020-04/ANTARABANGSA-2018.pdf

Figure 6.3 Huawei Technologies, (2021), 'Global Connectivity Index 2020 - Shaping the New Normal with Intelligent Connectivity'. [online] Available from: https://www.huawei.com/minisite/gci/en/ [Accessed on 12 June 2021].

Figure 6.4 Aminudin, R., Jamaiuddin, N., Abdul Hamid, R., Shukri, S., Lee, P.M. (2020), 'Need to address digital divide', *The Star*. [online] Available from: https://www.thestar.com.my/opinion/letters/2020/07/31/need-to-address-digital-divide [Accessed on 12 June 2021].

Figure 6.5 Ministry of Higher Education (MOHE) (2021), 'Number of HEI'. [online] Available from: https://www.mohe.gov.my/en/ [Accessed on 12 June 2021].

Figure 6.6 (a) Transparency international (2021), 'Corruption Perceptions Index 2015 & 2020'. [online] Available from: https://www.transparency.org/en/cpi/2020/index/nzl [Accessed on 12 June 2021].

Figure 6.6 (b) European Research Centre for Anti-Corruption and State-Building (ERCAS) (2021), 'Index of Public Integrity 2015 and 2019'. [online] Available from: https://integrity-index.org/ [Accessed on 12 June 2021].

Department of Statistics Malaysia, (2015-2020), 'Compendium of Environment Statistics 2015-2020'.

Figure 6.7 SciVal (2020), 'Percentage of Academic-Corporate Joint Publications from Total Collaboration Publications'. [online] Available from: https://www.scival.com/ [Accessed on 29 December 2020].

Figure 6.8 OECD (2019), 'OECD Time-Series Estimates of Government Tax Relief for Business R&D', *Horizon 2020 Programme of the European Commission*. [online] Available from: https://www.oecd.org/sti/rd-tax-stats-tax-expenditures.pdf [Accessed on 17 February 2021].

Figure 6.9 Twohey, M. Collins, K. and Thomas, K. (2020), 'With First Dibs on Vaccines, Rich Countries Have 'Cleared the Shelves', New York Times. [online] Available from: https://www.nytimes.com/2020/12/15/us/coronavirus-vaccine-doses-reserved.html [Accessed on 17 February 2021].

Figure 6.10 – 6.23 Surveys conducted by Sunway University Research Team

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Figure S2.4 International Institute for Management Development (IMD) (2020), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center.

Figure S2.5 World Economic Forum (WEF) (2020), 'Global Competitiveness Index', Global Competitiveness Report 2019. [Online] Available from: http://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf [Accessed on 29 December 2020].

Department of Statistics Malaysia (DOSM) (2020), 'National Accounts'. [Online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09 [Accessed on 29 December 2020].

Figure S2.6 World Bank (2020), 'GDP per Capita, PPP (Constant 2017 International $), 2010-2019'. [Online] Available from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=MY [Accessed on 29 December 2020].

World Bank (2020) 'GDP per Capita (Constant 2010 US$) – Malaysia (1950 – 1970)', *World Bank National Accounts Data, and OECD National Accounts Data Files*. Available from: https://data.worldbank.org/indicator/NY.GDP.PCAP.KD?locations=MY [Accessed on 29 December 2020].

Figure S2.7 Social Progress Imperative (2020), 'Social Progress Index 2011-2020'. [Online] Available from: https://www.socialprogress.org/?code=MYS&tab=2

International Institute for Management Development (IMD) (2020), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center

Department of Statistics Malaysia (DOSM) (2020), 'National Accounts'. [Online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09 [Accessed on 29 December 2020].

Figure S2.8 Yale University (2020), 'Environmental Performance Index, 2007-2020', Yale Centre for Environmental Law & Policy.

International Institute for Management Development (IMD) (2020), 'World Competitiveness Yearbook, 2000–2019', IMD World Competitiveness Center

Department of Statistics Malaysia (DOSM) (2020), 'National Accounts'. [Online] Available from: https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09 [Accessed on 29 December 2020].

Chapter 7 – Recommendations

1. Academy of Sciences Malaysia (ASM) (2018), Science Outlook 2017: Converging Towards Progressive Malaysia 2050, Kuala Lumpur, Academy of Sciences Malaysia.

2. Academy of Sciences Malaysia (ASM) (2020), '10-10 Malaysian Science, Technology, Innovation and Economy (MySTIE) Framework: Trailblazing the Way for Prosperity, Societal Well-Being & Global Competitiveness', Kuala Lumpur, Academy of Sciences Malaysia.

3. OECD (2016), OECD Reviews of Innovation Policy: Malaysia 2016, *OECD Reviews of Innovation Policy*, Paris, OECD Publishing. Available from: https://doi.org/10.1787/9789264255340-en

4. School of International Futures (SOIF) (2021), 'Features of effective systemic foresight in governments around the world', United Kingdom. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/985279/effective-systemic-foresight-governments-report.pdf

5. Soffel, J. (2016), 'Ten 21st-century skills every student needs', World Economic Forum. [online] Available from https://www.weforum.org/agenda/2016/03/21st-century-skills-future-jobs-students/ [Accessed on 25 August 2020].

Reference for Figures

Figure 7.1 Academy of Sciences Malaysia (ASM) (2018), 'Science Outlook 2017: Converging Towards Progressive Malaysia 2050', Kuala Lumpur.

Figure 7.2 Soffel, J. (2016), 'Ten 21st-Century Skills Every Student Needs', World Economic Forum. [Online] Available from https://www.weforum.org/agenda/2016/03/21st-century-skills-future-jobs-students/ [Accessed on 25 August 2020].

Figure 7.3 Academy of Sciences Malaysia (ASM) (2020), '10-10 Malaysian Science, Technology, Innovation and Economy (MySTIE) Framework: Trailblazing the Way for Prosperity, Societal Well-Being & Global Competitiveness', Kuala Lumpur, Academy of Sciences Malaysia.

Nair, M. (2011), 'Inclusive Innovation and Sustainable Development: Leap-Frogging Strategies to A High-Income Economy', *ICT Strategic Review 2011/2012*, PIKOM and MOSTI, Malaysia.

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–Ms Smita Kuriakose, World Bank Group (Malaysia)

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