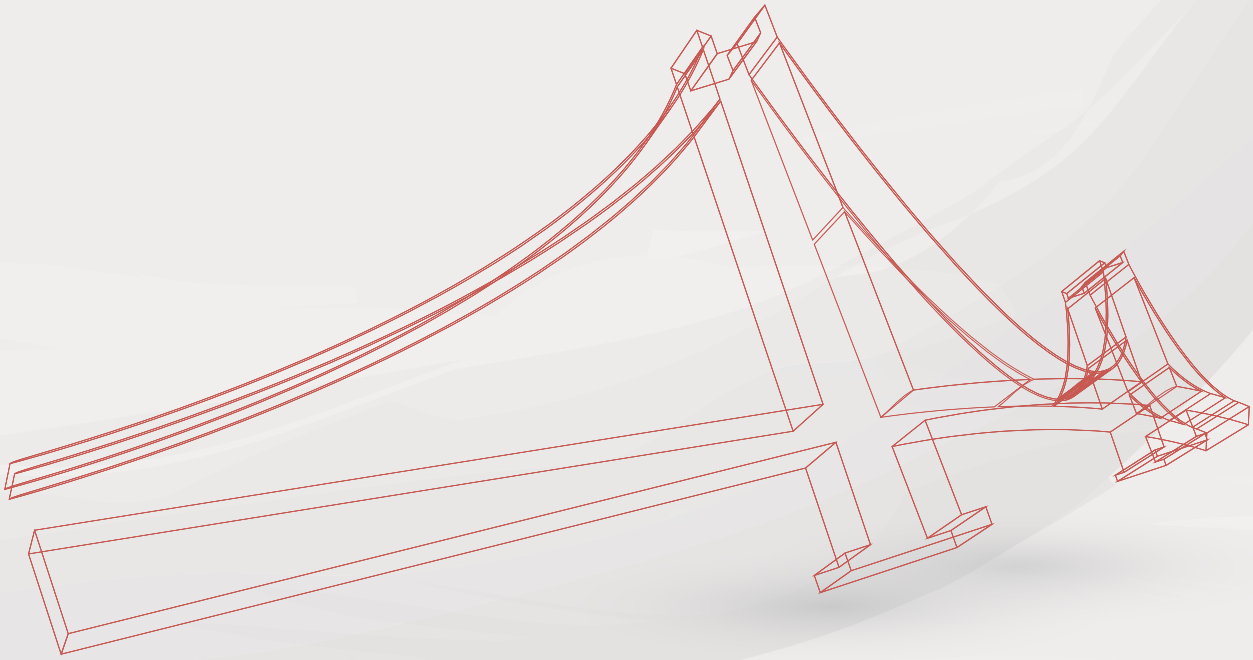
MEGA SCIENCE 2.0

SECTORAL REPORT



INFRASTRUCTURE

MEGA SCIENCE 2.0

Infrastructure Sector

AKADEMI SAINS MALAYSIA

Contents

FOREWORD ii
PREFACE iii
ACKNOWLEDGEMENT iv
EXECUTIVE SUMMARY v
LIST OF TABLES & FIGURES xxviii
ACRONYMS xxviii

CHAPTER 1: INTRODUCTION
1.1 Background 1
1.2 Objectives 3
1.3 Framework 3
1.4 Methodology 4
1.5 Summary 4

CHAPTER 2: LITERATURE REVIEW
2.1 The Future of Infrastructure 8
2.1.1 Global Infrastructure Development Scenario 8
2.1.2 Infrastructure Support for Economic Sustainability, Competitiveness and Productivity 8
2.1.3 Infrastructure Life Cycle 11
2.1.4 Current Status 15
2.1.5 Attributes of the Best Infrastructure Globally 17
2.2 Summary 19

CHAPTER 3: FINDINGS
3.1 National Transport Policy and Strategy 21
3.2 Passenger Transport 22
3.3 Freight Transport 22
3.4 Regional Connectivity 22
3.5 World Bank Preliminary Findings 23
3.6 Regional Key Needs and Issues 24
3.7 Transportation Infrastructure Stakeholders Engagement 28
3.8 Case Studies 32
3.9 Lessons Learnt 35
3.10 Summary 40

CHAPTER 4: RECOMMENDATIONS TO BRIDGE THE GAPS THROUGH RESEARCH AND DEVELOPMENT

4.1 Culmination of Findings 43
4.2 R&D Areas to Support Sustainable Infrastructure 45
4.2.1 R&D Needs 45
4.2.2 General Sustainability-driven Infrastructure Issues 45
4.2.3 Specific Issues for Each Sector 46
4.3 Summary 78

CHAPTER 5: THE SUSTAINABLE INFRASTRUCTURE FRAMEWORK OF MALAYSIA'S INFRASTRUCTURE

5.1 The Sustainable Infrastructure Framework 81
5.1.1 Sustainable Infrastructure Tool 83
5.2 Summary 88

CHAPTER 6: CONCLUSIONS

6.1 Sustainable Infrastructure for Malaysia's Future Productivity and Competitiveness 92
6.2 Infrastructure Sustainability Enabling the Sustainable Infrastructure 93
6.3 Outcomes and Recommendations 93

REFERENCES

FOREWORD

These Sectoral Reports are the output of the Academy's Mega Science Studies for Sustained National Development (2013-2050), a Flagship Programme of the Academy, first introduced by my predecessor, Academician Tan Sri Dr Yusof Basiron FASc. The first series of reports covering Water, Energy, Health, Agriculture and Biodiversity have already been published.

The Academy had adopted the concept of a Mega Science Framework as a comprehensive vehicle to drive the use of Science, Technology and Innovation (STI) to contribute towards economic growth. Mega essentially means big, therefore the disciplines of Mega Science implies a pervasive (broad-based), intensive (in-depth), and extensive (long period of engagement) use of science knowledge to produce technologies, products and services for all sectors of the economy to derive economic growth and development. It also calls for extensive investment in research and development activities to enhance the knowledge base for the targeted sectors. Since knowledge in marketing and finance is equally important in promoting the success of a commercial venture as compared to technical needs, it is envisaged that the Mega Science approach will require research to be conducted both in non-technical as well as in traditional scientific sectors.

We are confident that the ideas and findings contained in this second series of Reports covering the Sectors of Housing, Infrastructure, Transportation, Electrical and Electronics, and Environment, where the science, engineering and technological areas have been identified in the short-term (2013 – 2020), medium-term (2021 – 2035) and long-term (2036 – 2050) periods, will be of use by the central agencies' policy makers and planners as well as by the other relevant Ministries.

I would like to record our appreciation to the Government of Malaysia for supporting this Study financially as part of the 10th Malaysia Plan. Continued financial support from the Government is essential for the Academy to continue with its Flagship Programmes in the other Sectors which have already been identified. I would also like to congratulate the Sectoral Team Leaders and all Fellows of the Academy who were involved in producing these Sectoral Reports for a job well done.

TAN SRI DATUK DR AHMAD TAJUDDIN ALI FASc
President
Academy of Sciences Malaysia

PREFACE

In this second series of the Mega Science Framework Studies for Sustained National Development (2013-2050), undertaken by the Academy of Sciences Malaysia, STI opportunities have been identified and roadmaps provided for the short to long term applications of Science, Engineering and Technology (SET) in the critical and overarching sectors such as housing, infrastructure, transportation, electrical and electronics, and the environment sectors. These sectors were selected on the basis of their inter-connectedness with the electrical and electronics sector providing the platform towards the "Internet of Things" and linking the four other sectors seamlessly.

One of the most frequently asked questions by decision-makers and scientists themselves is "How can STI contribute more effectively to economic development and wellness in a sustained manner without compromising the environment's sustainability". There are good reasons to refer to STI because they have a track record to meet critical challenges posed primarily by the growth of human population and their wants. In this respect, and especially in the 5 new sectors, STI will rise again to meet the new challenges in response to the national and global demand to factor towards enhancing quality of life in all products, processes, services and development projects.

The biggest challenge to all scientists is how to use the fixed earth resources (especially water, land, forests and minerals) to produce food, water and goods for human needs without depriving habitats for the millions of other species and destroying the ecosystems. Proven existing technologies must continuously be improved to be eco-friendly whilst the emerging one such as renewable energy, genomics, stem cells, nanotechnology, biotechnology and the noveau-ICT must conform to the new order of sustainability, ethical and moral obligations whilst contributing to the economic development of the nation. The environment sector has attempted to address these issues.

There are vast opportunities in various sectors of the national economy which can be leveraged upon in an attempt to resolve challenges and problems faced by the populace through innovative approaches in the application of SET. Through identifying and developing various tools through SET, it will go towards ensuring that our economy is not only sustained but sustained in a sustainable manner.

The Academy recognises the importance of cross disciplines linkages that must be integrated during planning, implementation and monitoring of national programs and projects. Social engineering must be designed to match the rapid technical advances to minimise their negative impacts, including the implementation of Life Cycle Assessments (LCA) of the various products and services in these five sectors.

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THE INFRASTRUCTURE SECTOR STUDY TEAM

The Academy of Sciences Malaysia wishes to thank and acknowledge the following Sectoral Team Members for the provision of their expertise and technical input in the preparation of the Report as well as for ensuring that the Report was completed in a timely manner:

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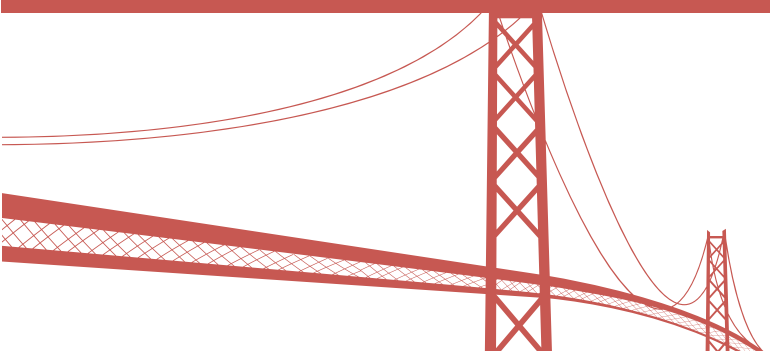
EXECUTIVE SUMMARY

MEGA SCIENCE 2.0 | INFRASTRUCTURE SECTOR



Malaysia's future will be driven by her state of productivity and competitiveness. Whilst there are many determinant factors, the infrastructure sector will be a key determinant to support the other 'softer' enablers. Infrastructure and its sustainability has been emplaced as one of the key thrust areas in this Academy of Sciences' Mega Science Framework Study initiative in order to preserve Malaysia's long term needs through sound science and technology efforts. The focus of this study is further scoped towards transport infrastructure, namely roads & highways, rails, airports and ports. In addition, the issue of Engineering, Procurement and Construction (EPC) has been addressed across the above sectors.

The time horizon has been set to be beyond 2020 and towards 2050, where Science, Technology and Innovation (STI) is expected to be instrumental in extending the present knowledge economy to a new economy that will be centred around sustained development and impact. STI is to be substantially represented by research priority areas that may help the nation to propel its efforts towards a common goal that would help achieve such aspirations.

The infrastructure sector must continue to play its conventional role in providing the basic needs of the population effectively. Additionally, in a new light, the infrastructure sector must also be able to perform the critical role in ensuring sustainable development of the nation. The state of our infrastructure is still open to argument, whether they are in the best state, or conversely, in an impoverished state. Nevertheless, despite the arguments, the realities of the present and the past must be established, and subsequently used to ensure that the future will be brighter for the infrastructure sector, in order for it to sustain the needed development of this nation. This study has addressed this through the following objectives:

i. To define the attributes of the infrastructure sector that would be appropriate to enhance competitiveness and sustained development;

i. To identify the prevalent gaps in the infrastructure sector between the present realities and the aspired ideals;

ii. To determine the role of STI in the Malaysian infrastructure sector through short, medium and long term measures; as well as

iii. To identify gaps in STI knowledge and development in the infrastructure sector and recommend appropriate measures through Research & Development (R&D) priority areas; product and technology development, and the nurturing of relevant industries.

The general approach used in this study has been to ascertain the prevailing gaps between the present state of affairs in and around the Malaysian infrastructure sector as compared to the best practices in the world. The findings of the four transport and infrastructure sectors have shown that there is much room for improvement. **Figure 1.1** depicts the framework used to approach this study.

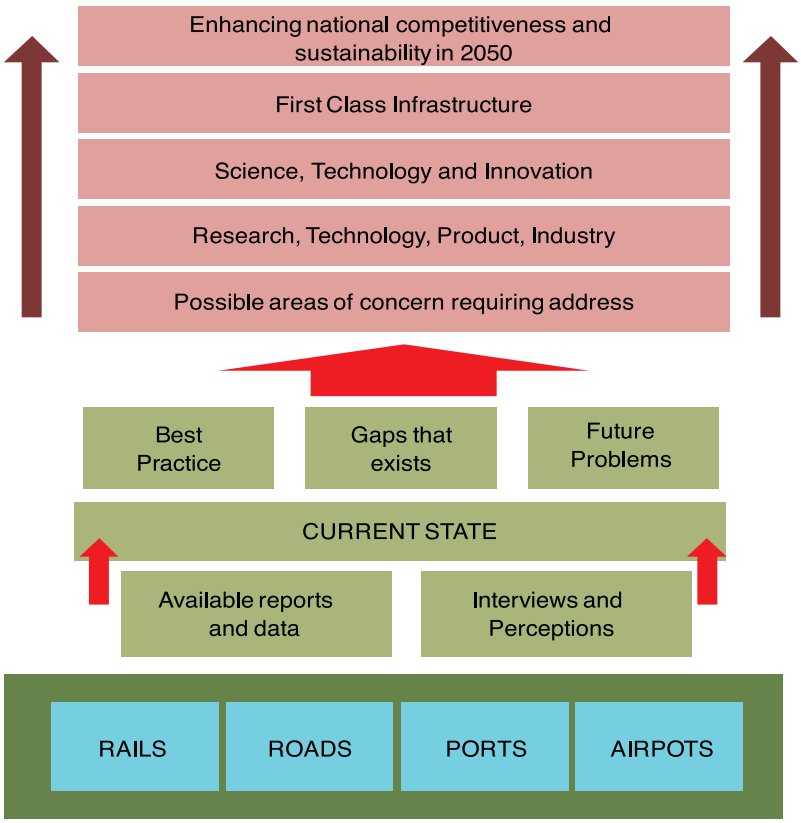


Figure 1.1. The Study Framework

A review of the current state of affairs in the domestic and global infrastructure industry has helped to establish appropriate points of reference in terms of infrastructure maturity and its levels of development and deployment. The roles of infrastructure in the national development of a country are then assessed to ascertain the contribution of infrastructure to economic growth and sustainability of a country. The study also looks at some of the options available for a country to respond to the increasing needs of their infrastructure to meet the challenges of reduced capital spending due in part to economic downturn, climate change, and people and goods mobility associated with urbanisation and enhancing the overall quality of life. It was then established that sustainable infrastructure could be one of the most important remedies for the global as well as Malaysia's challenges to its economic sustainability.

The infrastructure life cycle is a series of activities within fairly well defined phases, necessary to fulfil the infrastructure projects goals and objectives were laid out. Every well, planned and executed infrastructure projects will need to go through the various phases of its development from planning to eventual disposal and deconstruction. **Figure 1.2** depicts the infrastructure life cycle.

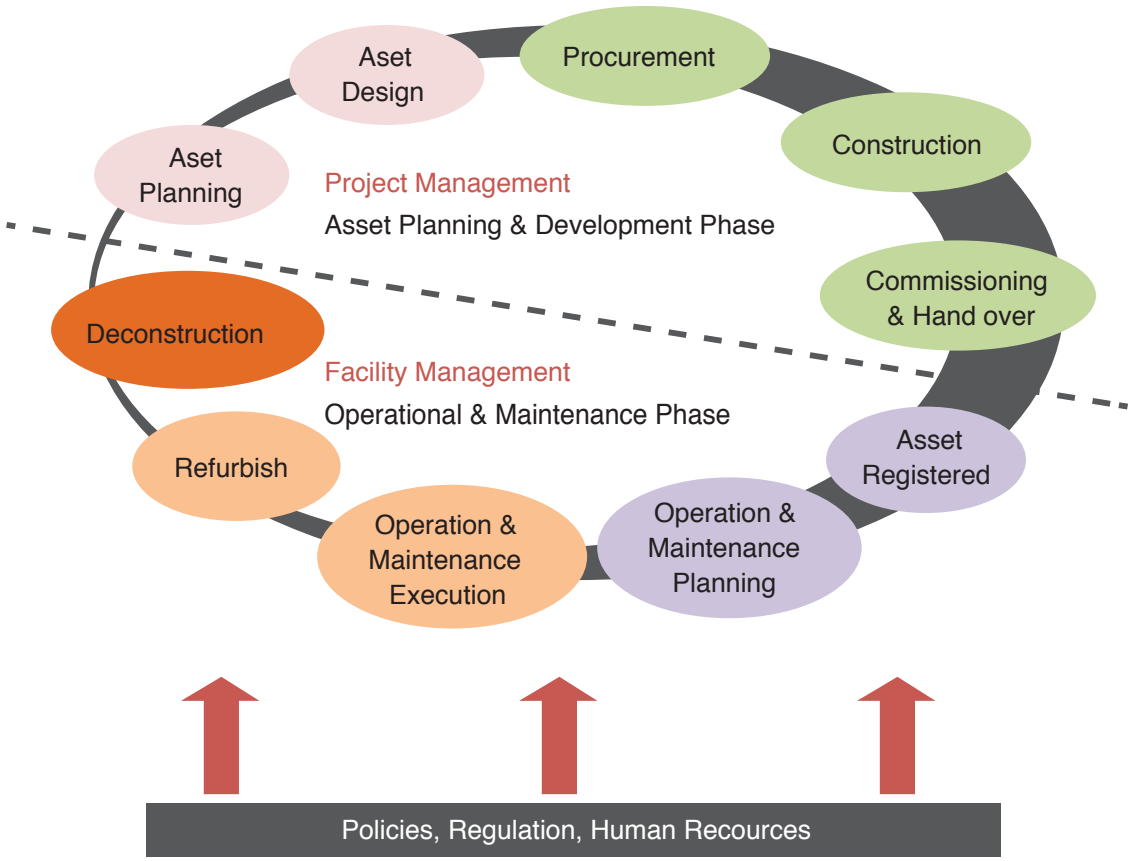


Figure 1.2. The Infrastructure Life Cycle

Based on the infrastructure life cycle, current status of infrastructure planning, design, construction, operation and maintenance is then reviewed in a bit more detail to understand the processes involved and the roles of various stakeholders and supply chain in the processes. Where appropriate, known deficiencies and shortcomings are highlighted and comparisons with international best practices are made. The various stakeholders and players involved, directly or indirectly, in different phases of infrastructure life cycle were also ascertained. Finally, an appreciation of best-in-class existing and future infrastructure at the international level is discussed to give some early indication of possible gaps between what Malaysia currently has and what the country should aspire to have.

A review of study results by global prominent organisations has ranked Malaysia's infrastructure state as average. The World Economic Forum (WEF) Global Competitiveness Report 2013 – 2014 has rated Malaysia with values in the region of 5.0 – 5.5 for the overall transport infrastructure quality, but with the exception of the rail infrastructure (4.8) and air transport infrastructure scoring a 5.8 out of possible 7. A more detailed analysis was carried out through the methodology of this project, and the findings are as follows:

- Malaysia has fragmented policies that do not integrate and guide the development of the transport sector as a whole. The absence of a national transport policy has resulted in various ministries and departments developing and expanding its designated transport mode without any regard to the different roles of the others. This has led to misallocation of resources, manifested by the duplication of facilities and even excess capacities among the various modes.

- The Economic Planning Unit (EPU) has recently embarked on developing a national transport strategy for Malaysia that can guide policymakers across agencies, sectors, and regions in the implementation of measures to improve the efficiency, integration, competitiveness, and environmental sustainability of the country's transportation system. The scope encompasses passenger transport, freight transport, rural transport and institutional framework and planning.

- Passenger transport issues stem from high private vehicle ownership and low public transport modal share resulting in significant congestion in urban areas. Transportation plans at national, regional and local levels are not integrated. Freight transport is fragmented due to single mode planning, limited interagency coordination and overlapping effort among agencies.

- Regional development authorities such as Iskandar Malaysia, Northern Corridor Economic Region, East Coast Economic Region, Sabah Development Corridor and Sarawak Corridor of Renewable Energy; need to ensure rural-urban connectivity to health and educational services, SME access to markets, suppliers and national networks, and connectivity for agriculture to national supply chains. The connectivity between Peninsular Malaysia and East Malaysia needs to be enhanced, not only for the purpose of economic development, but for national and social cohesion. They have unique needs but still share largely common issues whereby institutional challenges and bottlenecks seem to be a major area of concern. The feedback from transportation infrastructure stakeholders and preliminary findings from a World Bank study for EPU reveal that issues in the planning stage contribute greatly to the disintegrated development of the transportation sector.

- Planning issues include the absence of a national transport policy and strategy, regulatory and procedural bottlenecks that cost time, money or access to markets and services or inhibit financial sustainability; institutional bottlenecks as to overlapping or unclear authority and accountability that may hamper effective management and service delivery. The fragmented institutional environment causes disconnects in funding and policy making resulting in substandard physical and market outcomes.

- Procurement issues focusses on multiple levels of sub-contracting, adversarial relationship in procurement, price-driven, sustainability, disregard for health and safety measures, restricted funding amid global economic uncertainties and financial and business models that are restricted by rigid and unrealistic budgets.

- Design issues include current design practices that have not considered deconstruction, lacking of details on build-ability, lacking of specialisation and innovation, low utilisation of Industrialised Building Systems and alternative materials; and poor adoption of life cycle cost and value management analysis.

- Construction issues include inferior quality and durability, poor health, safety and environmental records, weak adoption of modern construction technology and innovation, low use of recycled and reusable materials, high-energy consumption and high wastage of materials.

- Operations and maintenance issues comprise of low quality and high maintenance cost, poor reliability and frequent breakdowns, weak preventive maintenance culture, lack of total asset management practices, no inventory of existing infrastructure and lack of skilled workforce.

- Deconstruction issues are generally not considered. However, deconstruction presents a significant potential for infrastructure sustainability in the reclamation, reuse and refurbishment of materials.

- Case studies and lessons learnt from transportation infrastructure projects in Malaysia indicate that issues exist in different phases of the infrastructure life cycle. Thus, the local industry needs to look beyond project management and realise the importance of facility management, which involves asset register, operations and maintenance, refurbishment and disposal. For infrastructure sustainability, it is imperative that both project management and facility management phases are considered in the infrastructure life cycle.

- Sustainable infrastructure may be loosely defined as "*Infrastructure that is in itself sustainable and will promote the sustainability of the nation and the people".* The initial definition has given rise to two concepts: "sustainable infrastructure" and "infrastructure sustainability"; both have been addressed by this work. The former defines the need for nations to be selective on infrastructure projects that will help the sustainability of the nation (as defined by the term sustainable development), whilst the latter addresses the needs for any planned, constructed and existing infrastructure to possess the sustainability attributes that will at least meet its intended purpose and functions satisfactorily.

As may be concluded from the issues highlighted on the state of Malaysian's infrastructure, it may be deduced that in order to address the problems completely, the efforts will be beyond just science and technology. It is also evident that the entire life cycle of the infrastructure sector faces many issues influenced greatly by shortcomings at the planning stage. The various methods used in this study have shown that there are commonalities among the different infrastructure sectors. There was a general agreement that sustainable infrastructure need to fit the following attributes:

- Infrastructure development that will serve its functions without compromising the needs and functions of others

- Infrastructure that meets the equilibrium between time, costs and quality requirements

- Infrastructure that will surpass its intended design years and continue to provide the same expected (or even better) level of service

- Infrastructure that will continue to provide the competitive advantage to the nations and its people to meet and exceed future expectations

Table 1. Outcomes of R&D (General)

No	Issues	Outcomes of R&D
1	The need to have the planning for infrastructure to be in an integrated manner	a) Establishment of causes of the present system that have deterred integrated planning b) Recommendations to overhaul the present governance to encourage integrated planning of infrastructure c) Evaluation of the effectiveness of the sustainable infrastructure tool and framework to encourage integrated planning for infrastructure
2	Development and imposition of sustainability-drive project feasibility analysis as compulsory requirement at the planning stage of infrastructure	a) Recommendation on implementing the sustainable infrastructure framework and tool for project feasibilitiy needs b) Recommendations to improve on constraining features (legal, procedures, culture, etc)
3	Facilitating financial models to support sustainable infrastructure	a) Recommendations on how to make a business case to support the sustainability-driven infrastructure effort in Malaysa b) An establishment of an effective financial, business and procurement model for Malaysian infrastructure projects
4	The state of readiness in terms of capacity, competency and capability amongst infrastructure players	a) An understanding of the present capacity, capability and competency of infrastructure industry players in embracing sustainability practices b) Prescribing an outcome-based approach to leverage the present state of readiness amongst the human resources, system of governance, mindsets and enablers to embrace sustainability-driven infrastructure. This may be done through formal certification at institutions of higher learning, structured continuous professional development programmes or the capacity-building programmes c) A special upgrading programme for infrastructure designers will be critical. Research into effective planning, execution and outcomes assessment will be needed d) A special upgrading programme for infrastructure contractors will be critical. Research into effective planning, execution and outcomes assessment will be needed
5	Programmes for self-driven mindsets for safety and sustainability outcomes amongst contractors and other players	a) An understanding of the prevalend mindset and practices that would hamper safety and sustainability outcomes b) A recommendation on efforts that will change such mindsets. Research to formulate effective execution and assessing outcomes under the continual quality improvement will be essential

The study has provided recommendations through a detailed but not exhaustive listing of R&D outcomes. The table provides a list of R&D outcomes that are common for the infrastructure sector. The purpose of providing R&D outcomes rather than topics is to allow the creativity of the research practitioners in Malaysia to define their respective approaches to achieve the intended outcomes

Accordingly, suggestions for R&D issues and outcomes for each of the four transport infrastructure are also given. They are organised with reference to the life cycle component, the dominant area(s) of discipline, and the appropriate time horizon for accomplishment. The nature of the recommendations is to address the identified issues as well as to prepare the nations for the other challenges in the future. It is hoped that the long list of recommended R&D outcomes may guide

the nation through systematic and comprehensive, yet prioritised tactical move for a more sustainable future for our infrastructure.

Overall, 17 areas and 36 R&D outcomes have been recommended for the roads and highways sectors. Whereas, 25 areas and 46 R&D outcomes have been recommended for the rail sector. Meanwhile, 20 areas and 42 R&D outcomes have been recommended for the port sector, and 24 areas as well as 48 R&D outcomes have been recommended for the airport sector (refer to **Appendix A**). Amongst these, the following are the areas that are the most critical and are the most practical to be achieved, and may be considered as the "low-hanging fruits" of Malaysia:

i. **Roads**

Reducing environmental impact:

- Stabilisation of unsuitable *in-situ* soils by chemicals or blending with local fibres
- Recycle of waste materials
- Establish local tunnelling of knowledge, skill and methodology to replace cutting of slopes in hilly terrain

Improve Resource Efficiency:

- Enhance localisation of ground improvement methods using lime/cement columns, jet grouting, stone columns, dynamic compaction, prefabricated vertical drains
- Utilisation of Intelligent Transport Systems (ITS) to optimise road network and operations

Improve Energy Efficiency:

- Establish methods to combat overloading of heavy goods vehicles
- Establish innovative techniques for quality control of road construction

Adaptation to Climate Change:

- Pavement materials and designs for better durability and lower maintenance

ii. **Rails**

Railway planning:

- Establishment of a rail network development plan for Malaysia

Rail inspection and maintenance:

- Develop methodology and capacity for rail system inspection and maintenance regime
- Create enablers/equipment and systems to support the inspection and maintenance of rail tracks

Tunnelling technology for rail:

- Establish a cost-effective tunnelling technology
- Produce enablers/equipment and procedures to construct, operate and maintain tunnels in a sustainable manner
- Establish a monitoring system that will help in ensuring the integrity of the tunnel infrastructure

iii. **Ports**

Planning

- Review and plan potential waterways to be used in a more optimised manner for purposes of passenger and goods transport

Environment

- Review the biggest contributor of air pollutions at the port and recommend mitigation measures
- Establish the critical contributing factors to coastal erosion and recommend short and medium term erosion protection

Materials

- Review more sustainable methods of disposing the dredged sediments such as mechanical dewatering instead of lagooning
- Innovative reuse of dredged materials as a substitute for other materials to be used for construction, reclamation and manufacturing

Design

- Design and maintain leading roads to provide the most acceptable level of service to complete the supply-chain logistic requirements

Maintenance

- Innovative maintenance regime and use of innovative products for port marine infrastructure for corrosion control and protection

iv. **Airports**

Design

- Designs to incorporate maximum airside and terminal flexibility to accommodate changing airline capacity

Maintenance

- Pavement technology for runways and taxiways incorporating reuse, recycle and reclamation materials

Planning

- Develop an integrated airport information management system looking at the following:
  1. Passenger experience
  2. Aviation Operations
  3. Real Estate & Space
  4. Security
  5. Energy
  6. Physical Assets & Human Resources
- Planning and designing of airport cities master plan by introducing the concept of Aerotropolis

v. **Procurement**

- Evaluate all options for private involvement in delivery of government services, e.g. PFI, PPP
- A study of partnering, alliance contracting, integrated team approach etc. to project procurement
- Study the incentives to be awarded for earlier completion or reduced price and better quality

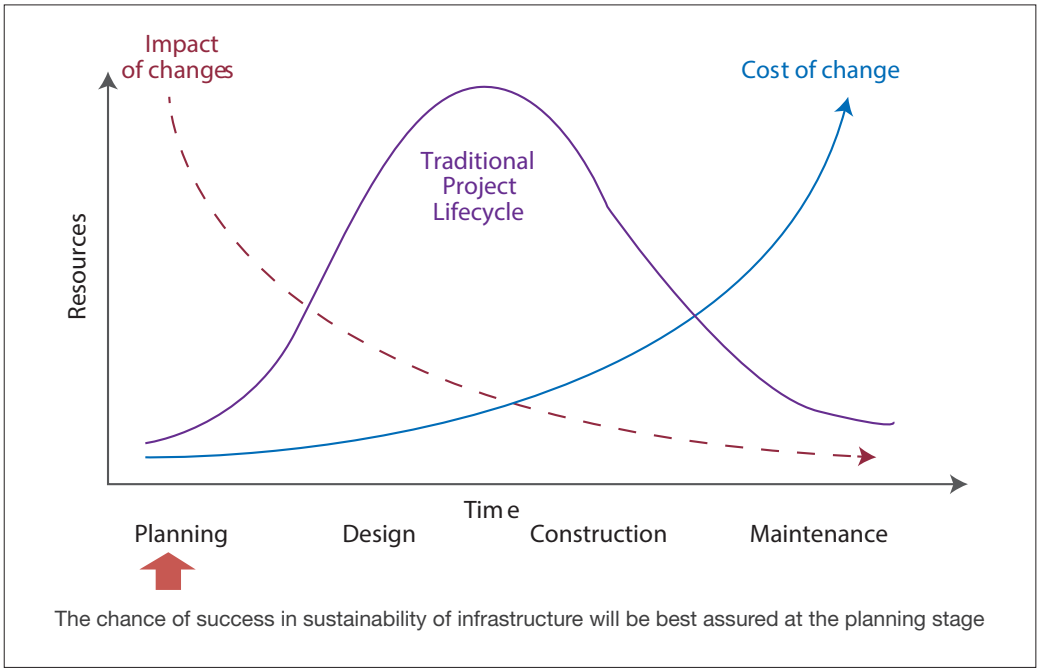


Figure 1.3. The Importance of the Planning Stage in an Infrastructure Life Cycle

A sustainable infrastructure framework is proposed to govern the entire life cycle and to ensure that they are driven by sustainability ideals and outcomes. The sustainable infrastructure framework has been positioned to play its role in the planning stage of any infrastructure development, as it is in the position where the benefits for sustainable infrastructure and infrastructure sustainability may be assured most, as depicted in **Figure 1.3**.

An integral enabler to the framework will be a sustainable infrastructure planning tool that will both address the macro and micro planning perspectives of the infrastructure life cycle. This will ensure the ability for the nations to ensure both sustainable infrastructure and infrastructure sustainability aspirations are to be met. The sustainable infrastructure planning tool is aimed at selecting the most sustainable infrastructure development and planning options to ensure that the outcomes of the infrastructure may be served through the route that is most sustainable to the nation, the people and the environment. Infrastructure sustainability on the other hand is a drive to ensure that the entire life cycle of any infrastructure is driven by the sustainability ideals, right from planning, procurement and elements of project delivery such as design and construction, as well as the operations and maintenance issues.

The development of the tool will best be served through adopt and adapt approach to ensure that the resulting tool is useable and suitable to the situation and needs of the country. The sustainable infrastructure framework covers the identification of the outcomes, the development of the tool stage, the implementation stage and the monitoring of the outcome stage. Hence, each will require much R&D work and relevant activities to make sure the intended goals are met, whose details have been described in the report.

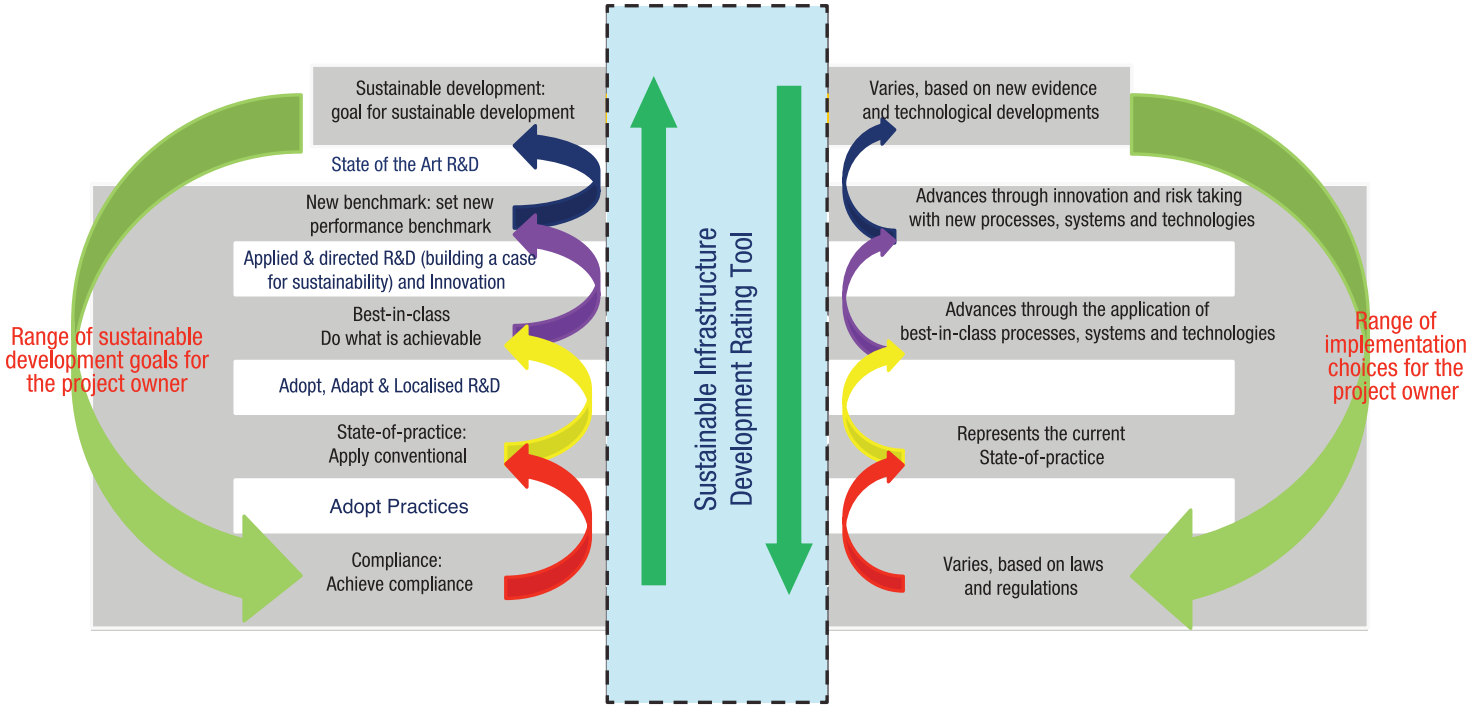


Figure 1.4. The Sustainable Infrastructure Tool and Its Progression for Sustainability

The sustainable infrastructure framework and the tool it aims to have will enable Malaysian infrastructure to progress towards better sustainability, as defined by the International Federations of Consulting Engineers (FIDIC) and refined for this study (refer to **Figure 1.4**).

The report has given an overview of the state of the Malaysian's infrastructure, identified the gaps and has given recommendations to quickly bridge any prevailing gap though key and pragmatic R&D interventions, initiatives and outcomes. It is hoped that such recommendations will be utilised to allow the Malaysian infrastructure sector to be sustainable, and in turn help the country to remain competitive and productive in years to come.

Appendix A

Table A1. List of Possible Research Outcomes for Road and Highway Infrastructure

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
1.	Land use integration	a) Ensures that proper land use and transport integration is applied in all land use development plans	X		
		b) Establishment of methods as smart imposition of road hierarchy despite pressures of development, especially in urban areas	X		
		c) Analysis of the effectiveness of the present Traffic Impact Assessment (TIA) to ensure sustainability through proper land use and transport planning integration	X		
2.	Managing road users	a) Establish the negative peculiarities of Malaysian road users towards jeopardising the sustainability aspiration of roads and highways	X	X	
		b) Recommend interventions to manage the negative peculiarities of Malaysian road users, in order to help sustain the operability and the effective state of the roads and highways	X		
		c) Recommend strict management regime to combat overloading of heavy goods vehicles and finding ways to manage the impacts of overloading on roads	X		
3.	Social impact of roads and highways	a) Identification of features and alignment of roads and highways that will bring benefit to the society and do not create serious social implications such as extreme severance due to the alignment	X		
		b) Recommend interventions that would prevent the deterioration of value of roads and highways that create negative implications to society	X		
		c) Ensure that the service levels provided to the road users are as expected	X	X	
4.	Economic impact of roads and highways	a) Identification of the correlation between roads and highways alignment to the local economy	X	X	X
		b) Determine the features of road and highways transportation that begin to have negative effects on the economy locally and at national level	X	X	
		c) Recommend interventions to ensure that the positive outcomes of roads and highways are sustained		X	

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
5.	Net sustainable impact of roads and highways	a) Establish the features that will influence the net sustainable impacts of roads and highways, vis-à-vis more sustainable options such as rail and other public transport means b) Establish the understanding of the effects of non-sustainable features and attributes of roads and highways to its net sustainability worth		X X	
6.	Roads and highways project financing	a) Identify the features of the present financial and business model that may have contributed to practices that jeopardise the sustainability qualities of roads and highways b) Establish innovative financing and business model that will encourage sustainability practices throughout the service life of the roads and highways	X	 X	
7.	Creating a business case for sustainability	a) Establish strategies and procedures to assure that sustainability ideals are part of the business strategy of players in the roads and highway industry	X	X	X
8.	Ensuring safer roads	a) Produce designs, procedures, and commitment towards ensuring Malaysia has forgiving roads, that will not cause fatality to the road user, even in the event of a crash b) Establish procedures and the will to ensure that continuous safety audit is carried out on operational roads to ensure that any unsafe road features are mitigated immediately	X X	 X	 X
9.	The use of materials that will help the sustainability cause	a) Produce innovative pavement materials that will increase the durability, strength and safety performance of road and highway surfaces. This will ensure safer roads and satisfactory level of performance b) Produce enablers/equipment and procedures to effectively monitor the state of the pavement and to come up with warning systems as well as suggestion for mitigation	X	X X	

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
10.	Roads and highways foundation issues	a) Establish innovative techniques to ensure that the foundation work for highways is consistently satisfactory and suitable to sustain the integrity of road and highway infrastructure.	X	X	X
		b) Find ways to help soil improvement for roads foundation			
		c) Produce enablers/systems and procedures to effectively monitor the integrity of road and highway foundation, and to come up with effective warning system and mitigation measures	X	X X	X
11.	Tackling the slope stability issues along the roads and highways alignment	a) Establish innovative techniques to ensure that the slope stability along and adjacent to roads and highways are designed, constructed and maintained satisfactorily and suitable as to sustain the integrity of the roads and highways infrastructure.	X	X	X
		b) Produce enablers/systems and procedures to effectively monitor the integrity of slopes along and adjacent to roads and highways, and to come up with effective warning system and mitigation measures		X	
12.	Tunnelling technology and maintenance	a) Establish a cost-effective tunnelling technology and procedure to make tunnelling a better option, compared to hill cutting	X	X	
		b) Produce enablers/equipment and procedures to construct, operate and maintain tunnels in a sustainable manner		X	
		c) Establish a monitoring system that will help ensure the integrity of the tunnel infrastructure		X	X
13.	Bridge technology and maintenance	a) Improve structural integrity and bridge inconsistent gaps through fully functional, certified, state-of-the-art inspection and testing facilities to carry out mandatory inspection and testing during construction of roads and associated infrastructure		X	X
14.	Effective road maintenance	a) Find better ways to sustain existing roads through upgrading and refurbishment, rather than build new ones	X	X	
		b) Establish ways to bring a business case for road maintenance	X	X	X
15.	Congestion management	a) Find ways to manage congestion in an effective and sustained manner	X		
16	Utilisation of technology and Intelligent Transport System (ITS)	a) Explore ways to use technology (ITS) to maximise the sustainability of roads and highways through efficient operations	X		

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
17.	Highway capacity issues	a) Establish highway capacity relationship that will allow continuous monitoring of the service performance of roads and highways	X	X	
		b) Design interventions that will ensure that roads and highways are sustained within its capacity operational limits.	X	X	

Table A2. List of Possible Research Outcomes for Rail Infrastructure

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
1.	Ownership issues of rail system	a) Recommend on the best ownership option for rail transport, especially between the track and the vehicles	X	X	
2.	Rail network planning	a) Establish a rail network development plan for Malaysia	X	X	
		b) Establish a hierarchy system for rail and the associated planning requirements for both passenger and goods mobility	X	X	
		c) Able to facilitate rail alignment choices with soil optimisation requirements as complementary	X	X	
3.	Rail integration with other modes	a) Establish a systematic planning tools to ensure that the rail system is integrated with the other modes in a seamless manner	X	X	X
		b) Recommend local transport strategies to provide the “last mile” for rail travel, and provide full access to public transport systems	X	X	
4.	Issues concerning regulating the rail system	a) An appreciation on the needs for regulating the rail systems	X	X	
		b) Recommend on the most effective regulatory function to be by the relevant authorities	X	X	
5.	The impact of rail on the environment	a) Understand the net benefits of rail to the environment as compared to other modes	X	X	X
6.	The socio-economic impact of rail	a) Understand the net benefits of rail to the society and the economy as compared to other modes	X	X	X
7.	Urban rail issues	a) Understand the roles and potential, as well as the possible impact of rail in an urban setting	X	X	X

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
8.	Regional rail issues	a) Understand the roles and potential, as well as the possible impact of rail as a regional service	X	X	X
9.	Intercity rail issues	a) Understand the roles and potential, as well as the possible impact of rail in an intercity	X	X	X
10.	The human capital to support the rail industry	a) Establish the present status of the human capital to support the rail industry	X		
		b) Establish the attributes of the knowledge body needed amongst professionals and labourers to support the rail industry	X		
		c) Design and deliver an effective capacity-building programmes to enhance the capacity and the capability of human resource to support the rail industry	X	X	X
11.	Financing the rail	a) Identify the features of the present financial and business model that may have contributed to practices that jeopardise the sustainability qualities of rail projects	X	X	
		b) Establish innovative financing and business model that will encourage sustainability practices throughout the service life of the rail systems	X	X	
12.	Ticketing and fare issues	a) Establish a ticketing system that will encourage seamless travel via rail on an integrated public transport system	X	X	
		b) Understand the elasticity characteristics of fares towards demand behaviour for rail	X	X	
13.	Design and construction of rail tracks	a) Develop the capacity and capability for rail track technology	X	X	
		b) Create enablers/equipment and systems to support the design and construction of rail tracks		X	X
14.	Track maintenance regime and competency	a) Develop methodology and capacity for rail system inspection and maintenance regime	X	X	X
		b) Create enablers/equipment and systems to support the inspection and maintenance of rail tracks		X	X

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
15.	Signalling issues	a) Establish the knowledge and capability in the design and delivery of the signalling system for rail systems and networks	X	X	X
		b) Establish the knowledge and ability to optimise signalling in order to maximise frequency and complexity of rail networks		X	X
16.	Foundation of rail track issues	a) Establish innovative techniques to ensure that the foundation work for railways are satisfactory and suitable as to sustain the integrity of the rail infrastructure		X	X
		b) Find ways to help soil improvement for rail foundation	X	X	
		c) Produce enablers/systems and procedures to effectively monitor the integrity of the rail foundation, and to come up with effective warning system and mitigation measures		X	
		d) Introduce a more cost effective foundation for rail tracks, with the quest to substitute slippers and ballast with new foundation form	X	X	
17.	Slope stability issues	a) Establish innovative techniques to ensure that the slope stability along and adjacent to rail tracks are constructed and maintained satisfactorily and suitable as to sustain the integrity of the rail infrastructure	X	X	X
		b) Produce enablers/systems and procedures to effectively monitor the integrity of slopes along and adjacent to rail tracks, and to come up with effective warning system and mitigation measures		X	
18.	Tunnelling technology and maintenance	a) Establish a cost-effective tunnelling technology		X	
		b) Produce enablers/equipment and procedures to construct, operate and maintain tunnels in a sustainable manner.		X	
		c) Establish a monitoring system that will help in ensuring the integrity of the tunnel infrastructure		X	
19.	Coach technology	a) Enhance the capability for coach technology design and manufacturing		X	X
20.	Intruders and vandalism management	a) Discover the behaviour of intruders and vandals with the aim to curb the menace.	X	X	
		b) Establish procedures, enablers and equipment to mitigate the number of intruders and vandalisms.	X	X	

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
21.	Optimised scheduling and time tabling	a) Obtain a clear understanding of the Malaysian rail user behaviour and attributes with regards to optimal performance expectation	X	X	
		b) Establish the algorithm to optimise scheduling of time tabling or rail systems as well as the associated supporting modes to minimise travel time		X	
22.	Passenger transfer facilities	a) Ability to identify, design and construct appropriate facilities in rail terminals and stations to facilitate transfer activities	X	X	
23.	The potential of information technology	a) Appreciate the role of information technology in helping manage the expectation of users and potential users	X		
		b) Design and utilise information technology to maximise the potential of the rail system as the primary mode of travel	X	X	
24.	Cargo potential	a) Identify the needs and potential for goods transportation in using rail	X	X	
		b) Design and allocate facilities and infrastructure support for goods mobility on rail	X	X	
25.	Inter-operability issues	a) Appreciate the needs for inter-operability of rail, in terms of technical specification	X		
		b) Define the specification for rail inter-operability needs in Malaysia	X		

Table A3. List of Possible Research Outcomes for Port Infrastructure

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
1.	The strategic location for ports in Malaysia	a) Evaluate the appropriateness of the present locations of ports in Malaysia	X		
		b) Recommend future ports based on its strategic position		X	X
2.	Security issues at ports and towards liners in the ocean	a) Analyse the security issues and risks at ports and on liners/vessels	X	X	X
		b) Recommend mitigation for security issues, especially with regards to infrastructure support		X	X

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
3.	Optimising the available waterways for transportation of passengers and goods	a) Review potential waterways to be used in a more optimised manner for purposes of passenger and goods transport	X		
		b) Recommend the governance to manage the new potential for such waterways		X	
		c) Develop technology and engineering standards and procedures to enable the usage of such waterways		X	
4.	Financing the development, operations and maintenance of ports	a) Identify the features of the present financial and business model that may have contributed to practices that jeopardise the sustainability qualities of ports	X	X	
		b) Establish innovative financing and business model that will encourage sustainability practices throughout the service life of the ports		X	
5.	Design of berth and landside facilities to optimise performance	a) Review of present performance of ports and correlating it with the berth and landside design	X		
		b) Recommend on optimum berth and landside design and continuous monitoring subsequently	X		
6.	Methods to maximise efficiency of the ports	a) Review present efficiency of port operations	X		
		b) Recommend improvement of the efficiency of ports (berth and landside), with subsequent continuous monitoring		X	
		c) Introduce ways to optimise cargo handling efficiency in Malaysian ports		X	
7.	Problems of siltation in ports and the dredging needs	a) Establish the siltation phenomena and to manage the impact of dredging needs and activities	X		
		b) Recommend management of siltation problems		X	
8.	Managing the risk of inclement weather, and weather change	a) Ability to predict the changes of weather patterns and prepare the ports accordingly through timely risk management activities	X	X	X
		b) Recommend on the most suitable design and technical specifications to prepare for the risk of inclement weather and future detrimental changes in weather patterns		X	X
9.	Corrosion issues and material engineering options	a) Establish an understanding of the corrosion issues on the present port infrastructure	X		
		b) Introduce innovative material and construction methods to combat corrosion problems		X	
		c) Adopt an innovative maintenance regime to sustain the port infrastructure through protection from corrosion problems		X	X

No	Issues of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
10.	Port/vessel congestion	a) Establish the factors influencing vessel congestion at ports	X		
		b) Recommend solutions to manage port congestion amongst vessels	X	X	
11.	Landside vehicle congestion	a) Establish the factors influencing landside congestion at ports	X	X	
		b) Recommend the solutions to manage port congestion amongst land side vehicles		X	
12.	Logistic supply and chain and hierarchy	a) Establish the full supply-chain logistic requirement for ports in Malaysia	X		
		b) Design and prepare the appropriate infrastructure to support the supply-chain logistic requirement	X	X	
13.	Poor access road state	a) Evaluate the poor state of roads leading to ports in Malaysia	X		
		b) Establish the most critical contributing factors and provide suggestions of mitigation	X		
		c) Design and maintain leading roads to provide the most acceptable level of service to complete the supply-chain logistic requirements	X		
14.	Addressing overloading on vessel and on land-vehicle	a) Establish the present overloading situation on vessels as well as on landside vehicles	X		
		b) Recommend mitigation measures to prevent overloading on vessels and on land vehicles	X	X	
15.	Safety and security	a) Establish the risk factors that will implicate the safety and security of port operations in Malaysia	X		
		b) Recommend mitigation measures to reduce the risk factors	X	X	
16.	Circulation and traffic management in ports	a) Establish ways to manage and provide the infrastructure support for ports, especially connectivity and land transport issues	X		
		b) Provide suggestions for traffic management schemes and enablers for smooth circulation within the ports and surrounding areas	X	X	
17.	Maritime capacity issues	c) Ability to represent the capacity of ports (both on water and land side), and forecast the future capacity state of ports			
18.	Landside capacity issues		X	X	
19.	Upgrading and maintenance of old port infrastructure	a) Establish the state of the present ports in Malaysia with the view of identifying the repair and upgrading requirements	X		
		b) Establish the repair and upgrading know-hows amongst industrial players		X	
		c) Recommend a repair and upgrading scheme for existing ports		X	

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
20.	Coastal erosion issues affecting the ports infrastructure	a) Establish the extend of erosion and the behaviour of erosion on coastal areas affecting port operations	X		
		b) Recommend methods to address the erosion issues in ports and nearby coastal areas through effective monitoring process as well as through mitigation measures		X	

Table A4. List of Possible Research Outcomes for Airport Infrastructure

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
1.	The strategic location for airports in Malaysia	a) Evaluate the appropriateness of the present locations of airports in Malaysia	X		
		b) Recommend future airports based on its strategic position	X	X	X
2.	Security issues of airports and aircrafts	a) Analyse the security issues and risks at airports and on aircrafts and its passengers/cargo	X	X	
		b) Recommend mitigation for security issues, especially with regards to infrastructure support	X	X	X
3.	The environmental impact of airports	a) Establish the environmental impacts of airports to the surrounding areas	X	X	X
		b) Recommend improvements to the Environmental Impact Assessment (EIA) features for airports	X	X	X
		c) Conduct continuous monitoring on environmental impacts and suggestion for mitigation measures		X	X
4.	Managing aviation industry perception	a) Identify ways to reduce the net impact the aviation industry has on sustainability		X	X
5.	The socio-economic impact of airports and the aviation industry	a) Establish the impacts of airports to the socio-economy of the nation, state, city and the surrounding areas	X	X	X
		b) Recommend improvements to the Socio-economic Impact Assessment (SIA) features for airports	X	X	X
		c) Conduct continuous monitoring on socio-economic impacts and suggestion for mitigation measures			X
6.	Passenger security management	a) Establish the passenger security features according to the global standard as well as peculiarly to the Malaysian situation	X	X	
		b) Provide the infrastructure to support the security management aims		X	X

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
7.	The influence of airports towards the image of the country	a) Establish the performance of Malaysian airports and identify their roles towards uplifting the image of the country	X		
		b) Recommend measures to improve the performance of airports and identify steps to improve the image of the country via airports		X	X
8.	The financing of airport development, operations and maintenance	a) Identify the features of the present financial and business model that may have contributed to practices that jeopardise the sustainability qualities of airports	X		
		b) Establish innovative financing and business model that will encourage sustainability practices throughout the service life of airports	X	X	
9.	Establishing an integrated transport to support goods mobility via airports	a) Establish the full supply chain logistic requirement for airports in Malaysia	X		
		b) Design and prepare the appropriate infrastructure to support the supply-chain logistic requirement	X	X	
10.	Pavement technology for runways and taxiways	a) Establish the present problems associated with pavements for runways and taxiways	X		
		b) Produce innovative pavement materials that will increase the durability, strength and safety performance of runways and taxiways.	X	X	
		c) Produce enablers/equipment and procedures to effectively monitor the state of the pavement and to come up with warning systems as well as suggestion for mitigation		X	X
11.	Baggage handling technology and logistics	a) Provide the infrastructure support for optimum baggage handling at airports	X	X	
12.	Optimal design for airports to minimise time	a) Establish the important factors that will influence total travel time for an air traveller	X		
		b) Incorporate optimal design to facilitate minimum travel time within the airport infrastructure	X	X	
13.	Scheduling of airlines	a) Ability to establish algorithms to ensure integration between the scheduling of airlines and the scheduling of support services including the public transport support	X	X	

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
14.	Passenger capacity analysis and forecast for future level of service	a) Establish an accurate demand behaviour analysis and subsequently to formulate forecasting ability for passenger demand	X		
		b) Ability to plan for future appropriate level of service	X	X	X
		c) Ability to timely plan for future infrastructure expansion	X	X	X
15.	Risk management for inclement weather	a) Ability to predict the changes of weather patterns and to prepare the airports for it through timely risk management activities	X	X	X
		b) Recommend the most suitable design and technical specifications to prepare for the risk of inclement weather and future detrimental changes in weather patterns	X	X	X
		c) Recommend the most suitable design and technical specifications to mitigate against the intrusions of birds and insects and other animals that would provide risk to flight path	X	X	X
16.	Service capacity analysis for the airports	a) Determine the service capacity values for the airport infrastructure	X		
		b) Monitor the prevailing service levels and predict the point of capacity and saturation		X	X
		c) Recommend the time for an expansion or a reconfiguration when the capacity is expected to be breached		X	X
17.	Managing passengers and customers expectation	a) Continuously monitor passengers and visitors level of expectation, and satisfaction	X	X	X
		b) Come up with innovative ways to maximise customer satisfaction towards the airport services	X	X	X
18.	The utilisation of information system	a) Appreciate the role of information technology to help manage the expectation of customers of the airport	X		
		b) Design and utilise information technology to help provide satisfactory services as the airport	X	X	
19.	Managing the changing trends of air travel	a) Ability to anticipate future trends and technology in air travel and the aviation industry, in order to be well prepared with any needed changes or upgrading in the infrastructure and the facilities	X	X	X
20.	Maintenance regime of runways and taxiways	a) Develop methodology and capacity for runways and taxiways pavement inspection and maintenance regime	X	X	
		b) Create enablers/equipment and systems to support the inspection and maintenance of runways and taxiways pavement		X	

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
21.	Maintenance regime of airport terminal building and services	a) Develop methodology and capacity for airport terminal inspection and maintenance regime	X	X	
		b) Create enablers/equipment and systems to support the inspection and maintenance of airport terminal building		X	
22.	Management of energy source and utilisation for airports	a) Establish a monitoring regime of energy utilisation in the airport	X	X	
		b) Recommend interventions to minimise energy usage in airports without compromising its level of service.	X	X	
23.	Good access to airports	a) Establish ways to synergise an airport with city connectivity and accessibility needs	X	X	
24.	Integrating airports with tourism needs	a) Establish ways to integrate airports with tourism needs	X	X	

Table A5. List of Possible Research Outcomes for Procurement

No	Areas of Concern	R&D Outcomes	Short Term	Medium Term	Long Term
1.	Limited Infrastructure Funding	a) Evaluate all options for private involvement in delivery of government services e.g. PFI, PPP	X		
2.	Financial and economic modelling for infrastructure procurement	a) Develop models for alternative procurement to ensure best value for money for each project type	X	X	
3.	Sustainable procurement with transparency and cooperative framework	a) A study on the incorporation of life cycle costing for certain types of projects	X		
		b) A study to incorporate elements of Green Procurement in the procurement processes	X	X	
		c) A study of partnering, alliance contracting, integrated team approach etc. to project procurement	X	X	
4.	Incentivise effective and efficient procurement	a) Study the incentives to be awarded for earlier completion or reduced price and better quality	X	X	X

LIST OF TABLES

Table 1: Outcomes of R&D (General)
Table A1: List of Possible Research Outcomes for Road And Highway Infrastructure
Table A2: List of Possible Research Outcomes for Rail Infrastructure
Table A3: List of Possible Research Outcomes for Port Infrastructure
Table A4: List of Possible Research Outcomes for Airport Infrastructure
Table A5: List of Possible Research Outcomes for Procurement
Table 2.1: Malaysia Infrastructure Competitiveness Ranking
Table 3.1: Regional Key Needs and Issues
Table 3.2: Agency Needs and Issues
Table 3.3: Issues Identified During Interviews, Consultations and Transportation Infrastructure Stakeholders Workshop
Table 3.4: Case Study 1: Pos Selim-Blue Valley Highway
Table 3.5: Case Study 2: Aring-Kelantan/Terengganu Border Road
Table 3.6: Case Study 3: Gap-Fraser's Hill New Road
Table 3.7: Lessons Learnt by MOF: Second Penang Bridge
Table 3.8: Lessons Learnt by MOT: Electrified Double Tracking Projects
Table 3.9: Lessons Learnt by MOT: Kota Kinabalu International Airport
Table 3.10: Lessons Learnt by MOT: Project Management
Table 4.1: R&D Efforts Towards
Table 4.2: List of Possible Research Outcomes for Road and Highway Infrastructure
Table 4.3: List of Possible Research Outcomes for Rail Infrastructure
Table 4.4: List of Possible Research Outcomes for Port Infrastructure
Table 4.5: List of Possible Research Outcomes for Airport Infrastructure
Table 4.6: List of Possible Research Outcomes for Procurement

LIST OF FIGURES

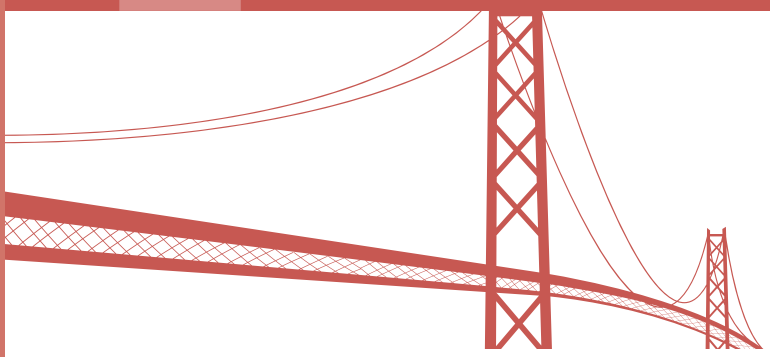
Figure 1: The Study Framework
Figure 2: The Infrastructure Life Cycle
Figure 2.2: Project Lifecycle
Figure 3: The Importance of the Planning Stage in an Infrastructure Life Cycle
Figure 3.1: Bottleneck Chain from Institutional to Market Outcomes (World Bank)
Figure 4: The Sustainable Infrastructure Tool and Its Progression for Sustainability
Figure 5.1: The Improved Study Framework
Figure 5.2: The Sustainable Infrastructure Framework for Malaysia
Figure 5.3: The Framework for the Infrastructure Sustainable Tool

ACRONYMS

ACI	—	American Concrete Institute
ASM	—	Academy of Sciences Malaysia
ASTM	—	American Standard for Testing and Materials
CBI	—	Cross-Border Infrastructure
CO^2	—	Carbon Dioxide
EIA	—	Environmental Impact Assessment
EPC	—	Engineering, Procurement and Construction
EPU	—	Economic Planning Unit
FIDIC	—	International Federations of Consulting Engineers
FYMP	—	Five-year Malaysia Plan
GAMP	—	Government Asset Management Policy
JKR	—	Jabatan Kerja Raya
MoT	—	Ministry of Transport
MITI	—	Ministry of International Trade and Industry
SPAD	—	*Suruhanjaya Pengangkutan Awam Darat*
JPBD	—	*Jabatan Perancangan Bandar dan Desa*
PEMANDU	—	Performance Management and Delivery Unit
GKL	—	Greater Kuala Lumpur
TAMM	—	Total Asset Management Manual
JTC	—	Joint Contract Tribunal
ICE	—	Institution of Engineers
ICC	—	Condition of Contract
ETP	—	Economic Transformation Programme
LCCT	—	Low-Cost Carrier Terminal
SPAD	—	*Suruhanjaya Pengangkutan Awam Darat*

LLM	—	*Lembaga Lebuhraya Malaysia*
MIMA	—	Maritime Institute of Malaysia
KTM	—	*Keretapi Tanah Melayu*
KTMB	—	*Keretapi Tanah Melayu Berhad*
RAC	—	Railway Asset Corporation
GGP	—	Government Green Procurement
GNI	—	Gross National Income
IAPG	—	Inter-Agency Planning Group
IT	—	Information Technology
ITS	—	Intelligent Transport System
IRDA	—	Iskandar Malaysia
NCER	—	Northern Corridor Economic Region
ECER	—	East Coast Economic Region
SDC	—	Sabah Development Corridor
SCORE	—	Sarawak Corridor of Renewable Energy
HNDP	—	Highway National Development Plan
CSR	—	Central Spine Road
EIA	—	Environmental Impact Assessment
SIF	—	Sustainable Infrastructure Framework
NPP-2	—	The second National Physical Plan
OECD	—	Organisation for Economic Cooperation and Development
PPP	—	Public Private Partnership
R&D	—	Research & Development
SCP	—	Sustainable Consumption and Production
SET	—	Science, Engineering and Technology
SIA	—	Socio-economic Impact Assessment
SIF	—	Sustainable Infrastructure Framework
STI	—	Science, Technology and Innovation
NDPC	—	National Development Planning Committee
TIA	—	Traffic Impact Assessment
UKAS	—	*Unit Kerjasama Awam Swasta*
WEF	—	The World Economic Forum

CHAPTER 1
INTRODUCTION



Infrastructure and its sustainability has been positioned as one of the key thrust areas in this Academy of Sciences Malaysia' Mega Science Framework Study initiative in order to safe guard Malaysia's long term needs through sound science and technology efforts. The focus of this study is further scoped towards transport infrastructure, namely roads & highways, rails, airports and ports. In addition, the issue of EPC has been addressed across the above sectors. The time horizon has been set to be beyond 2020 and towards 2050, where STI is expected to be instrumental in extending the present knowledge economy to a new economy that will be centred on sustained development and impact. Hence, it is to be substantially represented by research priority areas that may help the nation to propel its efforts towards a common goal that would help achieve such aspirations.

1.1 BACKGROUND

The Mega Science Framework Study was initiated by ASM to complement the government of Malaysia's transformational efforts. Through selected sectors, it is intended that the competitiveness of the nation shall be enhanced via STI initiatives. The five selected sectors were infrastructure, housing, transportation, environment, and electrical and electronics.

Through careful deliberation, it was agreed that the scope of the infrastructure sector is to look into the most critical types of transportation infrastructure to meet the aim of the Mega Science Framework study. The selected types of infrastructure are known to have a major influence on the socio-economic development and sustainable position of the country.

The types of infrastructure are:

i. rails

ii. roads and highways

iii. airports

iv. ports

The time horizon has been set to be beyond 2020 and towards 2050, where STI is expected to be instrumental to extend the present knowledge economy to a new economy that will be centred on sustained development and impact. STI will be substantially represented by research priority areas that will assist the STI community to propel its efforts towards a common goal that would help achieve such aspirations.The infrastructure sector continues to play its conventional role in providing the basic needs of the population effectively. With change, the infrastructure sector must also be able to perform the critical role of ensuring sustainable development of the nation.

In 2012, the International Federation of Consulting Engineers (FIDIC) commissioned a report titled 'The FIDIC State of the World Report'. This report is a follow up of 'The State of the World: FIDIC Infrastructure Report 2009'. The objective of the 2012 report is to provide an understanding towards sustainable development, from the context of infrastructure, with a focus on decision-making processes, which identified potential infrastructure projects that affect the lives of society

The three main aspects stressed in the report were risks, resilience and opportunity. In terms of risks, the report highlights the perceived increase in risks as key obstacle to sustainable infrastructure. Subsequently, the resilience of assets is compromised as the level of consideration for sustainability is minimal as an outcome of the perceived risks. In totality, the opportunities that arise from delivering a sustainable product can be gained from financial incentives, which act as spinoffs. Overall, the ability to manage the trade-offs between the three elements offers great potential.

The majority of the world infrastructure today has been laid after the Second World War, and these infrastructures are currently on the deteriorating curve. Infrastructure-based industries such as rail, airports, ports, telecommunication, energy, steel and others are traditionally state-owned and required high government expenditure. The Organisation for Economic Cooperation and Development (OECD) countries witnessed an increase in the expenditures from 20% of Gross Domestic Product (GDP), in the early 1960s to 35% in the 1990s (Dicken 2011). As for the developing countries, it was between 15% and 27% on average (ibid.). The impact of deregulation and privatisation provided greater opportunity for the private sector to participate in the delivery of government and public sector services to the citizens, thus, relieving the government of huge financial burden of providing the needed infrastructure. However, real reduction in government infrastructure development expenditure remains debatable.

Nevertheless, on the global front, the government continues to invest heavily in infrastructure development, as evidenced from the G20 countries expenditure of USD692 billion in 2009 in the form of stimulus packages. 40% of this expenditure was for the USA alone, which saw a further increase of up to 60% in the year 2010. China, Germany and Japan had similar measures in place amounting to a total of USD438 billion.

The ADB has forecasted the demand for infrastructure development in Asia to be around USD8 trillion between 2010 and 2020. In addition, ADB also projected USD290 billion is likely to be spent on regional infrastructure development, mainly in the transportation and energy sectors. These investments will garner greater regional infrastructure networks and linkages within Asia, promoting regional integration and enhancing the multi-billion dollar intra-regional commerce and trade.

The state of our infrastructure is still open to argument, whether they are in the best state, or conversely, in an improvised state. Nevertheless, despite the contention, the realities of the present and the past must be established, and subsequently used to ensure that the future will be brighter for the infrastructure sector, in order for it to sustain the needed development of this nation.

Infrastructure development is a key component as it brings socio-economic improvements to both people and the environment. The return of such development increases the economic value of the ecology in which we inhabit. In addition to economic returns, infrastructure development increases the quality of life in terms of connectivity, urbanisation, poverty reduction and the well-being of the population holistically.

1.2 OBJECTIVES

The scoping of the infrastructure sector will outline several directions to STI as to provide the needed impetus to steer the infrastructure in the right direction. The study is guided by the following objectives:

i. To define the attributes of the infrastructure sector that would be appropriate to enhance competitiveness and sustained development;

ii. To identify the prevalent gaps in the infrastructure sector between the present realities and the aspired ideals;

iii. To determine the role of STI in the Malaysian infrastructure sector through short, medium and long term measures; and

iv. To identify gaps in STI knowledge and development in the infrastructure sector and recommend appropriate measures through R&D priority areas; product and technology development, and the nurturing of relevant industries.

1.3 FRAMEWORK

In order for this effort to produce the best result for the nation, a framework was formulated to provide an overall perspective of the task at hand (**Figure 1**) depicts this framework.

The explanation of the framework may be best explained through dissecting it into three sections. The upper section of the framework is the successive aims that will bring the nation towards the ultimate goal of enhancing national competitiveness and sustainability. The middle section describes the methodology of this study, while the lower section represents the four selected types of infrastructure.

The upper section includes the deliverables of this project, which will be the identification of critical areas of concern that need to be addressed before the nation can hope to achieve the desired competitiveness and sustainability. This may then be served through recommended priority research areas, technology and innovation development, as well as the industry to provide the enablers and solutions. It is then desired, that these will bring about the first-class infrastructure that will be imperative to help our nation achieve the ultimate aspiration.

As far as the methodology is concerned, all related activities would be primarily focused towards establishing the following:

a. The best practices or the “gold standard” for each type of infrastructure

b. The anticipated future problems and scenarios that may influence the infrastructure sector

c. The prevalent gaps between the present state and the aspired condition

1.4 METHODOLOGY

The approach to serve the methodology may include, but is not limited to, the following:

i. Desktop study and literature search

ii. Interviews

iii. Focus group engagements

iv. Workshops

Desktop Study and Literature Search

The desktop study approach will be used to review various literatures available from scientific journals, reports and other publications to establish the point o reference. This baseline will be used to determine the future direction and strategies for the Malaysian context.

Surveys and Interviews

Surveys will be used to obtain preliminary information on the current state as the mechanism allows for in-depth Interviews with key individuals. They will be conducted to establish the present situation in Malaysia and as a test bed for the preliminary findings obtained from desktop study. Concurrently, the exercise will enable the process of verification and validation.

Focus groups

Focus groups will be used to obtain feedback on strategies, initiatives and R&D areas from various stakeholders in the Malaysian construction industry, which were previously established from the study. The focus group will also provide the necessary verification and validation exercise.

Workshops

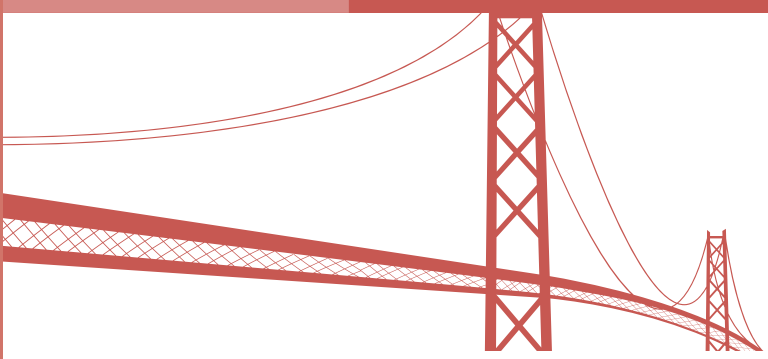
Workshops will be used to disseminate and gather feedback on the proposed strategies, initiatives and R&D areas from various stakeholders in the Malaysian construction industry, which were previously established from the study. The workshops will also provide the needed verification and validation exercise.

1.5 SUMMARY

In summary, Chapter 1 provided a comprehensive insight into the needs of ASM to carry out this study to establish STI initiatives in the infrastructure sector, mainly focusing on roads & highways, rails, airports and ports. Subsequently, four main objectives of the study were identified to ensure the outcome of the research meets with the needs of the study. Hence, to realise these objectives, a framework to define the methodology used by the research team was established and carried through with various approaches such as desktop study and literature search; interviews; focus group engagements and workshops.

The data and information gathered from these mechanisms were used to deduce the overall conclusions and recommendations. Chapter 2 provides a comprehensive literature review to establish the current state of infrastructure in Malaysia in comparison to the global arena. The issues and findings are presented in Chapter 3, while Chapter 4 highlights the recommendations put forth by the study. Chapter 5 presents the need for a framework to govern the sustainability of Malaysia's infrastructure and Chapter 6 discusses the conclusions. The references used in this study are presented in Chapter 7.

CHAPTER 2
LITERATURE REVIEW



Chapter 2 looks at the current state of affairs in the domestic and global infrastructure industry to enable the team to establish appropriate points of reference in terms of infrastructure maturity and its levels of development and deployment. The roles of infrastructure in the national development of a country are then assessed to ascertain the contribution of infrastructure to economic growth and sustainability of a country. Apart from that, the study also looks at the some of the options available for a country to respond to the increasing needs of their infrastructure to meet the challenges of reduced capital spending due in part to economic downturn, climate change, people as well as goods mobility which are associated with urbanisation as well as enhancing the overall quality of life. The chapter then argues on how sustainable infrastructure could be the only remedy for the global as well as Malaysia's challenges to its economic sustainability.

Chapter 2 then introduces the infrastructure life cycle, a series of activities within fairly well defined phases, necessary to fulfil the infrastructure projects goals and objectives. Every well planned and executed infrastructure projects will need to go through the various phases of its development from planning to eventual disposal and deconstruction

Based on the infrastructure life cycle, current status of infrastructure planning, design, construction, operation and maintenance is then reviewed in a bit more detail to understand the processes involved and the roles of various stakeholders and supply chain in the processes. Where appropriate, known deficiencies and shortcomings are highlighted and comparisons with international best practices are made. In addition, discussed in this chapter, is the various stakeholders and players involved, directly or indirectly, in different phases of infrastructure life cycle.

Finally, an appreciation of best-in-class existing and future infrastructure at the international level is discussed to give some early indication of possible gaps between what Malaysia currently has and what the country should aspire to have.

2.1 THE FUTURE OF INFRASTRUCTURE

2.1.1 GLOBAL INFRASTRUCTURE DEVELOPMENT SCENARIO

Infrastructure development is a key component in the process of nation building as it brings socio-economic improvements to both the people and the environment. In addition to economic returns, infrastructure development increases the quality of life in terms of connectivity, urbanisation, poverty reduction and the well-being of the population.

McKinsey & Company has projected that just to support projected economic growth between now and 2030; the global infrastructure investment would need to increase by nearly 60% from the estimated USD36 trillion over the past 18 years to USD57 trillion over the next 18 years. This baseline estimated investment, which is equivalent to 3.5% of GDP is deemed sufficient to support anticipated growth, maintaining current levels of infrastructure capacity and services relative to GDP (MGI Infrastructure Full Report).

With rapid urbanisation, the need for infrastructure in the urban areas is even more pressing. However, in order to function and sustain growth over the decades ahead, urban areas will require novel, new-age infrastructure and land use concepts that can foster mobility, limit congestion and pollution, deliver sufficient supplies of power and treated water, provide communications connectivity, and promote a desirable quality of life for millions of people living and working in the urban areas.

The new challenges of today‘s world, from social stability, to rapid urbanisation, climate change, technology and globalised issues such as food and energy crises call for more complex and interconnected infrastructure solutions, involving collaboration between many agencies and countries. In Malaysia, tackling these issues will require actions by multiple agencies and sectors. These actions can potentially contribute to sustained growth of the economy.

2.1.2 INFRASTRUCTURE SUPPORT FOR ECONOMIC SUSTAINABILITY, COMPETITIVENESS AND PRODUCTIVITY

Several external trends are shaping the future infrastructure agenda. Nevertheless, lack of access to basic infrastructure services continues to affect people‘s lives in low-income and some middle-income countries. Nonetheless, Malaysia’s aspiration to be a high-income economy by 2020 is fuelling the expansion of infrastructure networks across the country. Our continued investment in infrastructure, particularly transport infrastructure has contributed to placing Malaysia high in the global competitiveness ranking — 25 from a total of 144 countries. Nevertheless, as common with even most of the developed worlds, there has been increasing gaps in economic growth and investment in infrastructure. Furthermore, the new challenges faced by the country, from social stability, to rapid urbanisation, climate change, technology and globalisation will demand more complex and interconnected infrastructure solutions.

Improved infrastructure enhances people and freight mobility. These will then bring significant economic effects to the country. Lower costs or better service, or both, in people and freight movement have a positive effect on everyone and all firms engaged in the production, distribution, trade and/or retail sale of physical goods. Getting people cheaper and faster from and to their place of work reduces stress and improves productivity. Reducing the per-mile cost of goods carriage means that any production or distribution facility can serve a wider market area, with potential gains from scale efficiencies. It also means a factory can draw supplies from a wider area with potential gains in terms of cost and/or quality of parts and materials coming to the factory.

Similarly, a nation's competitiveness and productivity is largely measured by its infrastructure capacity and capability. Nowhere is this more evident than the World Economic Forum report, which clearly links the World Competitive Index with the Infrastructure Index. Malaysia is placed at the 24th position in the world competitiveness ranking and 29 for the Infrastructure Index. A detail of Malaysia's infrastructure ranking is provided in **Table 2.1**.

Table 2.1. Malaysia Infrastructure Competitiveness Ranking

Indicator	Value	World Ranking 2014
Overall Competitiveness	5.03	24
Overall Infrastructure	5.2	29
Quality of overall infrastructure	5.5	25
Quality of Roads	5.4	23
Quality of Railways Infrastructure	4.8	18
Quality of Ports Infrastructure	5.4	24
Quality of Air Transport Infrastructure	5.8	20

i. Economic sustainability

Extensive and efficient infrastructure is critical for ensuring the effective functioning of the economy. Well-developed infrastructure reduces the effect of distance between regions, integrates the national market and connects it at low cost to markets in other countries and regions. In addition, the quality and extensiveness of infrastructure networks significantly impact economic growth and reduces income inequalities and poverty in a variety of ways. Effective modes of transport, including quality roads, railroads, ports, and air transport enable entrepreneurs to get their goods and services to market in a secure and timely manner and facilitate the movement of workers to the most suitable jobs.

Infrastructure development is essential to the realisation of ASEAN's goal of economic integration, and indispensable to ASEAN's future success (Infrastructure Development for ASEAN Economic Integration, page 5).

ASEAN, which comes into force by the end of 2015, will see an integration of the ASEAN economies into a single production base, and creating a regional market of more than 600 million people. The sustainability of Malaysia's economy will be very much determined by the role it plays in the broader ASEAN economy which will provide immediate access to the world's two biggest growing economy China and India with a market of more than 2.6 billion people. Physical connectivity through Cross-Border Infrastructure (CBI) development is crucial for enhanced regional cooperation and economic integration (Kuroda 2006).

ii. Competitiveness and Productivity

Though productivity means different things to different people, all agree that productivity is closely linked with the economic performance of a country. Productivity growth is important to an economy because it enables increased standards of living (through increased economic growth), resulting in a higher level of community well-being. It can in turn increase the choices available to individuals and society, providing the means to boost social and economic infrastructure, environmental standards, crime prevention, and other aspects of non-material well-being.

Productivity growth comes from a number of sources, technology adoption, enhanced labour skills, process and managerial improvement and others. Efficient infrastructure directly results in improved productivity and competitiveness. No matter how well managed a private enterprise may be, if goods and services cannot be brought to market efficiently, the performance and competitiveness of that business will suffer. Productivity growth plays an important role in boosting the economy's competitiveness and responding to longer-term challenges such as population ageing and climate change.

The Malaysia logistic cost is estimated at 14% of the GDP. It is lower than Thailand at 18%, but higher than Singapore and most of the developed countries at around 9 – 11%. Transport component of freight logistics is about 25%. An efficient transportation system supported by an equally efficient infrastructure could reduce the overall logistic cost.

There is a strong linkage between infrastructure provision and getting health, welfare and education policy right. Wasteful misspending in these policy areas has a high opportunity cost that strikes right at the heart of productivity and competitiveness (Lindsay, Executive Director of The Centre for Independent Studies, Australia).

iii. Environmental Sustainability

As a developing country with vast natural resources, Malaysia has long recognised the need to fulfill development demands while sustaining the environment. This need has been explicitly expressed in the national economic planning since the Third Malaysia Plan (1976–1980). The Tenth Malaysia Plan (2011–2015) has taken the commitment a step further by incorporating sustainable development into national policies.

The Tenth Malaysia Plan states that the government's agenda "will be one of protecting the environmental quality of life, caring for the planet, while harnessing economic value from the process. To achieve this, the government will be guided by sustainable production practices to ensure that economic growth is achieved without degrading the environment." Markedly, sustainability, which is one of the three pillars of the New Economic Model, aims to propel Malaysia to a developed-country status by 2020.

Providing other frameworks for the environment are the National Policy on Environment 2002 and the National Physical Plan 2005. The policy aims to enable continued economic, social and cultural progress, and to enhance Malaysians' quality of life through environmentally sound and sustainable development. For its part, the plan identifies environmentally sensitive areas in Peninsular Malaysia, and aims to strengthen national planning by offering a spatial dimension to national development planning. The plan has been extended to state government and local authority levels.

iv. The need for sustainable Infrastructure

Rapid urbanisation (70% of Malaysia's population is expected to reside in urban areas by 2020), population growth and the push for a higher rate of economic development have necessitated the growing need for infrastructure, especially in the urban area. The economic downturn however has decreased the possibility of allocating adequate funding to finance the required infrastructure. As stated above, the Asian Development Bank has forecasted the demand for infrastructure development in Asia to be around USD8 trillion between 2010 and 2020; a huge investment to be spent on infrastructure. With the diminishing prospect of adequate infrastructure funding, nations must procure the infrastructures, which are sustainable at the best value. Nation can ill afford to continue demolishing and rebuilding infrastructure. Once built, the infrastructure must be serviceable during its useful life with minimum maintenance.

The burning of fossil fuels has contributed to greenhouse gas emissions, resulting in an increase in the surface temperature of the planet. This rise in temperature has brought about climate change issues, which include unpredicted weather patterns, severe storms, massive floods, melting icecaps and rise in the sea level.

Infrastructures built along coasts are in danger of being severely damaged or totally rendered useless. Under such conditions, the design, construction and maintenance of critical infrastructure need to be robust. The infrastructure, on which we rely on, must be designed in a sustainable manner. Furthermore, our power, road, rail, airport, port, water, and other infrastructure will need to be fit-for-purpose. In fact, designs for climate resilience infrastructure must now be the norm, especially along the coastal areas.

As the country continues to grow and prosper, the standard of living and quality of life for the community must grow in tandem. Hence, the implementation of sustainable infrastructure will be the bedrock for better living conditions that promotes community well-being.

The present provides an opportune time to review our past practices of infrastructure planning design, construction and operation. In the face of global economic challenges and the need to balance socio-economic development and environmental resilience, contribution from the scientific, technology and innovation community for a better and more sustainable infrastructure must be sought for and duly recognised. A more structured data and information handling and focused efforts of R&D must be in place to help create a sustainable future for all.

2.1.3 INFRASTRUCTURE LIFE CYCLE

Infrastructure development, like any other physical development, goes through the necessary phases that begins with preliminary planning and ends with operation of the finished infrastructure. The different phases in a project's development are often termed as project life cycle (See **Figure 2.1**). The major phases in project life cycle include the preliminary planning which incorporates feasibility studies and places a project on firm footing for advancement to the next phases. The strategic planning process works best when it focuses on the elements of the future, which presents the greatest uncertainty.

- Who are the ultimate beneficiaries of an infrastructure project?
- What social, economic and environmental benefits can be derived from the project, and will the project be sustainable throughout its life cycle?
- What are the major risks and uncertainties associated with the projects and what measures are likely to be taken to mitigate them?

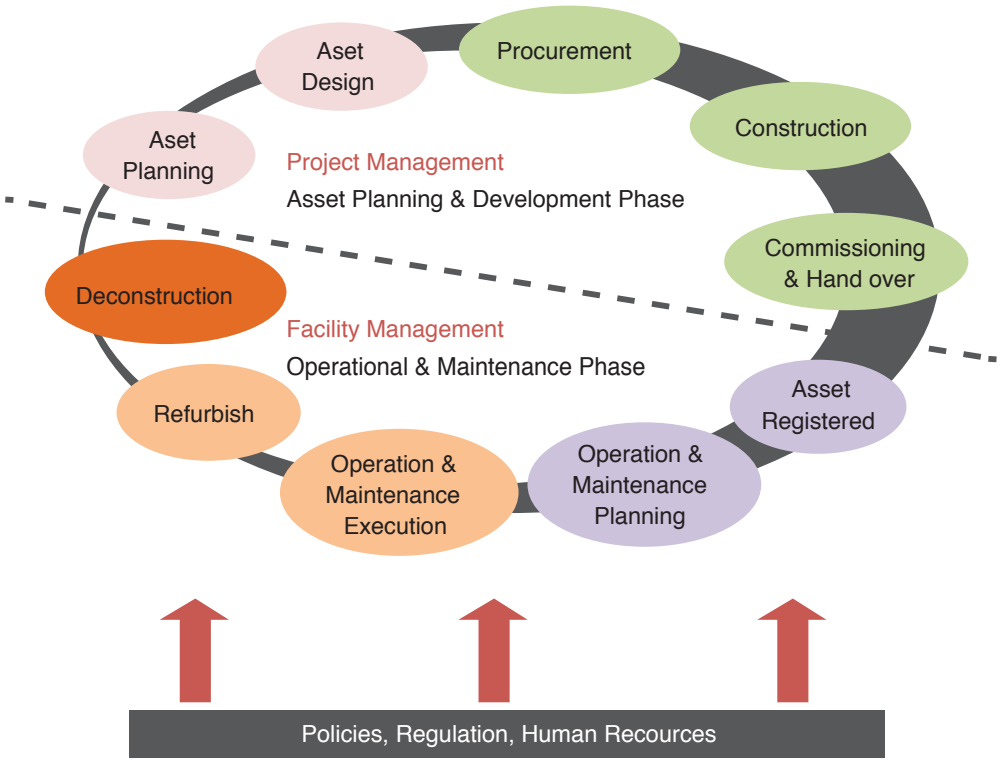


Figure 2.2. Project Lifecycle

More importantly, and like any major planning process, all parties directly involved in the infrastructure development must participate in the planning process. Professional advices from experts must be gathered to ensure a credible and sustainable solution.

The identification and mitigation of risks as well as uncertainties in infrastructure project development have taken on a more prominent role in the last couple of decades. By developing a clear understanding of the risks, which could impact a project, an organisation is better able to manage and mitigate these risks now and in the future. This could reduce or even eliminate unnecessary cost and schedule impacts, completing the project on time and within cost budget.

As the project goes through the various phases of its life cycle, a life cycle analysis must be undertaken to ensure that the original social, economic and environmental benefits are still intact. It is only when this is ascertained will the project move to the next phase. Many advanced countries have developed a system that would allow a project to go over systematic screening and evaluation on its sustainability goals and benefits. The UK has the Gateway Process that has been adopted almost wholeheartedly by Australia and New Zealand.

The following describes in detail the current practices of the major phases of an infrastructure project development:

i. *Planning*

All physical development in Malaysia is guided by the recommendation of the National Physical Plan (now into its second phase). The second National Physical Plan (NPP-2) is prepared in tandem with the Five-Year Malaysia Development Plan. It sets out the national strategic spatial planning policies and measures in respect to the general direction and broad pattern of the land use and physical development and conservation in Peninsular Malaysia by the year 2020. The NPP-2 is intended to become the main reference document on the nation's future physical planning and development. The spatial planning vision, policies, measures and land allocations of the NPP-2 will be translated primarily through the State Structure and Local Plans; and eventually through the Action Area Plans and programmes.

Actual infrastructure planning is carried out as part of the five-year development plan, coordinated by the EPU of the Prime Minister's Office. Every five years, it receives proposals from the ministries, implementing agencies and state government, which are then reviewed, prioritised and brought up for consultation, discussion and recommendation, right up to the National Development Planning Committee. The development plan, which incorporates infrastructure requirement then passes through the cabinet ministers after the approval of National Planning Council, makes its way to the parliament for deliberation and final endorsement. Once given the consent by the Supreme Head, the five-year development plan becomes a legal document.

It is unclear at which stage of the planning of the five-year development plan, is the requirement of the National Physical Plan considered, or whether any consideration is looked into at all. Where the socio-economic objectives have always been the prime criteria for the five-year development plan, it cannot be ascertained whether sustainability issues have been incorporated in the planning itself. Neither has any official sustainability guidelines been issued to the implementation agencies to incorporate sustainability in the design, construction and operation of the infrastructure.

In translating the proposals of the NPP-2 into projects and programmes, the following actions need to be taken:

a. Federal and State agencies should refer to the NPP and make project bids in conformity to the recommendations of the NPP-2 (refer Circular No. 2, Year 2006 NPP).

b. The National Development Planning Committee (NDPC) and EPU should give priority to projects that are recommended by the NPP.

c. The Director-General of Act 172 (Director-General of Town and Country Planning) should be a permanent

member of the NDPC to ensure that the aspirations of the NPP-2 are incorporated in the subsequent National Development Plans.

d. Act 172 should be included in the project budgeting and programming process.

e. The Inter-Agency Planning Group (IAPG) for the Five-year Malaysia Plan (FYMP), relating to physical planning, should be chaired by the Director-General of Act 172.

ii. *Design*

The Public Works Department and local designers undertake the bulk of infrastructure design in Malaysia. For complex and one-of-a-kind projects, the designs are likely to be undertaken by local and foreign collaborations. Where funding for the projects are by foreign investors, complete designs are sometimes accomplished by foreign designers operating from outside of Malaysia. However, for the purpose of securing the development and building approvals, the design needs to be submitted by local engineers and designers.

With increasing project complexities and the need to meet international best practices and standards, it is likely that future designs for such projects will be handled by foreign consultants. These tend to be well resourced with the desired expertise and access to international experiences and benchmarks.

The design of infrastructure in Malaysia is generally based on the engineering needs of Malaysian Standards and/or equivalent international standards from the UK and Europe. Meanwhile, Malaysia has also adopted the ISO standards from many countries and organisations such as American Standard for Testing and Materials (ASTM), American Concrete Institute (ACI), JIS AS/NZ, and considers them to be relevant to the Malaysian context.

With the advent of the Eurocodes, a number of BS, which was referred to previously by Malaysian designers, is being replaced by the equivalent Eurocodes, for e.g., EN 206-1 replaces BS 5328 part 1 to 4 and BS 4360 is replaced by EN10025. Malaysia is currently updating the structural Eurocodes, but the process is time consuming.

Infrastructure design is also guided by the requirement of relevant Environment and Occupational Safety & Health Acts and the Uniform Building By-Laws. Design for energy efficiency, carbon reduction and other green development will be undertaken as part of the initiative to secure the applicable Green Index rating, especially where buildings form a major part of the infrastructure. As there is no policy or law mandating the adoption of "green measures", the effort is often viewed as requiring additional costs. Thus, sustainable designs continue to remain as just an option.

iii. *Procurement*

Until the early 1980s, the bulk of infrastructure procurement was done through the conventional procurement route, where infrastructure contractors are selected after the design, which have been procured separately, and has been completed. After the 1980s, especially after the Eight Malaysia Plan, a number of infrastructure and other public sector works were procured through design and built, privatisation and Public Private Partnership (PPP). To facilitate the procurement of projects through PPP, the government set up *Unit Kerjasama Awam Swasta* (UKAS) under the Prime Minister's Office.

The PPP route has its beginnings in the UK, becoming the most important method in delivering public-sector services by the private sector. The total of government procurement works out at about 12–15% of GDP. Faced with growing concerns for environmental sustainability, low carbon emission, getting value for money and wastage reduction, the government is seriously looking at the option of Green Procurement as the major route to secure products and services for the public sector.

The Malaysian government has shown strong commitment towards the implementation of the Green Procurement. The Government Green Procurement

(GGP), which will initially be implemented at four ministries — Ministry of Education, Ministry of Home Affairs, Ministry of Health and Ministry of Energy, Green Technology and Water and feature four components, namely, MyHIJAU Procurement, MyHIJAU Directory, MyHIJAU Labelling as well as MyHIJAU Industry and SME.

This is in line with Malaysia's aspiration towards developing a low carbon economy, and thus, GGP can be a significant source of support for sustainable development policy goals in Malaysia. The implementation of GGP will encourage Sustainable Consumption and Production (SCP) practices while enabling Malaysia to achieve an inclusive and sustainable, high-income nation status by 2020. It is also intended that GGP will be key in helping Malaysia achieve the Carbon Dioxide (CO^2) emissions reduction targets by up to 40%. Moreover, the use of environmental-friendly products and services is expected to increase the potential of energy efficiency by 40% by the year 2020, which will result in cost savings of RM295 billion, generating RM7.2 billion in incremental Gross National Income (GNI) and creating over 47,000 jobs in the green industries (PEMANDU 2010b).

iv. *Construction*

In Malaysia, infrastructure construction is primarily undertaken by higher-grade local contractors. Complex projects with a lot more uncertainty or foreign-funded projects are likely to be constructed by international contractors. Generally foreign contractors undertake between 5–15% of construction works by value of Work (CIDB). Typical subcontracting works include foundation, earthwork, mechanical and electrical services, tunnelling, surveying, testing and other support services

Malaysian construction industry is fragmented, with a bulk of its 66,000 contractors consisting of small and medium scale businesses. The larger volumes of work are awarded to the bigger contractors, who then subcontract the jobs to a number of smaller contractors. They in turn may subcontract further, hence forming a multi-layered subcontracting practice.

The industry is plagued with wastage and quality issues largely due to unskilled foreign labour in which, the Malaysian construction industry is highly dependent on. This issue is partly addressed through the Industrialised Building System (IBS) initiative by the government, whereby projects worth more than RM10 million are required to have 70% IBS components.

Infrastructure contracts are often based on FIDIC contract and JKR 203 Conditions of Contracts. Other conditions that have been used may include those issued by Joint Contract Tribunal (JTC) and the Institution of Engineers (ICE) UK. Meanwhile, the UK, has adopted the Infrastructure Condition of Contract (ICC), which is largely based on the ICE condition of Contract

v. *Maintenance and Operation*

Infrastructure asset owners traditionally operate and maintain the assets. For "Build, Operate and Transfer or PPP" projects, the assets are operated and maintained by the private sector or the concessionaires for a contracted period of time. Following NAFAM 2007, government assets will be operated and maintained based on the Government Asset Management Policy (GAMP), which was launched during NAFAM 2009.

Apart from this, an accompanying document was launched, the 'Total Asset Management Manual' (TAMM) (JKR). The recently issued Procedure for managing Government Non-movable Asset by the Prime Minister's Office outlined in greater detail the procedure for managing such assets at the operation phase. Later procedures will cover other phases of asset management to complete the whole life cycle of the asset. TAMM has a chapter on managing infrastructure and building assets.

Local authorities which also operate and maintain substantial public infrastructure assets have been facing difficulties in determining quantity and type of assets, unfilled vacant assets, poor income generated by the asset and the high cost of maintaining the asset (Nur Berahim). In Malaysia, the Auditor's General Report for local government performance in asset management has found that the same weaknesses in

asset management are repeated every year. According to Asrina and Hasnira (2007), the issues that occur repeatedly include unregistered assets, assets are not labelled as government assets, weaknesses in disposal and maintenance, assets which are not used or wasted, and asset misappropriation.

2.1.4 CURRENT STATUS

i. *Roads and Highways*

The Malaysia road network covers a total distance of 98,721 km, of which 1,821 are tolled expressways. The road system in East Malaysia are less developed and of lower quality compared to those in the Peninsula. From 1986 to 2005, the government routinely allocated about 20% of the national development budget for the transport sector and the bulk of it went to road and highway development (CPPS 2008). Under the Economic Transformation Programme (ETP), 98.6% of Peninsula Malaysia rural population will be served by a road network, 87% for Sabah and 86% for Sarawak.

More than 80% of Malaysian road is paved. The Malaysia road density (km of road per sq. km of land area) is 41 in 2009 and 44 in 2010 respectively, indicating a continuous and sustained effort in the provision of this mode of transport infrastructure. Comparatively, almost all developed countries and a number of developing countries have road density of more than 100.

Vehicle ownership in Malaysia averaged 91 per 1,000 population in 1996, rising to 133 in 1996 and 210 in 2002,whereas in the Klang Valley, the figure stood at 247, 546 with 994 vehicles per 1,000 population, respectively. In 1991, there were 71 vehicles per road kilometre, compared to only 46 in 1994. Notably, Malaysia is second to Japan, in terms of vehicle ownership per households. In 2006, there were 6.91 million registered vehicles running on Malaysia roads. With the increase of vehicles, traffic on the tolled expressways increased from 1,488.52 million in 2011, to 1,567.19 million in 2012, a growth of 8.84%.

ii. *Railways*

The Railway system covers a total of 1,849 km. 1,792 km of the track is on narrow gauge while 57 km is on standard gauged. 150 km of narrow gauge and all standard gauge are electrified. A total of 332km is double-tracked and electrified. The railway network covers most states in Peninsular Malaysia. In East Malaysia, only the state of Sabah has railways. There are three light rail transits in Malaysia. Two in Kuala Lumpur and one in KLIA ferrying passengers from the Main Terminal Building to the Satellite Building. The two in Kuala Lumpur are the Kelana Jaya Line (driverless and 29 km long) and the Ampang Line, which has drivers and covers a distance of 27 km. The Kelana Jaya Line also has a 4 km underground stretch, the only monorail system which runs from North Titiwangsa of KL to KL Sentral (South), a distance of 8.6 km long. Apart from that, there is also the Asean Rail Express, a rail service that connects Kuala Lumpur to Bangkok, and eventually, from Singapore to China.

The main intercity rail line of KTMB, from Johore Bahru to Padang Besar on the Thai border in the North, is now being double-tracked and electrified. According to the World Bank (2009, 2010), Malaysian Railways carried 1,527 million km passenger. This figure dropped to 965 in 2011, indicating lesser number of people travelling on railways.

The Klang Valley MRT, with the proposed three lines, will be 150 km long. The first phase, the Sungai Buluh Kajang line, is expected to be operational by July 2016. Meanwhile, a high speed railway service has also been proposed, to link Kuala Lumpur to Singapore. At the time of this report, no firm decision has been finalised. As part of the Sarawak Corridor of Renewal Energy project, the government is also planning to build a 320 km railway track between Similaju in Bintulu to Tanjung Manis in Mukah. The cost and the date of implementation have yet to be decided.

In 2005, 3.7 million passengers took the trains, with a total passenger km of 1,181 million. Freight tonnage was 4 million, whereas the freight tonnage km was 1,178 million. Traffic density was 1.4 million and the average

length of freight haul was 295 km. The average person's trip was 319 km. Meanwhile, the traffic density for Japan and South Korea were 27.2 and 12.1, respectively for the same year. The rail freight volume is expected to rise from 2.2% to 6.379 mn tonnes in 2014, and to an average 3.9% annual growth in the five-year period to 2018. In terms of tonnage, rail freight is to grow to 18.6 million tonnes by 2020.

i. *Ports*

In 2007, seaborne shipping accounted for 95% by volume of Malaysia's total trade in goods. Altogether, there are 21 ports and harbours. Among the biggest and busiest include Port Klang, Port Tanjung Pelepas and Pasir Gudang Port. The ports contributed to a total trade of nearly RM1 trillion annually for the nation, with 70% of the sea freight are containerised. Malaysian ports have the capacity to handle 20.8 million, 20 foot equivalent units (TEU). Nonetheless, the capacity will be increased so that Malaysia ports are capable of handling 36 million TEUs by 2020.

Based on the World Bank report, there has been increasing container traffic; 15,922,800 in 2009, 18,267,474 in 2010 and 19,912891 Mil TEU in 2011. Container traffic measures the flow of containers from land to sea transport modes, and vice versa, in TEUs, a standard-size container. Whereas, Port Klang has ascended up to 12th position, according to the Containerisation International List; up one rank compared to 2010, whereas Port Tanjung Pelepas maintained its 17th position. The total of cargo volume handled at Port Klang will rise by 3.0% to 209.8 million tonnes in 2014, while volume at the Port Tanjung Pelepas will rise marginally higher by 3.2% to 126.2 million tonnes.

ii. *Airports*

Malaysia has 62 airports (38 in East Malaysia and 24 in Peninsular Malaysia), of which 39 of these airports are operated and managed by Malaysia Airport Berhad, incorporated in 1991. Furthermore, MAHB also operates three airports outside the country — international airports in Delhi, Hyderabad and Turkey.

The 38 airports are paved and have scheduled passenger services on commercial airlines. There are eight international airports. Of the paved airports, five have runaways longer than 3,047 m, 7 with 2,438 – 3,047 m, 10 with 1,524 – 2,437 m, 9 with 914 – 1,523 and 7 under 914m. From this, three of the biggest airports are KLIA, Kota Kinabalu and Penang International Airport, recording a total number of passengers for 2013 at 47.1, 6.93 and 5.48 million, respectively. With 23.76 million international passenger served in 2013, KLIA was classified as the 12th busiest airport in the world, ahead of Narita with 22.97 and Munich with 22.39 million.

The current capacity of KLIA is 40 million passengers. The temporary Low-Cost Carrier Terminal (LCCT) can handle up to 15 million passengers, though it now manages well over 20 million. The new KLIA2, which is under construction, should be able to accommodate 45 million passengers. The air freight volume is set to grow by 0.6% to 927,000 tonnes in 2014. The average growth in the next five years will be slow but steady at 0.5% per annum. Hence, growth is expected to reach 2.4 million tonnes by 2020 (MITI).

iii. *Roles and Responsibility – Relevant Stakeholders and Agencies*

At the highest level, agencies responsible for (transport) infrastructure policy and planning must necessarily be the EPU from the Prime Minister's Office, Ministry of Transport and Treasury. *Suruhanjaya Pengangkutan Awam Darat* (SPAD) will also be consulted on the planning for land transport development. Ministry of Works and its agencies, the *Jabatan Kerja Raya* and *Lembaga Lebuhraya Malaysia* (LLM) recommends new Federal roads including upgrades, develops technical specification and implements road development programmes. *Lembaga Lebuhraya Malaysia* regulates and monitors the performance of tolled expressways.

The Department of Civil Aviation regulates the civil aviation industry and provides key supporting services, in addition to providing a safe, efficient and orderly flow of air transportation. Airport maintenance and operations is managed mainly by Malaysia Airport Holding Berhad and its subsidiaries. *Jabatan Laut Malaysia*, conversely, provides a safe, secure and systematic sea communication system in ensuring safe passages of merchant vessels in Malaysian waters.

The respective ports (*Lembaga Pelabuhan*) such as *Lembaga Pelabuhan Kelang*, regulates the ports operation ensuring that rules and regulations are strictly followed. It also acts as the landlord in ensuring that land is properly used as planned, which is part of the overall development of the ports. Apart from that, the (Maritime Institute of Malaysia (MIMA)) too provides assistance in formulating national maritime policy planning and implementation. It achieves this through research and provides advisory services on maritime issues.

The Department of Railways ensures and promotes safe, efficient rail transport system. With the privatisation of Keretapi Tanah Melayu (KTM), Keretapi Tanah Melayu Berhad (KTMB) was established and given the mandate to operate the Malayan Railway. Assets and liabilities of the former KTM are now handled by Railway Asset Corporation (RAC). At the same time, RAC will also be responsible for the development of railway infrastructure.

2.1.5 ATTRIBUTES OF THE BEST INFRASTRUCTURE GLOBALLY

i. General Infrastructure

- Integrated infrastructure planning and prioritisation, with comprehensive financial projection, including demand modelling and business as well as operating models. Use of life cycle cost analysis or similar
- Infrastructure design to achieve technical and commercial balance, and at the same time, meet environmental needs. In particular, designs must be climate resilient and low carbon, in construction and operation
- Infrastructure asset management, a strategic approach to managing transport infrastructure. It embodies a set of principles for an efficient management of assets, set strategies for asset upgrading and rehabilitation and how asset owner manages asset information, including asset performance
- Infrastructure procurement strategy involving comprehensive exploration of a range of procurement models to determine the approach that is best suited for each infrastructure. This ensures government or asset owners derive value for money and improved outcome of the infrastructure investment
- Use of BIM models to provide accurate information that can be handed over to infrastructure operators for managing the assets post-construction
- Construction process improvement using Lean construction, Design for Adaptability and Dematerialisation, reduction in the amount of energy and raw materials needed to produce a product.
- Operational excellence with full understanding of cost of ownership, to minimise maintenance cost
- Use of sustainability rating tools and programmes

ii. Roads and Highways

- Solar roadways, replacing concrete or asphalt with solar cells beneath a layer of glass
- A smart-road design that features glow-in-the-dark tarmac and illuminated weather indicators
- Safe and forgiving roads
- Green lanes for high density buses, energy-efficient vehicles and sharing commuters
- Better sustainable designs, for e.g. tunnelling rather than cutting through hills
- Roads that are designed to facilitate economic and social development

- Facilitate mobility with unimpeded access
- Self-generating street lighting
- Preference for concrete roads over asphalt pavement for its durability, longer useful life and less maintenance
- Use of permeable pavements to help keep storm water infiltration at pre-construction rates, recharges groundwater, cleans roadway pollutants and strains suspended solids from runoffs

iii. Ports

- Growing international container trade requiring expansion in container capacities including supporting infrastructures
- Use of alternative energy source, for e.g., fuel cells to power port vehicles, plants, machineries and other mobile devices
- Optimising port infrastructure through improving local connection to the wider road, rail and air network
- Technology improvement in berthing and handling equipment
- State-of-the-art technology to detect and neutralise safety and security threats.
- Addition of complementary logistic spaces
- Strategic Information Technology (IT) adoption to enhance port operational productivity
- Efficient and economical channel deepening and port dredging operation

iv. Airports

- Airport as an integrated travel, entertaining, shopping and recreation centre. Airport customers are more than just travellers and airlines. They are also tenants, employees, visitors and other related stakeholders
- Highly integrated and synchronised with other mode of transport to and from the airports
- Most advanced security features with state-of-the-art system, which is passenger- friendly
- Integrated bundled contracts that would include maintenance of the critical asset of the airports
- A study by CAP Strategic Research Limited concluded that by 2025, there will be no check-in desks at the airport, and passengers will not have to go through an emigration procedure. “Trusted travellers” will not be subjected to any security checks, and passengers will not be able to check-in any luggage
- Maximising airport land value and economic return generated by the airport and airport-related businesses
- Airport construction using self-cleaning and self-repairing materials

v. Railways

- High Speed Rail (HSR) network
- Newly built Rail Stations will have marked routes, step-free access, and simple signage and information to ensure that the majority of passengers can move independently through stations
- Each carriage will provide both visual and audio information about the train’s journey, and a facility to alert and speak to the driver in the event of an emergency

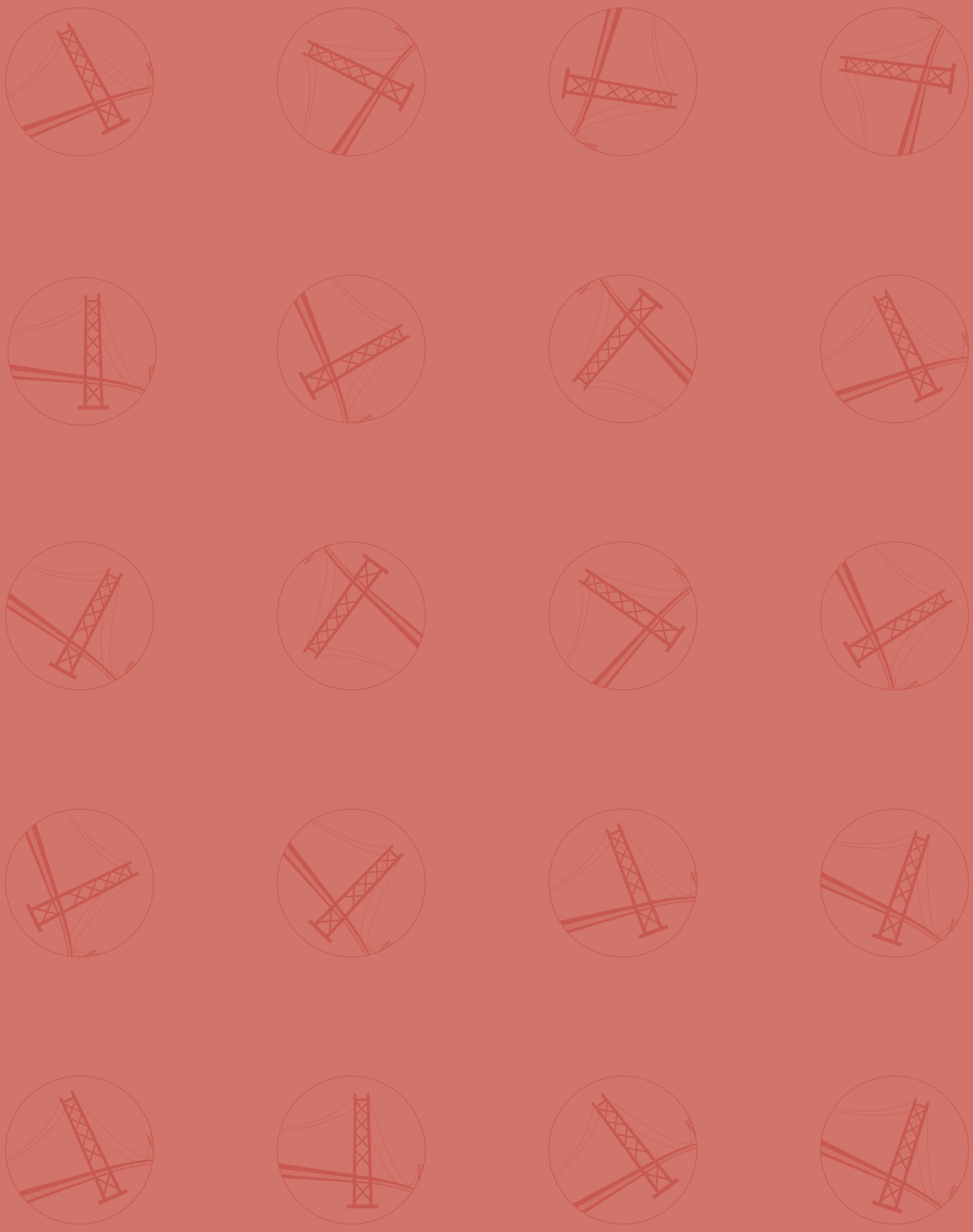
- Jet-propelled trains for HSR technology, which is faster and more environment-friendly
- Use of ballastless track system for longer lifespan, more comfortable ride, reduced maintenance and higher structural stability
- A separate passenger and freight rail network
- Making railways a major form of passenger transportation by extending the reach to many more destinations.

2.2 SUMMARY

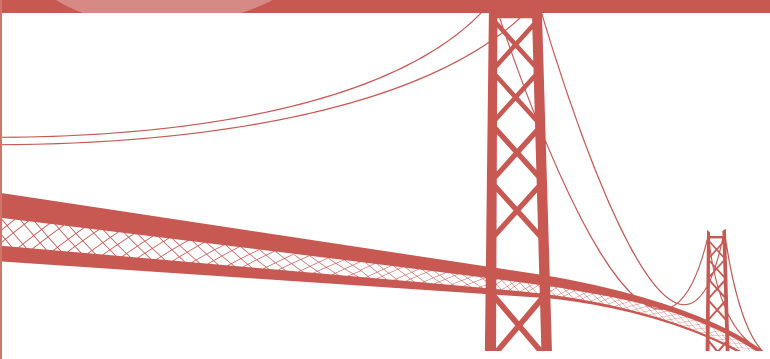
Chapter 2 has established the domestic as well as global infrastructure scenario. The need for infrastructure to sustain economic development has been discussed. The study has also revealed why major parts of the world, namely the more advanced countries, are now looking at sustainable infrastructure as a means to overcome the economic, social and environmental challenge brought about by unsustainable practices and behaviours by both the developed and developing nations.

A life cycle approach to infrastructure development has been discussed to understand the practices and processes and at the same time to ascertain the supply chains and active players involved in the area of study, which is the transport infrastructure development. Preliminary issues have also been identified and these will be studied and further reviewed in detail, in Chapter 3.

The current status of transport Infrastructure and the infrastructure development in Malaysia is documented and global best in class of the transport infrastructure has also been identified for possible adoption and adaption in Malaysia to bring up Malaysian transport infrastructure to higher sustainable levels. From these, it is possible to derive gaps in infrastructure development in Malaysia. Chapter 3 will provide a clearer argument on these gaps, validate the more important ones and set the tone for possible solutions to close the gaps, which will be discussed in Chapter 4.



CHAPTER 3
FINDINGS



The previous chapter has set out the present status of transportation infrastructure in Malaysia. It has also benchmarked against current best practices and world standards. In this chapter, the issues plaguing the transportation infrastructure in Malaysia are identified. The preliminary findings from an on-going EPU study on transport policy, passenger transport, freight transport and regional connectivity are presented. A workshop was held to obtain feedback on infrastructure sustainability issues from transportation infrastructure stakeholders comprising of Federal agencies, private sector, academia and civil society. The issues can be categorised into the different phases of the infrastructure life cycle, namely, planning, design, procurement, construction, operations, maintenance, refurbishment and deconstruction.

These issues are best exemplified by referring to case histories and lessons learnt from infrastructure projects in Malaysia, where weaknesses in the current practices has led to failures and resulted in increased costs, delays and a reduction in quality.

3.1 NATIONAL TRANSPORT POLICY AND STRATEGY

Malaysia currently has fragmented policies that do not integrate and guide the development of the transport sector as a whole. Though the National Automotive Policy was introduced in 2006, Malaysia does not have a National Transport Policy. The absence of such a policy has resulted in various ministries and departments developing and expanding its designated transport mode without any regard to the different roles of the others. In short, they are not developed as an integrated system, thus, lacking in cohesiveness. This

has led to the misallocation of resources, manifested by the duplication of facilities and even excess capacities among the various modes.

The government has identified the need to establish a National Transport Strategy (EPU 2013) to act as a long-term strategic plan to develop the transport sector. EPU has commissioned the World Bank to craft a blueprint for the strategy. The overall objective is to develop an implementable strategy for Malaysia that can guide policymakers across agencies, sectors, and regions in the implementation of measures to improve the efficiency, integration, competitiveness, and environmental sustainability of the country's transportation system.

In facilitating the task, EPU has been organising a series of working groups that gather stakeholders from the transport sector to discuss various aspects that encompass passenger transport, freight transport, rural transport and institutional framework and planning. The final report is due in November 2014. Some details from the Draft Inception Report and Project Update (World Bank 2013) are given in the following sections:

3.2 PASSENGER TRANSPORT

The country's economy has been on the fast track in development and progress since its Independence, 55 years ago. It has evolved since then, and demands for higher added-value manufacturing and service sectors. Apart from that, the population has migrated to urban areas in pursuit of better employment opportunities. The sustained economic growth and income-generating impact has driven up private vehicle ownership rates at a faster rate than the rate of growth in road and public transport capacity. This has led to congestion in and between urban areas with significant economic costs for the public and firms, including environmental impact.

The planning of land use and the planning of required mobility are key drivers of attaining a set of sustainable socio-economic and environmental outcomes (triple bottom line). There is a frequent mismatch between the plans for land use and their final implementation, as well as between the development the provision of sustainable modes and mixes of public and private transport.

The development of integrated transportation plans at the national, regional and local levels should be geared to providing urban mobility and inter-urban connectivity at competitive costs, with broad affordability and comprehensive coverage. The urban transport model split has declined from 34% in 1985 to 10% in 2008. The National Land Public Transport Master Plan (SPAD 2012) targets a more sustainable level of 30% share for public transportation in urban areas by 2020.

3.3 FREIGHT TRANSPORT

Malaysia's economic activity has been driven by trade and manufacturing, and multimodal transport is a critical driver of trade competitiveness. The combination of transport infrastructure, service delivery in transportation, and the institutional and regulatory environment governing the transport sector determine the most significant components of landed cost in supply chains, e.g. transportation costs and inventory carrying costs. A well-coordinated multimodal transport system linked to adequate handling facilities with minimal delays en route can minimise these costs. Currently, Malaysia's freight transportation planning and management have remained fragmented, with single-mode planning, limited inter-agency coordination, and overlapping efforts. This has led to demand-supply mismatches in transport infrastructure and substandard service delivery relative to leading regional peers such as Singapore, Hong Kong and South Korea.

3.4 REGIONAL CONNECTIVITY

The government has emphasised the need to provide and continue support to ensure rural-urban connectivity is maintained and improved. The rural transport system is vital to ensuring socio-economic inclusiveness of rural communities; focusing on public access to health and educational services, SME access to markets,

suppliers and national networks, including connectivity for agriculture to national supply chains.

Malaysia has embarked on a regionally oriented development strategy, executed through regional development authorities that seek to boost investment in targeted sectors such as Iskandar Malaysia (IRDA), Northern Corridor Economic Region (NCER), East Coast Economic Region (ECER), Sabah Development Corridor (SDC) and Sarawak Corridor of Renewable Energy (SCORE).

The connectivity between Peninsular Malaysia and East Malaysia needs to be enhanced, not only for the purpose of economic development, but for national and social cohesion. Hence, it is vital that the land, maritime and airborne transport systems meet the needs of the people and industries there.

3.5 WORLD BANK PRELIMINARY FINDINGS

Some early findings from the World Bank study, suggest that despite a number of key strengths in the transportation system, the choke points remain and their root cause seems to lie in the fragmentation at the institutional, planning and decision-making; and budgetary levels.

As far as transportation planning is concerned, there is a high level of engagement and commitment to the planning and development of the regions and economic corridors and transport networks. Each individual region and corridor plan is prepared by high quality strategic thinking. The regional and sector plans are quite compatible with a few perceived conflicting scenarios. Moreover, clear strategic thrusts have been identified to resolve transportation bottlenecks in the Klang Valley, Johor and Penang. These strategies are designed to manage growth in the eastern corridor, Sabah and Sarawak regions to attain long-term competitive advantage towards becoming a high-income economy in 2020 and beyond.

Nevertheless, at the execution level, while plans are not necessarily conflicting, they are often not followed through with the next agency or next modality. This has resulted in fragmented networks and lingering bottlenecks or choke points, which has become an increasingly urgent problem. The root cause appears to

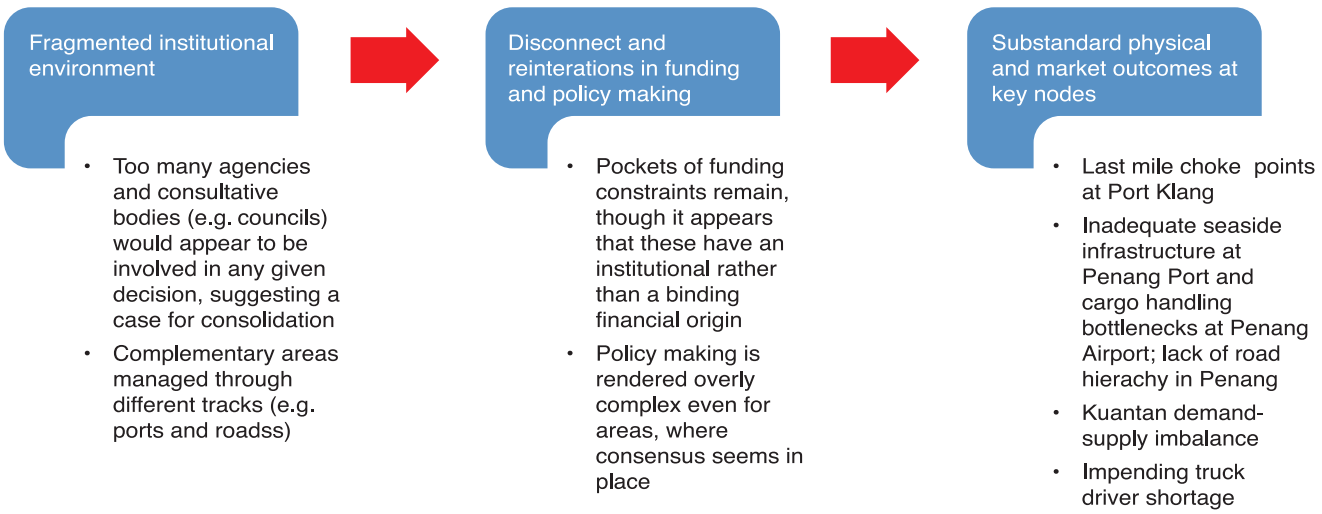


Figure 3.1. Bottleneck Chain from Institutional to Market Outcomes (World Bank)

be a fragmentation of responsibilities, desynchronised decision making and inconsistent budgeting priorities. A fundamental shift from project orientation to system orientation in policy making is necessary to address this weakness and ensure high-performing execution.

Figure 3.1 suggests the mechanisms at play; depicting a bottleneck progression from institutional challenges to funding and policy-making. It disconnects and eventually leads to physical choke points and substandard market outcomes.

Regulatory and procedural bottlenecks cost time, money or access to markets and services or inhibit financial sustainability. As a consequence, the existence of institutional bottlenecks causes overlapping or unclear authority and accountability that may hamper effective management and service delivery. The following are gaps and needs that must be addressed:

i. Develop a National Transport Strategy that can guide policymakers across agencies, sectors and regions in the implementation of measures to improve the efficiency, integration, competitiveness and environmental sustainability of the country's transportation system;

ii. Integrate requirements for comprehensive transport planning at national, regional and local levels;

iii. Contribute interventions to meet requirements, outcomes and costs for urban transport, intercity and rural passenger transport and the transportation of freight;

iv. Identify infrastructure investment priorities and suitable financing mechanisms for the transportation sector;

v. Transform institutional framework on effective transport sector to improve functions and roles between agencies;

vi. Create key linkages between plans for land use and transportation at the national, regional and local levels;

vii. Craft short-term strategy to resolve the bottlenecks experienced by transportation system end-users as well as operators of transport services and infrastructures;

viii. Design medium-term strategy to accommodate and manage the expected growth of the economy and resulting increases in transport flows and mobility requirements;

ix. Generate long-term strategy to achieve sustainable competitive advantage in meeting transportation needs of industrial, agricultural and service sectors as well as the connectivity needs of the country;

x. For passenger services, focus on urban transport access to education, jobs and housing, long-distance transport for national connectivity, as well as rural transport for access to services and tourism; and

xi. For freight services, emphasise on city distribution for access to markets and production locations, long-distance multimodal transport to support manufacturing and agricultural supply chains with linkages to international gateways, and rural networks for access to local markets and production sites.

3.6 REGIONAL KEY NEEDS AND ISSUES

The regional corridor development authorities, NCER, ECER, IRDA, SCORE and SDC have unique needs but still share largely common issues such as reducing urban traffic congestion and improving connectivity. In order to ensure rural-urban connectivity, each region has specific requirements on transportation infrastructure which needs to be developed, upgraded and maintained to boost investment and economic growth. The key needs and issues faced by the corridors authorities

are presented in **Table 3.1**. Institutional challenges and bottlenecks issues are a major area of concern.

The Federal agencies that are directly related to the transportation sector are the Ministry of Transport (MoT), Ministry of International Trade and Industry (MITI), *Suruhanjaya Pengangkutan Awam Darat* (SPAD), *Jabatan Perancangan Bandar dan Desa* (JPBD), Performance Management and Delivery Unit (PEMANDU) and *Jabatan Kerja Raya* (JKR).

Table 3.1. Regional Key Needs and Issues

Corridor	Key Needs	Key Issues
KORIDOR UTARA MALAYSIA	• Alleviate urban congestion • Increase urban public transport share • Remain competitive in sea and air freight • Be a hub for South Thailand	• Lack of proper road hierarchy impedes effective road management • State-Federal integration bottlenecks • Disconnect between rail infrastructure and rolling stock
EAST COAST ECONOMIC REGION	• Improve connectivity as a catalyst of investment and economic growth • Develop rail infrastructure to support special economic zones • Act early on emerging traffic congestion (e.g. at Kota Bharu)	• Complex institutional and decision-making matrix has delayed development interventions • Interventions that are implemented are done in piecemeal fashion, sometimes exacerbating the very issue they intend to solve • No clear way to implement 'studies'
ISKANDAR MALAYSIA	• Provide basic road connections at "missing links" and upgrade and maintain existing roads • Develop rapid transit buses to support urban transportation • Prioritise project blueprint • Expand rail infrastructure	• Authority observes major institutional bottlenecks impeding regional development • Local council plays a limited role in urban transport; special - purpose vehicles introduced under institutional uncertainty • Authority implements projects as a solution to agency-led execution delays

Corridor	Key Needs	Key Issues
SARAWAK CORE CORRIDOR OF RENEWABLE ENERGY	• Upgrade trunk road to dual carriageway • Connect coastal road • Upgrade state ports • Provide landing stages to support inland waterway transport	• Having a tenth of peninsular Malaysia's population and the lowest population density of all Malaysian states makes it difficult to justify large infrastructure investments • Reducing logistics costs for consumer products
SABAH DEVELOPMENT CORRIDOR	• Improve all-weather road connectivity region-wide to support competitive advantage in tourism • Improve air cargo handling capacity to support local manufacturing	• Challenging geography for infrastructure development

Source: World Bank

Table 3.2 presents the key priorities and issues of these agencies. Although each agency has its own priorities and faces challenges in their respective sectors, there is significant potential for inter-agency collaboration in many areas to coordinate and optimise their efforts towards achieving an integrated transportation system.

Table 3.2 Agency Needs and Issues

Agency	Key Priorities	Key Issues
MINISTRY OF TRANSPORT MOT	• Maintain competitiveness in maritime and airport connectivity • Support open policy approach to air services and maritime cabotage • Deliver integrated urban transport solutions for Klang Valley under NKRA unit	• Fundamental disconnect between ports/ airports and roads/rail in institutional setup • Financing bottlenecks in certain areas such as capital dredging • Need to extend Klang Valley public transport solutions to other states • Deliver on findings of Roadmap for the Logistics Industry as co-chair of the MLSC Council

Agency	Key Priorities	Key Issues
MITI MALAYSIA	• Promote trade and reduce the cost of doing business – transportation seen as fundamental enabler of this • Provide connectivity to industrial parks • Promote policy making for efficient and competitive service delivery in transport/ logistics • Promote infrastructure development for industry	• Last-mile gaps in road infrastructure at key nodes (e.g. Port Klang) despite perceived major impact • Major impending shortage of qualified drivers in trucking industry, particularly long-haul • Interagency and public-private collaboration in logistics
SPAD	• Finalise and secure buy-in for National Master Plan for land public transport • Increase Greater Kuala Lumpur (GKL) public transport share • Produce state-level master plans for land public transport • Engage with state and local authorities to support execution of public transport plans	• Attract and hone in-house public transport technical skills • Integrate road and rail networks and pricing dynamics into master plans • Address bus and truck driver shortages
JABATAN PERANCANGAN BANDAR DAN DESA SEMENANJUNG MALAYSIA	• Promote livability in four main conurbations of KL, George Town, Johor Bahru and Kuantan • Protect forest and green areas nationwide • Coordinate national physical plan with local priorities	• Emphasise rail (including high-speed) over roads • Smaller cities starved of resources to pursue Transit-oriented Development (ToD) • National policies considered “advice only” at local level

Agency	Key Priorities	Key Issues
PEMANDU	Attaining public transport modal share, peak ridership and coverage targets by promoting: • Adequate provision of feeder bus service for rail capacity • Ability of public transport operators in general and bus operators in particular to break even at the operating margin level • Rebalancing of bus and taxi supply and demand • Better enforce traffic violations and better regulate parking and pedestrian access to public transport facilities	• Low cost of car ownership and use • Public preference for commuting in private vehicles • Public transport fare regulation • Bus driver shortages • Feeder bus financing • KTM station location and redundancy • Lack of data on taxi fleet operations
JKR	• Implement Highway National Development Plan (HNDP) and in particular develop 3 priority corridors—Eastern Coastal Corridor, Western Coastal Corridor and Central Spine Road (CSR) • Monitor traffic behaviour and alleviate road bottlenecks	• Prioritisation of projects at the national and state level, including non-planned ad-hoc projects • Little, if any, communication with other ministries to inform projects on a multi-modal basis • Limited right-of-way availability restricts the country's ability to expand roads at key nodes (e.g., Greater KL and Penang) • Less than full funding of road maintenance

Source: World Bank

3.7 TRANSPORTATION INFRASTRUCTURE STAKEHOLDERS ENGAGEMENT

In order to obtain feedback from key representatives from the public sector, private sector, academia and civil society, a transportation infrastructure stakeholders' workshop was conducted at ASM on February 7, 2014. The participants who attended the workshop represented the road, rail, port and airport sectors. Apart from the workshop, discussions and consultations with various individuals were carried out to solicit views on the problems plaguing the transportation industry. The issues identified are compiled and presented in **Table 3.3**.

Table 3.3. Issues Identified During Interviews, Consultations and Transportation Infrastructure Stakeholders Workshop

Sector	Issues
General i) Planning Phase	• Absence of national transport policy and strategy to govern the transportation systems development in the country • No single responsibility for infrastructure planning. Too many agencies are involved • Lack of coordination between national and state levels for infrastructure development • Low sustainable practices to tackle issues such as carbon reduction, noise management, air quality, biodiversity, surface and ground water pollution and resource management • Development often hampered by land acquisition issues
ii) Design Phase	• Current design practice for construction, deconstruction not considered • Design lacks of details on build-ability • Lack of specialisation and innovation • Require greater utilisation of Industrialised Building Systems • Need for alternative materials • Poor adoption of life cycle cost and value management analysis
iii) Procurement Phase	• Multiple levels of sub-contracting • Adversarial relationship in procurement • Price-driven • Sustainability, health and safety not considered • Restricted funding amid global economic uncertainties • Financial and business model that is restricted by a rigid and unrealistic budget

Sector	Issues
iv) Construction Phase	• Inferior quality and durability • Poor health, safety & environmental records • Weak adoption of modern construction technology and innovation • Low use of recycled and reusable materials • High energy consumption • High wastage of materials
v) Operations and Maintenance Phase	• Low quality and high maintenance cost • Poor reliability and frequent breakdowns • Weak preventive maintenance culture • Lack of Total Asset Management practices • No inventory of existing infrastructure • Lack of skilled workforce
vi) Deconstruction Phase	• Not considered • Reclamation of material • Reuse of materials • Refurbishment of materials • Ease of deconstruction
Road	• Unable to balance between road development and road sustainability • Severance due to highway development • Poor road hierarchy compliance • Poor land use and transport integration • The need for government to compensate toll • Extensive damage due to overloading

Sector	Issues
Rail	• Rail planning not integrated with land use and tourism needs • Greater dependence on foreign technology for design, construction and supply of rolling stocks and signalling equipment • Reliability issues involving travelling times, cancellations and delays • Failure to realise the huge potential for passenger and freight mobility in rail network • Decline in rail transport, especially freight, in the face of competitions from other modes of transport, e.g. low cost carriers • Urban rail networks (in Kuala Lumpur) are not 'intimately' integrated • Track gauge issues preventing seamless cross border travel
Port	• The need to expand the capacity and capability, and boosting competitiveness to cater for growing regional and global trade • Some ports lack intermodal connectivity and feeder services and seamless integration with other modes of transport • Greater adoption of technology to improve safety and operational efficiency • Ports will be subjected to rising sea levels and other climate change effects • Shallow draft and siltation require dredging and finding ways to manage the dredged materials
Airport	• Current airport terminal buildings are not designed in modular fashion, making extension and expansion difficult • Capacity-planning for international-class airports • Need to create a pleasant air travel experience including efficient and rewarding mobility from airport entry to the planes • Infrastructure assets maximisation, making better use of existing space, land, movable assets and other assets like information, human capital and commercial rights • Enhancing non-aeronautical revenue, from retail, entertainment and tourism

3.8 CASE STUDIES

Three case studies from the Public Works Department (*Jabatan Kerja Raya* (JKR)) are presented. The projects described in the case studies involved the construction of new roads in the hilly terrain of Cameron Highlands and Fraser's Hill.

The Pos Selim-Blue Valley Highway case study is described in **Table 3.4**. The 46-km highway costing RM292 million was scheduled to be completed in 2000. However, a series of slope failures delayed the opening of the road by four years, and the total cost of slope repairs works amounted to RM110 million, where RM60 million was paid by the government while the Design and Build contractor reportedly paid RM50 million. A 1.5 km section of the road is still unstable and monitored continuously. A permanent solution to construct a bypass to avoid the unstable slopes is estimated to cost RM300 million.

The approach of cutting hills for road construction in hilly terrain needs to be reviewed and replaced with tunnelling, which is a more environment-friendly solution. Tunnelling is pricier than compared to the cut and fill approach but, if a life cycle costing analysis is carried out, it is a more sustainable approach. The four-year delay and costs during operations and maintenance must be taken into account. This case study shows that repair works have cost about 38% of the initial construction cost and a permanent solution to the unstable slopes around Gunung Pass would double the initial cost. Therefore, life cycle costing should be incorporated into feasibility studies, for better decisions to be made at the planning stage.

Table 3.5 describes the Aring-Kelantan/Terengganu Border Road case study. The poor performance of the contractors led to delays of completion date of four years, and a cost overrun of RM80 million constituting an increase of 78% over the original contract cost of RM103.5 million. The delays have resulted in economic loss and hardship to passenger and goods movement in the central region of the country. A sustainable strategy during the procurement stage is vital to ensure the selection of competent contractors and a win-win client-contractor relationship based on alliancing, partnering and relational contracting.

The Gap-Fraser's Hill New Road case study is described in **Table 3.6**. The 9 km road costing RM23.9 million was completed in 1997. The road was designed to follow the terrain with steep cuts and no fill embankments. However, continual failures have forced repeated closures of the road due to impassibility and safety. The repair cost has ballooned to RM50 million and has dwarfed the construction cost. The cheapest cost approach resulted in continuing failures till today. Hence, a robust and sustainable design to last in the long-term is desirable.

Table 3.4. Case Study 1: Pos Selim-Blue Valley Highway

Case Study 1 	
Pos Selim-Blue Valley Highway	
(i)	The East-West Highway 2 is also known as the Simpang Pulai-Lojing-Gua Musang-Kuala Berang Highway Project. It traverses across the Main Range at Lojing near Cameron Highlands. The road traverses over Perak, Pahang, Kelantan and Terengganu and the total distance is 355km. The road is divided into 8 packages and Package 2 connects Pos Selim with Blue Valley.
(ii)	The 46 km Pos Selim-Blue Valley road project began construction in 1997 and was scheduled to be completed in 2000. However it was only finished in 2003 and opened to the public in 2004. It was built based on a Design & Build contract at a cost of RM292 million. The location of the road which skirts around Gunung Pass has the highest road cut slope in the world which stands at 262 m above the road.
(iii)	The delay in opening of the road was due to the instability of slopes around Gunung Pass. The major problematic locations include 2 up-slopes and 1 down-slope. Downward movements of more than 30 m have been recorded at the main scarp near the mountain peak.
(iv)	The slopes are monitored continuously using two automatic total stations with prisms fixed at various locations on the slope surface. More slope instabilities are expected as the rocks become more weathered and continue to creep. It is extremely expensive to repair the slopes. Studies have been undertaken to bypass the area and such proposals will cost in excess of RM300 million for an 8 km-section of road. The approach is to monitor the slope and remove any debris from minor failures.
(v)	The cost of slope repairs for this package from 2006 to 2013 had reached RM60 million amounting to 21% of the initial project cost. The costs include soil and geophysical investigation works, slope monitoring, slope protection, stabilisation and repair works at various locations along this stretch. Though undisclosed, the contractor reportedly has spent RM50 million in slope repair works as this is a D&B contract.
(vi)	The “wait and see” approach is not a permanent solution but rather an approach which manages risks by monitoring slope movements. **The costs for a permanent solution would easily make the total expenditure of the road twice the initial cost, thus making it a case for a life cycle approach when planning for road infrastructure**

Table 3.5. Case Study 2: Aring-Kelantan/Terengganu Border Road

Case Study 2	
	Aring-Kelantan/Terengganu Border Road
(i)	Package 6A of the Simpang Pulai-Lojing-Gua Musang-Kuala Berang Highway Project connects Aring in Kelantan to the Kelantan/Terengganu border.
(ii)	The RM183.5 million project was awarded to a contractor and the duration of the contract was 2 years from November 2005 to November 2007. However, due to delays during the construction works, the contractor managed to achieve progress of work of only 6.2%. Due to the poor performance, the contractor was terminated in September 2006.
(iii)	The contract was then awarded to another contractor by direct negotiation using the conventional approach. The site possession date was November 2007 and the completion date was October 2010. Subsequently, the completion date was revised to August 2011 due to more delays.
(iv)	The original contract cost was RM103.5 million in November 2005. After termination and the subsequent award to the next contractor was RM 183.5 million. The increase in cost of RM80 million includes increase in quantities and items and increase in cost of construction materials and transportation fees. **This constitutes an increase of 78% over the original contract cost.**

Table 3.6 Case Study 3: Gap-Fraser's Hill New Road

Case Study 3	
	Gap-Fraser's Hill New Road
(i)	The construction of the new road linking Gap to Fraser's Hill was completed in 1997. The 9-km long road was built at a cost of RM23.9 million by a local Class A contractor. The project was awarded on an open tender basis. The general layout of the road followed the contours of the hills and designed with steep cut slopes and no fill embankments.
(ii)	Nevertheless, after the Defect Liability Period, the road had to be closed on numerous occasions due to slope failures along its alignment. JKR engaged a contractor well versed in construction of roads in hilly terrain to undertake the slope stabilisation and remedial works. The remedial works were awarded on a Design and Built basis with a contract value of RM6.2 million in 1999.
(iii)	In December 2000, major landslides occurred in many locations along the road during the monsoon period. The contractor was awarded another Design and Built contract valued at RM19.9 million to undertake repairs at 43 locations along the road. The repair work was completed in 15 months and the road was made open to the public in April 2001.

Case Study 3 (Con't)	
Gap-Fraser's Hill New Road	
(iv)	The prolonged rainy season from April to May 2002 resulted in 3 slope failures and 8 locations of pavement failures. These failures were outside the scope of the two earlier contracts. A Design and Built contract amounting to RM5.8 million was awarded to undertake repair works at these locations.
(v)	Further landslides and debris flows in 2007, 2008 and 2012 have resulted in additional repair work and provision of a steel bridge. The accumulated costs of the remedial work incurred is RM28 million.
(vi)	From the above, the total expenditure for repairs since the opening of the road amounts to RM 49.9 million. This figure is more than twice the initial cost of construction of the road of RM23.9 million. **This case study clearly shows that a robust and sustainable design is required when considering the budgetary requirements when planning road infrastructure projects.**

3.9 LESSONS LEARNT

The lessons learnt on major transportation infrastructure projects from the Ministry of Finance and Ministry of Transport are presented in the following tables:

Table 3.7 describes the lessons learnt in the Second Penang Bridge project. Weaknesses during the planning phase contributed to significant difficulties in the design, procurement and construction phases which then led to delays and cost escalation of the project.

The lessons learnt in the Electrified Double Tracking project are shown in **Table 3.8**. Similar weaknesses in stakeholder engagement and project management competency were evident during the planning and procurement phases. During the construction phase, the use of local materials and transport services were lacking and these can be traced to project needs statement and contractual requirements stipulated during the planning and procurement phases. Thus, it is evident that more emphasis should be given to project planning and procurement.

Table 3.9 illustrates the lessons learnt in the Kota Kinabalu International Airport project. During the planning phase, the project faced land acquisition issues and EIA approval delays. Contractual issues during the procurement phase exacerbated delays due to interfacing disputes during construction and poor project management led to loss of contract documents and test records.

A list of lessons learnt from a number of projects by the Ministry of Transport is described in **Table 3.10**. Land acquisition, contractor-driven projects and stakeholder management problems were identified as the major issues during the planning phase. During the procurement phase, the appointment of consultants and the form of contract for works were areas of concern. Quality not meeting the project specifications was common during construction and the resulting repairs and reworking added delays and costs to the project. The failures of projects were caused by insufficient human resources and poor competency and skill of staff resulting in their inability to carry out project management and contract administration functions.

It is thus evident that from the case studies and lessons presented from various transportation infrastructure projects that many issues exist in different phases of the infrastructure life cycle. The public and private sector in Malaysia has been very much concerned with project management which encompasses 5 phases, namely the planning, design, procurement, construction and handing over phases. However, project management

does not look beyond asset planning and development. In recent years, the government has realised the importance of facility management which involves asset register, operations and maintenance, refurbishment and deconstruction. For sustainability, it is imperative that both project management and facility management phases are included in the infrastructure life cycle.

Table 3.7. Lessons Learnt by MOF: Second Penang Bridge

	Second Penang Bridge	
Planning	(i)	EPU terminated the concession agreement with UEM Builders and awarded the concession to Jambatan Kedua Sdn. Bhd., a wholly owned government company. A dedicated project team was assembled as a mechanism to manage the project and work closely with the Design and Build contractors to ensure the government's interests were protected.
Design	(ii)	The original design developed under UEM did not meet the government's Needs Statement.
	(iii)	During the design development phase, the input of relevant government technical agencies was not included which later led to a revised design, impacting on additional time and costs.
Procurement	(iv)	Since the project was financed by China Exim Bank, the loan requirements needed to be scrutinised carefully to avoid undue financing costs. The loan facility and repayments were offered in US currency and fluctuations in the exchange rates could mean additional costs for the concessionaire. The terms and conditions by China Exim bank were different from other financial institutions and no grace period was allowed in the interest to be charged through a conventional contract enabling the client to have more control over the project.
	(v)	To ensure transparency and avoid any conflicts, the Arbitration Center should not be located in China.
Construction	(vi)	Interfacing issues between the marine bridge packages and the land expressway packages were not clearly defined and led to protracted discussions and delays.

Table 3.8. Lessons Learnt by MOT: Electrified Double Tracking Projects

	Electrified Double Tracking (EDT) Projects	
Planning	(i)	In the planning phase, the Statement of Needs must be detailed out and agreed upon by all relevant parties, i.e. authorities at the Federal, State and Local governments.
	(ii)	Land acquisition issues to be resolved and freed from encumbrances before the site is handed over to the contractor to prevent delays and cost overruns.
Procurement	(iii)	Normally for mega projects, the Design and Build method is used to save time but this incurs higher cost. The EDT projects should be implemented through a conventional contract enabling the client to have more control over the project.
	(iv)	Project Management Consultants need to be appointed during the planning and implementation phase to provide engineering expertise to manage the projects successfully.
	(v)	Local participation criteria should be made clear and at least 30% Bumiputera participation of the total contract value.
Construction	(vi)	The use of local materials to be promoted and the transport of import materials should utilise the local multimodal transport operators.

Table 3.9. Lessons Learnt by MOT: Kota Kinabalu International Airport

	Kota Kinabalu International Airport	
Planning	(i)	The upgrading of Kota Kinabalu International Airport was divided into two packages. Package 1 involved the upgrading of Terminal 1, passenger loading bridge, baggage handling system, aircraft parking bays and car park amounting to RM720 million. Package 2 involved upgrading of airside facilities, upgrading of Terminal 2, air traffic control tower and DCA administrative building totalling RM777 million. The contract period was for three years from 2006 to 2009.
	(ii)	Land acquisition issues contributed to delays of handing over the site free of encumbrances to the contractor.
	(iii)	Other contributing factors include the delay in obtaining EIA approvals from the Department of Environment – An approximately one year delay between the letter of intent and letter of appointment for the Environmental consultants.
Procurement	(iv)	The weakness in the contract was exposed by the absence of termination clauses.
Construction	(v)	Package 1 was delayed by 290 days while Package 2 was delayed by 1106 days. The delays were contributed by interfacing issues between Package 1 and 2, delays in handing over the site to the contractors and delays in completion of the works. The additional cost due to the delays amounted to RM20 million (only loss and expense).
	(vi)	It was also revealed that poor documentation by the project management office led to inability to produce contractual documents and test records.

Table 3.10. Lessons Learnt by MOT: Project Management

	Project Management Phase	
Planning	(i)	The approval of projects without the site being identified and land acquired, e.g. air traffic control in Sepang.
	(ii)	Contractor driven projects are forced to be undertaken by the ministry and proper planning of the projects was not carried out, e.g. Kota Kinabalu International Airport, Skypark and Mukah Airport.
	(iii)	All new projects to be reviewed by the relevant stakeholders within the ministry before implementation by the Development Section.
Procurement	(iv)	The appointments of consultants are made after the project is awarded. This led to the ministry unable to get technical advice on matters related to the scope of the project and difficulties during price negotiation.
	(v)	The JKR Design and Build form of contract approved by the Attorney General was not used and government interests could not be safeguarded, and rights not enforceable. Examples are the Integrated Transport Terminal-Bandar Tasik Selatan, Kuching Airport, Labuan Airport and Kota Kinabalu International Airport.
	(vi)	Tender documents are given free instead of being sold.
Construction	(vii)	The quality of works did not meet the project specifications and the stakeholder's requirements. Government interest and rights were not protected. A lot of repairs and rework were carried out, which led to delays and cost escalation. An example is Kempas Depot.
	(viii)	Low level of monitoring and auditing carried out on the projects by MoT staff. Lack of data, unverified information and communication issues are common problems. These are generally evident in all projects.
	(ix)	Insufficient staff and low competency in project management and contract administration. This has led to financial procedures not adhered to and contractual issues between contractor and government.
	(x)	Poor document management evidenced by leaked information, loss of documents and difficulty in tracking and retrieving information.
	(xi)	The approval of variation order after the works has been carried out.
	(xii)	Delays by the contractor in submitting as-built drawings after the Certificate of Practical Completion is issued, which creates difficulties for the maintenance contractor to carry out their work, e.g. Kota Bharu Airport.
Operations and Maintenance	(xiii)	For the Defects Liability Period, the classification of major and minor defects to be prioritised according to urgency for repairs and penalty clauses in case the contractor delays repairs to the detriment of the railway operator.

3.10 SUMMARY

Malaysia has fragmented policies that do not integrate and guide the development of the transport sector as a whole. The absence of a national transport policy has resulted in various ministries and departments developing and expanding its designated transport mode without any regard to the different roles of the others. This has led to misallocation of resources, manifested by the duplication of facilities and even excess capacities among the various modes.

EPU has recently embarked on a initiative to develop a national transport strategy for Malaysia which help guide policymakers across agencies, sectors, and regions in the implementation of measures to improve the efficiency, integration, competitiveness, and environmental sustainability of the country's transportation system. The scope encompasses passenger transport, freight transport, rural transport and institutional framework and planning.

Passenger transport issues stem from high private vehicle ownership and low public transport modal share resulting in significant congestion in urban areas. Transportation plans at national, regional and local levels are not integrated. Freight transport is fragmented due to single mode planning, limited interagency coordination and overlapping effort among agencies.

Regional development authorities such as the Iskandar Malaysia, Northern Corridor Economic Region, East Coast Economic Region, Sabah Development Corridor and Sarawak Corridor of Renewable Energy; need to ensure rural-urban connectivity to health and educational services, SME access to markets, suppliers and national networks, and connectivity for agriculture to national supply chains. The connectivity between Peninsular Malaysia and East Malaysia needs to be enhanced, not only for the purpose of economic development, but for national and social cohesion. Although, having unique needs, but they still share largely common issues whereby institutional challenges and bottlenecks seem to be a major area of concern.

The feedback from transportation infrastructure stakeholders and preliminary findings from a World Bank study for EPU reveal that issues in the planning stage contribute greatly to the disintegrated development of the transportation sector.

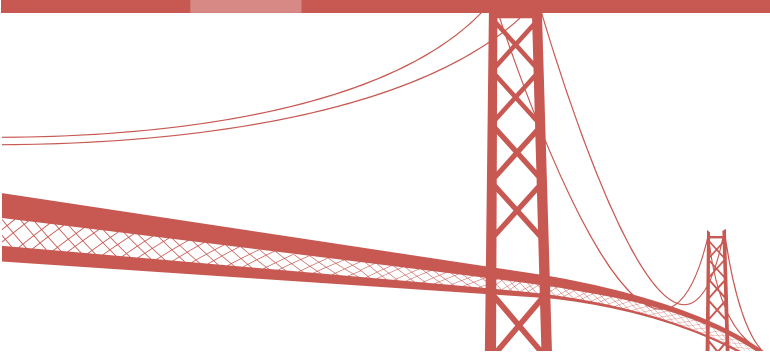
Whereas, planning issues include the absence of a national transport policy and strategy, regulatory and procedural bottlenecks that cost time, money or access to markets and services or inhibit financial sustainability; institutional bottlenecks as to overlapping or unclear authority and accountability that may hamper effective management and service delivery. The fragmented institutional environment causes disconnectivity in funding and policy-making, which results in substandard physical and market outcomes.

Meanwhile, design issues include current design practices that have not considered deconstruction, lacking of details on build-ability, lacking of specialisation and innovation, low utilisation of Industrialised Building Systems and alternative materials; and poor adoption of life cycle cost and value management analysis. Procurement issues centre on multiple levels of sub-contracting, adversarial relationship in procurement, price-driven, sustainability, health and safety not considered, restricted funding amid global economic uncertainties and financial and business models that are restricted by rigid and unrealistic budgets.

Whereas, construction issues include inferior quality and durability, poor health, safety and environmental records, weak adoption of modern construction technology and innovation, low use of recycled and reusable materials, high energy consumption and high wastage of materials. Operations and maintenance issues comprises low quality and high maintenance cost, poor reliability and frequent breakdowns, weak preventive maintenance culture, lack of total asset management practices, no inventory of existing infrastructure and lack of skilled workforce. On the other hand, deconstruction issues are generally not considered. Yet, deconstruction presents a significant potential for infrastructure sustainability in the reclamation, reuse and refurbishment of materials.

Case studies and lessons learnt from transportation infrastructure projects in Malaysia indicate that issues exist in different phases of the infrastructure life cycle. The local industry needs to look beyond project management and realise the importance of facility management which involves asset register, operations and maintenance, refurbishment and disposal. For infrastructure sustainability, it is imperative that both project management and facility management phases are considered in the infrastructure life cycle.

CHAPTER 4
RECOMMENDATIONS TO BRIDGE THE GAPS THROUGH RESEARCH AND DEVELOPMENT



Following the findings from the previous chapter, this chapter will provide the recommendations to address the issues known that may have and that will disrupt the nation's quest for achieving the sustainability of our infrastructure. This chapter will address the third and fourth objectives of the study, namely to determine the role of STI in the Malaysian infrastructure sector through short, medium and long term measures, as well as to identify gaps in STI knowledge and development in the infrastructure sector. Subsequently, this chapter will also recommend appropriate mitigation measures through R&D priority areas; product and technology development, and the nurturing of relevant industries.

However, as may be concluded from the issues highlighted on the state of Malaysian's infrastructure, it may deduced that in order to address the problems completely, the efforts will be beyond just science and technology. It was also quite evident that the entire life cycle of the infrastructure sector faces many issues that were much influenced at the planning stage.

This chapter will summarise the issues from the findings of this study, and recommends a systematic and comprehensive way to address the issues, in order to ascertain the sustainability of our infrastructures. The detail R&D outcomes will be recommended both in general terms for all the sectors, as well as specifically for each infrastructure sector covered in this study.

4.1 CULMINATION OF FINDINGS

The various methods used in this study have shown that there are commonalities among the different infrastructure sectors. There was a general agreement

that sustainable infrastructure need to fit the following attributes:

- Infrastructure development that will serve its functions without compromising the needs and functions of others
- Infrastructure that meets the equilibrium between time, costs and quality requirements
- Infrastructure that will surpass its intended design years and continue to provide the same expected (or even better) level of service
- Infrastructure that will continue to provide the competitive advantage to the nations and its people to meet and exceed future expectations

In simple terms, sustainable infrastructure has been defined as follows:

"Infrastructure that is in itself sustainable and will promote the sustainability of the nation and the people."

The concerns expressed by stakeholders in the infrastructure sector were much centred on the need for our infrastructure to meet the following attributes. While the issues were numerous, they may be reorganised as the following highly critical issues:

i. Poor and fragmented planning

It was generally acknowledged that the sustainability of the Malaysian infrastructure had suffered from poor and fragmented planning. While they are often dependent to each other, their planning was commonly carried out with poor integration; in other words' "in silo". For instance, ports and airports will be critically dependent on the roads and rail connections. Ports and airports in Malaysia are planned by the Ministry of Transport while roads and rail are planned by SPAD, respectively.

The EPU and MOF are often used as the convener to ensure integration. However, as these two agencies are relatively higher in the government's administrative hierarchy, they often consider matters at the macro-level, and will often put less importance to the details of planning. Unfortunately, such disposition has resulted in ineffective planning and may have led to the nation's generally unsustainable infrastructure. It was established that there is a general absence of a common platform and integrated tool to ensure that planning is done effectively across infrastructure sectors with the aim of not only developing them, but also to ensure of their sustainability.

ii. Cost escalation throughout the infrastructure life cycle

In order for any infrastructure to be sustainable, its value throughout its life must be within the expected boundaries. Infrastructure in Malaysia often witnesses an escalation of cost, at times, even at the construction phase. The growing costs of maintenance as well as the shifted costs to the user during operations are also indicative of non-sustainable infrastructure in the country.

It can be observed that many of the infrastructure suffer from poor implementation, and the players often compromise on the sustainability features on the project. Generally, Malaysians do not embrace the sustainability requirements in infrastructure development, and are likely to only exercise mere paper-compliant attitude towards them.

iii. Capacity and capability issues

Experience from countries, which have embraced and delivered sustainable infrastructure development, has shown that the elements of capacity and the capability of the relevant players are of paramount importance. This is much backed by effective R&D as well as by adequate technology development and driven by able and competent talent.

The entire talent profile behind any infrastructure development needs to be transformed in order for Malaysia to be able to be a true embracer of the sustainable infrastructure initiatives.

iv. A nation in haste

It cannot be denied that the nation's Vision 2020 has brought the realisation as well as the urgency to charter its development to meet the aspirations of this vision. Unfortunately, instead of being guided by wisdom, the experience of the country has very much being the victim of haste, especially in infrastructure development.

The hasty attitude may also be the result of ineffective planning, which have moulded the country's machinery to be too much a "process-based" nation, which emphasises on outputs, instead of focusing on the more sustainable, outcome-based approach. Along the way, the cost, time and quality relationship has often been compromised.

4.2 R&D AREAS TO SUPPORT SUSTAINABLE INFRASTRUCTURE

4.2.1 R&D NEEDS

The ultimate aim of this study is to provide the priority areas in R&D that can be used to guide researchers, academics, technologists and strategist to charter a strategic plan to prepare Malaysia for a better future in the medium and long-term. This section will further suggest several research questions that are intended to spur overwhelming interests and resources by relevant stakeholders to ensure that Malaysia can be prepared to transform her needs for a more sustainable infrastructure for tomorrow.

4.2.2 GENERAL SUSTAINABILITY-DRIVEN INFRASTRUCTURE ISSUES

The general issues warranting R&D efforts in order to ensure **Sustainable Infrastructure** are given in Table 4.1

Table 4.1. R&D Efforts Towards

No	Issues	Outcomes of R&D
1.	The need to have the planning for infrastructure to be in an integrated manner	a) Establishment of causes of the present system that have deterred integrated planning b) Recommendations to overhaul the present governance to encourage integrated planning of infrastructure c) Evaluation of the effectiveness of the sustainable infrastructure tool and framework to encourage integrated planning for infrastructure
2.	Development and imposition of sustainability-driven project feasibility analysis as compulsory requirement at the planning stage of infrastructure	a) Recommendations on implementing the sustainable infrastructure framework and tool for project feasibility needs b) Recommendations to improve on constraining features (legal, procedures, culture, etc.)

3.	Facilitating financial models to support sustainable infrastructure	a) Recommendations on how to make a business case to support the sustainability-driven infrastructure effort in Malaysia b) An establishment of an effective financial, business and procurement model for Malaysian infrastructure projects
4.	The state of readiness in terms of capacity, competency and capability amongst infrastructure players	a) An understanding of the present capacity, capability and competency of infrastructure industry players in embracing sustainability practices b) Prescribing an outcome-based approach to leverage the present state of readiness amongst the human resources, system of governance, mindsets and enablers to embrace sustainability-driven infrastructure. This may be done through formal certification at institutions of higher learning, structured continuous professional development programmes or the capacity-building programmes c) A special upgrading programme for infrastructure designers will be critical. Research into effective planning, execution and outcomes assessment will be needed d) A special upgrading programme for infrastructure contractors will be critical. Research into effective planning, execution and outcomes assessment will be needed
5.	Programmes for self-driven mindsets for safety and sustainability outcomes amongst contractors and other players	a) An understanding of the prevalent mindset and practices that would hamper safety and sustainability outcomes b) A recommendation on efforts that will change such mindsets. Research to formulate effective execution and assessing outcomes under the continual quality improvement will be essential

4.2.3 SPECIFIC ISSUES FOR EACH SECTOR

This section will suggest required R&D areas that will help to address the issues highlighted from the findings of this study. Each of the four sectors will be addressed, and the recommendations for R&D will be categorised as according to the following:

a. the stage of life cycle

b. the related discipline

c. the time horizon for outcomes achievement

i. ***Roads and Highways***

This type of transport infrastructure is the most established sector and is serving the majority of the mobility of people and goods in Malaysia. Roads and highways are regarded as a fundamental need of the people, with many stating that mobility on such infrastructure as the only alternative for them. This has also given cause to unsustainable mobility of people and goods, and Malaysia, where road transportation have overwhelmed other modes. The excessive demand on roads have also taken a toll on the sustainability of roads and highways, especially with poor road user behaviour and coupled with a prevalent poor maintenance regime.

The following are recommended "Low Hanging Fruits" and R&D areas to support the sustainability of the road and highway infrastructure. They may cover the entire life cycle from planning to maintenance, and they can roughly be categorised into social, economic and engineering issues:

Low Hanging Fruits:

Reducing environmental impact:

- Stabilisation of unsuitable in-situ soils by chemicals or blending with local fibres
- Recycle waste materials
- Establish local tunnelling knowledge, skill and methodology to replace cutting of slopes in hilly terrain

Improve Resource Efficiency:

- Enhance localisation of ground improvement methods using lime/cement columns, jet grouting, stone columns, dynamic compaction, prefabricated vertical drains
- Utilisation of ITS to optimise road network and operations

Improve Energy Efficiency:

- Establish methods to combat overloading of heavy goods vehicles
- Establish innovative techniques for quality control of road construction

Adaptation to Climate Change:

- Pavement materials and designs for better durability and lower maintenance

Table 4.2. List of Possible Research Outcomes for Road and Highway Infrastructure

No	Issues of Roads and Highways	Outcomes of R&D for Roads and Highways	Life Cycle	Discipline Areas			Horizon of achievement		
				Environment	Socio-economy	Science, Technology and Engineering	Short Term	Medium Term	Long Term
1.	Land use integration	a) Ensures that proper land use and transport integration is applied in all land use development plans	Planning	X	X		X		
		b) Establishment of methods as smart imposition of road hierarchy despite pressures of development, especially in urban areas	Planning			X	X		
		c) Analysis of the effectiveness of the present Traffic Impact Assessment (TIA) to ensure sustainability through proper land use and transport planning integration	Planning, Design and Operation	X	X	X	X		
2.	Managing road users	a) Establish the negative peculiarities of Malaysian road users towards jeopardising the sustainability aspiration of roads and highways	Fundamental		X		X	X	
		b) Recommend interventions to manage the negative peculiarities of Malaysian road users, in order to help sustain the operability and the effective state of the roads and highways	Design, and operation		X	X	X		
		c) Recommend strict management regime to combat overloading of heavy goods vehicles and finding ways to manage the impacts of overloading on roads	Design and operation		X	X	X		

				Discipline Areas			Horizon of achievement		
No	**Issues of Roads and Highways**	**Outcomes of R&D for Roads and Highways**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
3.	Social impact of roads and highways	a) Identification of features and alignment of roads and highways that will bring benefit to the society and do not create serious social implications such as extreme severance due to the alignment	Planning		X	X	X		
		b) Recommend interventions that would prevent the deterioration of value of roads and highways that create negative implications to society	Planning, design, construction and operation			X	X		
		c) Ensure that the service levels provided to the road users are as expected	Design and operation			X	X	X	
4.	Economic impact of roads and highways	a) Identification of the correlation between roads and highways alignment to the local economy	Fundamental		X		X	X	X
		b) Determine the features of road and highways transportation that begin to have negative effects on the economy locally and at national level	Fundamental		X	X	X	X	
		c) Recommend interventions to ensure that the positive outcomes of roads and highways are sustained	Design, construction, operations and maintenance			X		X	
5.	Net sustainable impact of roads and highways	a) Establish the features that will influence the net sustainable impacts of roads and highways, vis-à-vis more sustainable options such as rail and other public transport means	Fundamental	X	X			X	
		b) Establish the understanding of the effects of non-sustainable features and attributes of roads and highways to its net sustainability worth	Fundamental	X	X			X	

				Discipline Areas			Horizon of achievement		
No	**Issues of Roads and Highways**	**Outcomes of R&D for Roads and Highways**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
6.	Roads and highways project financing	a) Identify the features of the present financial and business model that may have contributed to practices that jeopardise the sustainability qualities of roads and highways	Planning and procurement		X	X	X		
		b) Establish innovative financing and business model that will encourage sustainability practices throughout the service life of the roads and highways	Planning and procurement		X	X		X	
7.	Creating a business case for incorporation of sustainability features in road and highway projects	a) Establish strategies and procedures to assure that sustainability ideals are part of the business strategy of players in the roads and highway industry	Fundamental		X		X	X	X
8.	Ensuring safer roads	a) Produce design, procedures, and commitment towards ensuring Malaysia has forgiving roads, that will not cause fatality to the road user, even in the event of a crash	Planning, design, operation			X	X		
		b) Establish procedures and the will to ensure that continuous safety audit is carried out on operational roads to ensure that any unsafe road features are mitigated immediately	Operational			X	X	X	X

				Discipline Areas			Horizon of achievement		
No	**Issues of Roads and Highways**	**Outcomes of R&D for Roads and Highways**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
9.	The use of materials that will help the sustainability cause	a) Produce innovative pavement materials that will increase the durability, strength and safety performance of road and highway surfaces. This will ensure safer roads and satisfactory level of performance	Design and construction		X	X	X	X	
		b) Produce enablers/ equipment and procedures to effectively monitor the state of the pavement and to come up with warning systems as well as suggestion for mitigation	Operation and maintenance			X		X	
10.	Roads and highways foundation issues	a) Establish innovative techniques to ensure that the foundation work for highways is consistently satisfactory and suitable to sustain the integrity of road and highway infrastructure	Design and construction			X	X	X	X
		b) Find ways to help soil improvement for roads foundation	Design, construction and operation			X	X	X	X
		c) Produce enablers/ systems and procedures to effectively monitor the integrity of road and highway foundation, and to come up with effective warning system and mitigation measures	Operation and maintenance			X		X	

				Discipline Areas			Horizon of achievement		
No	**Issues of Roads and Highways**	**Outcomes of R&D for Roads and Highways**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
11.	Tackling the slope stability issues along the roads and highways alignment	a) Establish innovative techniques to ensure that the slope stability along and adjacent to roads and highways are designed, constructed and maintained satisfactorily and suitable as to sustain the integrity of the roads and highways infrastructure	Design, construction, and maintenance			X	X	X	X
		b) Produce enablers/ systems and procedures to effectively monitor the integrity of slopes along and adjacent to roads and highways, and to come up with effective warning system and mitigation measures	Operation and maintenance			X		X	
12.	Tunnelling technology and maintenance	a) Establish a cost-effective tunnelling technology and procedure to make tunnelling a better option, compared to hill cutting	Design and construction			X	X	X	
		b) Produce enablers/ equipment and procedures to construct, operate and maintain tunnels in a sustainable manner	Design, construction and operation			X		X	
		c) Establish a monitoring system that will help ensure the integrity of the tunnel infrastructure	Operation and maintenance			X		X	X
13.	Bridge technology and maintenance	a) Improve structural integrity and bridge inconsistent gaps through fully functional, certified, state-of-the-art inspection and testing facilities to carry out mandatory inspection and testing during construction of roads and associated infrastructure	Design, construction, operation and maintenance			X		X	X

				Discipline Areas			Horizon of achievement		
No	**Issues of Roads and Highways**	**Outcomes of R&D for Roads and Highways**	**Life Cycle**	**Envi-ron-ment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
14.	Effective road maintenance	a) Find better ways to sustain existing roads through upgrading and refurbishment, rather than build new ones	Fundamental, operation and maintenance			X	X	X	
		b) Establish ways to bring a business case for road maintenance				X	X	X	X
15.	Congestion management	a) Find ways to manage congestion in an effective and sustained manner	Design and operations			X	X		
16	Utilisation of technology and Intelligent Transport System (ITS)	a) Explore ways to use technology (ITS) to maximise the sustainability of roads and highways through efficient operations	Design and operations	X		X	X		
17.	Highway capacity issues	a) Establish highway capacity relationship that will allow continuous monitoring of the service performance of roads and highways	Fundamental, design and operations			X	X	X	
		b) Design interventions that will ensure that roads and highways are sustained within its capacity operational limits	Design and operations			X	X	X	

ii. ***Rails***

Rail transportation provides a useful and a more sustainable alternative to road mobility. Both passengers and goods mobility will achieve a net gain for sustainability if they are transported more on rails rather than roads. Rails are less-polluting per kilometre travel, and are more efficient in terms of land space used.

However, modern rail transport has been slow to pick up in Malaysia. The only recent upgrading of railway tracks to be electrified and double-tracked provide both challenges and opportunities for rail transport in Malaysia, for passenger and goods traffic. The following are the low hanging fruits and R&D areas and outcomes recommended to the nation, not only to accelerate the potential of rail, but also to ensure its sustainability as well as helping the nation to instil a balance towards more sustainable transport qualities:

Low Hanging Fruits:

Railway planning:

- Establishment of a rail network development plan for Malaysia

Rail inspection and maintenance:

- Develop methodology and capacity for rail system inspection and maintenance regime
- Create enablers/equipment and systems to support the inspection and maintenance of rail tracks

Tunnelling technology for rail:

- Establish a cost-effective tunnelling technology
- Produce enablers/equipment and procedures to construct, operate and maintain tunnels in a sustainable manner
- Establish a monitoring system that will help in ensuring the integrity of the tunnel infrastructure

Table 4.3. List of Possible Research Outcomes for Rail Infrastructure

				Discipline Areas			Horizon of achievement		
No	**Issues of Rail**	**Outcomes of R&D for Rail**	**Life Cycle**	**Environ-ment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
1.	Ownership issues of rail system (between track and vehicles)	a) Recommendations on the best ownership option for rail transport, especially between the track and the vehicles	Fundamental		X		X	X	
2.	Rail network planning	a) Establishment of a rail network development plan for Malaysia	Planning	X	X	X	X	X	
		b) Establishment of a hierarchy system for rail and the associated planning requirements for both passenger and goods mobility	Planning and design			X	X	X	
		c) Able to facilitate rail alignment choices with soil optimisation requirements as complementary	Design			X	X	X	
3.	Rail integration with other modes, including the “last mile” issue	a) Establishment of a systematic planning tools to ensure that the rail system is integrated with the other modes in a seamless manner	Planning and design		X	X	X	X	X
		b) Recommendations for local transport strategies to provide the “last mile” for rail travel, and provide full access to public transport systems	Planning and design		X	X	X	X	

				Discipline Areas			Horizon of achievement		
No	**Issues of Roads and Highways**	**Outcomes of R&D for Roads and Highways**	**Life Cycle**	**Environ-ment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
4.	Issues concerning regulating the rail system	a) An appreciation on the needs for regulating the rail systems b) Recommendations on the most effective regulatory function to be by the relevant authorities	Fundamentals Planning	X X	X X		X X	X X	
5.	The impact of rail on the environment	a) Understand the net benefits of rail to the environment as compared to other modes	Fundamentals	X		X	X	X	X
6.	The socio-economic impact of rail	a) Understand the net benefits of rail to the society and the economy as compared to other modes	Fundamentals		X	X	X	X	X
7.	Urban rail issues	a) Understand the roles and potential, as well as the possible impact of rail in an urban setting	Fundamentals and planning	X	X	X	X	X	X
8.	Regional rail issues	a) Understand the roles and potential, as well as the possible impact of rail as a regional service	Fundamental and planning	X	X	X	X	X	X
9.	Intercity rail issues	a) Understand the roles and potential, as well as the possible impact of rail in an intercity	Fundamental and planning	X	X	X	X	X	X

No	Issues of Roads and Highways	Outcomes of R&D for Roads and Highways	Life Cycle	Discipline Areas			Horizon of achievement		
				Environ-ment	Socio-economy	Science, Technology and Engineering	Short Term	Medium Term	Long Term
10.	The human capital to support the rail industry	a) Establish the present status of the human capital to support the rail industry	Fundamental and planning		X	X	X		
		b) Establish the attributes of the knowledge body needed amongst professionals and labourers to support the rail industry			X	X	X		
		c) Design and deliver an effective capacity-building programmes to enhance the capacity and the capability of human resource to support the rail industry			X		X	X	X
11.	Financing the rail	a) Identify the features of the present financial and business model that may have contributed to practices that jeopardise the sustainability qualities of rail projects	Procurement		X		X	X	
		b) Establish innovative financing and business model that will encourage sustainability practices throughout the service life of the rail systems			X		X	X	
12.	Ticketing and fare issues	a) Establish a ticketing system that will encourage seamless travel via rail on an integrated public transport system	Planning and design		X	X	X	X	
		b) Understand the elasticity characteristics of fares towards demand behaviour for rail	Fundamentals		X	X	X	X	

				Discipline Areas			Horizon of achievement		
No	**Issues of Roads and Highways**	**Outcomes of R&D for Roads and Highways**	**Life Cycle**	**Environ-ment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
13.	Design and construction of rail tracks	a) Develop the capacity and capability for rail track technology	Design			X	X	X	
		b) Create enablers/ equipment and systems to support the design and construction of rail tracks	Design and construction			X		X	X
14.	Track maintenance regime and competency	a) Develop methodology and capacity for rail system inspection and maintenance regime	Operation and maintenance			X	X	X	X
		b) Create enablers/ equipment and systems to support the inspection and maintenance of rail tracks				X		X	X
15.	Signalling issues	a) Establish the knowledge and capability in the design and delivery of the signalling system for rail systems and networks	Design, operation		X	X	X	X	X
		b) Establish the knowledge and ability to optimise signalling in order to maximise frequency and complexity of rail networks			X	X		X	X

No	Issues of Roads and Highways	Outcomes of R&D for Roads and Highways	Life Cycle	Discipline Areas			Horizon of achievement		
				Environ-ment	Socio-economy	Science, Technology and Engineering	Short Term	Medium Term	Long Term
16.	Foundation of rail track issues	a) Establish innovative techniques to ensure that the foundation work for railways are satisfactory and suitable as to sustain the integrity of the rail infrastructure	Design, construction, operation and maintenance			X		X	X
		b) Find ways to help soil improvement for rail foundation				X	X	X	
		c) Produce enablers/ systems and procedures to effectively monitor the integrity of the rail foundation, and to come up with effective warning system and mitigation measures				X		X	
		d) Introduce a more cost effective foundation for rail tracks, with the quest to substitute slippers and ballast with new foundation form			X	X	X	X	
17.	Slope stability issues	a) Establish innovative techniques to ensure that the slope stability along and adjacent to rail tracks are constructed and maintained satisfactorily and suitable as to sustain the integrity of the rail infrastructure	Design, construction, operation and maintenance			X	X	X	X
		b) Produce enablers/ systems and procedures to effectively monitor the integrity of slopes along and adjacent to rail tracks, and to come up with effective warning system and mitigation measures				X		X	

				Discipline Areas			Horizon of achievement		
No	**Issues of Roads and Highways**	**Outcomes of R&D for Roads and Highways**	**Life Cycle**	**Environ-ment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
18.	Tunnelling technology and maintenance	a) Establish a cost-effective tunnelling technology	Design		X	X		X	
		b) Produce enablers/ equipment and procedures to construct, operate and maintain tunnels in a sustainable manner	Design, construct, operations and maintenance	X		X		X	
		c) Establish a monitoring system that will help in ensuring the integrity of the tunnel infrastructure				X		X	
19.	Coach technology	a) Enhance the capability for coach technology design and manufacturing	Design and construction			X		X	X
20.	Intruders and vandalism management	a) Discover the behaviour of intruders and vandals with the aim to curb the menace	Fundamentals		X	X	X	X	
		b) Establish procedures, enablers and equipment to mitigate the number of intruders and vandalisms	Planning and design		X	X	X	X	
21.	Optimised scheduling and time tabling towards optimal performance	a) Obtain a clear understanding of the Malaysian rail user behaviour and attributes, with regards to optimal performance expectation	Fundamental		X	X	X	X	
		b) Establish the algorithm to optimise scheduling of time tabling or rail systems as well as the associated supporting modes to minimise travel time	Design			X		X	

No	Issues of Roads and Highways	Outcomes of R&D for Roads and Highways	Life Cycle	Discipline Areas			Horizon of achievement		
				Environ-ment	Socio-economy	Science, Technology and Engineering	Short Term	Medium Term	Long Term
22.	Passenger transfer facilities	a) Ability to identify, design and construct appropriate facilities in rail terminals and stations to facilitate transfer activities	Design, construction and operations	X	X	X	X	X	
23.	The potential of information technology	c) Appreciate the role of information technology in helping manage the expectation of users and potential users	Fundamentals		X	X	X		
		d) Design and utilise information technology to maximise the potential of the rail system as the primary mode of travel	Design, construction and operations		X	X	X	X	
24.	Cargo potential and its infrastructure support	a) Identify the needs and potential for goods transportation in using rail	Fundamentals, planning and design	X	X	X	X	X	
		b) Design and allocate facilities and infrastructure support for goods mobility on rail				X	X	X	
25.	Inter-operability issues	a) Appreciate the needs for inter-operability of rail, in terms of technical specification	Fundamentals, planning, design and operations			X	X		
		b) Define the specification for rail inter-operability needs in Malaysia				X	X		

iii. ***Ports***

The maritime industry has been critical in supporting the Malaysian trade, and is expected to continue in years to come. It is therefore critical for the infrastructure to support the maritime industry, especially through the ports, to remain sustainable for many years to come. As Malaysian ports have potential to attract vessels, their sustainability is highly vital and especially important in this very competitive industry. The following are recommended low hanging fruits and R&D outcomes that will assist in ensuring the sustainability of ports in Malaysia:

Low Hanging Fruits:

Planning

- Review and plan potential waterways to be used in a more optimised manner for purposes of passenger and goods transport

Environment

- Review the biggest contributor of air pollutions at the port and recommend mitigation measures
- Establish the critical contributing factors to coastal erosion and recommend short and medium term erosion protection

Materials

- Review more sustainable method of disposing the dredged sediments such as mechanical dewatering instead of lagooning
- Innovative reuse of dredged materials as a substitute for other materials to be used for construction, reclamation and manufacturing

Design

- Design and maintain leading roads to provide the most acceptable level of service to complete the supply-chain logistic requirements

Maintenance

- Innovative maintenance regime and the use of innovative products for port marine infrastructure for corrosion control and protection

Table 4.4. List of Possible Research Outcomes for Port Infrastructure

No	Issues of Ports	Outcomes of R&D for Ports	Life Cycle	Discipline Areas			Horizon of achievement		
				Environment	Socio-economy	Science, Technology and Engineering	Short Term	Medium Term	Long Term
1.	The strategic location for ports in Malaysia	a) Evaluate the appropriateness of the present locations of ports in Malaysia	Planning	X	X	X	X		
		b) Recommendations for future ports based on its strategic position		X	X	X		X	X
2.	Security issues at ports and towards liners in the ocean	a) Analyse the security issues and risks at ports and on liners/ vessels	Fundamentals and planning	X	X	X	X	X	X
		b) Recommendations to mitigate these security issues, especially with regards to infrastructure support				X		X	X
3.	Optimising the available waterways for transportation of passengers and goods	a) Review potential waterways to be used in a more optimised manner for purposes of passenger and goods transport	Planning	X	X	X	X		
		b) Recommend the governance to manage the new potential for such waterways	Planning		X			X	
		c) Develop technology and engineering standards and procedures to enable the usage of such waterways	Design			X		X	

				Discipline Areas			Horizon of achievement		
No	**Issues of Ports**	**Outcomes of R&D for Ports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
4.	Financing the development, operations and maintenance of ports	a) Identify the features of the present financial and business model that may have contributed to practices that jeopardise the sustainability qualities of ports	Procurement		X		X	X	
		b) Establish innovative financing and business model that will encourage sustainability practices throughout the service life of the ports	Procurement and planning		X			X	
5.	Design of berth and landside facilities to optimise performance	a) Review of present performance of ports and correlating it with the berth and landside design	Operations and maintenance	X	X	X	X		
		b) Recommendations on optimum berth and landside design and continuous monitoring subsequently	Design and operations	X	X	X	X		
6.	Methods to maximise efficiency of the ports	a) Review present efficiency of port operations	Operations		X	X	X		
		b) Recommendations to improve the efficiency of ports (berth and landside) with subsequent continuous monitoring	Planning and design		X	X		X	
		c) Introduce ways to optimise cargo handling efficiency in Malaysian ports	Planning and design		X	X		X	

				Discipline Areas			Horizon of achievement		
No	**Issues of Ports**	**Outcomes of R&D for Ports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
7.	Problems of siltation in ports and the dredging needs	a) Establish the siltation phenomena and to manage the impact of dredging needs and activities	Operations	X		X	X		
		b) Recommendations to manage the siltation problems	Design	X		X		X	
8.	Managing the risk of inclement weather, and weather change.	a) Ability to predict the changes of weather patterns and prepare the ports accordingly through timely risk management activities	Fundamentals	X		X	X	X	X
		b) Recommendations on the most suitable design and technical specifications to prepare for the risk of inclement weather and future detrimental changes in weather patterns	Design	X		X		X	X
9.	Corrosion issues and material engineering options	a) Establish an understanding of the corrosion issues on the present port infrastructure	Operations			X	X		
		b) Innovative material and construction methods to combat corrosion problems	Design and construction			X		X	
		c) Innovative maintenance regime to sustain the port infrastructure through protection from corrosion problems	Operations and maintenance			X		X	X

				Discipline Areas			Horizon of achievement		
No	**Issues of Ports**	**Outcomes of R&D for Ports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
10.	Port/vessel congestion	a) Establish the factors influencing vessel congestion at ports	Operations			X	X		
		b) Recommend the solutions to manage port congestion amongst vessels	Design and operation			X	X	X	
11.	Landside vehicle congestion	a) Establish the factors influencing landside congestion at ports	Planning and design			X	X	X	
		b) Recommend the solutions to manage port congestion amongst land side vehicles	Design and operations			X		X	
12.	Logistic supply and chain and hierarchy	a) Establish the full supply-chain logistic requirement for ports in Malaysia	Planning		X	X	X		
		b) Design and prepare the appropriate infrastructure to support the supply-chain logistic requirement	Design, construction and operations			X	X	X	
13.	Poor access road state	a) Evaluate the poor state of roads leading to ports in Malaysia	Planning	X	X	X	X		
		b) Establish the most critical contributing factors and provide suggestions of mitigation	Planning and design		X	X	X		
		c) Design and maintain leading roads to provide the most acceptable level of service to complete the supply-chain logistic requirements	Design, construction, operations and maintenance			X	X		

No	Issues of Ports	Outcomes of R&D for Ports	Life Cycle	Discipline Areas			Horizon of achievement		
				Environment	Socio-economy	Science, Technology and Engineering	Short Term	Medium Term	Long Term
14.	Addressing overloading on vessel and on land-vehicle	a) Establish the present overloading situation on vessels as well as on landside vehicles	Fundamentals		X	X	X		
		b) Recommend mitigation measures to prevent overloading on vessels and on land vehicles	Planning and Design		X	X	X	X	
15.	Safety & health and environmental issues	a) Establish the contributors of safety & health and environmental issues like air pollution that will significantly affect the effective and efficient port operations in Malaysia	Fundamentals	X	X	X	X		
		b) Recommend measures to mitigate issues		X	X	X	X	X	
16.	Circulation and traffic management in ports	a) Establish ways to manage and provide the infrastructure support for ports, especially connectivity and land transport issues	Planning and design			X	X		
17.	Maritime capacity issues	b) Provide suggestions for traffic management schemes and enablers for smooth circulation within the ports and surrounding areas	Planning and design			X	X	X	
18.	Landside capacity issues	c) Ability to represent the capacity of ports (both on water and land side), and forecast the future capacity state of ports	Planning, design and operations			X	X	X	

				Discipline Areas			Horizon of achievement		
No	**Issues of Ports**	**Outcomes of R&D for Ports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
19.	Upgrading and maintenance of old port infrastructure.	a) Establish the state of the present ports in Malaysia with the view of identifying the repair and upgrading requirements	Fundamentals and planning			X	X		
		b) Establish the repair and upgrading know-hows amongst industrial players	Planning and design			X		X	
		c) Recommendation an repair and upgrading scheme for existing ports	Design, construction and maintenance			X		X	
20.	Coastal erosion issues affecting the ports infrastructure	a) Establish the extend of erosion and the behaviour of erosion on coastal areas affecting port operations	Fundamentals	X		X	X		
		b) Recommendations for methods to address the erosion issues in ports and nearby coastal areas through effective monitoring process as well as through mitigation measures	Design and construction	X		X		X	

iv. *Airports*

Being the main gateway for passenger traffic into the country, the sustainability of airports is paramount. Airports are not only the subject of efficiency and level of performance, but they are also vulnerable to the hazards of safety and security. The recommended low hanging fruits and R&D outcomes to help assure the sustainability of airports are given as follows:

Low Hanging Fruits:

Design

- Designs to incorporate maximum airside and terminal flexibility to accommodate changing airline capacity

Maintenance

- Pavement technology for runways and taxiways incorporating reuse, recycle and reclamation materials

Planning

- Develop an integrated airport information management system looking at the following:
    - Passenger experience
    - Aviation Operations
    - Real Estate & Space
    - Security
    - Energy
    - Physical Assets and Human Resources
- Planning and designing of airport cities master plans by introducing the concept of Aerotropolis

Table 4.5. List of Possible Research Outcomes for Airport Infrastructure

				Discipline Areas			Horizon of achievement		
No	**Issues of Airports**	**Outcomes of R&D for Airports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
1.	The strategic location for airports in Malaysia	a) Evaluate the appropriateness of the present locations of airports in Malaysia	Planning	X	X	X	X		
		b) Recommendations for future airports based on its strategic position	Planning	X	X	X	X	X	X
2.	Security issues of airports and aircrafts	a) Analyse the security issues and risks at airports and on aircrafts and its passengers/cargo	Fundamental	X	X	X	X	X	
		b) Recommendations to mitigate these security issues, especially with regards to infrastructure support	Planning and Design			X	X	X	X
3.	The environmental impact of airports	a) Establish the environmental impacts of airports to the surrounding areas	Planning	X		X	X	X	X
		b) Recommendations of improvements to the EIA features for airports	Design, construction and operations	X		X	X	X	X
		c) Continuous monitoring on environmental impacts and suggestion for mitigation measures	Operations and maintenance	X		X		X	X
4.	Managing the perception that the aviation industry is the most unsustainable form of transport	a) Identify ways to reduce the net impact the aviation industry has on sustainability	Fundamental	X	X			X	X

				Discipline Areas			Horizon of achievement		
No	**Issues of Airports**	**Outcomes of R&D for Airports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
5.	The socioeconomic impact of airports and the aviation industry	a) Establish the impacts of airports to the socio-economy of the nation, state, city and the surrounding areas	Fundamental and planning		X		X	X	X
		b) Recommendations of improvements to the socio-economic impact assessment (SIA) features for airports	Planning, Design, Construction and operations		X	X	X	X	X
		c) Continuous monitoring on socio-economic impacts and suggestion for mitigation measures	Design, operations and maintenance		X	X			X
6.	Passenger security management	a) Establish the passenger security features according to the global standard as well as peculiarly to the Malaysian situation	Planning, and design		X	X	X	X	
		b) Provide the infrastructure to support the security management aims	Design, construction and maintenance		X	X		X	X
7.	The influence of airports towards the image of the country	a) Establish the performance of Malaysian airports and identify their roles towards uplifting the image of the country	Fundamental and operations		X		X		
		b) Recommend measures to improve the performance of airports and identify steps to improve the image of the country via airports	Design, construction and operations		X	X		X	X

				Discipline Areas			Horizon of achievement		
No	**Issues of Airports**	**Outcomes of R&D for Airports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
8.	The financing of airport development, operations and maintenance	a) Identify the features of the present financial and business model that may have contributed to practices that jeopardise the sustainability qualities of airports	Planning and procurement		X		X		
		b) Establish innovative financing and business model that will encourage sustainability practices throughout the service life of airports	Planning, procurement and operation		X		X	X	
9.	Establishing an integrated transport to support goods mobility via airports	a) Establish the full supply chain logistic requirement for airports in Malaysia	Planning and Design		X	X	X		
		b) Design and prepare the appropriate infrastructure to support the supply-chain logistic requirement	Design, construction and operations			X	X	X	
10.	Pavement technology for runways and taxiways	a) Establish the present problems associated with pavements for runways and taxiways	Fundamentals		X	X	X		
		b) Produce innovative pavement materials that will increase the durability, strength and safety performance of runways and taxiways	Design and construction			X	X	X	
		c) Produce enablers/ equipment and procedures to effectively monitor the state of the pavement and to come up with warning systems as well as suggestion for mitigation	Design, operations and maintenance			X		X	X
11.	Baggage handling technology and logistics	a) Provide the infrastructure support for optimum baggage handling at airports	Design, construction and operations		X	X	X	X	

				Discipline Areas			Horizon of achievement		
No	**Issues of Airports**	**Outcomes of R&D for Airports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
12.	Optimal design for airports to minimise time	a) Establish the important factors that will influence total travel time for an air traveller	Design		X	X	X		
		b) Incorporate optimal design to facilitate minimum travel time within the airport infrastructure	Design, construction and operations		X	X	X	X	
13.	Scheduling of airlines and the complementary schedule of support services, including public transport services	a) Ability to establish algorithms to ensure integration between the scheduling of airlines and the scheduling of support services including the public transport support	Design		X	X	X	X	
14.	Passenger capacity analysis and forecast for future level of service	a) Establish an accurate demand behaviour analysis and subsequently to formulate forecasting ability for passenger demand	Fundamental		X	X	X		
		b) Ability to plan for future appropriate level of service	Planning and design		X	X	X	X	X
		c) Ability to timely plan for future infrastructure expansion	Planning and design			X	X	X	X

				Discipline Areas			Horizon of achievement		
No	**Issues of Airports**	**Outcomes of R&D for Airports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
15.	Risk management for inclement weather, changing weather patterns, including hazards such as birds and other animal/ insects	a) Ability to predict the changes of weather patterns and to prepare the airports for it through timely risk management activities	Fundamental	X		X	X	X	X
		b) Recommendations on the most suitable design and technical specifications to prepare for the risk of inclement weather and future detrimental changes in weather patterns	Design and operations	X		X	X	X	X
		c) Recommendations on the most suitable design and technical specifications to mitigate against the intrusions of birds and insects and other animals that would provide risk to flight path	Design and operations	X		X	X	X	X
16.	Service capacity analysis for the airports	a) Determine the service capacity values for the airport infrastructure	Design and operation		X	X	X		
		b) Monitor the prevailing service levels and predict the point of capacity and saturation	Operation		X			X	X
		c) Recommend the time for an expansion or a reconfiguration when the capacity is expected to be breached.	Planning and design		X	X		X	X
17.	Managing passengers and customers expectation	a) Continuously monitor passengers and visitors level of expectation, and satisfaction	Operation		X	X	X	X	X
		b) Come up with innovative ways to maximise customer satisfaction towards the airport services	Design and operation		X	X	X	X	X

				Discipline Areas			Horizon of achievement		
No	**Issues of Airports**	**Outcomes of R&D for Airports**	**Life Cycle**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
18.	The utilisation of information system	a) Appreciate the role of information technology to help manage the expectation of customers of the airport	Planning and design		X	X	X		
		b) Design and utilise information technology to help provide satisfactory services as the airport	Design and operation		X	X	X	X	
19.	Managing the changing trends of air travel and aviation industry	a) Ability to anticipate future trends and technology in air travel and the aviation industry, in order to be well prepared with any needed changes or upgrading in the infrastructure and the facilities	Fundamentals		X	X	X	X	X
20.	Maintenance regime of runways and taxiways	a) Develop methodology and capacity for runways and taxiways pavement inspection and maintenance regime	Operation and maintenance			X	X	X	
		b) Create enablers/ equipment and systems to support the inspection and maintenance of runways and taxiways pavement	Design, operation and maintenance			X		X	
21.	Maintenance regime of airport terminal building and services infrastructure	a) Develop methodology and capacity for airport terminal inspection and maintenance regime	Operation and maintenance			X	X	X	
		b) Create enablers/ equipment and systems to support the inspection and maintenance of the airport terminal building	Design, operation and maintenance			X		X	
22.	Management of energy source and utilisation for airports	a) Establish a monitoring regime of energy utilisation in the airport	Operation	X	X	X	X	X	
		b) Recommend interventions to minimise energy usage in airports without compromising its level of service	Design	X	X	X	X	X	

				Discipline Areas			Horizon of achievement		
No	Issues of Airports	Outcomes of R&D for Airports	Life Cycle	Environment	Socio-economy	Science, Technology and Engineering	Short Term	Medium Term	Long Term
23.	Good access to airports	a) Establish ways to synergise an airport with city connectivity and accessibility needs	Planning and design	X	X	X	X	X	
24.	Integrating airports with tourism needs	a) Establish ways to integrate airports with tourism needs	Planning and design		X	X	X	X	

v. ***Procurement***

At the international level, there is general consensus that, a sustainable procurement with a goal of achieving best value requires the integration of health & safety, quality, environmental and sustainability best practices into each element of a construction project. Due to restricted funding, more innovative procurement methods with smart partnership with the private sectors will be instrumental. There are a number of innovative modern procurement methods, especially for infrastructure projects which will contribute to higher process transparency, achievement of agreed outcome at a fair price and a more collaborative approach rather than adversarial.

The Alliance contracting Design and Build, Early Contractor involvement are some of these methods. Nevertheless, Malaysia will need to have a clear grasp of the economic and financial implications of these approaches since, it have been indicated that past-privatised projects tend to be costly. A review of the Malaysia Green Procurement and how best to incorporate its elements into the above modern procurement methods, will be required to achieve sustainable infrastructure procurement for Malaysia.

The recommended low hanging fruits and R&D outcomes that help assure the sustainability within procurement are given as follows:

Low Hanging Fruits:

- Evaluate all options for private involvement in delivery of government services, e.g. PFI, PPP;
- A study of partnering, alliance contracting, integrated team approach etc. to project procurement; and
- Study the incentives to be awarded for earlier completion or reduced price and better quality.

Table 4.6. List of Possible Research Outcomes for Procurement

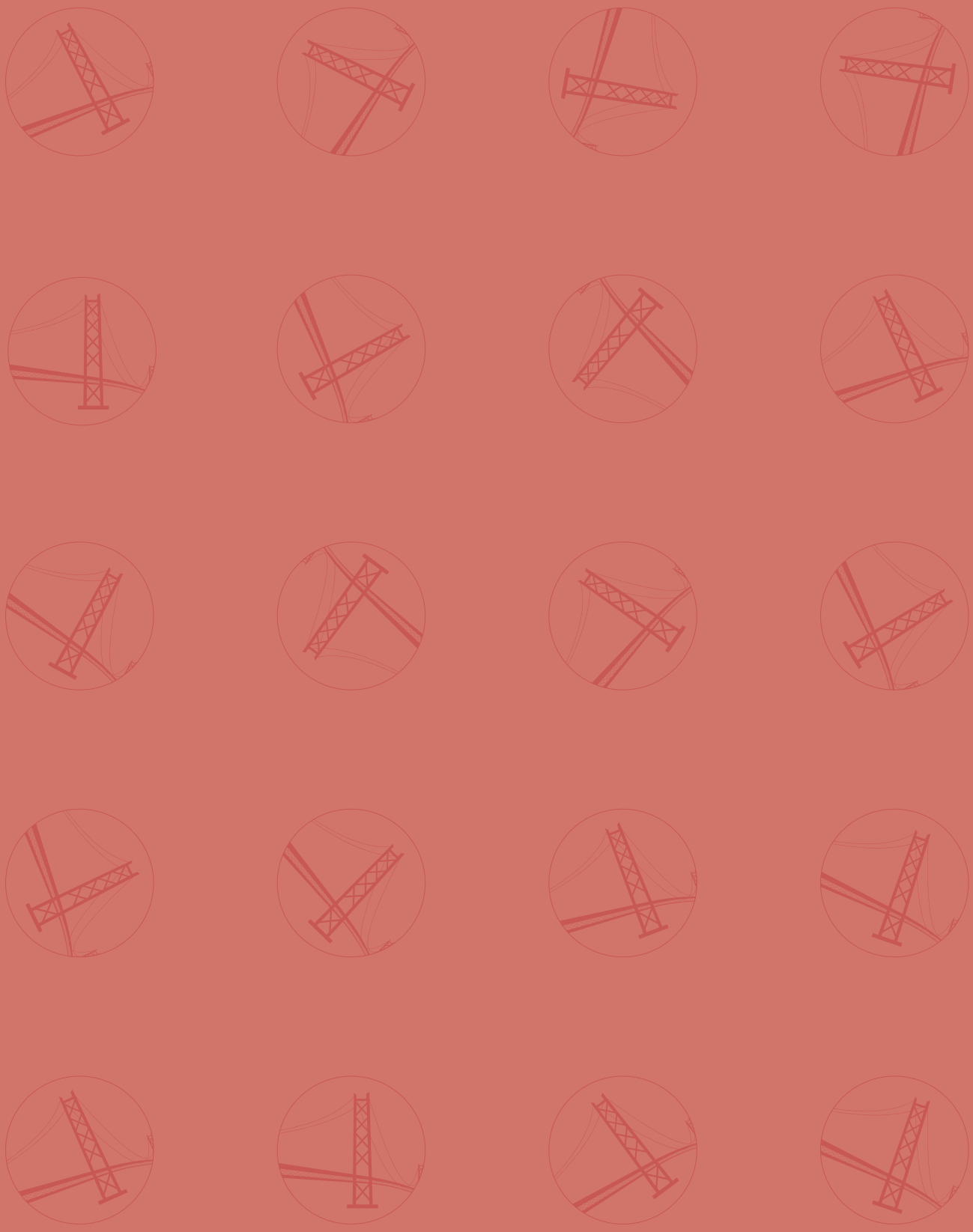
			Discipline Areas			Horizon of achievement		
Planning and procurement	**Issues of Procurement**	**Outcomes of R&D for Procurement**	**Environment**	**Socio-economy**	**Science, Technology and Engineering**	**Short Term**	**Medium Term**	**Long Term**
1.	Limited Infrastructure Funding	a) Evaluate all options for private involvement in delivery of government services, e.g. PFI, PPP	X	X	X	X		
2.	Financial and economic modelling for infrastructure procurement	a) Develop models for alternative procurement to ensure best value for money for each project type	X	X	X	X	X	
3.	Sustainable procurement with transparency and cooperative framework	a) A study on the incorporation of life cycle costing for certain types of projects b) A study to incorporate elements of Green Procurement in the procurement processes c) A study of partnering, alliance contracting, integrated team approach, etc. to project procurement	X X	X X X	X X X	X X X	 X X	
4.	Incentivise effective and efficient procurement	a) Study the incentives to be awarded for earlier completion or reduced price and better quality	X	X	X	X	X	X

4.3 SUMMARY

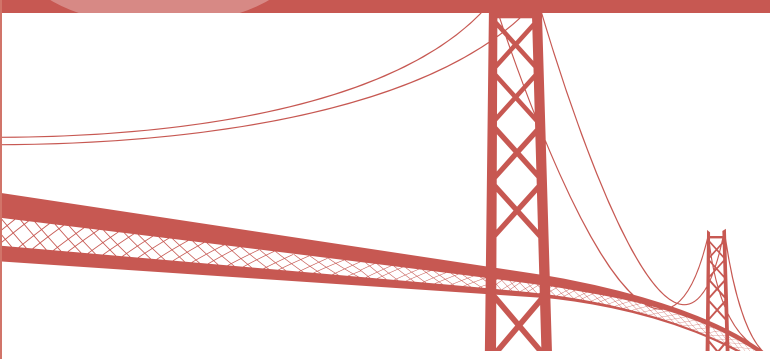
This chapter has provided recommendations through detail but not exhaustive listing of R&D outcomes. The recommendations were made mainly based on the life cycle of the infrastructure concerned. The attributes of a sustainable infrastructure were initially defined, and followed by general recommendations that were cutting across different infrastructure types. This was followed by a section that had suggested R&D issues and outcomes for each of the four transport infrastructure that is part of the scope of this study.

They were organised with reference to the life cycle component, the dominant area(s) of discipline, and the appropriate time horizon for accomplishment. The nature of the recommendations was to address the identified issues as well as to prepare the nations for the other challenges in the future.

It is hoped that the long list of recommended R&D outcomes may guide the nation through systematic and comprehensive, yet prioritised tactical move for a more sustainable future for our infrastructure. All in all, 17 issues and 36 R&D outcomes were recommended for the roads and highways sector; 25 issues and 46 R&D outcomes were recommended for the rail sector; whereas, 20 issues and 42 R&D outcomes were recommended for the port sector; while 24 issues and 48 R&D outcomes were recommended for the airport sector. The R&D recommended outcomes have been matched to the life cycle process in a typical infrastructure, as well as to the time horizon needs. In addition, relevant background discipline in delivering the outcomes has also been recommended.



CHAPTER 5
THE SUSTAINABLE INFRASTRUCTURE FRAMEWORK OF MALAYSIA'S INFRASTRUCTURE



The previous chapter has suggested many recommendations in order to ensure that the country's future infrastructure development will be sustainable. This is important as sustainable infrastructure may propel the country to achieve the nation's sustainable development aspirations, and simultaneously ensure Malaysian's productivity and competitiveness leading to the year 2050.

However, instead of merely prescribing a recommended list of initiatives and interventions, the future state of Malaysia's infrastructure will be better served if the forthcoming initiatives are outlined in a framework. A framework will not only be providing the big picture, but it will also articulate the details of the requirements. Especially, when the life cycle of any infrastructure must be given due attention in order for it to have any chance of being sustainable, and before it can even support the sustainability of the nation. This chapter describes the framework and the tool that will facilitate the achievement of the intended outcomes. This chapter will further address the third and fourth objectives of the study, namely, to determine the role of STI in the Malaysian infrastructure sector through short, medium and long term measures; and to identify gaps in STI knowledge and development in the infrastructure sector

5.1 THE SUSTAINABLE INFRASTRUCTURE FRAMEWORK

The formation of the framework will be much guided by the theoretical framework typically representing a traditional project life cycle, as shown in **Figure 3**. In a typical "resources vs. time" relationship, higher allowance of resources committed at the beginning of the life cycle will ensure better value through more impactful results for the entire life cycle of any project.

On the other hand, the inability to plan well will escalate the cost towards the end of the cycle, primarily at the operations and maintenance stage. The planning, design, construction and maintenance stages have been appended to the figure section to illustrate the approximate relevance of these important four stages in typical infrastructure developments. The fact that infrastructure development is also commonly resource intensive as well as potentially costly to sustainability and the environment, it has warranted the use of a special platform or tool to ensure that a sustainable approach can be employed for every infrastructure development in the country.

The framework will help address the problem of disintegration in planning, as it will be useful to the various responsible bodies for different infrastructure sector. This common tool will help the nation to better plan the infrastructure, integrate the activities, communicate the shared objectives and collaborate on common efforts to ensure its sustainability.

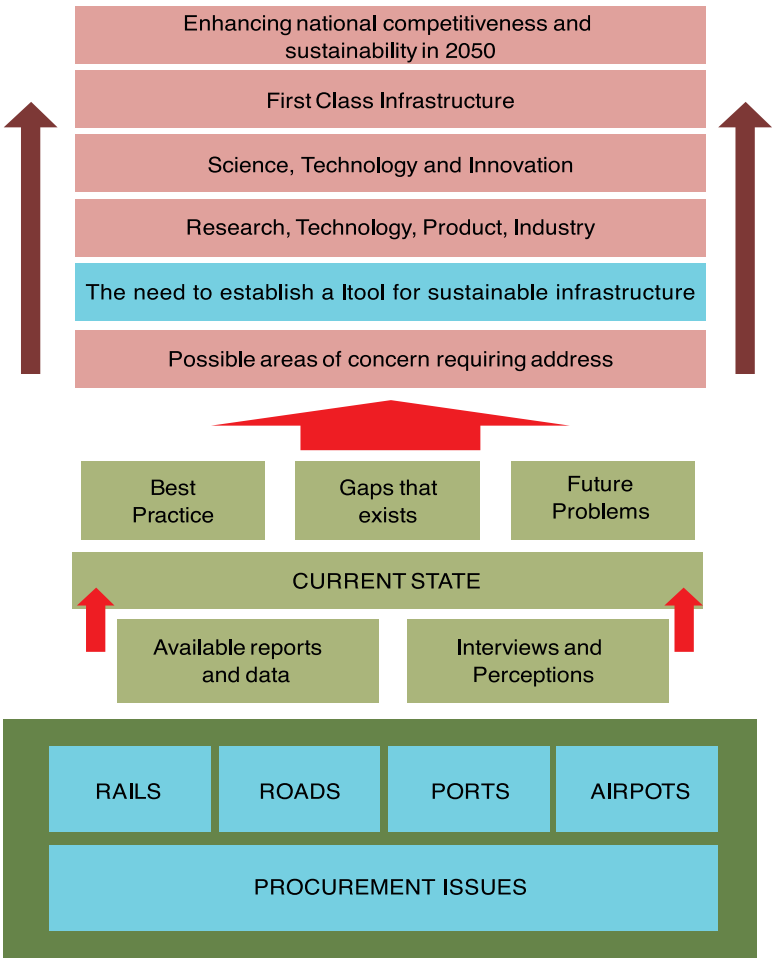


Figure 5.1 The Improved Study Framework

Figure 5.1 shows the improved study framework, which has incorporated the need to establish a tool for sustainable infrastructure compared to the original study framework shown earlier as **Figure 1.1** in Chapter 1.

5.1.1 SUSTAINABLE INFRASTRUCTURE TOOL

i. ***Motivations and aspired outcome***

The desire to incorporate the tool for sustainable infrastructure may be further illustrated by **Figure 5.2**. The task is to relate the needs surrounding the tool to the opportunities and requirements of R&D, and in particular, Science and Technology R&D. **Figure 5.2** attempts to relate the tool's development with the gaps that it is to bridge; in playing its role to ensure that infrastructure development in Malaysia will be sustainable in the future. The tool will have to go through its own development stage, followed by its implementation, and the consequent assessment of its outcome attainment. Each of these steps will require further elaboration, which they will be explained through **Figure 5.3**.

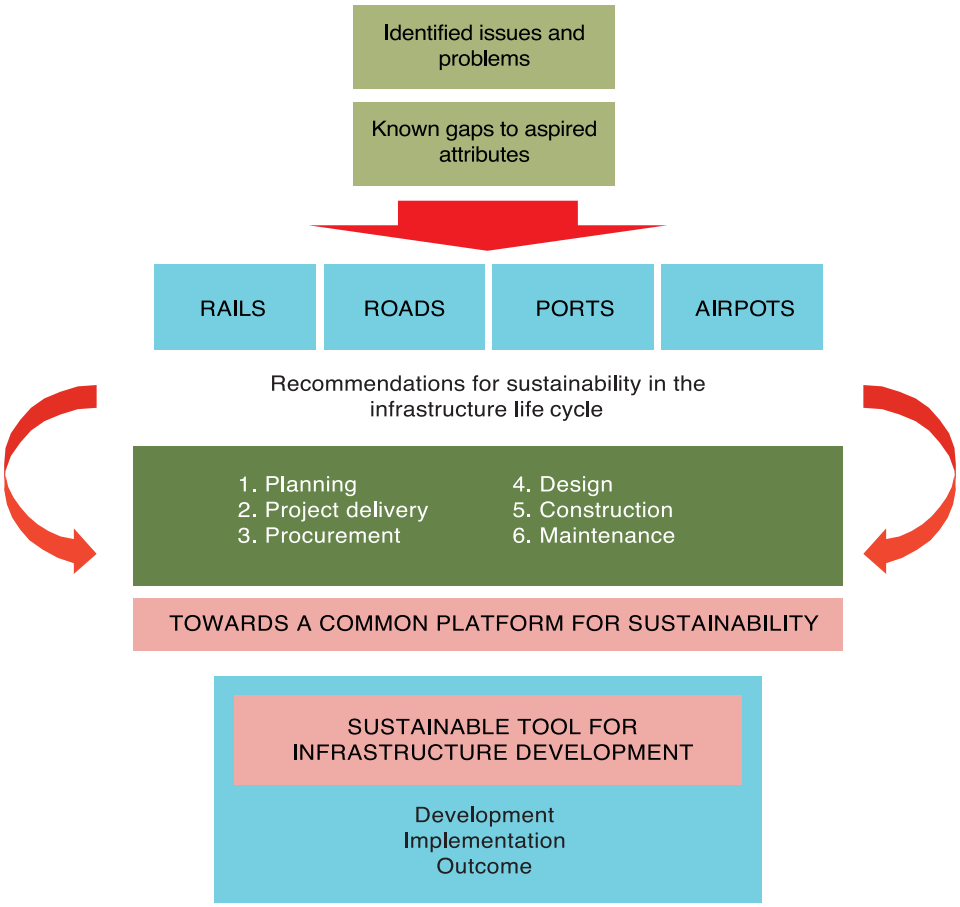


Figure 5.2. The Sustainable Infrastructure Framework for Malaysia

In addition, **Figure 5.3** also illustrates the proposed framework towards the development of infrastructure sustainable tool for Malaysia. The recommendations to be given by this study will be centred on this framework.

Generally, the framework will have four elements:

- Desired outcomes
- Development stage
- Implementation strategy
- Assessment of outcomes and continual quality improvement

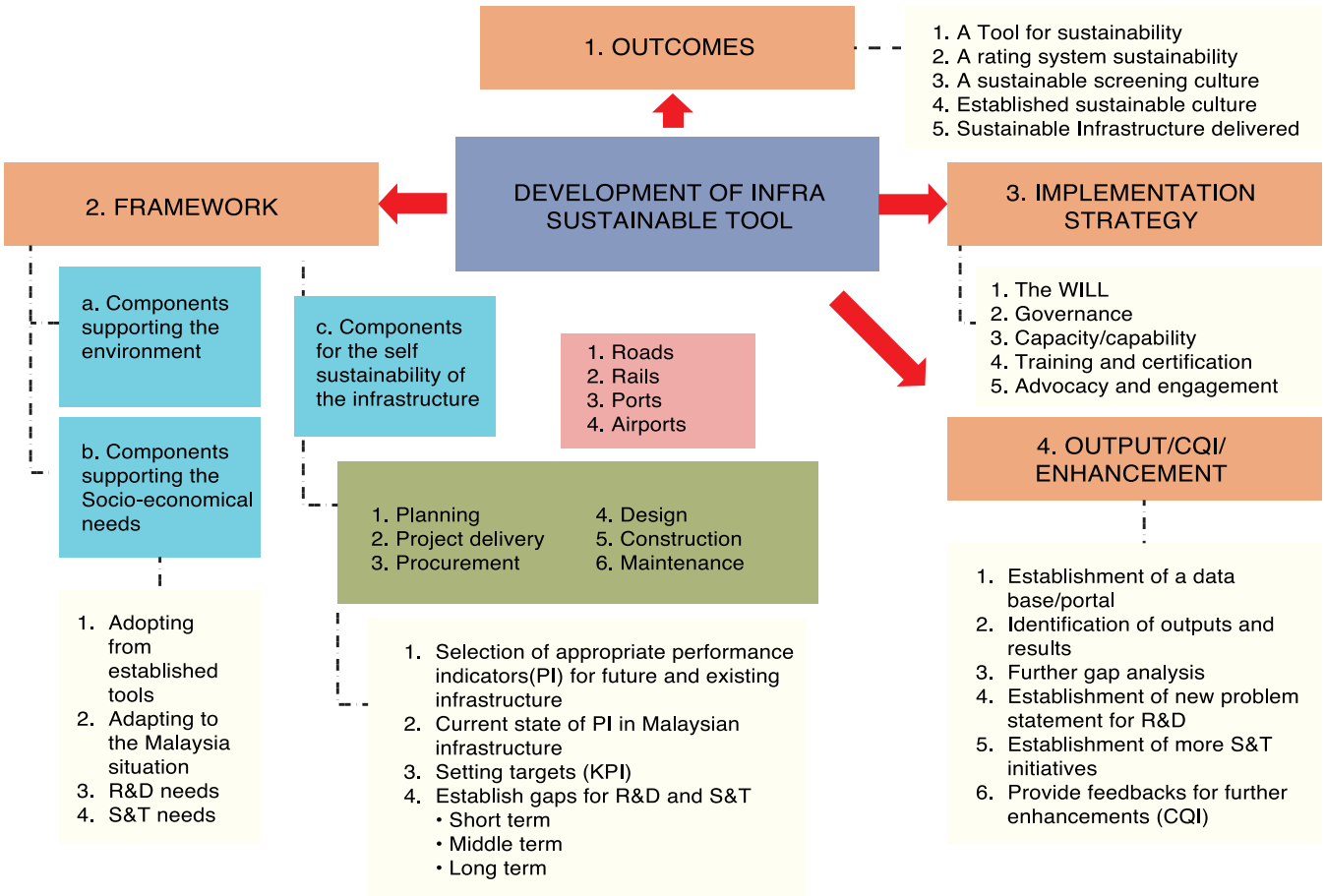


Figure 5.3 The Framework for the InfrastructureSustainable Tool

ii. ***Outcomes***

In any framework, the intended outcomes must be clearly defined to ensure that the entire effort is kept within the original vision and mission. The outcomes of the infrastructure sustainable tool are as follows:

a) A tool for sustainability – This is the main outcome, where any infrastructure can be assured of its sustainability through the utilisation of this tool. The tool may be used for macro planning as well as at individual project level.

b) Rating system for sustainability – The tool will have to introduce the elements of objectivity, in order for it to be used as a rating system. Part of the Sustainable Infrastructure Framework is on advocacy and positioning that a rating system for sustainability will be crucial.

c) A sustainable screening process – The tool must also provide the ability to screen and replace non-sustainable features of a proposed project, or even to eliminate any non-sustainable infrastructure projects. This is very critical, especially in a setting where the supply dictates the demand for development. At the moment, such function may not be executed effectively, in absence of the appropriate tool.

d) Established sustainable culture – This tool and the preceding outcomes are essential to create the culture for sustainability for the infrastructure-related players. Without an established culture, the vision to have sustainable infrastructure for the country will be immensely difficult to achieve. Perhaps, this is the most important outcome that must be achieved through the sustainable infrastructure framework.

e) Sustainable infrastructure delivered – This is the most obvious outcome that may still be elusive, if the preceding outcomes are not attained. In a way, the five listed outcomes are successive in nature, and each one must be satisfactorily attained before the ultimate promise of the sustainable tool and the sustainable framework may be delivered.

iii. ***Development Stage – the framework***

This development stage will be crucial and will provide the most opportunities for capacity enhancement for the nation. This may be achieved through activities covering knowledge acquisition, R&D as well as human and nation capacity-building. The following tables will provide further details:

1. **Components supporting the environment**	**Description**	**Opportunities for S&T R&D and other support**
a. Adopting from established tools	Established countries have created their own version of tools to assist in the planning of sustainable infrastructure. We may study them and look at their relevance to meet our needs. The list of such available tools is provided in Appendix A.	1. A thorough review on globally available tools to meet the outcomes set for the SIF for Malaysia 2. A comparative and critical analysis on available tools 3. Extraction of plus and relevant points for the development of the Malaysian tool in support of the environmental features of sustainability

b. Adapting to the Malaysian situation	There are tools that predominantly address the environmental dimensions of sustainability. However, a tool for Malaysia must also address other sustainability dimensions. Existing tools from elsewhere may also explore deeper environmental issues that may seem unimportant to Malaysians.	1. The present environmental sustainability indices previously established in Malaysia need to be reviewed as to provide a guide to adapt from adopted tools, or towards a fresh development of our own tool 2. Appreciating the limits of Malaysia towards the environmental sustainability agenda will be critical to guide on the possible acceptability and practicality of the intended tool 3. Identifying the most critical environmental indicators to help decision-making

2. **Components supporting the socio-economy**	**Description**	**Opportunities for S&T R&D and other support**
a. Adopting from established tools	Tools from other countries have also included the implication of infrastructure projects on the socio-economy, and thus have included them as parameters.	1. A thorough review on globally available tools to meet the outcomes set for the SIF for Malaysia 2. A comparative and critical analysis on available tools 3. Extraction of plus and relevant points for the development of the Malaysian tool in support of the socioe-conomic features of sustainability
b. Adapting to the Malaysian situation	The socio-economic attributes of countries are not identical to each other. There is a need to adapt the identified adopted socioe-conomic features from the available tools. Otherwise, there may be a need to start fresh for the Malaysian framework.	1. Review from relevant Malaysian socio-economic studies, especially on the impacts of infrastructure is needed 2. Identifying the most critical socio-economic parameters that is most sensitive to Malaysians and that will help better decision making

3. **TOOL integration and packaging**	**Description**	**Opportunities for S&T R&D and other support**
a. Selection of the final appropriate Performance Indicator is to be incorporated.	From all the established performance indicators, prioritisation will be made to select PIs that will be the most critical for achieving the sustainable goals	1. Development of a selection criteria and rubrics for evaluation

b. The packaging effort	The packaging into a comprehensive tool that is of practical use, meeting the outcomes and applicable for both macro planning as well as for screening at project level.	1. Establishment of the architecture for the tool package 2. The development and delivery of the tool with features and attributes that will help its utilisation as well as providing the intended outcomes.

iv. ***Implementation Strategy***

4. **Implementation Strategy**	**Description**	**Opportunities for S&T R&D and other support**
a. The Will	The will to use the tool will be imperative for the success of aspiring for sustainable infrastructure in Malaysia	1. Establishing ways of nudging through the decision-making procedures to get the 'will' 2. Sustaining the 'will' through strategic positioning of success stories and continual potential promise
b. Governance	An effective governance is needed to ensure effective implementation of the sustainable infrastructure tool and framework	1. Establishing effective governance to assimilate into the present authority's governance system 2. Transforming the present governance into a more effective governance system
c. Capacity and Capability	The capacity and capability of the country is critical to ensure the success of the sustainable infrastructure framework	1. The need to drive the enhancement of the country's capacity and capability to embrace and deliver a sustainable infrastructure culture
d. Training and certification	Human resource need to be trained and a certification process will be needed to regulate it to support the sustainable infrastructure framework	1. Curriculum development for training purposes 2. Research to assess the effectiveness of the programme, in terms of the outcome attainment
e. Advocacy and engagement	Engagement of all the stakeholders will be paramount in the implementation stage	1. Strategies to help effective communication and positioning of the sustainable infrastructure framework effort are to be in place 2. Research to evaluate the effectiveness of all advocacy and engagement process is needed

v. ***Outputs and Opportunities for Improvement***

5. **Outcomes assessment and continual quality improvement**	**Description**	**Opportunities for S&T R&D and other support**
a. Establishment of a database	A comprehensive database for all important data supporting the performance indicators is needed	Design and delivery of a database that can be used to monitor the nation's progress in the embracement, implementation and success of the sustainable infrastructure framework
b. Identification of outputs and results	An overall analysis of the results and outcomes	Ability to access the database and carry out critical analysis of outputs and outcomes
c. Further gap analysis	A critical gap analysis needs to carried out	Considerable room for R&D to identify the prevailing gaps in all entities of the framework
d. Establishment of new R&D problem statements	Continuous R&D will help stimulate and identify more problem statements for research	Section 4 has outlined the existing gaps identified in the infrastructure industry that can be bridged through R&D

5.2 SUMMARY

This chapter has addressed the recommendations made by the study team in order to provide the most practical ways to achieve sustainable infrastructure in Malaysia. The premise used has been that in order for an infrastructure to be able to support the sustainability of the nation, the infrastructure must in itself be sustainable. Accordingly, this chapter has provided the following recommendations:

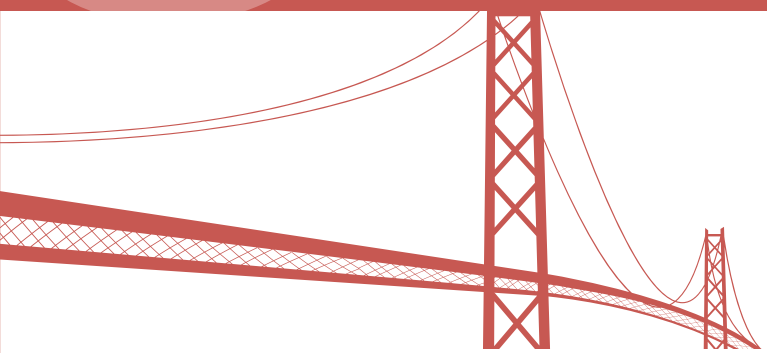
1. The need to establish a Sustainable Infrastructure Framework (SIF)

2. The need to create and utilise a planning tool to ensure the entire life cycle of an infrastructure to be remain sustainable

The sustainable infrastructure framework has been positioned to play its role in the planning stage of any infrastructure development. An integral enabler to the framework will be a sustainable infrastructure planning tool, that will both address the macro and micro planning perspectives of the infrastructure life cycle. This will ensure the ability for the nations to ensure both sustainable infrastructure and infrastructure sustainability aspirations are to be met. The sustainable infrastructure is aimed at selecting the most sustainable infrastructure development and planning options to ensure that the outcomes of the infrastructure may be served through the route that is most sustainable to the nation, the people and the environment. Infrastructure sustainability, on the other hand, is the drive to ensure that the entire life cycle of any infrastructure is driven by the sustainability ideals, right from planning, procurement and elements of project delivery such as design and construction, as well as the operations and maintenance issues.

The development of the tool will best be served through the "adopt and adapt" approach, in order to ensure that any useable tools are to be suitable to the situation and needs of the country. The sustainable infrastructure framework covers the identification of the outcomes, the development of the tool stage, the implementation stage and the monitoring of the outcomes stage. Each will require vast R&D work, as well as relevant activities to ensure the intended goals are achieved. This chapter has described these in detail, and in doing so has helped the study to cover all the objectives prescribed in the terms of reference for the study.

CHAPTER 6
CONCLUSIONS



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6.1 SUSTAINABLE INFRASTRUCTURE FOR MALAYSIA'S FUTURE PRODUCTIVITY AND COMPETITIVENESS

The scope of this study is to position sustainable infrastructure as one of the main enablers for the country's future productivity and competitiveness. While Malaysia has gained her reputation for possessing the best transport infrastructure in the region, arguments on whether they are sustainable have been raised many times. This study has outlined four objectives:

i. To define the attributes of the infrastructure sector that would be appropriate to enhance competitiveness and sustained development;

ii. To identify the prevalent gaps in the infrastructure sector between the present realities and the aspired ideals;

iii. To determine the role of STI in the infrastructure sector in Malaysia through short-, medium- and long-term measures; and

iv. To identify gaps in STI knowledge and development in the infrastructure sector and recommend appropriate measures through R&D priority areas; product and technology development, and the nurturing of relevant industries.

The findings for the first and the second objectives have established that if the country does not bridge the gaps between the aspired and the prevalent state of our infrastructure, the goal to leverage upon sustainable infrastructure for Malaysia's productivity and competitiveness will be compromised

This has given rise to the need to ensure that the most appropriate sustainable infrastructure is chosen and decided upon, warranting a need to help decision makers to select the best infrastructure project to serve the intended outcomes. In order for sustainable infrastructure to prevail in Malaysia, the right solution must be chosen, and the decision must be guided by sustainability principles. Furthermore, this study has also established that the present occasional practice, where the supply side of the equation that dictates and moulds the demand, is not in line with the sustainable infrastructure effort.

As such, there was a general agreement on sustainable infrastructure requirement attributes, such as the following:

- Infrastructure development that will serve its functions without compromising the needs and functions of others;
- Infrastructure that meets the equilibrium between time, costs and quality requirements;
- Infrastructure that will surpass its intended design years and continue to provide the same expected (or even better) level of service; and
- Infrastructure that will continue to provide the competitive advantage to the nation and its people to meet and exceed future expectations.

In simple terms, sustainable infrastructure has been defined as follows:

"Infrastructure that is in itself sustainable and will promote the sustainability of the nation and the people."

6.2 INFRASTRUCTURE SUSTAINABILITY ENABLING THE SUSTAINABLE INFRASTRUCTURE

Complementing the term sustainable infrastructure, infrastructure sustainability ensures that it will be delivered for Malaysia. It entails the need for infrastructure in Malaysia to continue meeting and surpassing its design life as well as the expected level of service to be rendered to users and beneficiaries.

The life cycle of any infrastructure has been the basis to ensure that both infrastructure sustainability as well as sustainable infrastructure will prevail in Malaysia. In order for infrastructure in Malaysia to be sustainability driven, the point of inception is no longer at only the project delivery stage but will have to start at the point of the conception of idea and will. Matching the most appropriate infrastructure to the needs of the country will be a crucial move towards establishing a sustainable infrastructure as well as a sustainable built infrastructure. Subsequently, at the procurement stage, along with the project delivery stage, the principles of sustainability must exist throughout the life cycle of the infrastructure.

Earlier on, examples of practices that have jeopardised the sustainability of existing infrastructure in Malaysia have been highlighted, and they have been used as motivation for gaps closure. They are in turn to be supported by the R&D effort in the science and technology domain as well as other supporting areas, as the nature and setting of any infrastructure will eventually encompass the society, the environment and the engineering dimensions.

6.3 OUTCOMES AND RECOMMENDATIONS

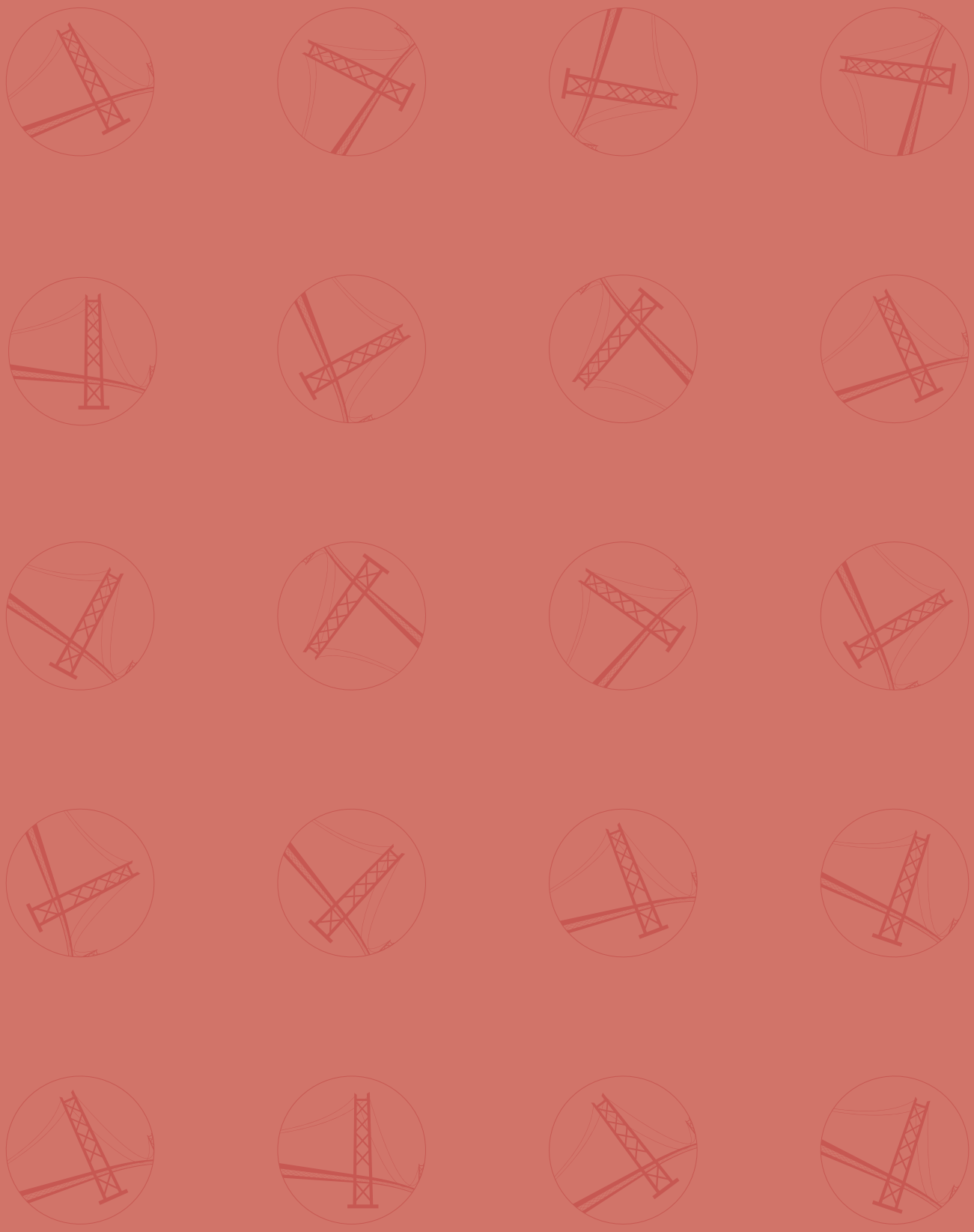
The study has concluded that in order for Malaysian infrastructure to be sustainable and pave the way towards a sustainable nation, the preproject and the planning stages are most critical. Thus, a framework on sustainable infrastructure has been formulated and tuned to act as a tool to evaluate both the attributes of a sustainable infrastructure as well as the attributes of the infrastructure sustainability.

Indeed, the sustainable infrastructure decision tool has to suit the Malaysian scenario and requirement. The decision tool will also be a mindset moulding agent, as much of the challenges for sustainability in Malaysia rests in the mindset and attitude of the players and stakeholders.The study team has acknowledged that there are available sustainable tools in the world, but analysis on them has shown that they are primarily applied to a particular infrastructure project, and all have a much higher level of sustainability values and appreciation as their background. This entails a possible “adopt and adapt” approach, which in turn, provide many R&D opportunities. Hence, the Malaysian infrastructure tool must have the following attributes:

- Able to be used as a screening mechanism to decide on the sustainability nature of any proposed infrastructure project
- Able to be used to encourage infrastructure projects to be sustainably driven throughout its life cycle, via an effective rating system

In addition to the tool, all four infrastructure sectors covered in this study have their distinctive sustainable issues. In order for the gaps to be bridged, an analysis of possible R&D outcomes was made to cover the environment, the socio-economic and the science and technology dimensions. These R&D outcomes were also categorised for the short term (five years), medium term (ten years) and long term (more than ten years).

Hence, it is the hoped that the findings and the recommendations from this study will help steer the future direction of both sustainable infrastructure and the sustainability of infrastructure in Malaysia for many years to come. It will not only help Malaysia to be more productive and competitive, but more importantly to provide a better world for her future generations.



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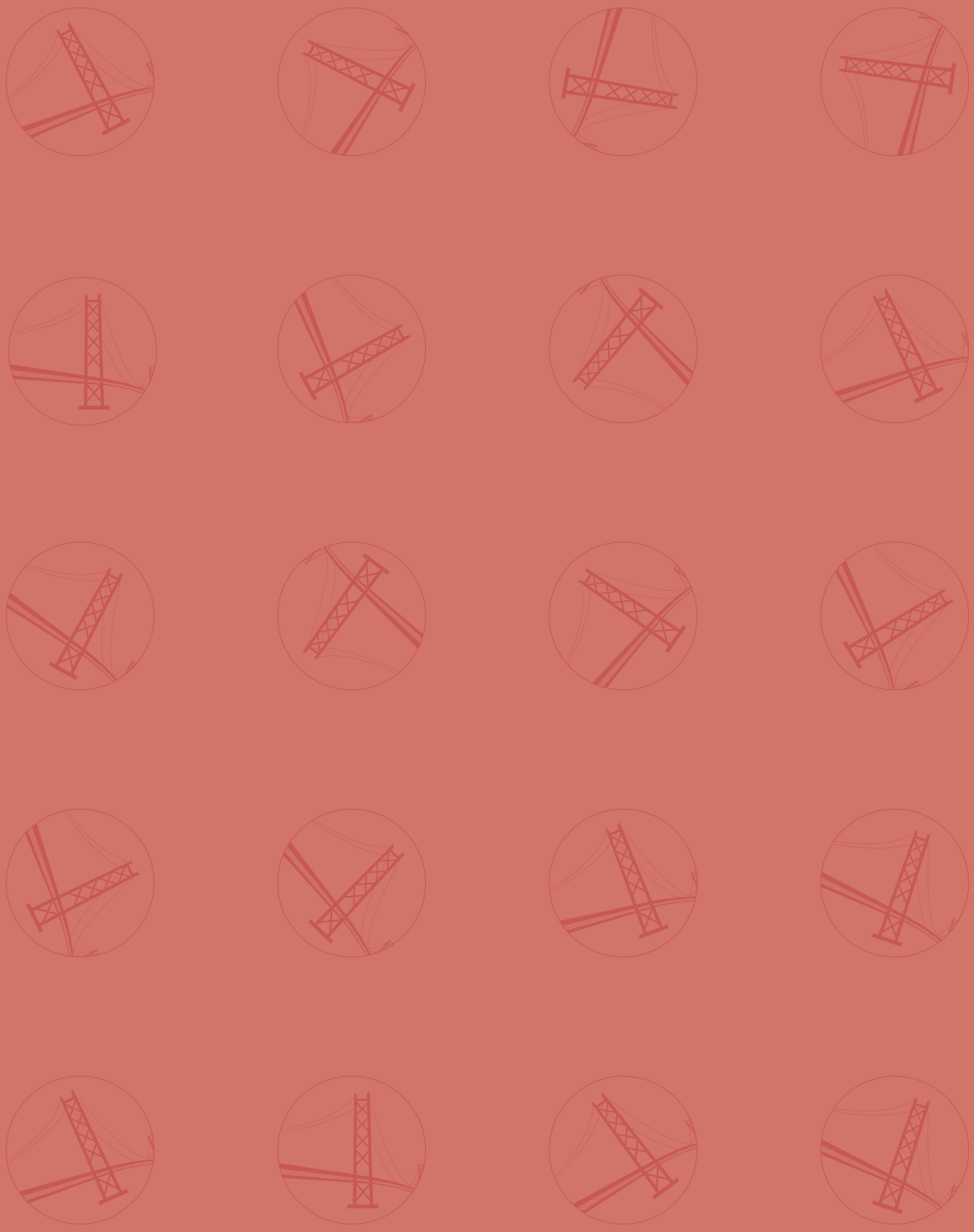

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