2015

Academy of Sciences Malaysia

SCIENCE OUTLOOK

action towards vision

Executive Summary

SCIENCE OUTLOOK

action towards vision

EXECUTIVE SUMMARY

"STI cannot be considered in isolation as it cuts across economic sectors, ministries and knowledge domains.

I consider the Science Outlook 2015 by ASM, a strategic document that offers timely insights into the Malaysian STI landscape and the way forward."

Datuk Seri Panglima Madius Tangau
Minister of Science, Technology and Innovation

As Malaysia prepares itself towards 2020, there is a need to better understand and harness Malaysia's STI capabilities, capacity and potential to devise a more realistic and pragmatic implementation strategy, as well as an approach for socio-economic transformation and inclusive growth. The Science Outlook signifies a new beginning in an effort to bring Malaysia's STI development to the next level.

"ASM is pleased to publish Malaysia's first Science Outlook that presents an independent review of key trends in science, technology and innovation in Malaysia.

The issues highlighted are 'nothing new'. However, ASM has endeavoured to present the issues with supporting data and evidence along with recommendations to address them effectively.

I hope this Science Outlook will facilitate the harnessing of STI for national development and global competitiveness."

Tan Sri Datuk Dr Ahmad Tajuddin Ali FASc
President, Academy of Sciences Malaysia

"Science Outlook highlights pertinent areas that need to be effectively addressed concerning Malaysian STI policies, capabilities, initiatives, opportunities and aspirations by various stakeholders such as policy makers, government officials, academics, industry leaders, international partners and the general public.

It is hoped that this Science Outlook initiative would catalyse the transformation of STI for wealth creation and societal well-being."

Professor Datuk Dr Halimaton Hamdan FASc
Chairperson, Science Outlook 2015

Science, technology and innovation (STI) is critical for socio-economic development in today's knowledge-intensive, innovation-led economy. As the world becomes more competitive and globalised, countries that have embraced the knowledge paradigm with high proficiency in STI undoubtedly command success and prosperity. STI plays an indispensable role in catalysing knowledge-based development, a knowledge society and knowledge-centric, high value-added enterprises. As Malaysia aspires to become a high-income, developed nation by 2020, STI is a key enabler to enhance productivity and competitiveness as well as catalyse inclusive growth. Thus, it is imperative to evaluate Malaysia's STI performance and strategies to ascertain if we are on track towards realising envisioned outcomes.

The Science Outlook 2015: Action towards Vision presents an independent analysis and consolidated report on key STI trends and development in Malaysia. The Science Outlook provides a reality check based on the 6 strategic thrusts of the National Policy on Science, Technology and Innovation (2013-2020) (NPSTI) (Figure 1). Namely STI Governance, Research Development, and Commercialisation (R,D&C), STI Talent, Energising Industries, STI Enculturation, and Strengthening International Alliances.

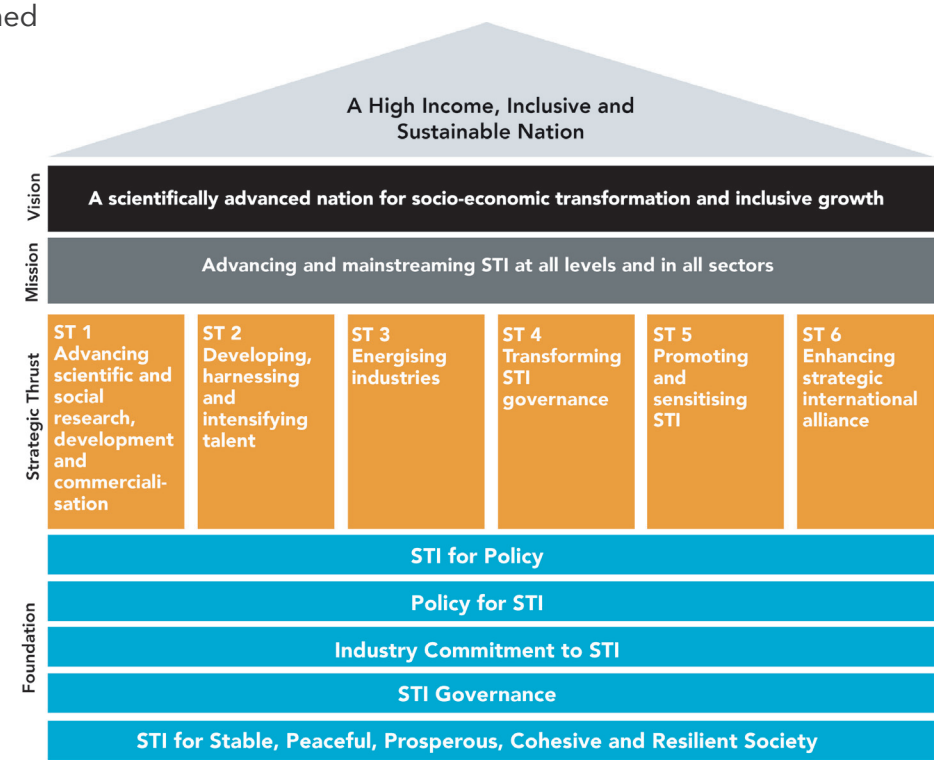


Figure 1. National Policy on Science, Technology and Innovation (2013-2020) (NPSTI)
Source: MOSTI 2013

Figure 2. The philosophy of Science Outlook

The philosophy of the Science Outlook is to evaluate where we are in STI, benchmark ourselves with other countries that are advancing well in STI, identify the gaps, consider future implications and advocate the way forward to realise our aspirations. The Science Outlook presents insights and fresh perspectives on the Malaysian STI landscape with relevant supporting data in the spirit of promoting informed, evidence-based decision making.

From the introduction of the STI agenda in the national policy framework in 1986 to the current National Policy on Science, Technology and Innovation (2013-2020) (NPSTI), we have come a long way. The Government has demonstrated commitment to build national STI capacity and capability through requisite infrastructure, institutional framework, collaborative platforms and incentives. However, much more strategic and synergistic action is needed to realise a robust STI ecosystem. Such an ecosystem is characterised by an efficient STI governance system, competent scientific community, vigorous research, development and commercialisation, STI encultured society, innovative private sector as well as formidable local, regional and global STI networks. This calls for transformative thinking, integrated planning and inclusive implementation. Only then, would we be able to effectively deploy ideas, talents and resources to advance Malaysian STI to be world class.

01 STI GOVERNANCE

Do we have a robust STI Governance Framework in place?

STI Governance, the focus of the first chapter of the report, is essential for many reasons. The vast scope of governance requires objectivity, a fundamental understanding of the STI development and management cycles, and above all, an unbiased appraisal by an independent body at critical phases. Top eleven countries with high economic output such as USA, Germany, Sweden, South Korea, Japan and Taiwan and others have a stable STI governance structure. A sound STI governance framework enables structured and continuous monitoring of policy implementation and STI performance. In addition, the effectiveness of targets set, best practices adopted, strategies deployed and solutions realised can also be regularly evaluated. Ultimately, effective STI governance will set the stage for a dynamic and enabling STI ecosystem.

In Malaysia, we have had comprehensive development plans since Independence. This has been complemented with the development of a solid institutional framework, infrastructure, collaborative platforms and incentive mechanisms. Since the first science policy, the National Science and Technology Policy (1986-1989) (NSTP) to the current National Policy on Science, Technology and Innovation, 2013-2020 (NPSTI), much has been expended to ensure STI creates both economic and social value. There are 81 national policies out of which, 56 are STI-related with multiple agencies (around 458) promoting or implementing them. However, these multiple agencies and institutions are not working in synergy but often seen to be competing to get their voices heard. This has proved to be counterproductive in fully harnessing our STI potential. As such, even with robust policy frameworks, government support and private sector participation, the implementation of policy measures seem to be fragmented and eclectic (Figure 3), yielding poor results.

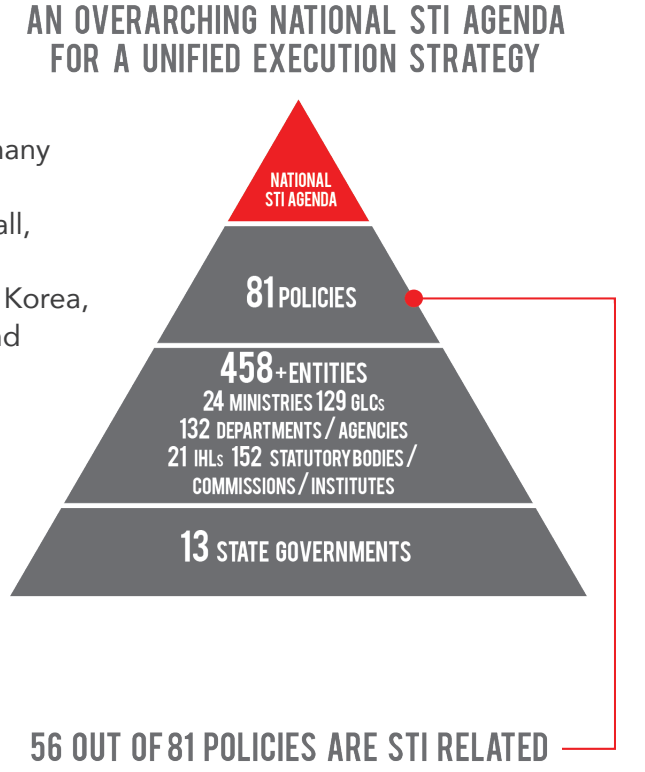


Figure 3. Multiple policies and implementing agencies and institutions

The main reasons cited for implementation weakness are "insufficient political will and legislative drive to address STI-related issues", "absence of an overarching STI Master Plan", "lack of direction, co-ordination and focus" and most importantly "failure to converge STI with economics and finance, geopolitics as well as society and culture through integrated planning and inclusive implementation". This calls for an urgent rationalisation of Malaysia's STI governance structures.

Furthermore, we often fail at the implementation stage because we do not start right with a robust ideation process that can give rise to better strategic thinking for planning, target setting, and regular evaluation and monitoring. STI inputs and interventions should not be seen just as a precursor to policy development or as a support for decision making, but must be an integral part of the whole ecosystem of policy implementation towards meeting set targets. The availability of credible, relevant and timely STI data is also central to evidence-based decision making and in Malaysia, this has often been the missing link to effectively measure the performance of STI related policies and interventions. As a result, STI directions may be charted without a strong rationale based on relevant and timely data. In keeping with global best practices, there is a need to strengthen the STI management cycle (Figure 4) with emphasis on ideation as well as monitoring and evaluation. For this to happen, we should empower a centralised STI co-ordination and monitoring body, that will transcend all ministries to realise greater stakeholder participation and synchronised implementation.

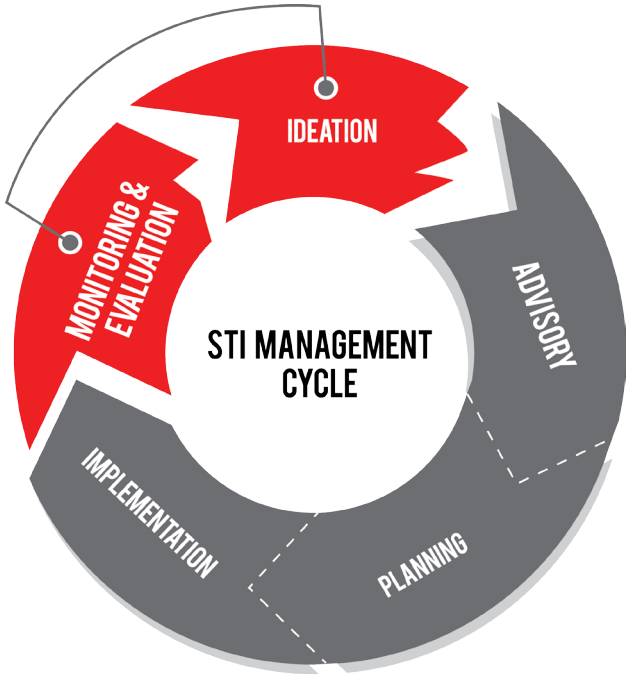


Figure 4. STI Management Cycle

Hansard (transcripts of Parliamentary Debates) analysis in Malaysia from 2008 to 2013 showed that the debates focused primarily on toeing the party line, topical according to media sentiment or constituency centric (Figure 5). This has resulted in STI issues taking a backseat leading to a lack of legislative drive and motivation to correlate STI contributions or its potential with national goals. In benchmarking with other advanced countries that are progressing well in STI, it was found that most of these countries have a formal platform at the legislative level such as a Parliamentary Select Committee to deliberate on STI issues with relevant expert and stakeholder inputs. Malaysia would do well to emulate this.

Given that STI is pervasive and cuts across economic sectors, ministries and knowledge domains, a National Science Act (NSA) would be instrumental to strengthen Malaysia's STI framework and ensure sustainability and stability in the long run. An NSA is advocated to provide legislative impetus for the implementation of STI related policies or action plans and serve as an overarching STI Master Plan for a unified execution strategy.

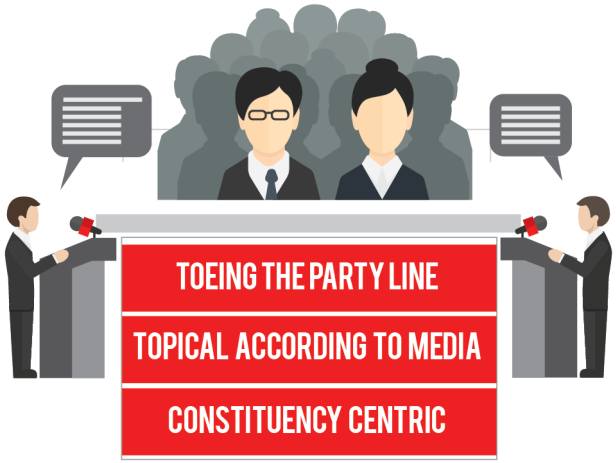
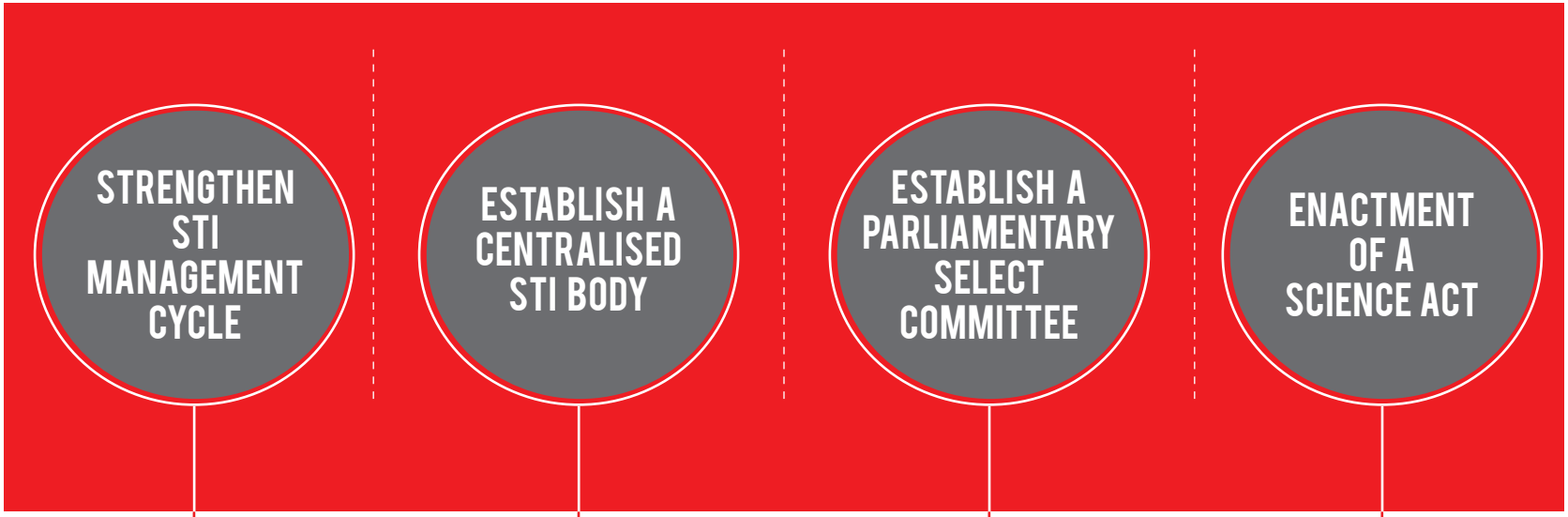


Figure 5. Parliamentary debates

Recommendation

An enabling environment for effective STI Governance



- We need to strengthen the STI Management Cycle by focusing on continuous Monitoring and Evaluation, as well as Ideation, in keeping with global best practices.

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

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

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

02 R,D&C

Does R,D&C address national priorities, challenges and opportunities?

In the past two decades, Malaysia has progressed significantly in research, development and commercialisation (R,D&C) in terms of increases in R&D budget, expansion in research manpower, infrastructure development and institutional support. These have contributed to Malaysia moving up in global rankings such as 20th position amongst 144 countries in the Global Competitiveness Report 2014 and 33rd position amongst 143 countries in the Global Innovation Index 2014. However, the Government's aspiration is to position Malaysia amongst the top 10 countries in both the index by 2020. This is a tall order and enhancing Malaysia's research, development, commercialisation and innovation (R,D,C&I) capacity and capability would be a key factor towards realising this aspiration. While Malaysia may be doing well in several areas of competitiveness, it is not being effectively translated to innovation capacity and capability as reflected in the much lower ranking of the Global Innovation Index.

Although Malaysia has seen a rise in gross expenditure in R&D per gross domestic product (GERD/GDP) from 0.5% in 2000 to 1.13% 2012, the country is still far from achieving its desired GERD/GDP of 2.0% by 2020. The average R&D spending in G20 countries was 2.04% in 2012 and in comparison, Malaysia has relatively low R&D expenditure. In this context, it is important to note that several studies have shown a direct correlation between R&D investment and commercialisation success rates. However, we must bear in mind that R&D resources (human capital, infrastructure and funds) must be optimally utilised to achieve intended outcomes. For example, having qualified and quality researchers /scientists and technologists has been proven to have a significantly greater impact on the outputs compared to amount of R&D spending (Figure 6).

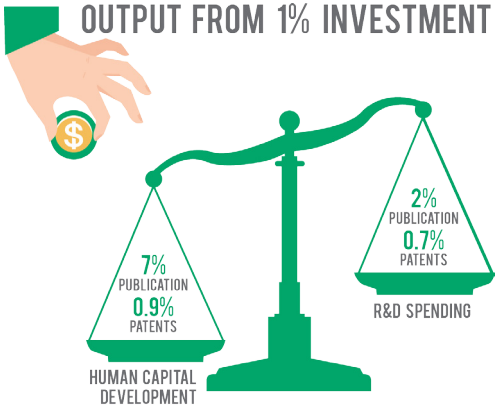


Figure 6. Drivers of publication and patent output
Source: Chandran et al. 2014

Over the years, multiple ministries and agencies have been allocated R&D funds from the Government, expanding the scope and opening many possibilities for meaningful R,D&C. The composition of the R&D pie in Malaysia is skewed towards applied research, with relatively low emphasis on basic or experimental research. This is unlike other advanced countries such as Singapore and South Korea where experimental research has more traction. It is vital for Malaysia to have a balanced strength in basic and applied research in order to generate and own scientific discoveries and indigenous technology platforms. This in turn will create a competitive edge for the nation.

Another observation of the Malaysian R,D,C&I landscape is that Government ministries often undertake the role of policy maker and implementer. This could result in one role or the other being undermined. A conflict of interest arises when ministries carry out both roles of policy maker and implementer. This also prevents the execution of effective monitoring and evaluation.

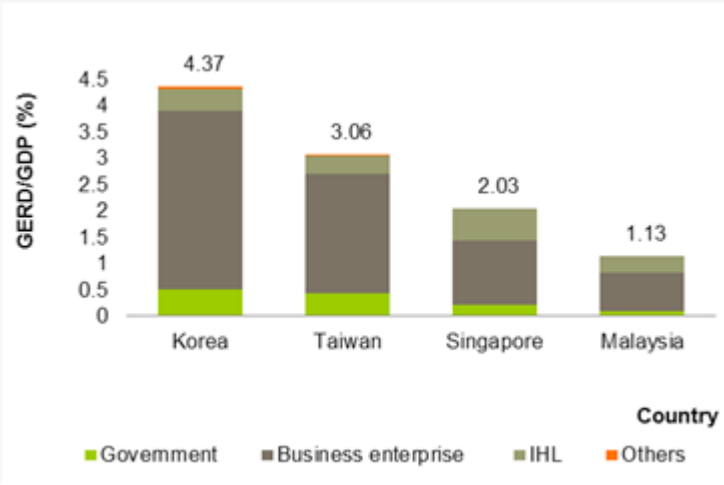


Figure 7. GDP invested in scientific research (%) 2012

Industry or business sector participation alongside Institutions of Higher Learning (IHLs) and Government Research Institutes (GRIs) has been minimal. This is reflected in Malaysia's business sector R&D expenditure per GDP was 0.7% in 2012 compared to 1.4% in Singapore, 2.3% in Taiwan and 3.1% in Korea (Figure 7). Low private sector participation in RD&C in Malaysia has limited opportunities to strengthen R&D output for commercial intent and application. In addition, research prioritisation is currently practised without organised efforts, monitoring and follow-through. This often results in abandoned projects with no practical outcomes.

One of the major issues identified in the R,D&C value chain in Malaysia is fragmented research activities. There is no single, cross-cutting co-ordinating body that transcends all ministries to effectively implement the nation's R,D,C&I activities. The existence of a multitude of R,D,C&I institutions has resulted in a lot of duplication. Diversification of R&D funding and allocation has resulted in the budgets being assigned to a greater number of research projects, leaving little or no room to create enough pool or economies of scale (masses) in specific sectors or fields of research. This impedes the realisation of value and impact from R&D. The management, administration and coordination of the funds are also believed to be an issue due to the involvement of multiple agencies.

Fundamentally, there is also a need for a standardised definition and a common understanding of various stages of R,D&C. Pre-R&D and R&D in the context of experimental, basic and applied research along with pre-commercialisation and commercialisation must be clearly defined and understood by all actors in the R,D,C&I landscape. This will help bridge the current gap in prioritisation and implementation of R,D,C&I.

Fragmented research activities are further compounded by the lack of a seamless process to allow for research projects to move from one stage to another along the R,D&C value chain. Records show that only 2% of projects managed to move between different stages. Basic research is not funded on a national level in priority areas for the nation's future development but seemingly on the basis of researchers' personal liking. Applied researchers on the other hand should be expected to productise their findings to the point that a business case for commercialisation can be validated. Once this has been proven, actual entrepreneurs and investors need to be brought in, who will bring in their own money to commercialise the product. There seems to be a significant gap between the pre-commercialisation and commercialisation stages in Malaysia. Overall, value realisation from R&D in S&T remains weak.

Against such a backdrop, a long term R,D&C perspective is often side-lined in the quest for quick wins and low hanging fruits. Typically in Malaysia, the progress of R&D is only monitored across a five-year cycle. In the 10 Malaysia Plan (2011-2015), R&D activities are treated as a rolling plan, creating uncertainty among IHLs and GRIs. This does not augur well for long-term research project continuity. Sustained commitment to R,D&C over the long haul is imperative to realise impactful economic and social gains.

In order to fully realise an innovation-led economy in the nation, R,D,C&I must move beyond mere return on investment (ROI) to value creation. Innovation results from successful realization of value. Information and knowledge applied creatively results in products and services that are unique and differentiated. They can command higher prices and produce higher returns. Value creation is also be maximised through dynamic interaction and collaboration of researchers with industry, government and community.

This requires a holistic approach that would address aspects such as industry set-up, role of solution-providers, intellectual property (IP) bundling as well as interest of researchers and project managers for sustainable R&D with socio-economic benefits. In this context, the introduction of a special purpose Ideation Fund may help evidence-based decision making, when it comes to establishing R,D&C priority areas and ensuring efficient allocation of resources to achieve optimum capacity.

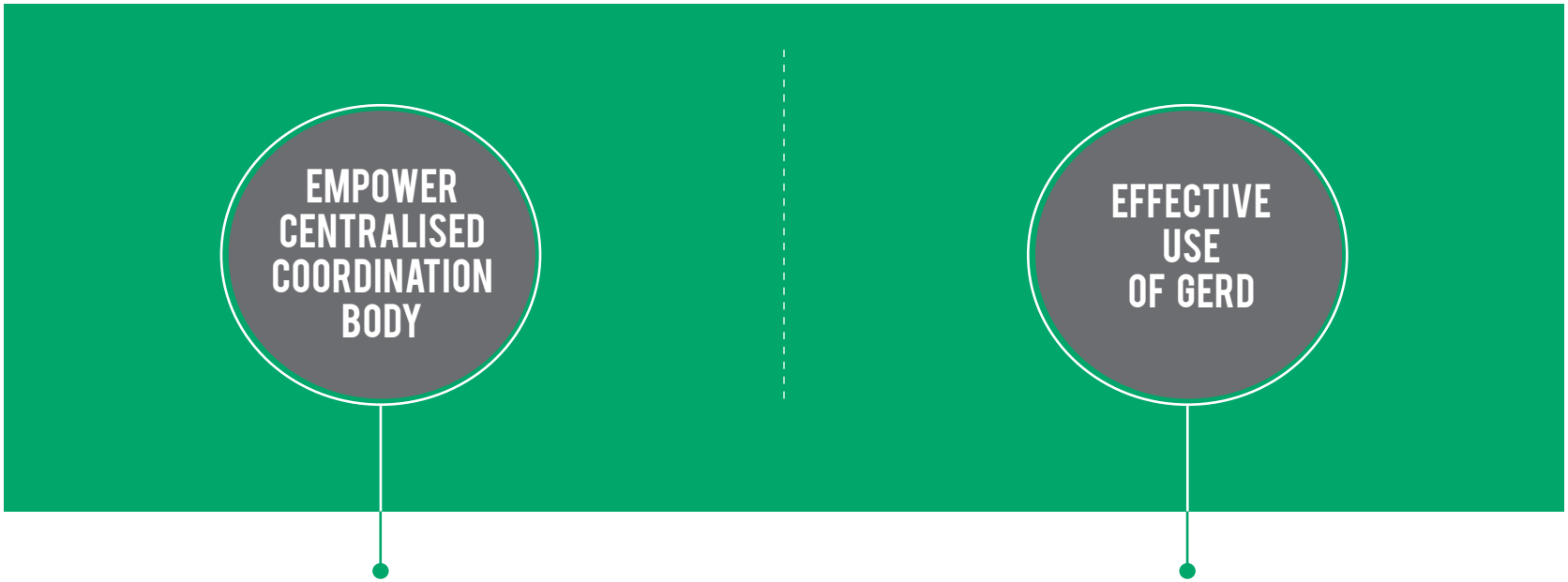
Clearly, there is an urgent need to engender greater coherence and continuity both at the policy and implementation levels where R,D,C&I is concerned. Various incentives and instruments should be well strategized and aligned to national priorities to improve co-ordination and integration. One way to achieve this would be for the government to empower an existing centralised body to function as a research council or a research management agency that transcends ministries to promote seamless R,D,C&I implementation, management and monitoring.

Such an entity should be given a mandate and requisite resources to manage public R,D,C&I effectively and efficiently. It can undertake planning, coordination, and monitoring of public-funded R,D,C&I projects, conduct studies on technology foresight, set national priority areas and foster interdisciplinary as well as multi-agency research efforts. In addition, overlapping or low-impact programmes can be eliminated. A much needed centralised database on R,D,C&I schemes, grants and research activities can also be established and efficiently maintained through this entity.

Multiple efforts and initiatives should be synergised to nurture a holistic and robust R,D,C&I ecosystem to tackle intertwined challenges that concern people, planet and profit. Only then can we successfully translate public and private investments in R,D,C&I to socio-economic impact in Malaysia.

Recommendation

Measures to build capacity and establish the socio-economic impact of Malaysian R,D&C



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

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

05 STI TALENT

How is Malaysia positioned with regards to our STI talent pool?

"We cannot be on the road to a knowledge-intensive, innovation-led economy without talent to drive it."

Prime Minister, YAB Dato' Sri Mohd Najib Tun Haji Abdul Razak

Talent or quality human capital who are able to use their scientific, technical, conative (know-what, know-how and know-when) and life-long learning skills to promote understanding of science to society; extend boundaries of knowledge; provide pathways towards better, more sustainable life and enhance the nation's economic growth. As such, talent is an imperative that is most fundamental not only in pursuit of science, technology and innovation (STI) targets but to also sustain STI development. Indicators point to a worrying trend that we are lagging in developing, harnessing, intensifying as well as retaining STI Talent at a rate that is required to support our national aspirations and initiatives.

Quality human capital or talent is needed to promote Malaysia's growth and position its excellence in the global marketplace. A national study, S&T Human Capital: A Strategic Planning Towards 2020 (2012), confirmed that the country will need one million S&T workers by 2020. This is based on a 6% projected annual economic growth and the emergence of EPPs (Entry Point Projects) under the National Key Economic Areas (NKEAs) as well as the emergence of new high value-added, technology-driven sectors.

Out of the 1 million S&T workforce required by 2020, there needs to be 500,000 high skilled workers with at least a diploma or university degree. The remaining 500,000 workforce are to have completed a technical or vocational programme aimed at providing support services (Figure 5).

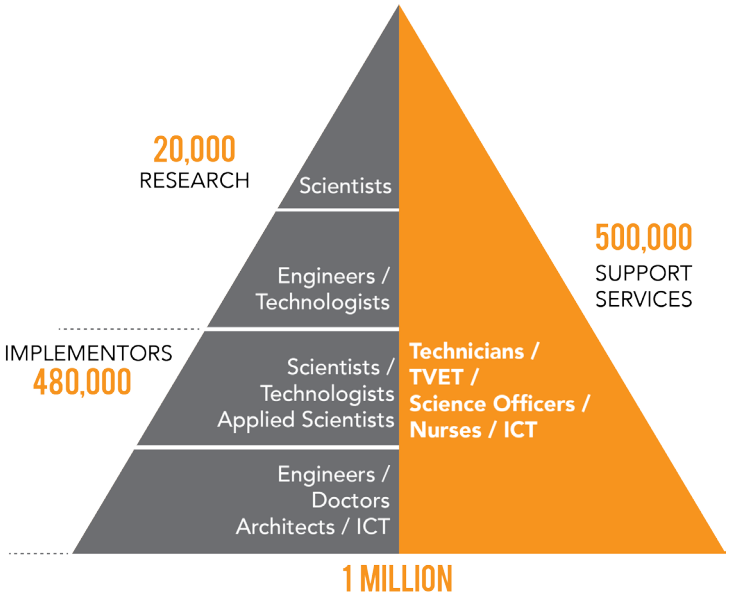


Figure 8. STI human capital quantitative distributions by 2020
Source: MOSTI 2012

In most advanced countries, skilled STEM workers make up about 30% of the total workforce. In Malaysia, the targeted 500,000 skilled STEM workers would only make up 3% of our expected total workforce of 15 million in 2020.

Table 1. Talent juxtaposition of current and targeted cohort size

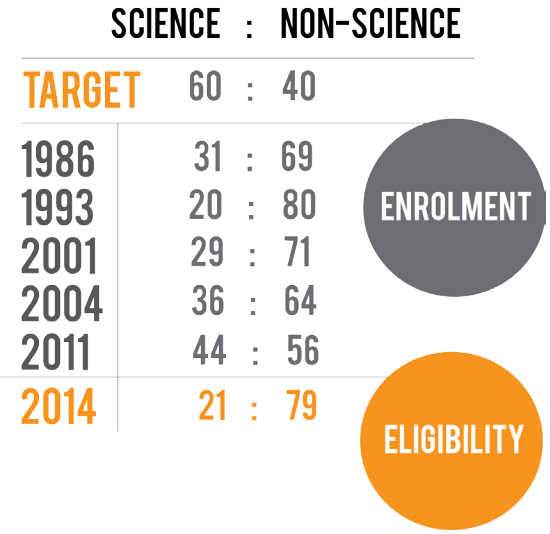
Cohort	2012 (Current)	2020 (Projection)	Advanced Countries
Total Workforce (WF)	13 mil	15 mil	
Skilled WF	29% 3.48 mil	40% 6 mil	
STEM WF	1% 120K	6.7% 1 mil	
Highly skilled STEM WF	0.7% 85K	3% 500K	30% (Average)
RSEs	58 : 10,000 WF (69K RSEs)	70 : 10,000 WF (105K RSEs)	

Source: MOSTI 2012; MOSTI 2013; MASTIC 2014b

Qualified researchers, scientists and engineers (RSEs) are essential to scientific advances, innovation and productivity growth. Malaysia had 58 RSEs per 10,000 workforce in 2012. The 2020 target for Malaysia is 70 RSEs per 10,000 workforce (Table 1). This is well below the OECD countries' average of around 115 RSEs per 10,000 workforce in 2012 (Source: UNESCO Institute for Statistics).

The talent we see in the market place today is a product of 20 or 30 years ago. The supply of STI talents depends to a great extent on new entrants into STI higher education. The target of 60:40 science to non-science students ratio had been around since 1967 and has never been achieved as of 2014 (Table 2). Barely around 20% of our students are currently in the science stream. The interest to take up science and mathematics is rapidly dwindling. If this issue is not urgently addressed to reverse the current trend, Malaysia will not be able to produce the much needed future researchers, scientists, engineers and innovators. As a result, future Malaysians will remain merely as consumers of technology and not transcend to become producers of technology for wealth creation.

Table 2. Science to non-science students ratio



Source: MOE 2012

There are multiple gaps along the entire STEM talent chain from the secondary school level to the R&D personnel level. Despite many efforts and substantial investment in STEM education, there seems to be a decline in interest in science and mathematics, contributing to STI talent depletion. Some of the reasons that could contribute to the declining interest in Science and Mathematics are ad-hoc changes in education policies, the low bar on quality teachers and ineffective STEM teaching methods. Generally, science is not appealing to students due to a teaching approach that is theoretical, textbook-based and examination-oriented.

This also does not help develop higher order thinking skills that emphasise critical and analytical thinking. Something must be done now to inculcate, nourish and develop the interest of students in science and technology. Conventional approaches will not work as many students today tend to be ahead of their teachers owing to a hyper-connected world with ready access to information. These students may also become less and less interested in school unless a conducive ecosystem that stimulates their interest is created to engage and sustain them in the science stream.

Quality of teachers is a very important factor in nurturing STI talent right from the early years. Approximately 41% of science teachers in the country do not possess a Bachelor's degree, with 37.13% holding only SPM/STP qualifications and 3.75% holding diplomas. Additionally, a high number of teachers holding a Bachelor of Education did not have the prerequisites for entering the Bachelor's programme. The requirement for the programme is at least three distinctions at the SPM level, but 70% of those offered a place in the programme fall short of this. Only 3% of the offers went to applicants who were considered to be high-performers (World Bank, 2013).

Many also turn away from pursuing STEM-related careers due to low levels of awareness of the demand for specialised talent, attractive remuneration packages and prospects for dynamic career paths. As Malaysia advances closer to 2020, a natural trend should be increasing job prospects with high-income opportunities in sectors that have traditionally relied on STEM talent as well as emerging and high growth areas such as biotechnology, nanotechnology and environment-related fields. Similar trends have been reported by developed nations. For example, according to the US Department of Commerce, not only are STEM occupations in the country growing faster (at 17%) than others (at 9.8%), but professionals in related fields are earning more (Science Pioneers, 2014). Likewise, in UK, average salaries for graduates in science occupations are higher than those in non-science occupations (Sjoberg & Schreiner, 2005).

The situation is aggravated by an exodus of Malaysian talent. To quote the National Economic Advisory Council (NEAC, 2010), "Not only is our education system failing to deliver the required talent, we have not been able to retain local talent of all races or attract foreign ones due to poor prospects and a lack of high-skilled jobs." Malaysia's brain drain is quite intense relative to a narrow skill base (World Bank, 2013). In 2000, one in ten Malaysians with a tertiary degree migrated to an OECD country – that is twice the world average. The shrinking talent pool would have a negative impact on our productivity and competitiveness. In order for Malaysian talent, to thrive and contribute effectively to the nation, there needs to be a sustained exercise to position the right opportunities and incentives through a rewarding, professional environment. The answer may also lie in intensifying brain circulation through targeted engagement of highly skilled Malaysian talent, wherever they may be based.

When it comes to developing, intensifying, harnessing as well as retaining talent, in particular STI talent, it cannot be business as usual! The way forward would be to endorse the Human Capital Roadmap for Science and Technology for systematic planning and development of STI Talent. The government also needs to take drastic intervention measures to bridge the gap between policy targets and reality through a review of implementation action plans. Finally, there is a need to devise a comprehensive, sustainable action plan to ensure Malaysia is talent-ready for 2020 and beyond.

Recommendation

Developing, harnessing and intensifying talent

- Having a strategic framework that will guide human capital development in S&T services and delivery is essential. The Human Capital Roadmap for Science and Technology 2012 – 2020 (HCRST) which includes a review of the current status of people, processes, technology and culture and the identification of S&T human capital goals and priorities, measurable success factors that will drive the development of an actionable roadmap has already been strategised and documented.

- Drastic intervention measures need to be taken at each domain of the human capital value chain in order to reach the targeted number of 500,000 skilled S&T workforce.

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

04 ENERGISING INDUSTRIES

How engaged are our Industries in existing STI frameworks?

Industries play a paramount role in the national STI framework to transform innovative ideas into commercially successful products and services. As observed by OECD, "business enterprises that thrive on innovation are at the centre of all national innovation systems". This highlights the need to energise industries to foster new economic growth through innovation and commercialisation particularly in high priority sectors of the economy.

The NPSTI has identified and defined ten policy measures to invigorate industries and stimulate productivity and innovation powered by STI. One of the key targets is to increase private sector investment in R&D to 70% by 2020. This is necessary to reduce reliance on the Government and bring industry players to the forefront as investment partners to drive the STI agenda of the nation. Considering that the business enterprises have traditionally been the largest contributor to R&D activities in Malaysia with 64.5% R&D expenditure in 2012 (Figure 9), this may be a realistic target for 2020. The other important aspects addressed by the NPSTI are enhancing industry-driven collaborations, developing knowledge enterprises with distinctive STI capabilities as well as encouraging social, grassroots and prosumer-driven innovation.

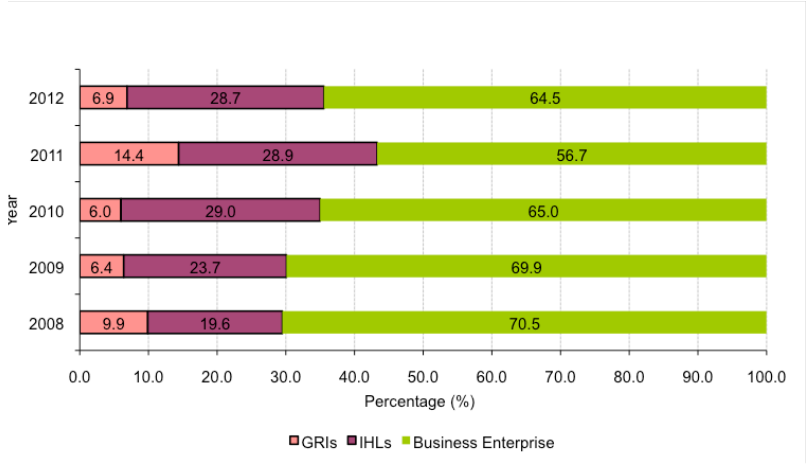


Figure 9. Share of R&D by sector
Source: MASTIC 2014b

Industries should see innovation in a broader sense. Innovation is not restricted to technology and R&D but it is essentially about ideas that are successfully implemented to create new value. Companies that innovate have been reported to grow twice as fast as those which do not. As such, our industries must examine how their businesses can embody 'innovation' in their processes, modules and practices for greater productivity, capacity, pricing and competitiveness.

In this context, the fundamental question is how engaged are industries in Malaysia with the national STI agenda to positively contribute to advancing national priorities. The general trend in Malaysia (as in other developing countries) is that the industry is only receptive to research that provides direct solutions to their business and promises return on investment (ROI). In addition, industries are mainly focused on attracting investments and maximising profits while neglecting to develop indigenous technologies and competencies.

An Industry Perception Audit carried out in 2014 by ASM found that there was poor industry awareness on existing STI policy frameworks, as well as sources and criteria for research funds. Only 36.7% of industry leaders were aware of national policies or infrastructure that supports the industry to achieve local, regional and global growth. The other two-thirds were either not aware of any such policies or were unsure of the policies that are related to them (Figure 10). Further to this, only 29.5% have existing partnerships with any R&D institute or university for product innovations. These findings are consistent with a 2008 survey where the industry viewed clients, suppliers and competitors as top three external innovation information sources i.e. a consumer/demand driven market. Nonetheless, an upward trend of accepting universities as a primary source of innovation information was also observed. This provides opportunities for universities, particularly research universities to effectively partner industry as solution providers for specificindustry needs that require STI interventions.

Figure 10. Poor industry awareness on the existing STI policy frameworks
Source: ASM Industry Perception Audit 2014

Poor awareness of STI policy measures, action plans and incentives prevents industry players from fully contributing or participating in national STI initiatives (Figure 6). Industry is often disconnected with the many facets of the national STI Agenda due to minimal engagement of industry in the very process of strategising national STI policies and frameworks, a lack of effective two-way communication platforms as well as the absence of a comprehensive, national database of relevant STI information for industry reference.

As stated in the Global Innovation Index 2015, innovation is strongly influenced by knowledge-based activities. Malaysia's ranking on knowledge-based workers, innovation linkages as well as knowledge and technology output has fallen from the year 2011-2014. This has also led to weak value realisation from R&D in science and technology. As the knowledge-driven economy takes centre stage, we must examine if Malaysian industries are committed to undertaking R&D with deployment of requisite resources. According to OECD (2013), only 5.5% of firms actively participate in R&D, mainly multinational corporations (MNCs). However, the ASM Industry Perception Audit (2014) found that industry (including Small and Medium Enterprises (SMEs)) preparedness in adopting technological innovation is quite evident from their willingness to allocate funds and undertake R&D. 58.7% of the local firms interviewed have a section/unit/division/department devoted to R&D. 16.0% of respondents foresee an increase in overall corporate spending in research and technology in the next five years. They felt the need to invest in research and technology to ensure a high quality products or services that can be sustained in the long term. In addition, technology will help them increase productivity and save cost.

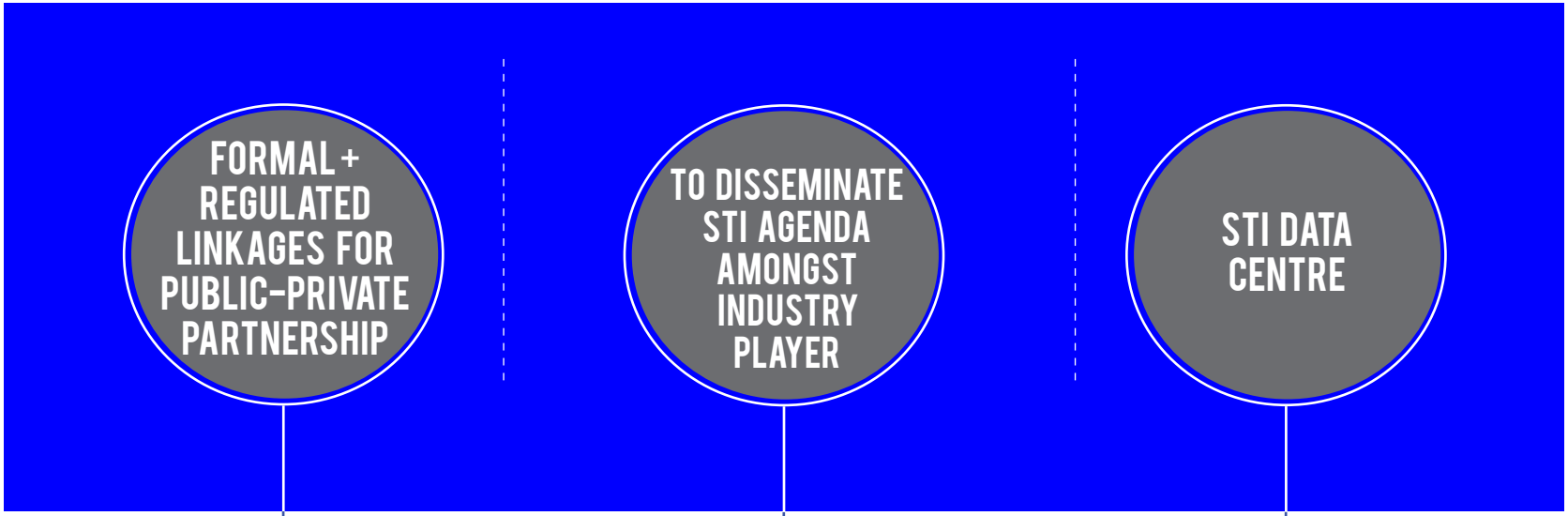
There is merit in understanding what really motivates the business sector or the industry players in general to significantly invest in R&D or STI initiatives. 54.8% of respondents indicated that they have insufficient funds to engage in or outsource R&D. As such one of the primary motivating factors to carry out R&D is availability of public funds for R&D. Industries in Malaysia seem to have an appetite for value creation through R&D and this should be leveraged to stimulate greater investments in R&D and accelerate commercialisation.

The complex challenges in innovation and commercialisation necessitate collaboration. A quadruple helix partnership among Government, research & academia base, industry and community is crucial to drive socio-economic transformation. Such collaborative linkages would facilitate the flow of ideas, knowledge, skills as well as relevant information on enabling mechanisms towards meaningful R&D outputs, innovation and successful commercialisation. For example, researchers cannot be expected to be entrepreneurs because they are not business savvy and lack market knowledge. Business people should be the ones to realise a business plan. However, researchers need the industry feedback in order to ensure targeted research that caters to industry demand.

The current and future success of STI development will largely depend on the extent and quality of linkages between relevant stakeholders and industry. Indeed, such linkages should be established to enable cross-pollination of STI ideas, programmes, investments, resources and outcomes. It is important to strategise effective implementation of formal and regulated linkages for public, private, university and government. There is also the need to have aggressive and continuous information channels to disseminate the focal areas of the national STI agenda to industry players towards enhancing understanding, engagement and involvement.

Recommendation

An ecosystem that will motivate the industry to undertake more R&D and to contribute significantly to the STI Agenda of Malaysia



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

- An awareness and enculturation campaign for the industry using appropriate and innovative ICT channels will help enhance the level of understanding as well as involvement in promoting STI agenda. The industry associations, with measurable KPIs, can educate and mobilise the industry towards creating a better STI ecosystem. This should encompass nominating industry associations as well as successful companies to represent on various policy-making committees, R&D review panels, and consultation clinics of ministries.

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

05 STI ENCULTURATION

Is STI exciting and meaningful to the society?

Today's globalised world is highly demanding and constantly changing. Mega trends and disruptive technologies, fuelled by STI are impacting society at an unprecedented rate. Additionally, mitigation of global risks requires STI interventions. We cannot escape from the significance of science in our world. Being science literate will no longer be just an advantage but an absolute necessity. However, to fully participate and benefit from a knowledge economy, society must transcend from being science literate to becoming science encultured. This would give way to a new mindset that not only welcomes and embraces positive life-changing applications of STI but makes society efficient learners, creators and users of knowledge. Mindset and attitude are paramount because even when equipped with knowledge and skills, innovation may not take place if society remains entrenched in hierarchical structures of command and control, intolerance of failure, turf protection etc. This kind of mindset must be nurtured from birth and continue into adult working life. This would lay a solid foundation for society to transition from being a mere consumer to a prosumer.

The global philosophy of 'Science beyond Scientists' is relevant for Malaysia as it sensitises society to various aspects of development powered by STI. The enculturation of science in society should be pervasive in every strata of society. Enculturation of science in society should be viewed to be as critical as the application of science for development. Hence, we need to strengthen the integration of STI into the mainstream consciousness of society. The Government has introduced various grants and schemes to promote the enculturation of STI among Malaysians. These endeavours in synergy with other factors appear to have brought positive results as interest in STI among Malaysians have doubled in recent years.

78% of Malaysians have expressed interest in STI related issues compared to 19% of Malaysians who were not interested with the rest being uncertain. This is a relatively high level of interest in STI amongst the Malaysian public.

Figure 11. Interest and knowledge on STI issues
Source: MOSTI 2014b

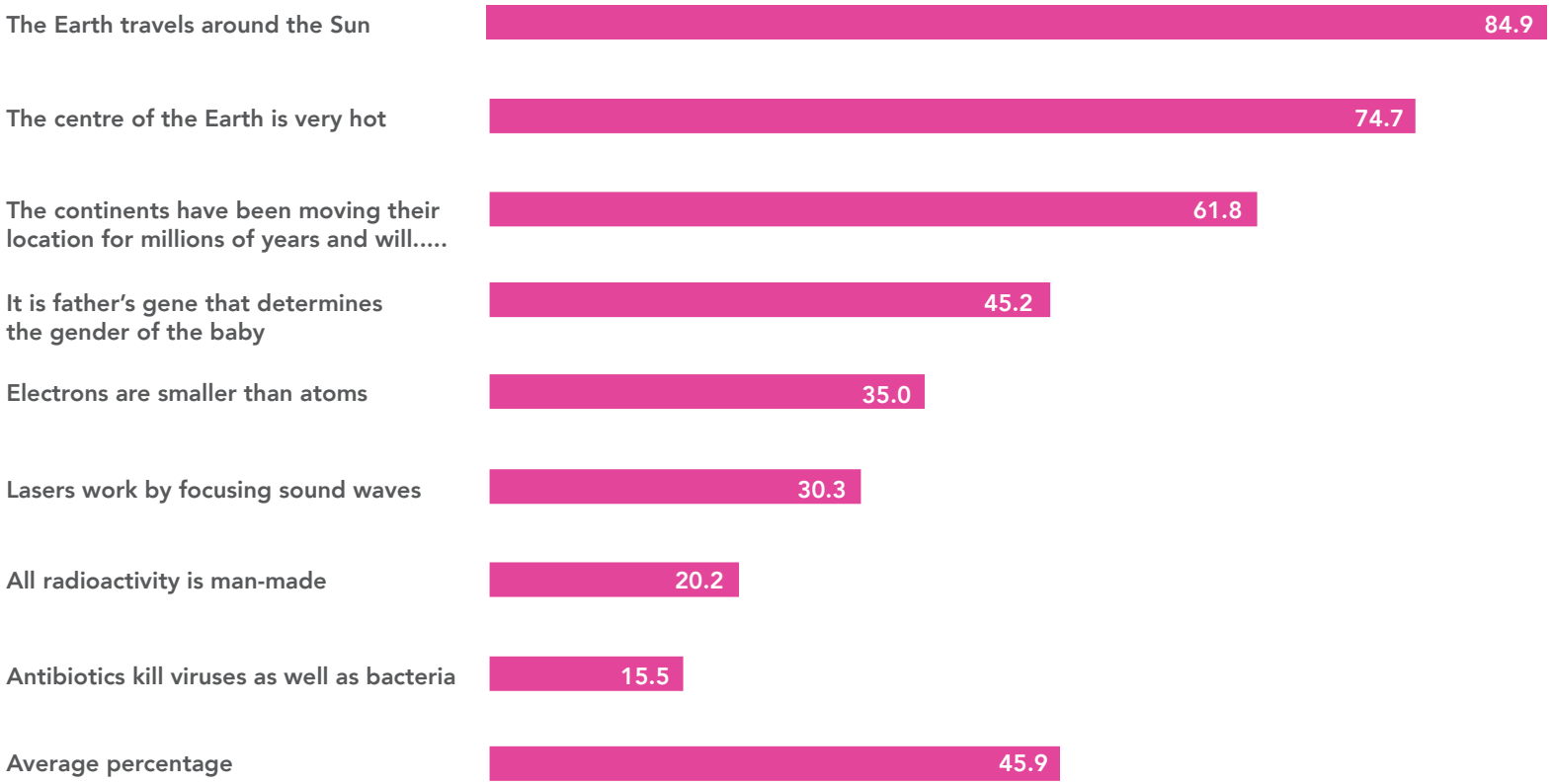


Figure 11. Correct answers to questions on scientific concepts and statements
Source: MASTIC 2014b

However, this interest seems to be temporal, driven by current issues and is not translated into a corresponding level of scientific literacy (Figure 11). In comparison, high STI interest in other developed countries such as USA (89%) and the EU (83%) has been well translated to high STI capacity. Further cause for concern is the low knowledge of STI among Malaysians with only 46% able to correctly answer an STI factual knowledge survey in 2014 (Figure 12). Despite multiple efforts by the government and inculcation through the education curriculum, the public's average knowledge levels of STI has hovered below 50% over the past 16 years (1998 till 2014). This is an alarming trend that must be addressed.

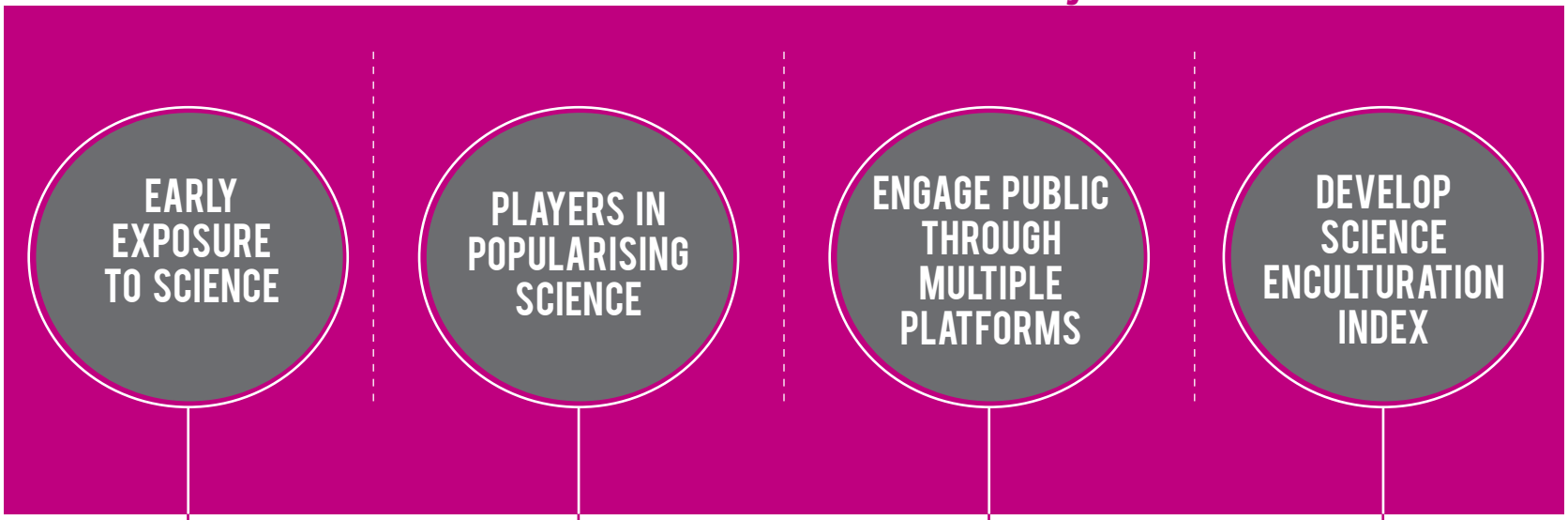
To further step-up the STI enculturation process, since 2013, through the NPSTI, the Government has initiated four measures to popularise STI among the public: Establish an advisory body to guide STI public awareness and promotions; Expand and empower science centres to popularise STI in society; Promote STI among school children, professional bodies and science-oriented societies as well as Conduct outreach programmes to raise awareness on ethics and humanities in society.

There are also several flagship events, programmes and concepts (e.g: National Science Challenge, Petrosains' Volunteer Scheme, Young Inventors Challenge etc.) in Malaysia that were successful in imparting scientific knowledge, enhancing science exploration, innovation and communication amongst the future citizens and professionals of the country. However, these programmes could be even more effective if there is sustained follow through to enhance STI understanding in society beyond merely having a cursory appreciation of technology in their daily lives.

To sustain the process of STI enculturation in the country, a strategic, long-term STI Enculturation Plan should be constructed. This plan should recommend early exposure to science in schools, ways to popularise science to society, and strategies on engaging public using multiple platforms. Such a plan should define the roles of multiple stakeholders (Government, scientists, prosumers, businesses, media, parents and youth, and the society at large) and the platforms for public engagement, including the frequency and the content to popularise science amongst non-science communities. The government should promote enculturation of knowledge-enhancing applications and content for the society to move from being just consumers to prosumers. There is also a need to introduce an STI Enculturation Index to meaningfully measure the level of STI enculturation in society. This data can be used for effective decision making towards influencing intended outcomes.

Recommendation

STI Enculturation Plan to enable and sustain the process of STI enculturation in the country



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

- Such a Plan should define the roles of multiple stakeholders such as the Government, scientists, prosumers, businesses, media, parents and youth, and the society at large, in promoting the cause of science for development.

- The Plan should also clearly define the platforms for public engagement, including the frequency and the content to popularise science amongst non-science communities.

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

05 STRATEGIC INTERNATIONAL ALLIANCE

Can Malaysia tap into global opportunities through strategic STI collaborations?

Knowledge knows no boundaries. In the era of knowledge-based development, science has become a global enterprise. The current global scientific landscape is marked by millions of researchers worldwide, having an increased intensity to collaborate with each other, motivated by the desire to work with the very best people and facilities in the world, driven by curiosity and creativity to discover new knowledge to advance their field or find solutions to specific problems for the benefit of humanity (The Royal Society, 2011). As such, Malaysia must address the question of how international scientific collaboration can be harnessed to tap into global opportunities, position Malaysia strategically in the global STI arena, contribute to the advancement of global science as well as tackle grand challenges that are interrelated in a holistic manner.

The digital revolution has contributed to the scientific world becoming highly interconnected, efficient and effective in the way knowledge and skills are acquired, shared and used. Open learning and open innovation are gaining credence in terms of facilitating cross-fertilisation of ideas, rapid adoption of technology as well as spawning a creative and innovative milieu. Indeed, one of the buzzwords for making progress in the innovation-led economy is collaboration. This calls for comprehensive, well-strategised, flexible as well as inclusive policy frameworks and mechanisms to co-ordinate STI collaborations across international networks. There is also a need to address new ways of measuring and evaluating the deliverables of international collaboration to maximise benefits for scientists as prime movers of collaborations as well as the overall STI agenda of the nation.

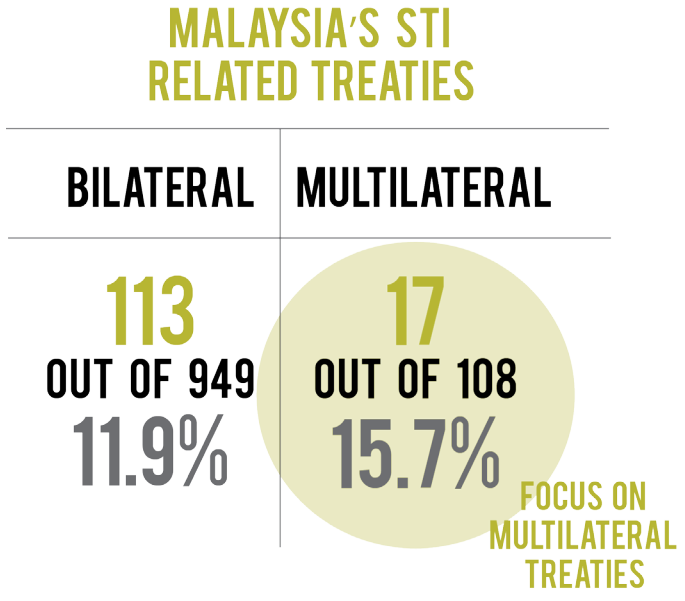


Figure 13. Malaysia's STI-related treaties
Sources: MOSTI 2014; KLN 2014

The need for enhancing strategic international alliances was neither articulated nor highlighted in Malaysia's initial S&T frameworks, at least not until the current policy was introduced. The focus (in the past) was primarily centred on building and strengthening national capabilities and capacity for research, technology and innovation. However, we are now on the right track and in synch with how the world is moving forward. Today, in Malaysia internationally collaborative STI is in many ways encouraged, supported and facilitated. There is evident commitment to collaborate, co-create and foster strategic STI partnerships for socio-economic growth through Memoranda of Understandings (MoUs), agreements and treaties with high-potential partner countries. However, we may not be faring well in terms of strategizing and deriving targeted STI outcomes from the collaborative initiatives. According to the Ministry of Foreign Affairs, Malaysia has signed 108 multilateral treaties but only 15.7% or 17 of the treaties are STI-related (Figure 13). To-date, 26 bilateral MoUs have also been signed between Malaysia and other countries for cooperation in STI. However, there seems to be no evidence on how these agreements have provide benefits related to STI development for Malaysia. These international alliances may be limited to promoting business and trade, as opposed to facilitating meaningful exchange of knowledge, skills, talent or technology. There is a need to establish a formal advisory process for distributing information to stakeholders regarding benefits and opportunities arising out of such agreements.

Malaysia as a developing nation, has been a member of several high profile multilateral organisations or platforms such as the United Nations (UN), Organisation of Islamic Countries (OIC), Commonwealth, APEC and ASEAN just to name a few. Participation in these platforms has helped the nation to contribute effectively in various global policy deliberations and international agendas. This has positively impacted Malaysia's position in the competitive regional and global marketplace. However, robust participation and contribution must also be spearheaded in the global STI platforms. In this context, effective positioning of Malaysia's STI knowledge, competencies & infrastructure is needed to be considered as a strong potential partner in the regional and global arena. For example, Malaysia should focus on highlighting our STI capabilities and establish linkages with ASEAN and emerging economies such as MIST (Mexico, Indonesia, South Korea and Turkey) and BRICS (Brazil, Russia, India, China and South Africa).

ASEAN leaders have long since recognised science and technology (S&T) as a key factor in sustaining economic growth, enhancing community well-being and promoting integration in ASEAN. This is evidenced by the Krabi initiative mooted in 2010 that outlines strategic directions for a competitive, sustainable and inclusive ASEAN. The regional integration of the 10 ASEAN member countries into a single market under the ASEAN Economic Community (AEC) in 2015 is certainly a big opportunity for Malaysian industries to strategically position themselves and highlight their STI competencies.

ASEAN has a combined population of approximately 625 million people or 8.8% of the world's population. In 2015, ASEAN's combined nominal GDP had grown to more than USD 2.6 trillion. ASEAN is projected to rank as the fourth-largest economy by 2050. ASEAN is an economic powerhouse that is making great strides in enhancing its productivity. In addition, ASEAN is a growing hub of consumer demand. Herein lie tremendous opportunities for STI. However, ASEAN is clearly not a homogenous group as it has great variance in the level of STI capabilities among Member States as well as great diversity that extends to culture, religion and langauge. Therefore, there is a need for enhanced collaboration and more platforms for collective action to fast track competitiveness. Capability for technological innovation is one area where ASEAN needs to improve its standing. Effective collaboration would enable us to avoid competing with each other in the same areas. Instead, we can complement each other's strengths and compensate for each other's weaknesses.

In the case of MIST and BRICS who are members of the G20 (an international forum for the governments and central bank governors from 20 major economies) and comprise a mix of the world's largest advanced and emerging economies, an analysis of socio-economic indicators shows that Malaysia is on par. As such Malaysia should identify synergistic opportunities with MIST and BRICS to upgrade STI capabilities and tackle common issues that require STI interventions.

The way forward to strengthen international strategic alliances is to increase well-strategised, STI-focused international alliances to gain better benefits at the individual country level, intra ASEAN level as well as international level. Considering the multipolar scientific world, for greater impact, multilateral partnerships should be prioritised as emphasised in the "Knowledge, networks and nations: Global scientific collaboration in the 21st century" report by the Royal Society UK.

Scientists should be positioned as torch bearers to drive international scientific collaborations towards acquiring, sharing and utilising knowledge that resides anywhere in the world to connect the scientific community and their endeavours meaningfully.

There must also be concerted effort to target strategic partners for STI collaboration on an international scale. The basis for targeting such partners cannot be confined to only the researchers or government goals but in the best interest of advancing the nation's STI agenda. Attracting strategic partners would of course require the right projection of STI capacity and capabilities to potential partners at various international platforms.

Recommendation

Identifying and establishing practical models for strategic international alliances

- STI-focused international alliances such as the following should be increased to gain better benefits:
  i. Individual Country (Inter-Ministries): Partner with respective ministries from various countries and develop a comprehensive engagement plan.
  ii. Intra ASEAN – MOSTI to MOSTI equivalent: Define development strategies for Intra- ASEAN collaborations.
  iii. International (ASEAN-Rest of World): Develop ICT and mobile engagement platforms that will allow the ASEAN scientific community to engage with Malaysian STI stakeholders.
  iv. Scientists as Torch Bearers: Establish multilateral linkages with global research institutions, technology houses, innovation hubs, STEM talent and experts.

- Cross-border STI alliances with strategic partners such as ASEAN, BRICS and MIST can be pushed as:
  i. An investment with clear economic benefits for the stakeholders involved;
  ii. Corporate Social Responsibility; and/or
  iii. A technology transfer programme (as part of a larger trade deal).

CONCLUSION

The Science Outlook has reviewed the six strategic thrusts of the NPSTI, taken stock of Malaysia's performance thus far, identified gaps and forwarded eighteen recommendations to mobilise action in critical areas. The key takeaway messages are firstly that STI inputs and interventions should not be seen just as a precursor to policy development or as a support for decision making, but must be an integral part of the whole ecosystem of policy implementation towards meeting set targets. Secondly, STI must converge with economics and finance, geopolitics as well as society and culture to fuel a robust ideation process for socio-economic transformation. Thirdly and most importantly, we must adopt transformative thinking, integrated planning and inclusive implementation to mainstream STI in national development.