A Conceptual Framework for Science, Technology and Innovation Driven Sustainable Development and the Role of ESCAP

1. Overview of the Paper

This paper describes a conceptual framework for understanding the role of Science, Technology and Innovation (STI) in the evolving sustainable development challenge. It develops the key concepts behind STI and draws linkages between STI and the sustainable development goals, identifying some of the key challenges in strengthening STI capacities in ESCAP Member States. Lastly it sets out a pathway for ESCAP to increase its efforts in driving STI-driven sustainable development in response to the new global development agenda for the Post-2015 era.

2. STI and Development

It is difficult to imagine the modern world without technology. Almost all products, processes and services serving the needs of people embody some kind of technology. Technology continues to evolve and develop in sophistication with the globalization of economy, technology and society. STI has been a core driver of the development process to date and addresses emerging national, regional and global developmental challenges across many sectors. Annex 1 provides some useful and broadly understood definitions of Science, Technology and Innovation.

Technology can be acquired through transfer or indigenous development. Both require knowledge and skills embedded in the institutional and human resources. Whereas technology transfer requires know-how skills to acquire, adopt and utilize the technology effectively, technology development requires deeper levels of know-why, knowledge and skills. Technology utilization requires skilled workers, while technology absorption and technology development requires resilient STI infrastructure that include engineers, high quality academic institutions, R&D institutions, industries and others. Technology transfer, especially in modern manufacturing and cleaner production, can be expensive and sophisticated that involves trade and/or investment. Transfer of technology can take place through foreign direct investment (FDI) or through licensing (import). But FDI does not automatically result in technology transfer or in the transfer of the required or suitable technology, while licenses are not easy to obtain from the owner of the technology and are expensive.

IPR issues play an important role in this regard and form a significant obstacle to technology transfer. It can also form an obstacle to technology development which often relies on the analysis and reverse engineering of existing technologies. The WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) that provides a framework for IPR protection has significantly strengthened the international regime for IPR in recent decades. However, most of
developing countries have limited capacity to make use of certain provisions of TRIPS such as compulsory licensing and defining national patent eligibility as market forces appears to dominate or prevail over the national development objectives. There has also been a proliferation of regional and bilateral trade agreements and bilateral investment treaties with even higher standards of IPR protection.

While R&D outputs are ideally expected to become commercially viable technologies, in most of the developing countries they would end up at the laboratory- or pilot- or demonstration-scale due to fragmented STI capabilities at various levels and most of R&D is carried out by public institutions without or only having limited knowledge of the market. Innovations are important as they may improve the effectiveness of existing technologies and find new practical applications of such technologies. However, since innovations are often linked to existing technologies, the contribution of technology innovation to achieve national development agenda in many countries has remained elusive. This is often linked to due to limited STI infrastructure, ranging from education to technology innovation financing and a fragmented technology innovation ecosystem. It is also important to note that though large developing countries have emerged as world leaders in clean technology production, export and use, most of the developing countries try to obtain the technology through copying (sometimes illegally), reverse engineering or by incorporating the transfer of technology as a requirement for investment. In the long run, however, there is no substitute for the development of sound STI infrastructure, indigenous R&D capability, innovation and technology development of capacity in selected technologies or technology domains in the current setting of technology globalization. This should therefore be at the forefront of national development strategies and planning.

With regard to innovation and business, it is important to highlight the role of small and medium-sized enterprises (SMEs) as a key driving force of the modern market economy due to their multifaceted approach to innovation\(^1\). SMEs have proved that they are the cradles of major innovations, some of which famously originated in garages. Innovation is considered as a key enabler of competitiveness and growth of SMEs and hence their innovation capacity plays a critical role. To maintain SMEs' innovation capability requires the promotion of advanced technology transfer and acquisition, and the conduct of research and development. Successful commercialization and utilization of technology is a hallmark of SMEs; however, SMEs are not homogenous in terms of their technological and business attributes. Different SMEs need to have different strategies for enhancing their innovation capability. Also, most SMEs, particularly in the developing countries, do not engage in R&D as they simply do not have the resources for it.

While innovation and technology development are important for the business sector to remain competitive, they are important at the macro level as well for any country to thrive in the long run. It is also important for countries to align their innovation and technology development policy and strategies with their national development goals. For instance, the emergence of new diseases requires the development of new medicines (e.g. anti-biotics or vaccinations against viral diseases such as Ebola or HIV) either from public or from private sources. Where the market incentive is lacking for business to be active in this area, governments have to step in to provide the necessary policy environment. Innovation is generally required in the way public goods and services are delivered, for instance the way people are educated and trained, or connected through ICT. Innovation is therefore not strictly speaking only a private sector requirement but a national requirement that needs the active cooperation of public and private sector, with learning and academic institutions resulting in effective national innovation systems (see Figure 1). Successful national innovation systems (NIS) ensure that innovation not only takes place in

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\(^1\) For examples see JSBRI, 2009.
accordance with national development priorities but that it results in concrete improvement in people’s living standards. For the business sector, a viable NIS can provide necessary environment to make innovations successful as well as commercially viable and profitable.

In summary, new and emerging scientific and technological advances have created evolutions in innovation processes, and technology (and the associated human capital) is a primary enabler of innovations in enterprises.

3. STI for Sustainable Development

Innovation and technology development are also required to enhance the sustainability of products and services, not only through their application (for example renewable energy technologies such as solar photovoltaic panels) but also in the way they are produced (sustainably). Embracing sustainability therefore requires substantial changes in the way people think, act, produce and consume. Many of these changes either constitute or require innovations not only in the commercial sector but across the board to achieve Sustainable Development Goals (SDGs) and implementing the post-2015 development agenda. STI indeed touches on virtually every proposed SDG and has a cross-cutting role to play in addressing the interconnected challenges of sustainable development and providing effective solutions to the emerging problems of a post-2015 world. Major challenges faced by the world today, such as emerging diseases and resistance of microbes to treatments of diseases, climate change mitigation and adaptation, disaster risk reduction and disaster management, improving global and regional connectivity, increasing food production with dwindling arable land and rising populations, increasing access to safe drinking water, sanitation and hygiene, to name a few, all require the development of new technologies, production methods and understanding of systems and life cycle analysis.

While there is a strong link between the concepts of science, technology and innovation, it is important to clarify the interrelationships and stakeholders in order to arrive at a coherent national and regional strategies and national policy frameworks which promote STI for sustainable development. In this context, the prevailing challenge is to develop and govern dynamic policies, institutions and processes that increase national capabilities not only to develop, access and adapt appropriate technological innovations, but also to leapfrog in new and emerging technology areas.

Since SDGs will be the key indicators of progress in the years to come, it is important that STI strategies are aligned with SDGs and plans for achieving SDGs take into account STI strategies. While most countries do understand the importance of STI and higher investment in STI they lack the capacity to translate the outcomes of STI investments in terms of SDGs. On the other hand for many countries including India and China, STI policy is part of the national developmental strategy. So linking SDGs with STI policy is not an easy task given the orientations of the STI policy. Another challenge is that most SDGs require policy frameworks to be applied in multiple areas and STI policy can play a part as one among the policies except in specific goals and targets that are related to STI. For example, while biodiversity is a scientific topic, there is more to conservation than simply science and in biodiversity conservation is not often constrained by the lack of scientific knowledge or policy. Other factors play an important role and this includes

land use, trade and state control over forests. Hence while STI policy and strategy can play an important role, their effectiveness is limited by other factors.

To address the sustainable development challenges, national STI capacity building efforts in the Asia Pacific region – with specific reference to the least developed countries (LDCs), the land-locked developing countries (LLDCs) and the Pacific island countries (PICs) – could focus on promoting low-cost “pro-poor” innovations that are based on locally available resources. These efforts would require vital support in terms of enhancing the countries' capacity in training and skill development in a number of technology areas relevant to sustainable development. There is also a need to explore new and innovative mechanisms for financing and implementing STI partnership initiatives for sustainable development projects in LDCs, LLDCs and PICs in the region.

In the Asia-Pacific region, STI can be used as an enabling mechanism to address priority developmental challenges through developing technological solutions to these challenges. Some of these barriers to developing sound STI include: weak and fragmented national STI policies; lack of STI statistical data and knowledge base for evidence-based policy making; poor STI mainstreaming in development policies and strategies; conventionally used top-down approaches for STI policy and planning; poor interlinking and networking among National Innovation System (NIS) components and stakeholders and limited access to intellectual property in core areas of sustainable development.

4. Strengthening of National Innovation Systems

The concept of ‘National Innovation System (NIS) refers to the complex and interactive web of knowledge flows and relationships between industry, government and academia and making them work systematically to sustain innovation and science and technology development efforts. The innovative performance of a country depends to a large extent on how these NIS actors relate to each other as elements of collective system of knowledge creation and use, as well as the technologies they use.  

NIS can consist of Sectoral Innovation Systems (SIS), which are closely associated with a specific sector or industry. This may also include other sectors or technologies since inter-sector boundaries are ‘porous’ and one technology can impact many sectors or technologies. Often NIS is linked with regional and global innovation systems and is also influenced by them. In some cases within a country there can be a strong regional innovation system (RIS) that caters to global markets and with linkage to global innovation system. In case of Asia-Pacific, it has been suggested that a comprehensive and inclusive Asia-Pacific Innovation System can contribute to inclusive growth and economic integration. A regional innovation system consisting of innovation clusters and Exclusive Export Zones can be a strategy to attract FDI, enhance competitiveness and absorb the technology acquired through transfer.

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3 http://www.oecd.org
4 Wenying Fu Towards a Dynamic Regional Innovation System: Investigation in to Electronics Industry in Pearl River Delta, Springer 2014
While there are many common elements in NIS, SIS and RIS, the major difference is in the boundaries of the system. NIS is limited by national boundaries, RIS by the borders of the region and SIS by the boundaries of that sector; however, in this globalized world the borders and boundaries of innovation systems are porous and permeable.

Figure 1 shows the NIS concept in some details with the inner ring constituting the institutions and policies directly involved in scientific and technological innovation. The outer circle shows a “broad” NIS perspective, which takes into account the economic, social and political environments of the country examined. As STI cuts across the work of various ministries, effective coordination among government ministries and agencies in advancing and mainstreaming STI for development is called for to ensure policy consistency and coherence.

Figure 1: Elements of a national innovation systems

Source: OECD (1999)
The following flow diagram was developed by ESCAP’s regional institution the Asian and Pacific Centre for Transfer of Technology (APCTT) was used to promote the concept and strengthening of National Innovation Systems in the Asia-Pacific Countries.

It is important to understand as to how strong or weak the interlinkages are between the various NIS actors and how effective is the flow of knowledge and resources across the sectors. A clear understanding of the linkages between the actors involved in innovation would lead to improving technological performance. Creating and implementing a responsive NIS requires a holistic policy design and formulation that fosters and encourages collaboration and partnerships among firms, and between public and private institutions. These collaborations and partnerships are increasingly becoming international, regional and global in the current context of globalized technology and economy. Therefore, it is essential to diagnose or evaluate the quality and efficiency of an NIS by conducting evidence-based studies to understand the strengths and weaknesses of various components of NIS and evolve an informed policy decision and implementation mechanisms. Good analysis of an existing system can provide useful information for policymakers in planning changes to, and strengthening the existing science, technology and innovation (STI) systems and strategies relevant to the evolving national context and development objectives.

http://nis.apcctt.org/asia-pacific-summary-of-presentation.html#germany
5. National STI Policies and Strategies

STI has been recognized as a means of implementation of the post-2015 development agenda and SDGs. It should therefore figure prominently in developing countries’ development plans and strategies. The following are some of the important areas where governments can influence the development, promotion and utilization of STI to achieve their national development goals.

a) **Education**: Successful STI depends on the availability of a quality education system, from elementary (or even kindergarten) through secondary to universities and vocational schools and facilities for life-long learning. Though the private sector plays a prominent role in the area of education in some countries and many businesses provide on-the-job training and learning-by-doing opportunities, education is essentially a public good and should be open and accessible to all. Education is not only necessary to develop the human capital to undertake R&D and develop new technologies, it is also essential to develop the skills to properly utilize, adapt, assimilate and diffuse technologies. Public spending on education varies widely across Asia-Pacific countries. For fewer than 30 countries in the region with available data for the period 2011-2013, only one third of them made public expenditures on education at or above 4% of their GDP. However, these figures mask the actual access to education by the population at large and do not reveal the impact of income and gender inequalities and geographical disparities on education access and quality of education received.

For instance, according to the ESCAP Statistical Yearbook 2014, less than two thirds (64.7%) of the children in the South and South-West Asia subregion in 2011 completed their primary education. In addition, the figures do not say much about the general quality of education. For instance, the education system in Thailand is generally considered to be substandard despite the apparently high level of public spending on public education. The quality of education depends on the quality of teachers and professors, the natural interest and motivation of young people to learn, the value society puts on education and knowledge and the availability of the hard infrastructure (i.e. schools, universities, labs, R&D institutions, science parks, libraries, museums, etc.) that enables and promotes learning. Countries that have more of all that will also have a superior education system that delivers superior results. Those countries also perform better in the area of R&D and, hence, national and international competitiveness. However, improving a country’s education system is a long-term goal as it often requires a shift in attitude, mind set and resources.

b) **R&D spending**: Educated citizens will be more capable to engage in R&D which is essential for technology development and strengthening national competitiveness. Based on available data spanning the period from the mid-1990s to 2012, total investments in R&D increased drastically across Asia and the Pacific. For instance, the amount of such investment more than doubled in Australia and the Russian Federation and more than tripled in India, Republic of Korea, Singapore and Turkey. However, public spending on R&D in most Asian-Pacific developing countries remains well below par compared with developed countries worldwide. Increase in R&D expenditure without national R&D strategies and priority areas, availability of quality researchers and facilities will do little but only result in wasting public resources. The largest spenders on R&D in the region are also among the most developed or most rapidly developing countries (e.g. China, Japan,
Republic of Korea, Singapore) but evidently these countries were able to translate higher spending into high quality results.

c) **R&D in private sector:** In technologically advanced countries, most of the R&D, technology development and innovation stem from the private sector. Therefore, governments need to stimulate the private sector through providing an overall enabling business climate for promoting technology innovation. This includes the assurance of fair competition through anti-trust policies and legislation, and the overall promotion of competition in the economy through promoting inward FDI and import liberalization. Continued protectionism of domestic industries (including the so-called “infant” industry protection) stifles competition and generally does not lead to the development of an innovative economy. Apart from the competitive pressures it puts on domestic industry, FDI also helps in transferring technology and especially skills (its workers learn by doing and working with new technologies) apart from the tax revenue it generates that can be used for public spending on education and STI development. Successful technology transfer also depends on liberal trade and investment policies. Hence, countries with open trade and investment regimes generally also have higher levels of innovation and development.

d) **Entrepreneurship development:** Innovation is not merely dependent on science and technology development. It also depends on the overall level of creativity found in any society or economy. People without scientific knowledge can still be very innovative. Everywhere there are people with excellent ideas and who are creative. However, they need to be enabled to use that creativity and their good ideas and translate them into workable methodologies for “doing things better” or commercially viable products or new practical approaches and processes that improve the quality of life. Countries that have a culture promoting entrepreneurship do generally better in the area of innovation also (coupled with competition). Entrepreneurs often start small (the “garage” entrepreneur) and hence, SMEs require special attention. Governments can help SMEs with start-up capital (venture and working capital), tax incentives, preferential procurement and the overall provision of infrastructure. In this context, the establishment of science parks and incubator programmes for SMEs with the government assisting in providing technology, financial and infrastructure support goes a long way in promoting technology development and innovation. Governments can also strengthen the financial system for lending to SMEs and promote venture capital and the use of capital markets for raising investment capital. They can organize fairs and exhibitions, both physical and online that allow investors to meet budding entrepreneurs. A good example in this respect is the recently established Myanmar SME Link by the ESCAP Sustainable Business Network.

On the one hand, governments also need to reduce the red tape associated with start-ups and requirements for operating a business and simplify the number of licenses and tax requirements. On the other hand, governments should not relax but rather strengthen requirements for sustainability. In fact, such requirements help companies to be more efficient and competitive as long as they are enforced on a level playing field and, in the long run, such requirements benefit society at large.

e) **Collaborations and partnerships:** It is important to point out that creativity and innovation can only be enhanced in a culture that favours the free flow of information and ideas. Information and sharing of ideas help people be innovative and provide fresh perspectives, including ideas on how to “do things in a different way” to achieve superior results. It also stimulates people to work together and pull resources to make an idea work and lead to commercial success. It is therefore required to encourage collaborations and partnerships
among different components of a national innovation system, such as between firms, and between public and private institutions. The governments need to pull all policies together and promote partnerships and cooperation among all STI stakeholders, i.e. government itself, the private sector, academic institutions, R&D institutions and facilities etc. and develop such partnerships into viable national and subnational innovation systems. These collaborations and partnerships are increasingly becoming international, regional and global in the current context of globalized technology and economy.

f) **Mainstreaming open innovation in STI:** The concept of ‘Open Innovation’ is being increasingly used as a policy and management tool by technologically advanced enterprises and organizations to sustain and grow in the globalized economy. Open Innovation enables enterprises to achieve competitive advantage by combining and utilizing both internal and external ideas and competencies. Through this approach, SMEs and R&D institutes can get vital support to further their innovation capability in many ways: networking and interaction with other companies, sharing of R&D facilities, setting up of new technology ventures, partnership with universities as well as sharing and accessing information and technology.

Mainstreaming of open innovation in national STI policies could be used to bridge the gap between innovation and industrial applications. NIS diagnosis exercises should therefore aim at identifying policy mechanisms and instruments that promote open innovation to bridge this gap and to reduce barriers and facilitate technology development and commercialization both in the private and public sectors. The recent STI Outlook 2014 from OECD points out the increasing importance of Open Innovation in innovation initiatives and states: "In today’s complex and highly competitive global market, companies have to adopt new approaches to innovation and engage in new modes of collaboration. While firms traditionally seek to retain their core capabilities, open innovation may offer a faster and less risky route to diversification than internal development. The balance between internal and external sources of innovation is shifting, and innovative activities are increasingly organized across firm boundaries".\(^7\) In the context of sustainable development, the open innovation approach is being considered important for addressing many of our challenging technological, environmental and economic problems.

g) **Intellectual Property Protection:** Governments need to strengthen their IPR regime and legal framework. Developing countries have a tendency to view IPR as a protectionist agenda of developed countries that restrict their access to technology and they are right up to a point. However, IPR can help and motivate domestic entrepreneurs and scientists to develop new products, technologies and services as well and should therefore promote technology development rather than technology transfer. As mentioned above, successful technology development has a longer-term impact on a country’s overall innovation rate and economic development.

h) **Mainstreaming gender in STI:** Gender imbalance is known to exist in science, technology and innovation worldwide with significantly less number of women in primary and secondary schools, universities, laboratories, teaching and decision making. There are consistently low levels of women in the skilled technology workforce in the private sector, with even fewer females in senior management and as leaders of large companies.\(^8\) The United Nations has underscored the importance of gender equality and mainstreaming of

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\(^7\) OECD STI Outlook 2014 P 73  
gender in national development processes. The Millennium Development Goal (MDG) 3 focuses on promoting gender equality and empowering women while other MDGs also contributed towards this endeavor. Gender equality and women’s empowerment was also one of three key topics on the agenda for the eighth session of the Open Working Group (OWG) on Sustainable Development Goals, which met last week at UN Headquarters to discuss the post–2015 development agenda.9 This OWG session gave extraordinary support for a specific goal for post-2015, with more than 100 Member States expressing widespread support for a stand-alone goal on gender equality, supplemented by cross-cutting gender targets in all other goals. Accordingly, an exclusive goal – SDG 5: Achieve gender equality and empower all women and girls – has been included in the proposed seventeen SDGs.

Since STI is being considered as critical for countries to achieve the sustainable development goals (SDGs), mainstreaming of gender in the STI-driven sustainable development process becomes extremely important. Unless women participate in significantly large numbers in the national STI processes, achievement of SDGs will remain a distant reality. The Asia-Pacific region is home to about 60 per cent of the world’s population and even though women constitute 50 per cent of Asia-Pacific’s total working age population, their participation in formal employment is uniformly lower than that of men.10

According to an UNCTAD paper,11 the following three elements are key to gender mainstreaming in effective STI policies:
1. Promoting and leveraging S&T to support women's development (“Science for Women”)
2. Promoting gender equality in science, technology and engineering education, workforce and leadership (“Women in Science”)
3. Encouraging and supporting the role of women in innovation systems at national and grassroots levels.

6. The Regional Dimension of STI and South-South Cooperation

The achievement of the SDGs will impose enormous challenges to the world at large and cannot be achieved without major technological advancements. With rapidly rising populations in developing countries, dwindling arable land as a result of erosion, overuse of pesticides and the effects of climate change, emergence of new diseases and rising resistance of microbes to treatments for existing ones, the challenges to reduce poverty, hunger and greenhouse gas emissions, to name a few, require solutions through STI. Progress is being made but may not be fast enough to face the formidable problems the world faces. Already, many countries in the Asia-Pacific region are among the most innovative worldwide.

However, although new consumer products continue to flood world markets, technological breakthroughs are not proceeding fast enough to face the formidable problems the world faces. Three examples of problems of a pressing kind can be mentioned here: (1) the need for new antibiotics and vaccines against diseases such as HIV, Ebola and Malaria; (2) the ever growing threat of climate change and the economic costs involved in reducing greenhouse gas emissions necessary to mitigate the effects of climate change; and (3) disaster risk reduction and coping with the aftermath of disasters, including rehabilitation needs. Vast increases in R&D spending on solutions for such problems are needed. Not all solutions make commercial sense and therefore

10 http://www.unescap.org/op-ed/empowering-women-smart-approach-sustainable-development
one cannot solely rely on the private sector to address all the problems faced by society. Given the scope of the challenges affecting all countries, no one country by itself will be able to find solutions and, therefore, cooperation among countries and all stakeholders at all levels is called for, both at the global level and the regional level, in particular in the area of STI. Regional and South-South cooperation (SSC) in STI has gained momentum in the recent years which can be attributed to various reasons such as:

1) Emergence of technological capacity in the South particularly in countries like Brazil, South Africa, Republic of Korea, China and India;  
2) Increase of the share of high technology from and within South particularly within regions;  
3) Emergence of blocks and groupings such as IBSA, BRICS and BASIC;  
4) Increased STI expenditure in South has created capacity to enter into cooperation and benefit from it; and  
5) As collaborations in STI are increasing and IT is becoming more globalized SSC in STI also part of this trend.

Some of the potential areas of regional cooperation are: pooling of financial and human resources, establishing exchange programmes of students and professors among universities, joint cross-border research, networking of research institutions, joint R&D among businesses, establishment of cross-border or subregional science and technology parks and incubators, promoting free flow of information across countries, facilitation of cross-border movement of educators and researchers, facilitating technology transfer among developing countries of the region through technology banks and fairs, etc. Regional cooperation would pull the different competitive advantages of different countries. For instance, some countries have superior infrastructure while others have superior knowledge or skills in particular areas. All these forms of cooperation are already ongoing in some form or another but perhaps not sufficiently given the challenges. Already, various (sub)regional organizations in Asia-Pacific exist that can be utilized for this purpose. Among them, ESCAP is well placed to forge this cooperation through various modalities based on its region-wide mandate.

In the context of Asia-Pacific, the presence of Republic of Korea, China and India should have resulted in more and strong SSC cooperation but it has not happened to the desired extent although these countries are cooperating with many developing countries and LDCs in the area of STI. Regional STI capacity building can be part of Science Diplomacy or part of Overseas Development Assistance. However Science Diplomacy has not been effectively used by South to build a comprehensive STI cooperation and efforts are often targeted at specific sectors than to build capacity in STI. Given these factors it will be desirable to assess the current status of STI capacity building activities in the region and explore the role of SSC in STI capacity building. To begin with the current SSC in the region in STI should be studied and whether the SSC has been successful in capacity building in STI. It is possible that SSC might have worked well in some sectors but not in STI capacity building and some of the initiatives in STI capacity building might have had a narrow/sectoral focus that has helped build capacity in some sectors while the overall STI capacity may be weak.

Need for strategic interventions: The challenges as outlined above are considered particularly critical for the developing and least developed countries of the region in their efforts to achieve sustainable development goals. The Commission could foster STI-driven sustainable development in the region by enhancing capacity of Member States through a multi-pronged strategy including:

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12 Xiaolan Fu and Luc Soete (eds) The Rise of Technological Power in the South, Palgrave 2010  
13 World Science Report 2010
7. The Role of ESCAP

As the regional arm of the United Nations, ESCAP is strategically positioned to assist Member States in achieving SDGs through STI and technology transfer capacity building in the relevant sectors underlined by the post-2015 sustainable development agenda. ESCAP can promote research, regional cooperation and capacity building in trade, investment and energy required for development of STI through its existing programmes on trade facilitation (UNNExT) and through forums such as the Asia-Pacific Trade Facilitation Forum, Asia-Pacific Business Forum and Asia-Pacific Energy Forum. Through its convening power, ESCAP is probably the best organization in the region that can convene all stakeholders for this purpose. These platforms provide useful opportunities for policy makers, researchers, NGOs and the private sector to exchange ideas and identify common solutions to overcome constraints and utilize capabilities of all stakeholders effectively and efficiently. Such forums are also necessary to develop both national and (sub) regional innovation systems involving all stakeholders, and hence, the organization of an annual Asia-Pacific multi-stakeholder STI Forum could be considered, while the Asia-Pacific Business Forum 2015 or 2016 could focus on the role of business in STI.

A ministerial conference on STI every four years could also be considered. Such forums would also play an important role in policy advocacy in the area of STI. Special awards could be granted to outstanding organizations or individuals who have successfully developed new ways of thinking, doing, organizing or delivering a product or service, developed new technologies or found new uses for existing technologies or have been innovative in any other way.

Generally, the role of ESCAP in the area of STI can be articulated in four dimensions:

i. Fostering STI for sustainable development,
ii. Strengthening technology transfer capacity,
iii. Nurturing new and emerging technologies and
iv. Promoting technology intelligence.
i. Fostering STI for sustainable development

The critical evaluation of the NIS of a country is imperative in understanding and improving the complex and interactive relationships among key actors of an NIS such as industry and business, research and development (R&D) institutions, government, and academia. This evaluation can increase the effectiveness of the NIS to drive STI development. However, many ESCAP Member States undoubtedly face challenges in deploying STI for inclusive and sustainable development. These may include subcritical resource allocation, lack of skills, ineffective policies, delivery and support mechanisms and weak inter-ministerial coordination. In order to re-engineer, enhance effectiveness and bring cohesion among various policy measures, there is a need to promote benchmarking and adopt best practices among the ministries and institutions within and across countries.

ESCAP can draw on its multi-disciplinary expertise to outline and identify linkages between STI and other areas of development, including the SDGs, and develop conceptual frameworks and development paradigms accordingly. It can serve as a catalyst of research, both by doing its own research to find evidence-based policy solutions to pressing problems, including in the area of STI, but also through networking of research institutions and academic institutions to forge synergies and efficiencies through sharing of costs and minds. Already, ESCAP is networking trade research institutions through the Asia-Pacific Research and Training Network on Trade (ARTNeT). Similar networks can be set up in the area of STI or ARTNeT could be expanded to other areas of economic and scientific research.

ESCAP can promote exchange of information and ideas, including best and good practices, through seminars, workshops and conferences, including its conference structure and ministerial conferences at the policy level but also at the working level by networking researchers, scientists and policy makers across the region in designated forums. In addition, ESCAP, through its regional institution the Asian and Pacific Centre for Transfer of Technology (APCTT), would be in a prime position to provide capacity building in the area of STI, as it is already doing, while tailored advice to individual countries could be provided by a regional adviser on STI.

In summary, ESCAP can promote STI among Member States through a multi-pronged strategy including the following:

- Promoting the concept of National Innovation System;
- Strengthening NIS and its key-components;
- Carrying out national innovation system diagnosis and strategy development;
- Strengthening sectoral innovation systems with particular focus on new and emerging technologies;
- Promoting adoption of new approaches to develop technology solutions (i.e. open innovation approach); and
- Introducing, scouting, documenting and dissemination of grassroots innovation

ii. Strengthening technology transfer capacity

The pivotal role of SMEs in fostering inclusive and sustainable economic growth through their contribution to employment generation and value-added exports is well recognised. Acquiring technology from R&D institutions and university laboratories as well as through inter-firm technology transfer (TT) to enhance their competitiveness and growth is critically important for SMEs. However, SMEs in many developing countries find the planning and implementation of a TT project problematic. When planning a TT project, they lack the capacity for business case
preparation, identifying sources of technology, assessment, selection, and pricing of sourced technologies, negotiating and finalizing contractual arrangements of the selected technology and assessing its impact on business performance after commissioning. Building the capacity of SMEs to plan and implement technology transfer projects can make a significant impact on the growth of the SME sector in Member States.

ESCAP can embark on a strategy to strengthen the technology transfer capacity of key stakeholders including SMEs, policy makers, R&D institutions, chambers of commerce, SME support institutions and technology transfer intermediaries in member countries. Technology transfer capacity building of member country stakeholders is considered key to achieve SDGs in relevant sectors in the Asia-Pacific region. ESCAP can promote technology transfer among developing countries through already existing mechanisms and databases operated by APCTT.

The strategic interventions required in this area could include the following activities:

- Providing free of cost technology transfer services to SMEs and value chain actors;
- Strengthening capacity of SMEs and value chain actors to successfully handle the technology transfer process and develop skills ranging from business case preparation, technology sourcing, technology assessment, technology selection, technology pricing, drafting of license agreements, negotiation, contract finalization, implementation and impact assessment;
- Facilitating cross-border technology transfer and technology-based business partnerships in the Asia-Pacific region;
- Establishing specialized technology transfer networks in specific sectors for enhancing cross-border technology-based business and/or research cooperation; and
- Promoting cross-country R&D collaboration and research commercialization in new and emerging technologies such as renewable energy and nanotechnology

iii. Nurturing New and Emerging Technologies

In a knowledge-based society, R&D and innovation in new and emerging areas of technology (e.g. biotechnology, nanotechnology, ICT, new and renewable energy) are critical for stimulating economic growth of countries. In the context of sustainable development, the new and emerging technology areas are being considered important for addressing many of our challenging technological, environmental and economic problems. These technologies possess immense potential to offer cost-effective and innovative solutions in critical areas of sustainable development such as climate change through renewable energy and energy storage technologies, clean water, wastewater treatment, food safety, enhancing agricultural production, prevention of diseases and affordable health care. For example, nanotechnology offers wide-ranging applications such as: enhancing the ability of crops to absorb nutrients, for enhancing the soil binding properties and moisture retention of agricultural soils, water and wastewater purification, detection of food-borne bacteria and toxins, increasing efficiency of solar cells, development of greener technologies with nanomaterials thus reducing CO₂ emissions and energy consumption for buildings and transport, energy-efficient light emitting diodes (LEDs), super-insulating and self-cleaning windows, oil spillage clean-up with nanoporous membranes, etc. Similarly, the scope of other sectors like biotechnology, ICT and new and renewable energy is very well recognized across the globe.

For getting the most out of the new and emerging technologies, the role of national STI policies and strategies is considered vital. However, most Asia-Pacific countries lack basic infrastructure and capability for promoting new and emerging technologies in the areas of: R&D and innovation management, IPR management, collaborative research and networking, adoption of best practices in R&D, research commercialization, technology transfer, access to and utilization
of relevant knowledge and information resources, and training of R&D personnel. There are also wide gaps between countries and LDCs in the region. These limitations can pose serious threats to national efforts leading to imbalances in technological and industrial development in the region. Therefore, it is essential to promote networking among NIS actors (e.g. policy makers, universities, R&D institutions, enterprises, etc) at the regional level which can catalyze cross-border technological cooperation. Such an effort can promote international R&D collaborations and strengthen institutional capacity in R&D management and research commercialization through exchange of knowledge, best practices and experience-sharing.

iv. Promoting technology intelligence

The competitiveness of organisations depends on how well they acquire and apply knowledge. Organisations with a good knowledge base are able to quickly adapt in today’s volatile global business setting. A successful firm is one that knows how to do new things well and quickly. Knowledge is thus widely regarded as a firm’s critical asset for competitive advantage. It is therefore essential to provide a regional platform for the provision of technology intelligence and information services to policy makers, technology transfer intermediaries and SMEs in the Asia-Pacific region to enable them to build up a technology knowledge base to foster balanced growth in an environmentally sustainable manner. Indeed, there is a need to go beyond mere transmission of technology information to the provision of technology intelligence to help member states and their enterprises to conquer the challenges arising out of today’s dynamic business and technological setting.

ESCAP can seek to provide technology intelligence to help Member States, their institutions and enterprises to address the challenges of today’s dynamic business and technological setting in the context of post-2015 sustainable development agenda. Technology Intelligence activities of the Centre are aimed at (a) policymakers to keep them abreast of emerging science, technology and innovation (STI) policy approaches and delivery mechanisms for technology-based national inclusive and sustainable development; (b) small and medium enterprises (SMEs) and intermediary agencies to emphasise on technology innovation to succeed in the market and participate in the globalization of technology, and in making informed and rational decisions during the technology transfer process and; (c) research and development (R&D) institutions to focus on new and emerging technologies for sustainable development.

Key interventions required in the area of technology intelligence are:

- Developing and disseminating technology-related knowledge products among stakeholders through online and printed modalities;
- Disseminating trends in STI, technology transfer and development, technology policies, data and analysis with respect to relevant issues, case studies, best practices and innovative technologies;
- Providing value-added technology information products and services; and
- Undertaking normative and analytical studies of regional relevance to identify trends, highlight good practices and policies.

Table 1 suggests the potential roles for ESCAP in promoting STI for sustainable development but does not claim to be exhaustive. In many cases it would need the involvement of partners. The table does not list ESCAP existing and potential work in other areas that are related to STI development (i.e. trade and investment), unless there is direct link with STI, as this work is already firmly established. ICT is presumed as a subset of STI.
<table>
<thead>
<tr>
<th>Research and analysis</th>
<th>Undertaking evidence-based research related to STI, NIS diagnosis studies to develop appropriate STI strategies for respective countries, and interface of STI with other development areas, in particular trade and investment, the role of business and public-private partnerships but also on linkages between STI and SDGs, including the role of STI in addressing environmental and social development challenges and with particular attention to the impacts on and requirements of STI for women and other disadvantaged groups in society.</th>
<th>Developing and expansion of STI and ICT indicators</th>
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<tr>
<td>Dissemination of information on STI (and related areas such as ICT)</td>
<td>ESCAP Economic and Social Survey (dedicated STI chapter)</td>
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<td></td>
<td>Asia-Pacific Trade and Investment Report (dedicated STI section)</td>
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<td></td>
<td>APCTT’s Asia-Pacific Tech Monitor and Value Added Technology Information Service (VATIS) Updates</td>
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<td>Working Papers, monographs, articles publishing research findings</td>
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<td>Regional meetings and conferences</td>
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<tr>
<td>Regional cooperation and connectivity</td>
<td>Networking of research institutions in various areas.</td>
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<td>Promoting government-business dialogue and partnerships and business-business cooperation in STI (e.g. APBF).</td>
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<td></td>
<td>Organization of an annual Regional Forum on STI.</td>
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<td>Organization of an Asia-Pacific Technology Fair (perhaps back-to-back with the Forum).</td>
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<td>Establishment of a Committee on STI under ESCAP’s conference structure.</td>
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<td>Development of regional standards and certification mechanisms</td>
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<td>Organization of Ministerial Conference on STI.</td>
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<td>Designing platforms and agreements/arrangements for a regional innovation system (linking national level innovation systems)</td>
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<td>Continuation of the Regional Space Applications Programme</td>
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<td></td>
<td>Including negotiation of liberalization of trade and investment in environmentally sustainable technologies in APTA</td>
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<tr>
<td>Capacity building</td>
<td>Regional and national level training workshops in selected areas of STI (e.g. biotechnology, nanotechnology, NIS, RETs, etc.) organized by APCTT and in the area of ICT organized by APCICT.</td>
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<td>Tailored advisory services at countries’ demand delivered by a regional adviser on STI.</td>
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<td>Expansion of online technology banks (e.g. technology4SMEs; APTITUDE search engine, renewable energy technology bank) as operated by APCTT.</td>
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<td>Policy advocacy</td>
<td>Committee on STI (with perhaps a subcommittee on ICT).</td>
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<td>Ministerial Conference on STI.</td>
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<td></td>
<td>Other regional conferences (both ESCAP and non-ESCAP),</td>
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Table 1: Role of ESCAP in promoting STI for sustainable development
| | including APBF, APTFF and APEF.  
| | • Technology or innovation awards for businesses, government bodies, NGOs, individuals (inventors, researchers, educators, etc.).  
| | • Regional adviser on STI.  
| | • Publications (see dissemination of information above). |
Science can be defined as systematic study of the physical or material world (natural science) and society (social science) that generate data from which information is drawn. Knowledge is gained through study, analysis, practice and comprehension with contextualization. Observation, experimentation and interpretation are the main constituents of scientific research that may lead to discovery of new knowledge and development of technologies, products and processes which can be used to increase the quality of life. In other words, research and development (R&D), both basic and applied, leads to the broadening of knowledge and application of science to produce or improve materials, products, technologies, processes and services. The idea is that science should lead to knowledge by enhancing our understanding of what we observe and experiment and develop techniques and technologies to improve the welfare of people and, more generally speaking, the experience of life (on earth). Since science is closely associated with knowledge, scientific knowledge can be gained and distributed through education and training that further increase participation of people in science, application of knowledge and skills thus expanding the horizons of knowledge.

Technology has different definitions but all definitions have common elements. In short, technology is the application of scientific knowledge to develop techniques to produce a product and deliver a service. Technologies are generally associated with manufacturing industries that constitute machines and devices that are in turn developed from technology. Technology can also be defined as a scientific or industrial process, invention, method or the like, or, more broadly as the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society and the environment and the application of knowledge for practical ends. It is clear that technology is a direct offshoot of science and its practical application. Hence, science and associated R&D lead to robust technologies or new inventions or innovations to address the current and emerging issues confronting to improve the quality of life and environment.

Inventions or innovations are the direct result of science and technology (S&T). Inventions truly involve the creation of new things (products, technologies or processes). Innovations can be defined as (incremental) improvements of existing things (e.g. products, processes and services) or a combination of proven and new S&T to develop a new product, processes or services. Another approach is to define invention as the first occurrence of an idea for a new product or process to gain new knowledge, while innovation is mainly aimed at tackling a specific problem or to derive benefits (including commercial) from S&T. Under this approach, innovation involves the actualization or realization of S&T, whether it is a societal benefit, commercialization, market entry or monetization. Innovations, however, are generally understood as to constitute a lower degree of invention, i.e. minor changes and improvements vis-à-vis completely new product/process which would be termed as an invention. Others define inventions as “radical” innovations vs. incremental innovations. Inventions are more likely to be protected by intellectual property rights (IPR) such as patents. Innovations are more regular and allow businesses to grow and stay ahead of competitors as inventions are more rare. Simple improvements or changes in designs, manufacturing methods and processes, technologies, management practices, organization, marketing, etc. can constitute essential

innovations that keep successful businesses competitive in the marketplace. While inventions are the direct result of research and, hence science, and often translate into new technologies or products, innovations can simply be the result of thinking out of the box, i.e. creativity. However, with the exponential growth and convergence of S&T, it is increasingly difficult to distinguish between invention and innovation. The emphasis is currently on innovation, hence the usage of Science, Technology and Innovation (STI). Simply put, there can be no innovation without (an existing) technology (or process/product embodying that technology) while there can be no technological progress without scientific discoveries and research to invent and develop technology. For development purposes, technology can be identified as the core driver as it links science with innovation.