UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

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

Thoughts for regional dialogue

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 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

[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.[2] 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

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[2] Scientific Advisory Board of the UN Secretary-General The Crucial Role of Science for Sustainable Development and the Post-2015 Development Agenda July 2014; see also P.G.Sampath Benefits and Costs of the Science and Technology Targets for the Post-2015 Development Agenda http://www.copenhagenconsensus.com/sites/default/files/science_tech_viewpoint_-_sampath.pdf

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.[3]

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.[4] 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.[5] 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.

[3] http://www.oecd.org

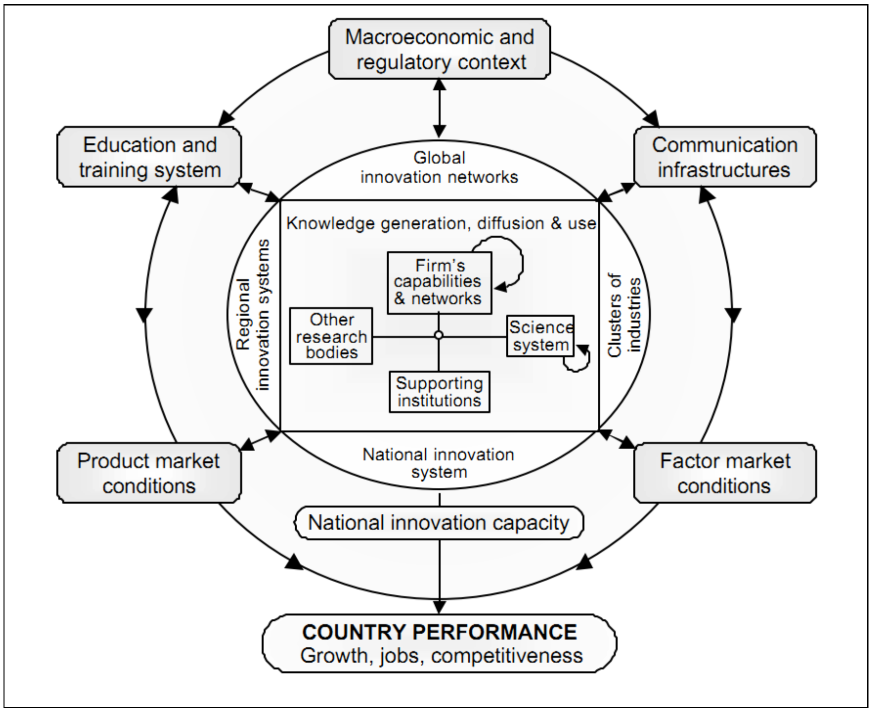
[4] Wenying Fu Towards a Dynamic Regional Innovation System: Investigation in to Electronics Industry in Pearl River Delta, Springer 2014

[5] Haider A. Khan National Innovation Systems and Regional Cooperation in Asia: Challenges and Strategies from a Study of China MPRA Paper No. 40118, 2012 http://mpra.ub.uni-muenchen.de/40118/

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.

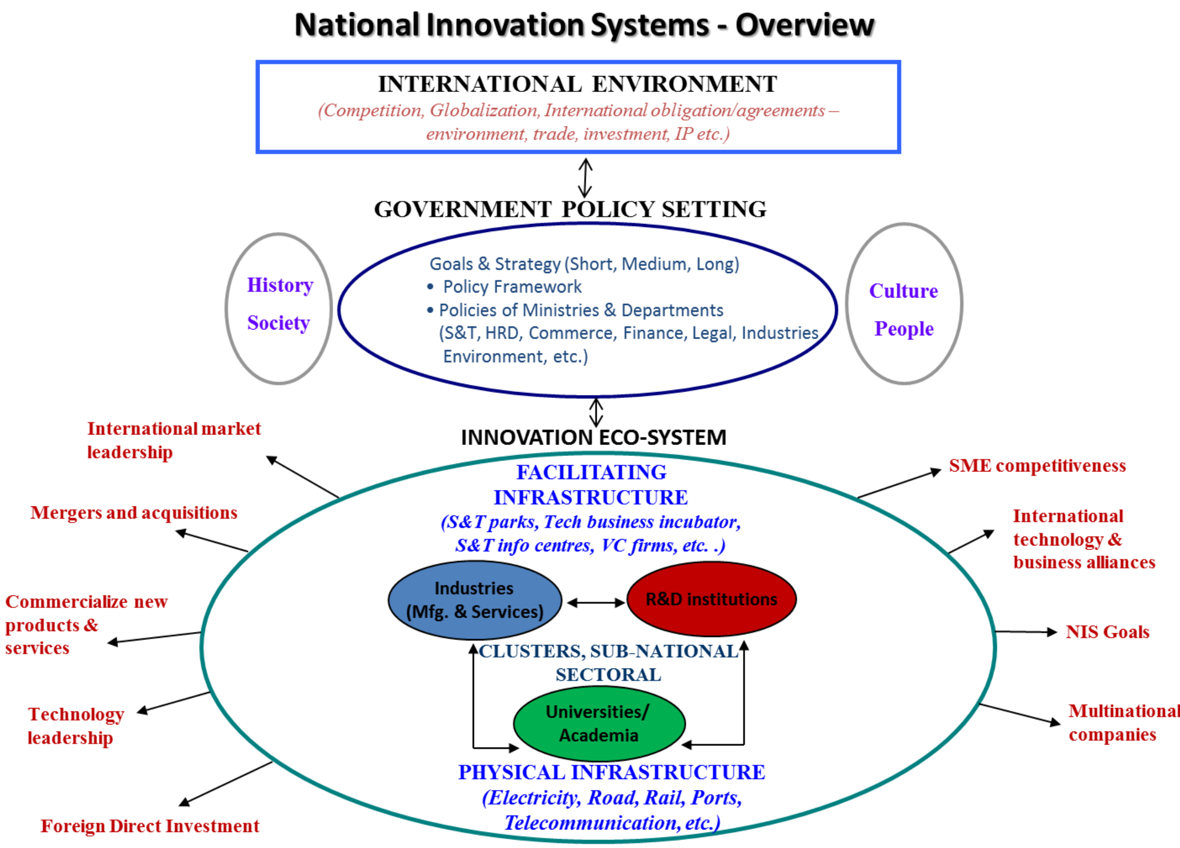
Figure 1 shows the NIS concept in some details with the inner ring constituting the institutions and policies directly involved in scientific and technological innovation. The outer circle shows a “broad” NIS perspective, which takes into account the economic, social and political environments of the 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[6]. 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.

[6] http://nis.apctt.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.