ROLE OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN ADVANCING REGIONAL CONNECTIVITY

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ABSTRACT

The United Nations adopted the 2030 Agenda for Sustainable Development in 2015 to achieve sustainable development, which has economic, social and environmental dimensions. In achieving the Sustainable Development Goals (SDGs), science, technology and innovation (STI) can be a key means of implementation with its effective use. STI, in particular information and communication technology (ICT), has significantly contributed to progress of people, society and the world. Certain emerging ICTs have great potential to change the way people make their living more sustainable, also contributing to achieving the SDGs effectively.

The current study identified major emerging ICTs through desk top research, reviewing their characteristics and implications through literature review. A small expert survey was conducted against 20 carefully selected experts. The survey addressed questions on relevance of selected ICTs to international trade, transport and logistics for advancing regional connectivity, policy and technological requirements for their application, success factors for their application and policy considerations for governments in promoting application of ICT in international trade, transport and logistics for regional connectivity in the context of developing countries.

The outcome of the survey confirms relevance of certain emerging ICTs to regional connectivity, though their relevance varied. The study identified several policy and technological requirements for successful application of the selected ICTs as well as success factors, including use of international standards and standards-based technologies, business process re-engineering, government's policy will, satisfactory basic ICT technical requirements, availability of relevant technologies and skilled human resources, and certain level of ICT deployment and utilization as a basis for further innovative application.

Though not impossible, it was recognized that it would not be easy for developing countries to narrow gaps from counties with advanced ICT application through innovative application of ICT, due to such reasons as inherent limit of ICT in controlling/harnessing informal practices in businesses, lack of relevant technologies and skilled human resources, insufficient ICT network and system infrastructure, lack of opportunity to build cross-sectoral ICT eco-system and synergy, lack of opportunity to learn from enough trial and error processes, and short-sighted ICT R&D practices.

Due to time and resource constraints, the current study had several limitations in drawing more generalizable implications and may desire further studies. However, implication from findings of the current study on capacity building worth attention of international organizations and development partners in designing and implementing capacity building programmes on ICT application and innovation for developing countries. Capacity building, catering creation of ICT eco-system and virtuous circle, requires long-term human resource

development, opportunity for iterative implementation and holistic or cross-sectoral application ICTs, making people to become part of ICT-based innovation itself.

1. INTRODUCTION

1.1 BACKGROUND

The United Nations adopted the 2030 Agenda for Sustainable Development in 2015 to achieve sustainable development, which has economic, social and environmental dimensions. The agenda has 17 goals and 169 targets to achieve sustainable development until 2030. Among the goals, two goals focus primarily on economic dimension; Goal 8 intends to "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all," while Goal 9 attempts to "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" In achieving the Sustainable Development Goals (SDGs), including goals 8 and 9, science, technology and innovation (STI) can be a key means of implementation when it is effectively used (ESCAP 2016).

STI, in particular information and communication technology (ICT), has significantly contributed to progress of people, society and the world. There are many emerging ICTs that have drawn much attention of people in the world, such as artificial intelligence (AI), having great potential to change the way people make their living more sustainable. Innovative use of emerging ICTs can significantly contribute to achieving the SDGs effectively.

1.2 PURPOSE

The purpose of the study is to assess impact of STI, in particular the role of IC T in facilitating regional connectivity, an economic dimension of sustainability, an d draw policy implications. The study examines how application of emerging innovative ICTs can facilitate international trade, transport and logistics to advance regional connectivity in Asia and the Pacific.

1.3 SCOPE OF THE STUDY

The study focuses on selected countries in the East and North-East Asian s ubregion where application of ICTs had been successful, and yet a huge potential remains for economic development and integration through further innovative use of ICTs, from which Asia and the Pacific region as a whole can also be benefited.

The research addresses the following issues:

1) How relevant are application of emerging and innovative ICT to international trade, transport and logistics for advancing regional connectivity?
2) What would be policy and technological requirements for such ICT application, in particular in the context of developing countries?

3) What are success factors in application of ICT in international trade, transport and logistics?
4) What are policy considerations for governments in promoting application of ICT in international trade, transport and logistics for regional connectivity?

2. STUDY OUTCOME

2.1 STUDY APPROACH TAKEN

The current study identified major emerging ICTs through desk top research, and reviewed their characteristics and implications for applying them to enhance trade, transport or logistics through literature review. Then, a small expert survey was conducted against 20 carefully selected professionals with more than 10 years of field or research experience in applying ICT in trade, transport, logistics and/or other related economic and social domains in the Northeast Asia. The survey was conducted through either physical interview or completion of online questionnaire in the second half of 2016. In the survey, the following questions were asked to collect expert view on application of selected emerging ICTs in trade, transport, and logistics and to draw policy implications:

1) Which emerging innovative information and communication technology (ICT) can be applied to facilitating trade, logistics and transport to enhance regional connectivity? (Please indicate their level of relevance in the scale of 1 to 5, 5 being most high)

No.	Technologies
1	Internet of Things (IoT)
2	Big Data
3	Cloud Computing
4	Artificial Intelligence (AI)
5	Virtual Reality (VR)
6	Augmented Reality (AR)
7	BlockChain
8	3D Printing
9	Robot technology
10	Drone
11	Self-driving car
12	Bio-metrics
13	Wearable Devices

2) What would be policy requirements for successful application of the above listed ICT, in particular in the context of developing countries?

3) What would be technological requirements for successful application of the above listed ICT, in particular in the context of developing countries?

4) What are success factors in application of the above listed ICT in international trade, logistics and supply chain?

5) Is it possible for developing countries to narrow gaps from advanced counties in ICT application with innovative application of ICT? If yes, then how? If not, why not?

2.2 STUDY FINDINGS

2.2.1 Demography of respondents

Table 1 shows demography of the survey respondents.

Table 1: Demography of responding experts

Work Area/ Organization	Academia	1
	Research Institute	3
	Transport/Logistics Services	1
	Trade services	1
	Government agency	1
	ICT related public/private institute	12
	Other	1
Gender	Male	15
	Female	5
Country	China	1
	Mongolia	1
	Republic of Korea	18

2.2.2 Analysis of survey response and their implications

In this part, questions answered in the survey are analyzed with elaboration on their implications for advancing regional connectivity.

2.2.2.1 Relevance of selected emerging ICTs

For the question on relevance of selected emerging ICTs to facilitation of trade, transport and logistics to enhance regional connectivity, the experts indicated their relevance as shown in Table 2

Table 2: Indication of relevance of selected emerging ICTs

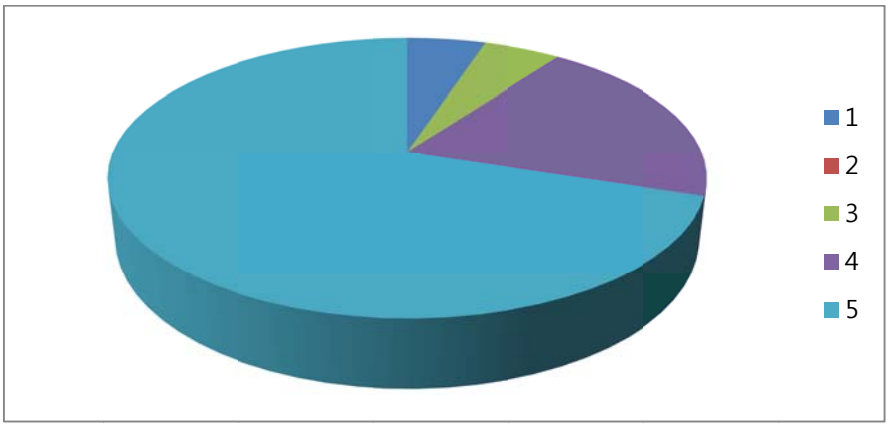
No.	Technologies	Relevance				
		5	**4**	**3**	**2**	**1**
1	Internet of Things (IoT)	14	4	1		1
2	Big Data	11	4	3	1	1
3	Cloud Computing	8	8	3		1
4	Drone	8	1	8	2	1

5	Artificial Intelligence (AI)	6	6	5	2	1
6	Robot technology	6	4	6	1	3
7	Self-driving vehicle	5	7	8		
8	Wearable Devices	4	5	7	3	1
9	Bio-metrics	3	3	8	2	4
10	3D Printing	2	4	7	6	1
11	Augmented Reality (AR)	1	8	5	2	4
12	Virtual Reality (VR)	1	6	8	1	4
13	BlockChain	1	5	12	2	

Note: In the scale of relevance, 5 indicates most high while 1 indicates not relevant. Number in relevant relevance columns indicates number of persons that made such selection.

Internet of Things (IoT) received most indication of relevance from experts as shown in Figure 1. Telecommunication standardization sector of the International Telecommunication Union (ITU), a specialized UN agency, or ITU –T, defines IoT as a "global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies" (ITU 2012); in IoT, thing is inclusive of both "object of the physical world (physical things)" and information world (virtual things). The Internet has enabled people to communicate one another anytime and anywhere, overcoming time and space constraints in communication. The IoT has further added another dimension of anything in communication

Figure 1: Relevance of IoT

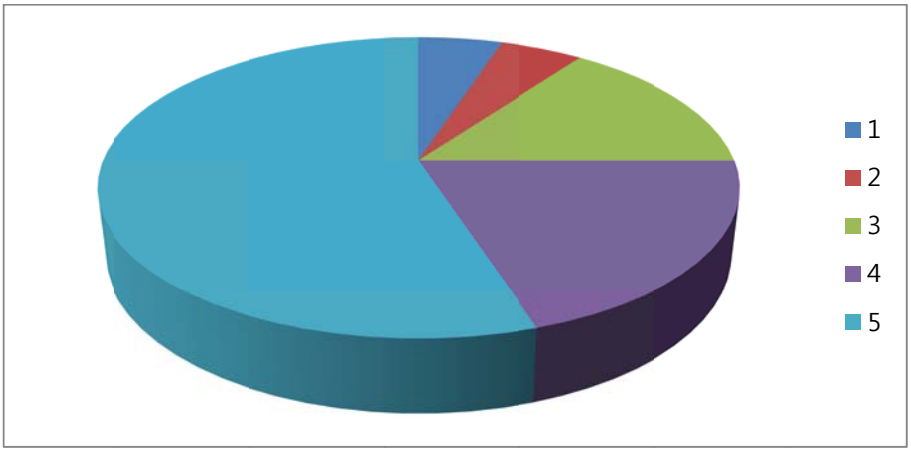


There are numerous emerging cases of IoT application in daily life. Most commonly referred application examples of IoT may include refrigerator and connected car. In CES 2016, a global consumer electronics and consumer technology tradeshow held in 2016, Samsung showcased an IoT-based refrigerator called 'Family Hub', which incorporated Internet connectivity for online shopping, touch screen, internal camera and possible connectivity with other appliances such as a smartphone, to enables users to monitor and re-stock contents in the refrigerator (Ashok 2016). A car, connected to other devices and information through an IoT and/or cloud services, can enable drivers to enjoy such services as "enhanced navigation, real-time traffic and parking information, streaming infotainment and integration between dashboards, smartphones and wearable devices such as health trackers and smart watches", further allowing to "check us into hotels, notify people when we're running late, confirm appointments, make dinner reservations, order movie tickets, even pay for gas and parking" (O'Brien 2015). All major car-makers have planned or already initiated development of connected cars using IoT. For example, BMW, a German carmaker, plans to connect its cars to other devices such as home appliances using SIM card, to allow people's life connected to their cars (Sheehan 2016).

While IoT can be applied to any domain, application of IoT can bring particular advantage to logistics management. According to DHL (2015), application of IoT can bring benefits to whole of logistics value chain, including warehousing operations, freight transportation, and last-mile delivery. Because international trade, transport and logistics deal with movement of cargos, enabling communication between cargos and objects surrounding them along trade and transport corridors using IoT can facilitate their secure and efficient movement, even across borders.

The second biggest indication of relevance from the responding experts was made on big data as shown in Figure 2. IBM characterizes big data with four dimensions – volume, variety, velocity and veracity (2012).

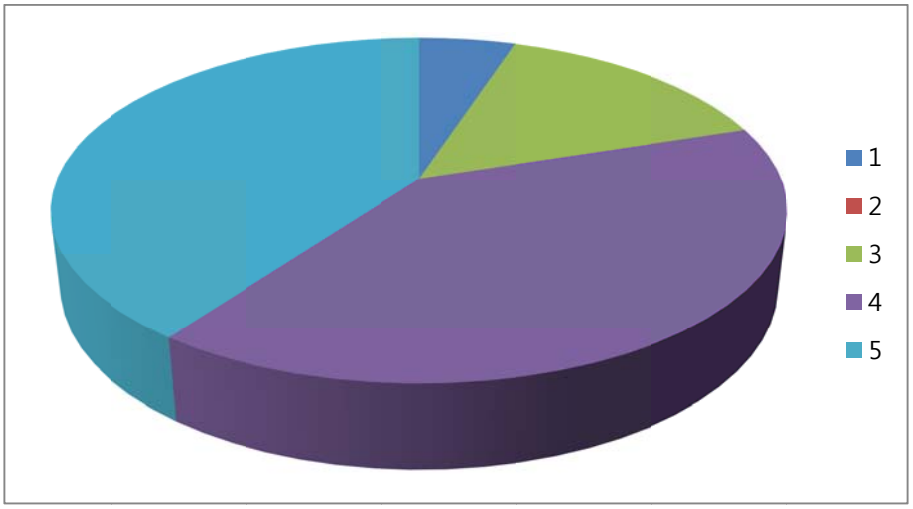
Figure 2: Relevance of big data



By using big data, logistics and supply chain management can be optimized for operational efficiency and better customer relationship. Oracle points out that big data projects can help logistics management and transportation companies in “accurate business demand planning”,” route optimization”, “increased customer wallet share”, “risk analysis”, and “IT operational efficiency” (2015).

The third biggest indication of relevance from the responding experts is on cloud computing as shown in Figure 3. Cloud computing allows enterprises to optimize their resources, by enabling them to minimize ICT investment while making them accessible to IT resources ubiquitously.

Figure 3: Relevance of cloud computing

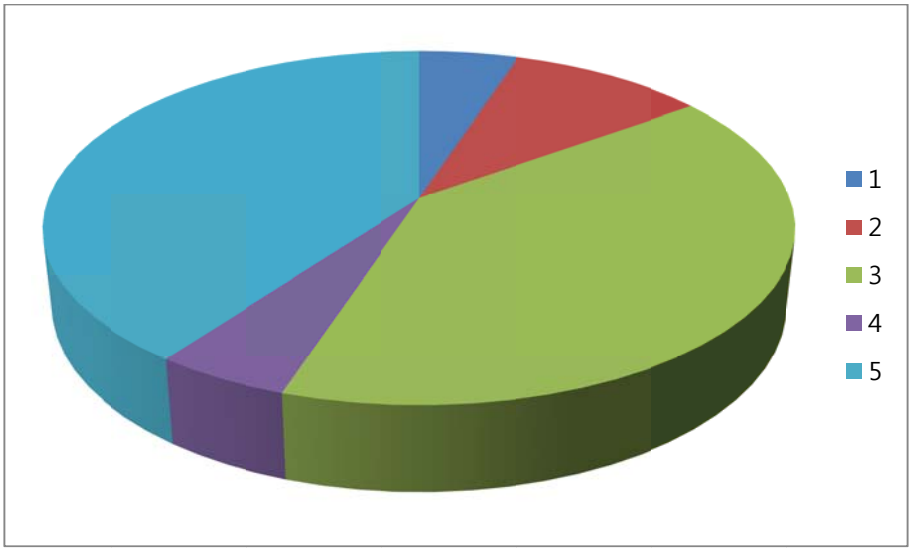


Wyatt points out that cloud computing can bring several benefits to logistics management, including real-time pricing, real-time inventory, removal of duplicate transportation and warehousing management systems, optimization of equipment utilization, better synchronization of supply chain processes and better office resources accessibility (2013).

Drone or Unmanned Aerial Vehicle (UAV) was ranked fourth as shown in Figure 4. UAV can be applied to many different domains, and applicable domains are increasing ever. Handwerk (2013), in addition to Amazon’s application of UAV for delivery, expects more utilization of UAV in such civilian areas as hurricane data collection, 3D map, wildlife protection, agricultural farming and search and rescue.

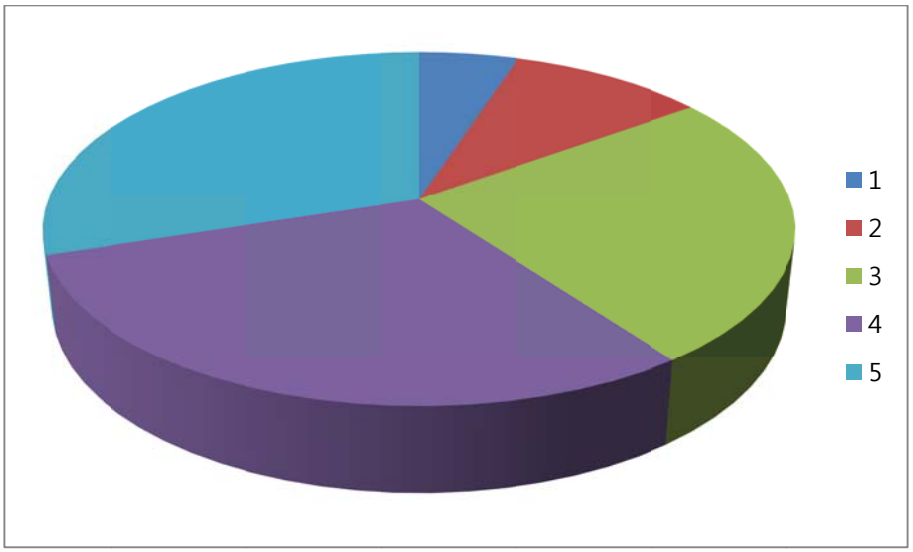
Logistics is not an exception for application of UAV. DHL, noting that UAV is in an early stage of application, anticipates that UAV can be utilized for delivery in densely populated urban areas, rural areas with inadequate access infrastructure, surveillance of infrastructure and facilities and intralogistics within a huge facility or site (2014).

Figure 4: Relevance of drne



Artificial Intelligence (AI) was ranked fifth by the experts as shown in Figure 5. AI drew much of public attention from a competition between a famous Korean Go player and the AlphaGo of Google DeepMind, resulting in winning of an AI computer programme. Areas that AI can be applied include language understanding, learning and adaptive systems, problem solving, perception, modeling, robot and games (Pannu 2015).

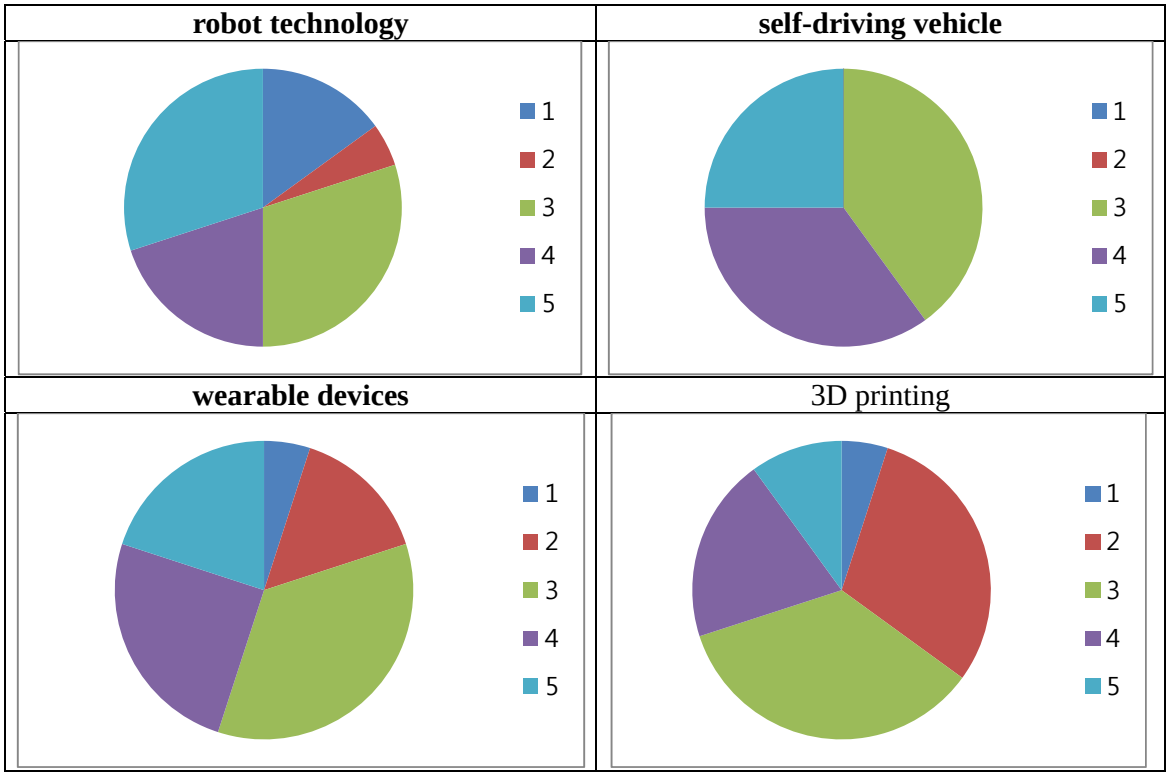
Figure 5: Relevance of AI



AI can be applied to many operational aspects of logistics and supply chain management, in particular in optimizing logistics and transportation operations. For example, AI can more efficiently optimize delivery and procurement routes than existing optimization techniques.

Robot technology for efficient warehouse management, self-driving vehicle for improved transportation, wearable devices for safety in logistics operation, 3D printing for innovative production and distribution and Augmented Reality (AR) for enhanced decision-making and task-performing of workers can have high implications in advancing transport and logistics. Figure 6 shows relevance of robot technology, self-driving vehicle, wearable devices and 3D printing.

Figure 6: Relevance of robot technology, self-driving vehicle, wearable devices and 3D printing



DHL, in its 2016 Logistics Trend Radar report, listed robot technology, self-driving vehicle, wearable devices, 3D printing and AR as well as IoT, big data, cloud computing, UAV and AI on technology trend side, in particular newly adding UAV, self-driving vehicle and wearable devices in 2016 version (2016). Bio-metrics have implication in enhancing security and safety in global supply chain operations. BlockChain would be more relevant to international trade, in particular in payment process. Virtual Reality (VR) might have limited applicability in trade, transport and logistics, as indicated by the responding experts.

2.2.2.2 Policy and technological requirements

Regarding the question on policy requirements for successful application of the selected ICTs,

the responding experts indicated 1) political/policy will of relevant government agencies, 2) legal framework for supporting application of the ICTs, 3) recognition of validity on electronic communication and electronic data, 4) tentative (sunset) incentive system, such as tax reduction, certification, etc., to promote application and use the ICTs, 5) existence of difficulties/challenges resulting from not participating in relevant initiatives for application and use the ICT, such as no acceptance of paper-based application, and 6) government support to application and utilization of the ICT, such as training, development of manual, distribution of software, etc.

The first policy requirement emphasizes policy commitment of government, while the second and the third ones highlight importance of legal and regulatory support. What is noticeable from three policy requirements is importance of leadership from public sector in application of ICT. The fourth and fifth ones are related to advantage/disadvantage associated with application of ICTs; interestingly, more experts indicated effectiveness of giving disadvantage over advantage for wide adoption, illustrating that enforcement of disadvantage can be useful policy measure in certain context. The last one is government's support to stakeholders in use of ICTs, including awareness-raising, technical assistance and capacity building, to promote widespread adoption of ICT application. The last policy measure can be important in developing countries' context to accelerate stakeholders' buy-in.

On technological requirements for successful application of the selected ICTs, the responding experts pointed out 1) availability/accessibility of system and network infrastructure, 2) availability of different access/utilization options for user-friendliness, 3) skilled human resources for development, operation and maintenance of relevant technologies, 4) optimized system/service options for minimized costs in development and use, such as cloud computing services, and 5) policies for physical security, control and audit to counter security related threat.

Among technological requirements, many responding experts indicated importance of availability of different access/utilization options, skilled human resources, and optimized system/service options. Importance of skilled human resources is critical because application of ICTs demands specialized skills that could not be accumulated in a short period of time. Availability of different access/utilization options and optimized system/service options would be critical in developing countries' context, since they usually have limited financial and human resources; with resource optimized options for application of ICTs, stakeholders in developing countries have better chance to be exposed to/transitioned to ICT-based society.

2.2.2.3 Success factors

With regard to success factors in application of the selected ICTs in international trade, transport and logistics, the responding experts listed 1) use of international standards and standards-based technologies to promote compatibility and interoperability, 2) improvement

and upgrade of business operations through business process re-engineering, 3) government's policy will, 4) fulfillment of basic technical requirements, including ICT infrastructure, such as network, and system infrastructure, 5) availability of relevant technologies and skilled human resources, and 6) wide deployment and utilization of ICT in various industrial domains to enable further innovative application of ICT for productivity.

Many responding experts indicated importance of use of international standards and standards-based technologies to ensure interoperability among ICT systems. They also pointed out importance of business process re-engineering to maximize benefits of ICT application in innovating business operational processes and skilled human resources to continue and further advance development of relevant technologies and services.

2.2.2.4 Opportunity for narrowing gaps

On the question of whether innovative application of ICT can provide an opportunity for developing countries to narrow gaps from advanced counties in ICT application, most experts responded no while some answered yes. Those who answered yes highlighted potential of ICTs to improve economic development greatly, pointing out a few success cases of Asian countries such as Republic of Korea. However, they pointed out that certain prerequisites are to be met to realize such possibility, including skilled ICT human resources and government policy commitment to promote ICT.

Those who answered no listed such reasons as 1) inherent limitation of ICT in controlling/harnessing informal practices, such as detouring and bribery, accompanied to existing business operations, 2) lack of relevant technologies and skilled human resources, 3) insufficient network and system infrastructure, 4) lack of opportunity to build cross-sectoral ICT eco-system and synergy due to insufficient deployment of ICT in different social, economic and industrial domains, 5) lack of opportunity to learn from enough trial and error to build improvement capacity for optimizing subsequent initiative, and 6) lack of visionary and long-term Research and Development (R&D) practices.

Limit of ICT application to control informal practices concerns limitation of automation. It is usually not possible to automate whole of business process, especially in areas where human interactions are required. To minimize informal practices, a thorough business process re-engineering would be useful in the process of ICT application. However, more fundamental issue would be change of people in their mindset, which would require more than effective application of ICT.

The second reason is unavailability of relevant technologies as well as human capacity to harness them. The third reason is lack of basic ICT infrastructure to further advance application of ICT and to create relevant ICT-based services. The fourth reason is concerned with challenges in creating ICT eco-system in whole of a society. It is usually not possible to create synergy and drive innovation when ICT is applied only in certain domain or sector,

because all activities and interactions of a society are directly or directly related.

The fifth reason lies with evolutionary nature of ICT advancement. Innovation in ICT services cannot be created only with availability of technology. It is necessary to go through enough trial and error process to learn lessons and expand service dimensions through innovation. It would be not feasible for developing countries to innovate and narrow ICT gaps, only given with relevant ICT technologies and infrastructure; they need to integrate such technologies and infrastructure into their society through iterative application process.

The last reason deals with limitation of short-sighted ICT R&D policy of developing countries, frequently characterized by their focus on short-term achievement and culture of not accepting failure. R&D can usually produce meaningful outcome when it is exercised over mid and long-term through numerous trial and error process. Developing countries, due to lack of resources and other constraints, often do not cater such approaches.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 SUMMARY OF MAIN FINDINGS FROM THE STUDY

The survey of the current study, conducted against selected experts, confirms relevance of certain emerging ICTs in facilitating trade, transport and logistics for regional connectivity, though their relevance varied. Emerging ICTs received highest selection for their relevance include IoT, big data, cloud computing, drone, AI and robotics, while VR and blockchain were rated for their low relevance.

Indicated policy requirements for successful application of the selected ICTs include political/policy will of government, necessary legal framework, recognition of electronic communication, incentive and disincentive systems, and government support programmes. For technological requirements, experts listed basic ICT system and network infrastructure, user-friendly utilization options, skilled human resources, optimized cost-friendly system/service options, and proper ICT security policies.

Identified success factors for application of the selected ICTs include use of international standards and standards-based technologies, business process re-engineering, government's policy will, satisfactory basic ICT technical requirements, availability of relevant technologies and skilled human resources, and certain level of ICT deployment and utilization as a basis for further innovative application.

It would be not easy for developing countries to narrow gaps from counties with advanced ICT application through innovative application of ICT, because of inherent limit of ICT in controlling/harnessing informal practices in businesses, lack of relevant technologies and skilled human resources, insufficient ICT network and system infrastructure, lack of opportunity to build cross-sectoral ICT eco-system and synergy, lack of opportunity to learn from enough trial and error processes, and short-sighted ICT R&D practices.

3.2 IMPLICATIONS OF THE STUDY

ESCAP report (2014) points out that issue of connectivity in the context of Asia and the Pacific is not on its mere increase, but on forms of connections; it also notes that "Greater use of ICT applications for trade and transport facilitation, both behind and at borders, would also improve the efficiency of freight movements and pave the way for the development of paperless trade and e-logistics." The 2030 Agenda duly recognizes international trade as an engine for inclusive economic growth and poverty reduction, contributing to the promotion of sustainable development. Application of the emerging ICTs, identified and reviewed in the current study, can greatly enhance regional connectivity, taking the form of advancing seamless and sustainable regional supply chains with higher efficiency, coordination and security in their operation.

However, an issue remains on how effectively developing countries in Asia and the Pacific can apply those emerging ICTs to better participate in achieving targets contained in the 2030 Agenda and contribute to advancing regional connectivity. As the current study reveals, it would not be easy for developing countries to effectively harness emerging ICTs and create innovative ICT eco-system, unless they address policy and technological requirements as well as issues around the identified success factors. It is noteworthy that issues identified for application of emerging ICTs in the current study are in general congruent with five core elements of an effective innovation system for inclusive and sustainable development elaborated in an ESCAP study report (2016); they are visionary leadership, effective institutions, incentivizing investment, supporting people to be part of innovation and creating innovative knowledge systems.

In either effective application of ICTs or creation of effective innovation system, there are certain issues that only governments of developing countries, not international organizations and development partners, can initiate and lead implementation efforts. However, international organizations, including the United Nations, and development partners, can provide support in capacity building, which is a critical enabler. The 2030 Agenda also emphasizes capacity building by putting great importance on trade related capacity building for developing countries as well as for the promotion of regional economic integration and interconnectivity.

Implication from findings of the current study on capacity building worth attention of international organizations and development partners in designing and implementing capacity building programmes on ICT application and innovation for developing countries. ICT eco-system and virtuous circle, which nurtures sustainable and chain-reactive ICT-based innovation system, cannot be created with mere provision of ICT systems and network. It requires long-term human resource development, opportunity for iterative implementation and holistic or cross-sectoral application ICTs, leading to empowering people to become part of ICT-based innovation itself.

3.3 STUDY LIMITATIONS

Though the study, in particular the survey, produced many valuable implications on application of emerging ICTs for regional connectivity, the study has the following limitations to draw more generalizable implications and may require further studies.

First, the survey approached experts from only limited number of countries and even heavily depended on one country, Republic of Korea, due to time and resource constraints. To draw more generalizable subregional perspectives, future study should cover more experts from the other two countries as well as experts from the countries in the subregion not covered at all in the survey.

Second, the survey asked expert views broadly on application of emerging ICTs on trade,

transport and logistics. However, application of certain emerging ICT can have different relevance depending on target domain of trade, transport or logistics, though these three domains are closely related one another. At the same time, it is possible that experts having work or research experience in different domains may indicate different level of relevance to different ICT. Therefore, future study may conduct survey by expert groups with different work/research background as well as design questions with separate domain categories.

Third, the survey conducted as part of the current study had small sample size due to time and resource, restricting its generalizability and application of quantitative data analysis techniques such as factor analysis. Future study, with allocation of enough time and resources, may conduct a survey against a big sample to draw more generalizable perspectives.

Fourth, different subregions may have different contexts and constraints, such as development level, affecting outcome on their perspectives. Future studies may be conducted on different subregions to identify implications bearing subregional contexts, which can help designing effective capacity building strategies and programmes.

Fifth, the current study conducted a survey with questions mainly focused on government policy perspectives. It is highly likely that private sectors would have quite different perspectives on application of ICTs for regional connectivity. Therefore, it would be valuable to design and conduct a survey for collecting private sector perspectives, which can shed valuable insights for relevant policy formulation.

Sixth, the current study focused on identifying mainly relevance of emerging ICTs. Note should be given that inherent constraints embedded in applying certain emerging ICTs, such as privacy and security issues, may play the role of inhibitors of their application, despite their relevance. Further study on embedded constraints of emerging ICTs and possible ways to minimize such constraints would provide valuable perspectives on designing more effective policy measures for application of emerging ICTs.

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