WORLD ECONOMIC AND SOCIAL SURVEY 2016:

Climate change resilience — an opportunity for reducing inequalities

BACKGROUND PAPER

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Enhanced international cooperation on adaptation technologies and statistics for sustainable development

By: Alex Julca*

Summary:

Understanding the full range of economic and social impacts of climatic hazards on populations and countries requires access and capacities to collaborate and use large sources of data and complex statistical tools at national, regional and global levels. Adapting to climatic hazards with a long-term view of building resilience also demands greater access to adaptation technology and innovation. The global nature of climate change and the increased connectivity between countries' economies and societies demand an enhanced collective response from the international development community. This paper recognizes the tremendous challenge that the adverse impacts of climate change represent for livelihoods and countries' commitments to global partnership for climate-resilience development. It comprises two sections: a) Access to and use of adaptation technologies to build resilience, and b) Access to and use of ICTs and environmental/climate change statistics. The main objective is to underline the key role of international cooperation in harnessing different countries' capacities, risks and opportunities to coalesce and craft an integrated approach to build climate-resilience in key development areas such as water, health, food and energy.

** The author is affiliated with the Development Policy and Analysis Division (DPAD) of the United Nations Department of Economic and Social Affairs (UN/DESA). Views and opinions expressed are those of the author and do not necessarily reflect those of the United Nations.*

1. Introduction

Many countries and populations have been affected by higher frequency and intensity of extreme weather events and climate variability for the past twenty-five years or so (UN/DESA 2011), weakening adaptive capacities and livelihoods, thus reducing prospects for development and widening the gaps between more and less resilient communities (see chapter 1 for detailed impacts). Broadly, persistent inequalities, political insecurity and the differential impacts of climatic hazards threaten to unwind progress on poverty reduction and development in many developing countries (Julca 2012). The global annual average cost of climatic disasters, including floods, storms, droughts and heat waves, rose from US$ 196 billion during 1985-1994 to US$ 270 billion in 2005-2014, with over eighty per cent being absorbed by developing countries[1]. These trends also challenge the effective implementation of the 2030 Agenda for Sustainable Development and the international commitments agreed in the Programme of Action for the Least Developed Countries, Sendai Framework for Disaster Risk Reduction, Addis Ababa Action Agenda, Paris Agreement, and other relevant intergovernmental decisions.

Understanding the full range of economic and social impacts of climatic hazards on populations and countries requires access and capacities to collaborate and use large sources of data and complex statistical tools at national, regional and global levels. Availability and good use of data and statistics can enable effective public policy. Adapting to climatic hazards with a long-term view of building resilience also demands greater access to adaptation technology and innovation as well as stable and large sources of finance. While some countries are able to respond with resources and expertise to climatic hazards, the multiple adverse effects on other countries challenge the international community for a more coherent and coordinated response.

The global nature of climate change and the increased connectivity between countries' economies and societies demand an enhanced collective response from the international development community. Indeed, the task of effectively reducing climate change impacts on vulnerable populations and the limiting of global warming to less than 2° C require a great transformation of international cooperation. Countries and populations have to embark on an unprecedented cooperation exercise on key issues such as access and use of adaptation technologies – as in water management and agriculture, Information and Communication Technologies (ICTs) and climate change statistics to support countries' capacity development and resource mobilization efforts[2]. Climate-driven risks in livelihoods and life on the planet demand swift action and the scale up of current endeavours for building a global partnership for development.

The situation thus represents a great opportunity for effective global cooperation and coordination to support national and regional cooperation endeavours in sustainable

[1] UN/DESA calculations based on data from the Centre for Research on the Epidemiology of Disasters (CRED) International Disaster Database (EM-DAT). Available from www.emdat.net

[2] See Chapter III for a detailed analysis of adaptation strategies.

development. In fact, a revitalized global partnership for climate-resilient development is critical to build resilience and reduce inequalities heightened by climate change. As Rhinard and Sundelius (2010) states, “the capacity to cooperate across borders is an important condition for resilience. Whether we speak of cities, regions, or nations, today’s complex crises (of which Hurricane Katrina is an example) can easily outstrip the coping capacities of a single social system. The capacity to draw in necessary resources from outside a particular political-legal jurisdiction, and to incorporate and deploy these, is an essential source of resilience,” (p.197).

Chapter V recognizes the tremendous challenge that the adverse impacts of climate change represent for e.g. agriculture, water, health, and energy sectors, livelihoods and countries’ commitments to global partnership for climate-resilience development (see chapter II for a detailed analysis of climate change impact on livelihoods). The main objective of the chapter is to underline the key role of international cooperation in harnessing different countries’ capacities, risks and opportunities to coalesce and craft an integrated policy approach to build climate-resilience in key development areas. A review of nearly half of 150 Intended Nationally Determined Contributions (INDCs) submitted by developing countries to the Secretariat of the UNFCCC underlines the need for international cooperation in food security/agriculture, water management, energy, health, infrastructure, and biodiversity. There is evidence that many countries, particularly countries in special situations (LLDC, SIDS, LDCs), have inadequate statistical capacities, human resources and access to technologies and finance for transforming their economies towards “climate-resilient development” pathways[3].

Based on these results and the commitments of the international community above-described, chapter V comprises three sections: a) Access to and use of adaptation technologies to build resilience, b) Access to and use of ICTs and environmental/climate change statistics, and c) Financing local climate adaptation at a global scale.

[3] See United Nations (2015).

2. Access to and use of adaptation technologies to build resilience

This section examines existent international partnerships with different scopes and modalities among organizations, national governments and the private sector in the production, development and transfer of adaptation technologies to vulnerable countries and populations. It further discusses mechanisms to enhance such collaboration to promote technology transfer and development among universities, research centers, businesses and countries. In particular, it is important to support skills development and institutional capacities in countries in special situations and reduce the gap between available technologies and their use for building resilience to the adverse impact of climate change and variability.

Enhanced international cooperation and alignment to national development priorities are important to tap more effectively on the expertise from more advanced countries in the use of tools and adaptation technologies. In this sense, it also assesses the role of the United Nations and developed countries in supporting actions in developing countries directed to strengthen local adaptation technologies and capacity building. Broadly, the 2030 Agenda for Sustainable Development agrees to "enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals" (Goal 17.9, p.27). In particular, South-South cooperation and cumulative learning among member countries with relative similar development and environmental challenges are important to enhance capacities to build regional and global resilience to climatic hazards (see Annex 1 with UN Agendas including international cooperation on technology development and transfer).

The section starts by defining adaptation technologies for development (see box 1 below) and presenting a framework for assessing the role of international cooperation in the transfer of adaptation technologies, identifying local, sub-national, national and international stakeholders for effective international cooperation. It then identifies adaptation technology priorities for international cooperation.

Box 1 Adaptation technologies for climate-resilient development

The UNDP (2010) defines adaptation technologies as "all technologies that can be applied in the process of […] adapting to climate variability and climate change," (p.IX). Likewise, the UNFCCC defines them as 'a broad set of processes covering the flows of know-how, experience and equipment for… adapting to climate change'. These definitions have given rise to a classification of three kinds of adaptation technologies: software, hardware and orgware technologies. The first refers to the knowledge-based systems required to design, manufacture and use **hard- (ware) technology**, which covers manufactured goods and equipment. **Orgware** refers to the ownership and institutional arrangements of the community/organization where the technology would be used (see also UN/DESA 2011, Chapter III, Table IV.3). Examples of this typology for different sectors are illustrated in the table 1 below:

Table 1 Typology of adaptation technologies

Sector/Technology type	Hardware	Software	Orgware
Agriculture	Crop switching	Farming practices, research on new crop varieties	Local institutions
Water resources and hydrology	Ponds, wells, reservoirs, rainwater harvesting	Increase water use efficiency and recycling	Water user associations, water pricing
Coastal zones	Dykes, seawalls, tidal barriers, breakwaters	Development planning in exposed areas	Building codes, early warning systems, insurance
Health	Vector control, vaccination, improved water treatment and sanitation	Urban planning, health and hygiene education	Health legislation
Infrastructure	Climate proofing of buildings, roads and bridges	Knowledge and know-how	Building codes and standards

Source: Christiansen et al. (2011)

In the context of climate-resilient development, adaptation technologies represent a key factor for strengthening the adaptive capacity of populations, communities and regions affected by the adverse impact of climate change and variability. Adaptation technologies along with skills upgrading, adequate information, infrastructure, economic resources, and institutions are development-driven factors, thus the inclusion of 'hard', 'soft' and 'org' parts of adaptation technologies are key elements for climate-resilient development (Olhoff 2015).

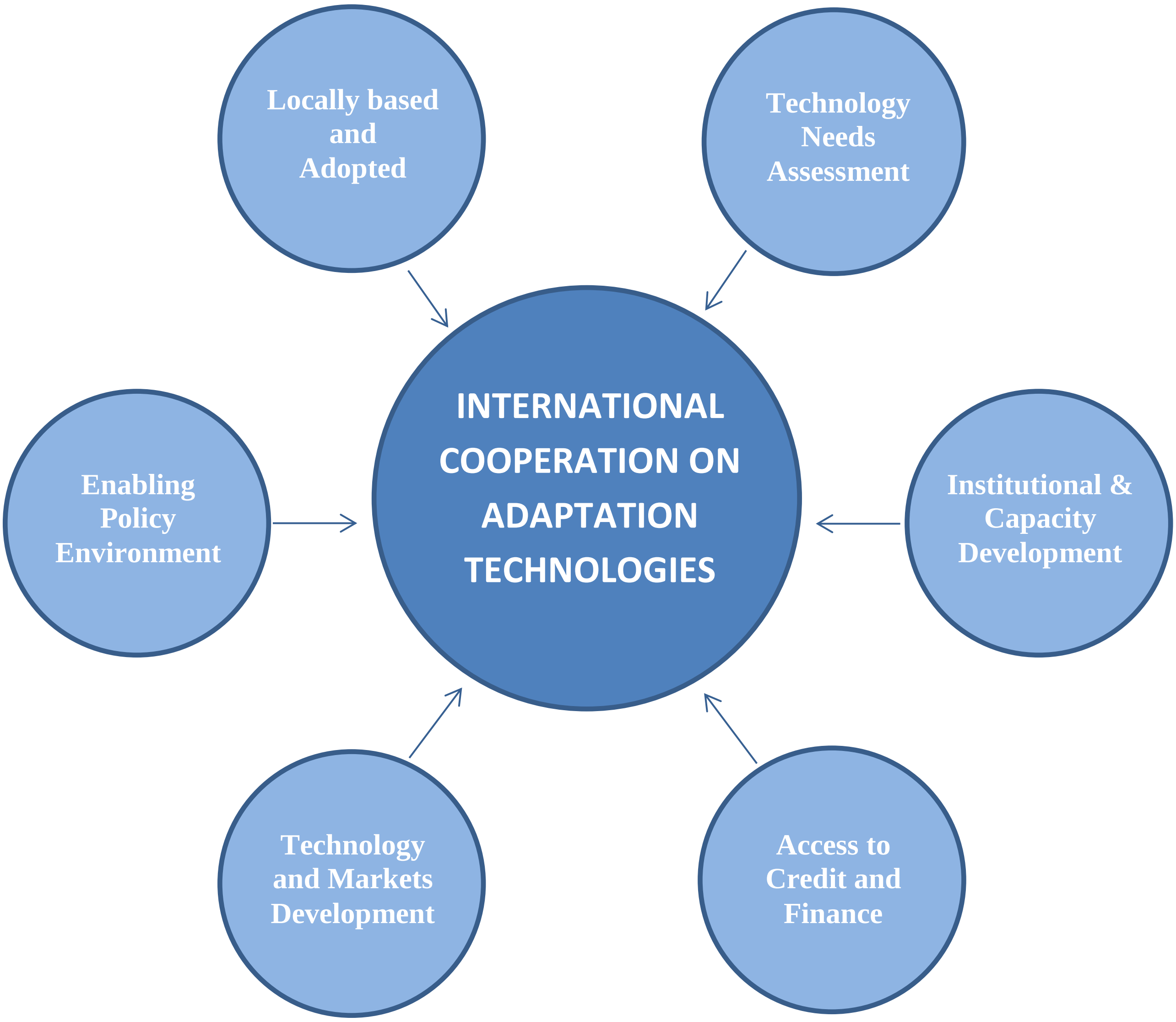
Source: UN/DESA

3. A framework for international cooperation on adaptation technologies

Adaptation technologies have received much less attention compared to mitigation in the literature and programmes on development and transfer of technologies. In this regard, the UNFCCC's technology transfer framework is meant to include both adaptation and mitigation, yet its structure reflects more the transfer of mitigation technologies. The latter underscores the importance of well-developed markets, technologies and institutions at the national level. Conversely, Olhoff (2015) and Biagini et al. (2014) underlines the importance of both national and local adoption processes as well as a long-term commitment to international cooperation on adaptation technologies -- in line with the Cancun Adaptation Framework (UNFCCC 2013)[4] and the focus of many developing countries. In this sense, the framework for facilitating international cooperation on adaptation technologies proposed in diagramme 1 has been informed by the UNFCCC Technology Transfer Framework (UNFCCC 2016), the Cancun Adaptation Framework and the analytical proposals presented by Olhoff (2015) and Biagini et al. (2014).

[4] The 2010 Cancun Agreements negotiated under the UNFCCC Conference of the Parties (COP), consolidated an equal importance of adaptation and mitigation, including the setup of development and transfer of technology (UNFCCC 2011).

Diagramme 1 Framework for facilitating international cooperation on adaptation technologies



Source: UN/DESA

1. Locally based and adopted: Indigenous knowledge and technologies/processes of adapting technologies to local climatic, geographical, and institutional conditions (e.g. education levels, culture).
2. Technology Needs Assessment (TNAs): Country-driven activities to identify the priorities for development and transfer of adaptation technologies to developing countries.
3. Enabling Policy Environment: Long-term climate-resilient development policies, regulations, investment conditions and incentives (at origins and destinations).
4. Institutional & Capacity Development: Institutional building and development of technical skills through international learning networks (ILN) to promote collaborative R&D and innovation practices.

5. Technology and Markets Development: Domestic information technology, infrastructure and suppliers/users of adaptation technologies.
6. Access to Credit and Finance: Improvement of access to and use of credit and finance, from private and public sources (see Annex 2 with UN Agendas including international cooperation on finance).

The structure of the framework proposed above is also partly captured by the modes of international cooperation on adaptation to climate change identified by Oberlack and Eisenack (2014) in the context of adaptation processes in urban settlements in developing countries. These modes include development, transfer and diffusion of adaptation technologies to improve local adaptation capacities; learning (e.g. development of capacities to understand and access to information/data); institutional development and organization to improve systems of decision making (e.g. establishment of rules, procedures, and rights at regional, national and sub-national levels); finance to enhance resource opportunities; and insurance and risk reduction to reduce financial/disaster risks and to improve incentives to invest.

Available adaptation technologies and those that could be modified to local conditions indicate that their adoption and diffusion at the local level is often on of the most challenging processes, more so than their transfer and availability (Olhoff 2015). Policy and institutional changes are necessary for encouraging the innovation of agricultural practices and transfer of technologies to developing countries. At the adoption stage, for example, access and use of new adaptation technologies by farmers can be accelerated by densely integrated and functioning markets, effective institutions and infrastructure, adequate extension systems and access to credit and insurance markets.

Based on the framework presented above, the next sub-sections a) identify the adaptation technology priorities for international cooperation, b) examine the barriers and enabling opportunities for international cooperation in adaptation technologies, and c) propose a strategic integrated approach for international cooperation on adaptation technologies.

4. Identifying adaptation technology priorities for international cooperation

The identification of key adaptation technologies for international cooperation are crucial to stave off the adverse impact of climate change and variability on inequalities, including a higher burden on rural populations, the reinforcement of differentiated access to and use of key resources such as water and energy; and the erosion of health care in vulnerable populations to climate-related epidemics. In agriculture, adaptation technologies can deliver effective and timely information to small- and medium-farmers so new crop varieties and cultivation techniques can be produced. In the energy and health sectors, adaptation technologies can be part of knowledge systems that require specific management skills and regulations to redesign and upgrade energy and health standards.

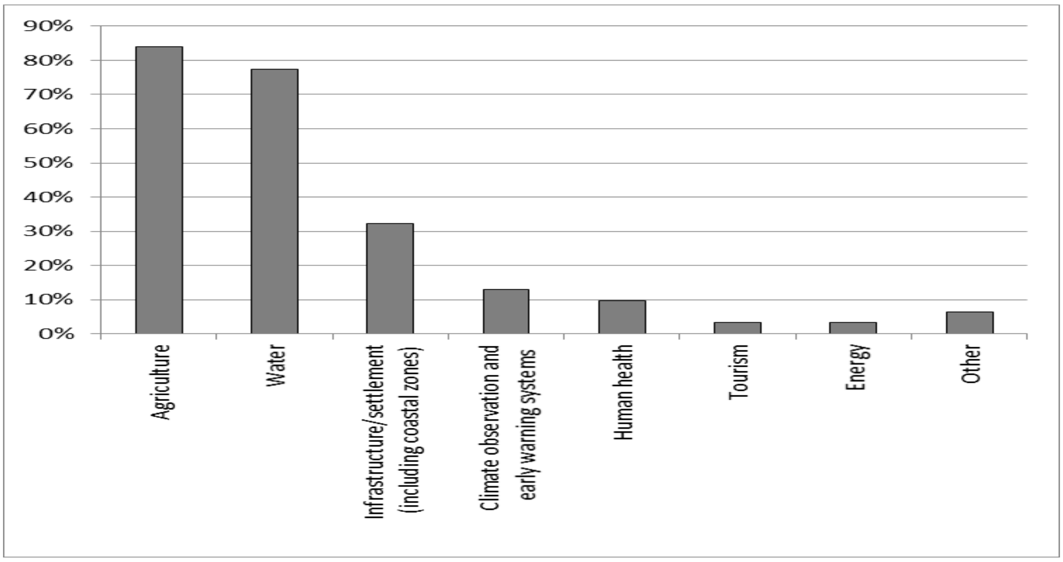
Nonetheless, the priority for low- and lower-middle income countries is to reduce the huge gap in access to cleaner and resilient energy technologies relative to upper-middle and high-income countries, whose one of the main challenges is to maintain the energy supply by having alternative sources of clean energy.

The third synthesis report (UNFCCC 2013a) identified the priorities for the transfer of adaptation technologies in 31 developing countries based on the Technology Needs Assessments (see figure 1 below). Countries applied social, environmental and economic criteria for prioritizing adaptation technologies; for identifying the potential contribution of technology to build resilience to climate change; and for assessing the magnitude of technology's investment and operational costs. Countries prioritized agriculture and water as the two most important adaptation technologies needed, followed by infrastructure/settlement and climate observation and early warning systems.

This prioritization was a selection from over 150 different adaptation technologies from initially more than 320 different technology options identified in preliminary "long lists" of technologies within prioritized adaptation sectors. The identification of adaptation technology needs included hard technologies (e.g. dikes and floodwalls, community irrigation systems and salinity-tolerant rice varieties) and soft-and org-technologies (e.g. organization of water user associations and knowledge transfer). A few countries also prioritized indigenous technologies that could be applied to assist national adaptation to changing climate conditions, such as traditional designs for housing, levees, dikes and mangrove plantations.

Within the agriculture sector, the majority of the prioritized technologies were linked to crop management, techniques for efficient production, livestock breeding, hydro-agricultural technologies, and agro-forestry. Biotechnologies, including technologies related to crop improvement, new varieties and drought-resistant, salient-tolerant and short-maturing varieties, were prioritized by over 50 per cent of countries. In the water sector, over 50 per cent of countries prioritized technologies relating to rainwater harvesting and nearly 40 per cent on water catchments. Other technologies needed and prioritized by developing countries included drip irrigation, water desalination for drinking water, and re-use of waste water.

Figure 1 Priority sectors for the transfer of adaptation technologies (*)



Source: UNFCCC (2013a)

Agriculture and water adaptation technologies can build resilience to climate change and bring co-benefits of adaptation and mitigation. In agriculture, these technologies contribute to foster food security, sustainable livelihoods and local and national economies. For the sake of illustration, it is important to note that particular adaptation technologies in strategic sectors in countries' TNA had wider consensus and considered their application as of high priority among consulted stakeholders. In the South African's TNA, for example, the provision of water supply and sanitation as well as the control of the spread of vector-borne disease were quite important in the human health sector. Along these lines, new crop species and cultivars, information technology, macroeconomic diversification and livelihood diversification, pest management and vulnerability research were considered relevant in the agriculture, land use and forestry sector. Likewise, technologies that would promote water efficiency were highlighted in the water resources sector (Christiansen et al. 2011).

In response to the results observed and the identification of studies reporting on specific country-experiences, the next sub-sections of the chapter focus on agriculture, water, human health and energy sectors for the analysis of main barriers/challenges and opportunities for international cooperation on adaptation technologies as well as for proposing an integrated policy approach to build climate-resilient development.

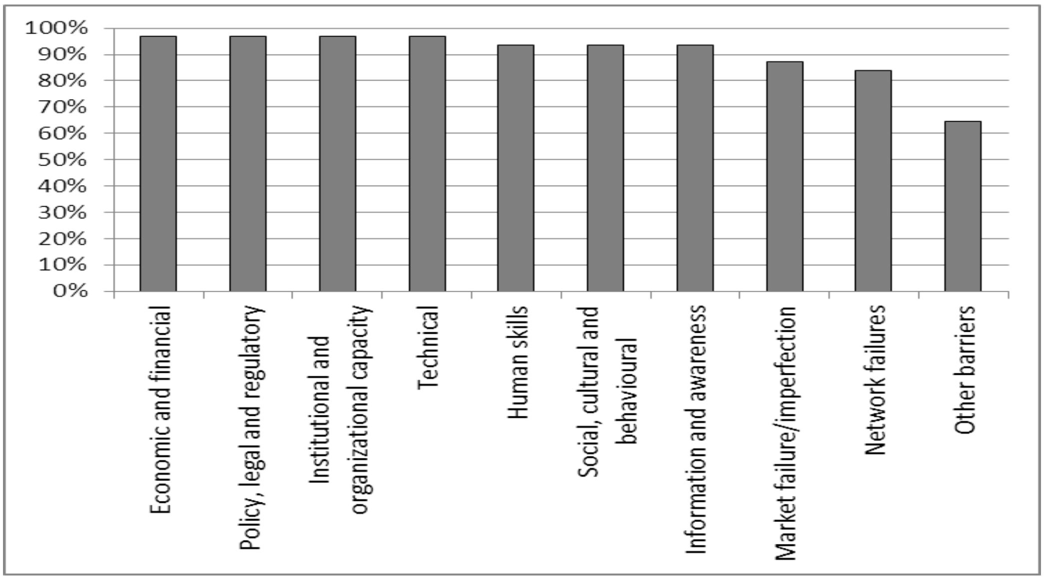
5. Barriers to international cooperation on adaptation technologies

The UNFCCC third synthesis report also informed on the main barriers for the transfer of adaptation technologies identified in the Technology Needs Assessment. Most countries identified relevant barriers to the transfer of priority adaptation technologies in several areas: economic and financial; policy, legal and regulatory; institutional and organizational capacity related; and technical capacities (see figure 2 below). African countries emphasized the lack of training to enhance human capacities; Asian countries underscored the lack of information, awareness and financial incentives; and all three developing regions, including Latin America & the Caribbean, identified the need for technical capacities to develop, deploy, disseminate, operate and maintain adaptation technologies. These barriers have manifested in e.g. inadequate funding to improve service availability and to reduce risks of outages due to climate hazards; limited funding for information-sharing on adaptation to climate change; poor knowledge of climate change risks and adaptation plans needed to maintain electricity and telecommunications; and limited access to online services which may advise on climate change adaptation in food, water, health, and transport.

Within the category of economic and financial barriers, the UNFCCC (2013a) reported that the majority of countries identified the lack of or inadequate access to credit and financial resources as the main barrier. For the policy, legal and regulatory barrier, the most frequent barrier was the insufficient legal and regulatory framework. For the institutional and organizational capacity barrier, the most typical barrier was weak institutional capacity; and for the technical barrier category the most common barrier was system constraints.

In the agriculture sector (the most prioritized adaptation sector), the barriers identified by different stakeholders from thirty-five developing countries were economic and financial; policy, legal and regulatory; market imperfection/failure; human skills, and information and awareness.

Figure 2 Main barriers to the transfer of adaptation technologies



Source: UNFCCC (2013a)

Among technical barriers, the study by Biagini et al. (2014) on the application of adaptation technologies in two projects in Ethiopia and Peru indicated that 'monitoring and data collection technologies' often required highly technical knowledge to use and modify the equipment and conduct data analysis, which was typically difficult and time-consuming for local staff. Other barriers were related to the task of balancing technologies that were beneficial under current climate conditions with those that were more adapted to expected extreme climate conditions in the future. For example, the promotion of vegetable crops in the Ethiopian project received better price in the market, which increased farmers' income; however, some of the vegetable crops had higher water needs, so they failed under current moderate climate conditions. It became clear that medium-term expectations of extreme temperatures would demand that promoted crops be drought- and flood- resistant.

Market formation policies and value chain promotion can also be challenging barriers. The adaptation technologies promoted in the Ethiopian and Peruvian projects were designed to increase crop yields, but it was not clear whether local markets could absorb higher yields, which can potentially affect crop and input prices. Further, the promoted adaptation technologies were not commercially available locally in the Ethiopian project and farmers did not have access to the right financial mechanisms, so higher demand for these technologies did not occur. The lesson is that both supply and demand factors have to be considered to ensure the sustainability of technologies in the long-term (Ibid.).

The literature on international cooperation for technology transfer also draws attention to other barriers such as the technology gaps between developed and developing countries in terms of R&D intensity (as a share of GDP) and the access to and quality of digital technologies – and within developing countries. Low-income countries tend to have 0-0.5 percent of R&D intensity; middle-income countries average around 0.5-1.5, and many high-income countries have a 1.5-3.5 range (United Nations – General Assembly 2013). More broadly, Balboni (2010) argues that the 'digital divide' is manifested within developing countries and between developed and developing countries, which includes uneven computer literacy levels. In Latin America and the Caribbean (LAC), for example, the richest quintile households exceed over 44 times the access to Internet by the poorest quintile. On the other hand, broadband access in LAC is six per cent compared with 33 per cent in OECD countries; and the broadband capacity for transmission and speed connection are many times higher for the latter group of countries. Similarly, the average cost of Mega Bits per Second (Mbps) in fixed broadband access as a share of GDP is ten times higher in LAC than in OECD countries.

Nussbaumer et al. (2015) also informs that major barriers to technology development and transfer were highlighted by a thorough stakeholder's consultation undertaken in the context of establishing the Climate Technology Centre and Network (CTCN). Barriers included the need for a policy framework and enabling conditions (e.g. strategic and long-term planning, political will, policy integration, disincentives to fossil fuel subsidies, macroeconomic environment); awareness and engagement (e.g. reluctance to new technologies, lack of a platform for coordination, need of case studies); lack of infrastructure (e.g. technology providers, inexperience in adaptation technologies to suit local needs); asymmetry in access to information and data (e.g. baseline data, benchmarking, information on IPRs); innovation capacity (limited capacity to develop bankable projects, restrained skills); and access to financing (inability to access to existing funding mechanisms, unavailability of suitable financing mechanisms). Regional expert dialogues included representatives from government institutions, international organizations, non-governmental organizations, private sector and financial institutions.

IPRs: a barrier or enabler of international cooperation?

After lengthy negotiations, there is no consensus on whether intellectual property rights (IPRs) can be considered a barrier or an enabler in the development and transfer of climate change technologies. In practice, the confrontation of two opposing viewpoints has prevented the emergence of a middle ground in the UNFCCC and WTO discussions. On the one hand, the proposals to use the flexibilities of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) and other arrangements to facilitate access to green technologies emanate not only from developing countries and NGOs, but also from the World Bank (2012). The latter suggests the use of compulsory licensing and patent pools to support policies to facilitate access to green technologies, which may entail changes to existing global Intellectual Property rules, in particular those of the TRIPS Agreement.

On the other hand, many developed countries and private-sector organizations consider IPRs as a facilitator of technology transfer. At the same time, IPRs may not be the major barrier or enabler for facilitating access and transfer of climate change technologies; finance and trade restrictions as well as compulsory licensing, patent pools and skilled human resources can also play important roles. Latif (2014) suggests that public research institutions, public-private partnerships and publicly funded research also play a role in the development and diffusion of climate change technologies, particularly in developing countries. After all, IPRs do not seem to have prevented some emerging economies to access key mitigation technologies e.g. India, China.

Even so, only a handful of developed countries dominate the patenting in mitigation and adaptation technologies. For example, 80 per cent of all patent applications in adaptation-related crop biotechnology were invented in OECD countries, while less than 1 per cent of the world’s clean energy technology patent applications in 1980-2009 were filed in Africa. The increase of patenting in biotechnology such as drought-resistant crops, and biofuels, which are strongly dependent on patent protection, are areas where the enabling role of IPRs can be debatable.

Overall, wide knowledge gaps remain for understanding the impact of IPRs on the transfer and development of adaptation technologies in e.g. agriculture and water use. Latif (2014) proposes a “parameters” approach to overcome the current stalemate. Under this approach, discussions should start with concrete country- and sector- specific examples to assess the impact of IPRs on the transfer of adaptation and mitigation technologies and address the knowledge gaps identified.

6. Enabling opportunities for international cooperation on adaptation technologies

The TNAs identified the two most common factors for facilitating the transfer of adaptation technologies: a) the strengthening of relevant institutions with improved human resources & facilities and b) wider access to and larger credit and financial resources (UNFCCC 2013a). As part of the TNAs exercise, countries prepared 76 adaptation Technology Action Plans (TAPs) that identified capacity building as an important need and subject to the support of the international community e.g. capacity building for extension agents; operation and maintenance of irrigation systems; understanding of financing mechanisms for adaptation technologies; and data collection.

For the economic and financial barriers in the agriculture sector, over 60 per cent of developing countries suggested the need to create new financial products for the prioritized technology. Half of the countries identified the need to create an allowance in the national budget for technology (including for R&D activities). Other countries mentioned the need to review national policies to address price competitiveness in the market. Commonly suggested enablers within the agriculture sector included the setup of coordination and communication channels for information exchange between partners (46 per cent), increasing research & development programmes (54 per cent), and conducting R&D of the prioritized technology (26 per cent).

In the context of urban squatter settlements, Oberlack and Eisenack (2014) argues that non-governmental and international organizations can become enabling mechanisms to reduce infrastructure and service barriers to the transfer and development of adaptation technologies. These organizations can help facilitate the provision of infrastructure (e.g. water, energy and housing), education and health services, information (e.g. community awareness' raising) and finance. Moreover, in terms of the provision of adaptation-related public goods by municipal authorities, the interaction between national and transnational municipal networks can lead to the development of urban adaptation strategies and transfer of knowledge-systems in cases in which the interactions enable learning on climate change and best adaptation practices. Overall, international cooperation can reduce vulnerability and adaptation barriers of squatter dwellers in two general ways by working towards: a) the improvement of state-poor relations, and b) more direct access of the urban poor to projects and programmes.

More broadly, a systematic evaluation of 18 adaptation projects supported by three of the Global Environment Facility's adaptation programmes (the Strategic Priority for Adaptation, the Special Climate Change Fund, and the National Adaptation Programmes for Action), including three introducing adaptation technologies through international cooperation, found that local stakeholder engagement is crucial for the success of any adaptation project implementation in terms of efficiency, effectiveness, equity and flexibility. Yet, stakeholder engagement often implied longer negotiation processes and some delay in the projects. On the other hand, low institutional capacity constrained projects' success and effective community participation, although projects that hired international staff to assist implementation experienced higher performances (Sherman and Ford 2014).

The use of multilateral frameworks for technology transfer and in-country capacity development for research and development in developing countries are two main ways how international cooperation facilitates the development and transfer of climate technologies, including adaptation, to reduce technology gaps in developing countries. For example, effective adaptation in developing countries means the strengthening of R&D on improving livestock breeds, agro-forestry, maintaining sustainable water and food supplies, and how to manage land (and ocean) for food production and carbon capture. In the same vein, national frameworks in more advanced countries can also support technology transfer. In particular, small and medium enterprises (SMEs) can be a great source of innovation, even though they often lack the experience and resources to engage in technology transfer to the South. More advanced countries can contribute to international technology transfer by supporting domestic SMEs and helping them to overcome market information barriers through integrated policies and measures. For example, by funding R&D aimed at technology transfer, insuring risk, providing matchmaking services to overcome difficulties in identifying private sector partners in the South, and finding demonstration sites. If such difficulties could be overcome, the benefits would arise through increased transfer of appropriate innovations to the South and through an internationally active private sector for most advanced countries (Belman Inbal and Tzachor 2013).

It is important to be aware, nonetheless, that a fragmented system of capacity-development mechanisms for technology has occurred over the past two decades. For example, a myriad of entities in many countries are part of the international clean technology cooperation and the density of the networks differs between clusters, which manifests different national policy objectives and priorities, resources available and political interests. There have also been many technology transfer provisions in international agreements and conventions, in particular in environment and health technologies (United Nations – General Assembly 2012).

In this context, there was a need for a technology mechanism to accelerate technology progress more evenly and widely, with particular attention in supporting resilience building in countries and populations vulnerable to the adverse impact of climate change. As a result, the 2015 Addis Ababa Action Agenda includes 8 references to international cooperation in technology and an especial reference to the Technology Facilitation Mechanism (TFM; Paragraph 123); the Sendai Framework for Disaster Risk Reduction 2015-2030 and the 2030 Agenda for Sustainable Development have 9 references to international cooperation on technology each, with the latter having a reference to the TFM (Paragraph 70); and the Paris Agreement with 12 references to international cooperation on technology.[5] See Box 2 for a summary of the main structure and objectives of the TFM.

[5]None of these international agreements make a distinction between adaptation and mitigation technologies.

Box 2 Progress of the Technology Facilitation Mechanism

The TFM is an opportunity to harness efforts of the international community to facilitate the development, transfer and deployment of technology (including adaptation) more widely and in a coordinated fashion. The mechanism was established by the Addis Ababa Action Agenda and launched at the 2015 United Nations summit for the adoption of the post-2015 development agenda. The TFM is based on a multi-stakeholder collaboration between Member States, civil society, the private sector, the scientific community, United Nations entities and other stakeholders. It has three components: a) the United Nations inter-agency task team (IATT) on science, technology and innovation for the SDGs, b) a collaborative multi-stakeholder forum on science, technology and innovation and c) an online platform. The TFM will seek to develop synergies with the Technology Bank for Least Developed Countries, which was agreed in 2011 at Istanbul, Turkey[6].

The **United Nations IATT on science, technology and innovation for the SDGs** promotes coordination, coherence and cooperation within the United Nations system on science, technology and innovation-related matters, enhancing synergy and efficiency, in particular to enhance capacity-building initiatives. The IATT draw on existing resources and will work with **10 representatives** from civil society, the private sector and the scientific community to prepare the meetings of the multi-stakeholder forum on science, technology and innovation, as well as in the development and management of the online platform, including preparing proposals on the modalities for the forum and the online platform.

The Secretary-General appointed the 10 representatives for two-year periods. The IATT is open to the participation of all United Nations agencies, funds and programmes and the functional commissions of the Economic and Social Council and it is initially composed by entities that currently integrate the informal working group on technology facilitation, namely, the Department of Economic and Social Affairs of the Secretariat, the United Nations Environment Programme, the United Nations Industrial Development Organization, the United Nations Educational, Scientific and Cultural Organization, the United Nations Conference on Trade and Development, the International Telecommunication Union, the World Intellectual Property Organization and the World Bank.

The **multi-stakeholder forum on science, technology and innovation** will be convened once a year, for a period of two days, to discuss science, technology and innovation cooperation around thematic areas for the implementation of the SDGs, congregating relevant stakeholders to contribute in their area of expertise. The forum will provide a venue for facilitating interaction, matchmaking and the establishment of networks between relevant stakeholders and multi-stakeholder partnerships in order to identify and examine technology needs and gaps, including on scientific cooperation, innovation and capacity-building, and help to facilitate development, transfer and dissemination of relevant technologies.

The meetings of the forum will be convened by the President of the Economic and Social Council before the meeting of the high-level political forum (HLPF) under the auspices of the Council or, alternatively, in conjunction with other forums or conferences, as appropriate, taking into account the theme to be considered and on the basis of a collaboration with the organizers of the other forums or conferences. The meetings of the forum will be co-chaired by two Member States and will result in a summary of discussions elaborated by the two co-Chairs, as an input to the meetings of the HLPF and in the context of the follow-up and review of the implementation of the post-2015 development agenda. The

[6] See Programme of Action for the Least Developed Countries for the Decade 2011-2020.

meetings of the HLPF will be informed by the summary of the multi-stakeholder forum. The themes for the subsequent multi-stakeholder forum on science, technology and innovation for the SDGs will be considered by the HLPF, taking into account expert inputs from the task team.

The **online platform** will be used to establish a comprehensive mapping of, and serve as a gateway for, information on existing science, technology and innovation initiatives, mechanisms and programmes, within and beyond the United Nations. It will facilitate access to information, knowledge and experience, as well as best practices and lessons learned, on science, technology and innovation facilitation initiatives and policies. The online platform will also facilitate the dissemination of relevant open access scientific publications generated worldwide. It will be developed through an independent technical assessment which will take into account best practices and lessons learned from other initiatives, within and beyond the United Nations, in order to ensure that it will complement, facilitate access to and provide adequate information on existing science, technology and innovation platforms, avoiding duplications and enhancing synergies.

In 2016, the 10-Member Group to support the TFM held its First Virtual Meeting and the Under-Secretary-General of DESA Mr. Wu Hongbo briefed Member States on the progress made by the TFM. In addition, a First Face-to-Face Meeting of the 10-Member Technology Group with the IATT and the First Annual Forum on Science, Technology and Innovation for the SDGs will also take place in the current year.

Sources: UN/DESA, based on the 2030 Agenda for Sustainable Development and AAAA.

In sum, the identification of countries' priorities, barriers and enablers for effective international cooperation on adaptation technology transfer represented the opinion from a wide spectrum of relevant stakeholders, public and private,[7] evenly distributed among all regions worldwide. Broader analysis coming from the scientific community, adaptation technology specialists and a larger sample of countries can complement the analysis above. Based on scientific research of country experiences, the next sub-section proposes a strategic integrated approach to enhance international cooperation on adaptation technologies and capacity development.

[7] They included national government, universities, businesses, independent consultants, NGOs, electricity utility companies, media/consumer groups; IGOs/potential donors, local government, international experts, households/community; finance community and political parties (Ibid.).

7. A strategic integrated approach to international cooperation

It is a challenging exercise to systematize all scales of policy integration for an effective international cooperation on adaptation technologies. There is not abundant literature on the topic and integration would have to be an iterative process in order to examine the links among sectors, institutions, and local, national and international frameworks.

An integrated approach can encompass three policy pathways to facilitate the international cooperation on adaptation technologies and knowledge-based systems in low- and middle-income countries:

a) The integration of development with climate policies.
b) The integration of local, national and global institutional frameworks.
c) The integration between strategic productive sectors and development programmes.

The integration of development with climate policies

International cooperation can scale up the integration of development programmes with adaptation technologies. International organizations can play a key role in expanding the integration of development with climate strategies in developing countries. They can provide a springboard for innovative approaches, share good practices, strengthen human and social capacities, promote international partnerships, and set international standards and guidelines. For example, international cooperation can greatly scale up the Senegalese policies and actions to reduce the pressure on land as a consequence of growing urbanization and climate change. International cooperation on adaptation technologies and finance can a) increase the area for restoration of soil fertility for agricultural development, b) improve the provision of local energy supply for the rural poor, c) enhance the rehabilitation of degraded lands, and d) increase the sequestering of carbon from the atmosphere (Kok et al. 2008).

The integration of local, national and global institutional frameworks

In agriculture, the green revolution of the 1960s-1970s was achieved through the integration of international innovation systems with countries and communities where innovative technology was applied. Food insecurity and poverty levels were substantively reduced through government-supported laboratories working together in the Consultative Group on International Agricultural Research (CGIAR), improving farmer extension services and other infrastructures. The institutions and researchers involved constituted an innovative productive system, embedded in a context created and enabled by policymakers around the world (UN/DESA 2011). Nonetheless, this revolutionary approach to higher agricultural productivity was not absent of criticism, reproached by its harm to traditional knowledge systems, ecosystems and land erosion precipitated by the intensive use of artificial fertilizers and insecticides. On the other hand, the study by Oh et al. (2010) also found that international cooperation in Korea Republic did typically enhance basic research output, where universities and Government-supported research institutes were the major participants. However, in contrast with the CGIAR experience, international cooperation on development and transfer of technologies in the Korean case was not linked to a worldwide and dense network of innovation systems, but rather concentrated in a few countries e.g. U.S., Japan, India, China and Germany. Most of the Korean international public R&D cooperation activities were directed to attract foreign researchers, exchange relevant information, and sign agreements. Notably, international cooperation did occur in technology areas where Korea had both relatively low technological advancement, such as biotechnology, and in areas with a high level of technology such as physics and chemistry.

Skills and capacity development levels are also important to absorb the potential benefits from international technological cooperation. A quantitative survey of companies in the Zhongguancun Science Park (ZGC) in Beijing, found that ZGC absorbed scientific knowledge originating in foreign companies and local universities and public research organizations (Liefner et al. 2006). International cooperation with foreign companies helped ZGC companies to get new ideas and enter the market with new products, while cooperation with universities was mainly to design new products. The patterns of cooperation showed that ZGC was able to absorb knowledge and innovation from different sources; nonetheless, not all high-tech ZGC companies were able to make use of international linkages in the innovation process since about half of them lacked the necessary capabilities. On the whole, policies should focus on the enhancement of innovation capacities, in particular the development of technical skills, organizational capital and diversified networks of firms and research centers (Tawney et al. 2013).

The consultation and coordination process with a wide array of stakeholders for the TNAs has generated a critical mass of positive synergy. In this vein, LDCs have been more inclined to integrate TNAs with the implementation of National Adaptation Programmes of Action (NAPAs), including the identification of priority projects and technologies, which have often been supported by domestic and international resource mobilization. Moreover, NAPAs have become integral part of National Development Plans in many developing countries. The Malawi's NAPA priority projects, for example, identify the kind of adaptation technologies needed e.g. hard, soft and org, and whether these technologies can be locally developed or supported by the international development community (see table 2 below). For example, geospatial technologies, irrigation technologies and climate-resistant crop varieties would need regional and global international cooperation due to high cost; crop & farm management skills and specialized knowledge may require the international collaboration of scientists and specialized technicians as well as of universities and R&D centres. The accumulated knowledge of local people would be key to enhance and capitalize effective innovation and capacity development. In this regard, table 2 also serves to illustrate the integration of hardware adaptation technology with indigenous knowledge-based systems; in particular the contribution of local stakeholders to the effective implementation of Malawi's NAPA priority projects.

Table 2: Adaptation technology needs in Malawi's NAPA priority projects

NAPA Priority Project	Examples of Supporting Adaptation Technologies
Improving community resilience to climate change through the development of sustainable rural livelihoods	Hard Technology: Geospatial technologies, improved varieties, water and food storage systems Soft Technology: Crop and farm management skills
Restoring forests in the Shire River Basin to reduce siltation and the associated water flow problems	Hard Technology: Geospatial technologies Soft Technology: Growing of tree seedlings and land management skills Orgware: Creation of buffers
Improving agricultural production under erratic rains and changing climatic conditions.	Hard Technology: Geospatial technologies, irrigation technologies Soft Technology: Community radios, short messages. Seed multiplication technologies and animal breeding technologies, improved farm management, seasonal forecasts
Improving Malawi's preparedness to cope with droughts and floods	Hard Technology: embankments for flood control, water harvesting and recycling, wetland restoration, drought-resistance varieties and those varieties that can cope with a lot of water Soft Technology: Crop weather insurance, seasonal forecasts Orgware: Floating agriculture for areas that remain inundated
Improving climate monitoring to enhance Malawi's early warning capability and decision- making and sustainable utilization of Lake Malawi and lakeshore area resources	Hard Technology: Geospatial technologies, automatic weather stations and floating buoys, community flood information systems Soft Technology: knowledge and skills

Source: Christiansen et al. (2011)

In general, the study by Fernandez-Ribas and Shapira (2009) argues that the effect of national innovation programmes can have positive spillovers beyond improvements in private R&D spending and patents. In fact, domestic-level programmes, not necessarily designed to enhance international collaboration in science and technology, can indirectly strengthen international cooperation in innovation, by providing additional finance, experience in domestic cooperation projects, and learning on how to apply for public funding. More precisely, the study found that firms with public support from national and regional sources are more likely to undertake cooperative research with international partners than non-supported firms, Policy implications include the recognition that public support for private innovation can induce unintended spillovers to other innovation activities, the need to include behavioral changes when evaluating public innovation policies, and the role of national and regional policies in supporting transnational innovation networks in regions where domestic firms such as SMEs, face barriers in applying for public funding at supranational agencies.

The integration between strategic sectors and development programmes

Policies that link water, energy and agriculture are typically formulated without deep understanding of their inter-relationship and the possible unintended consequences and respective costs. The sectoral nature of approaches to policy design in different development areas and at different government levels contributes significantly to the incoherence. Institutional mechanisms, policies and policy instruments need to be retooled to identify the multiple intersections in these areas, at different spatial and temporal contexts. International cooperation for supporting capacity development on drip irrigation, for example, can have integrative synergies between food security, water efficiency, and energy saving, which would benefit many drought-prone low- and lower-middle income countries. Indeed, the invention of drip irrigation by Israel in the 1960s has greatly reduced evaporative losses from agriculture and has enabled to produce high-value crops with high productivity and low-use of fertilizer (Lindberg and Lefleive 2015).

Local adaptation practices and international cooperation on science- and technology-driven adaptation strategies can complement each other and build long-term resilience to climate change. Their synergies can upgrade e.g. drought adaptation strategies of the most vulnerable, and prompt the support of international cooperation for the integration of water, land, food, health, and capacity development programmes. Access to and use of adaptation technologies such as genetic modification, mixed farming, extension service, construction of water supply, irrigation systems, training, and earth observation and monitoring services are a call for international cooperation and coordination, which can greatly enhance an integrated and effective approach to poverty reduction, food security, water efficiency, early warning, energy access, health care and community resilience. A study that reviewed and synthesized research-based literature on drought adaptation practices among small-scale farmers in southern Africa indicated that the integration of indigenous and technological-driven adaptation practices set the stage for a wider integration of key sectors in the countries under study (Makhado et al. 2014).

Multi-sectoral approaches are important for affective adaptation and to improve the chances for international cooperation and scaling up. For example, the management of health risks linked to climate change needs the commitment of the health sector and other social, economic and environmental sectors. Hydro-meteorological services should provide data on weather trends and projected climate variability. Consultations and strong links with weather and other services may also include regional and international agencies. A plan for engagement in regular interactions facilitates building capacity across sectors. In an Uzbekistan project led by UNDP/WHO GEF, for example, the international collaboration among these institutions and the Ministry of Health and Uzbekistan Hydromet enabled data collection on cardiovascular, intestinal and respiratory diseases, which entered into a database of weather and climate data. These data will be used by the Ministry of Health to manage risks of climate-sensitive diseases (WHO 2015).

In the same vein, international cooperation projects have been an integral component of China's response to HIV/AIDS. Funding from international projects was one-third of the financing allocated to the HIV/AIDS response in China (Sun et al. 2010). As the HIV/AIDS epidemic grew across China twenty years ago, projects became part of a comprehensive and integrated national endeavor. For twenty years China was part of 267 international cooperation projects related to HIV/AIDS and received US$ 526 million from 40 international organizations. These programmes also promoted best practices, accelerated the introduction of AIDS policies, developed capacities, enhanced the development of grassroots organizations and established a platform for experience sharing with the international community (ibid.).

8. Access to and use of ICT data and environment/climate change statistics

The objective of this section is to map out the access and use of ICT data and environmental/climate change statistics in order to identify significant gaps and effective regional and current and potential global cooperation practices, which can improve countries' capacities for disaster risk reduction and prospects for climate-resilient development. Having access to, being able to produce and improve the use of environmental and climate change statistics are essential for mapping different types and degrees of vulnerability of countries and populations, enhance evidence-based public policy and inform the international community on the scope of risks to the adverse impacts of climate change.

The production of ICT data through Internet-based applications, satellites, mobile phones, tele-centres, and community radio are fundamental to improve the generation, monitoring, exchange and application of relevant climate change information and knowledge on ICT-based climate change adaptation measures.

In fact, evidence-based policymaking for climate-resilient development needs accurate time-series information on e.g. greenhouse gas emissions, forest cover, biodiversity; energy production and use; waste; water availability; and the occurrence and diverse impact of extreme events on populations (United Nations – Economic and Social Council 2015). This information should also be geospatially mapped to population distribution and characteristics such as occupation, income and rural and urban residence. Incidentally, even though "three out of four poor people in developing countries live in rural areas", no breakdowns of poverty statistics consider vulnerability to natural hazards; meanwhile "over the last two decades the quantity and quality of agricultural statistics have undergone a serious decline. Many countries, especially in the developing world, lack the capacity to produce and report even the minimum set of agricultural statistics required to monitor national trends" (FAO, World Bank and UN Statistical Commission 2012, page XI). Broadly, developing countries face big challenges in overcoming the lack of an established environment statistics programme and in coordinating the production of environment statistics that is often done with inadequate coherence and through different unrelated agencies. In some countries, environment statistics also has to compete with social and economic statistics in the assignation of resources.

To anticipate and adapt to climate change impacts, indicators are needed on populations in vulnerable zones, which meet international criteria of simplicity, relevance, and are statistically sound. For each country and its low-elevation coastal zones, coastal flood plains and deltas, dry lands, and mountain and remote regions, these indicators include population and population growth rate; urban and rural populations and growth rates; and poor and non-poor populations (urban and rural). As stated in the United Nations Fundamental Principles of Official Statistics, "Official statistics that meet the test of practical utility are to be compiled and made available on an impartial basis by official statistical agencies to honour citizens' entitlement to public information" (United Nations General Assembly 2013). As sophisticated users and data analytics increase, the demand is not just of basic series and tables but for detailed underlying micro-data, whose release requires new policies and programmes by national offices to make the data easily available (Johnston 2016).

On the whole, there is a need to establish international standards in order to harmonize concepts, definitions and classifications relating to vulnerable eco-zones and their vulnerabilities within and among countries; ensure the capacity to "layer" data on population and population characteristics such as occupation, urban-rural and poverty in small administrative areas; and establish comprehensive national capacities to compile time series on vulnerable populations in countries, from national and international sources (Ibid.).

Nevertheless, many developing countries have inadequate access to and capacities to produce and use basic statistics, let alone to be capable of producing environment and climate change statistics as well as have access to ICT data. Vulnerable countries to the impact of climate change, in particular, need the support of the international community to build capacity development, well-developed statistical systems to monitor the weather and environmental trends, and predict the frequency, geography and intensity of natural hazards, populations at risk, erratic changes in rain and wind patterns, and long-term changes in the environment. Yet, statistics on vulnerability, adaptation and resilience are the least developed relative to other climate change statistics and require investment in methodology development and capacities to be produced at the local level (UN/DESA 2016).

In this regard, the multiple impacts of climate change on vulnerable livelihoods and infrastructures increasingly demand an international collective effort to enable access to ICT data and finer measurement of environmental changes and their impacts at local and regional levels. In fact, there is increasing international awareness and demand for the production of good-quality environment statistics, which includes climate change statistics, to identify key environmental policy issues and enhance evidence-based policymaking.

ICT data and Statistics to build climate-resilient development

This sub-section identifies common and differentiated characteristics of information provided by standard statistics and ICT, including big data (see box 3 below). Good information and data can create demand for more good information, change behaviour and ignite further innovation (Fishman 2011). It also assesses country experiences and potential innovative use of ICT data on building resilience of vulnerable livelihoods and strengthening evidence-based development policymaking. More importantly, it analyses regional and global partnership experiences in producing and using ICT. A sizable part of information and data production by ICT originates in current communication technologies (e.g. satellites, cell phones), so wider use of ICT implies larger computational and storage capacities as well as the development of institutional capacities and technical skills.

Box 3 Are standard statistics and big data (BD) complementary?

Standard statistics tend to be different from BD with respect to data collection, measurement, and analytics. BD are often produced as large sets of unstructured and heterogeneous data sets in real or nearly real time, originated insystems of geographical information (SGI) such as satellites, mobile communications, web logs (Google earth, crowd-sourcing, private-public web platforms), social media (Twitter, Facebook), iCloud and financial transactions. On the other hand, official statistics are mainly structured data sets that countries have often collected, compiled, standardized, and analyzed for public use and as input for decision-making on development.

Standard statistics can take the form of cardinal numbers (e.g. 5 million people unemployed) and indicators (e.g. 5 per cent of GDP growth). BD takes the form of messages, updates, and images posted to social networks; satellite information; readings from sensors; GPS signals from cell phones, and the like. For example, smart-phones and other mobile devices provide enormous streams of data tied to people, activities, and locations.

Most BD production is owned by a few national and international scientific organizations; banks, mobile phone, Internet and social media providers. Standard statistics are mainly owned by countries and have been of public use almost since States were formed. In contrast, important sources of big data are relatively new; for example, the large amounts of data/information originated in social networks such as Facebook (2004) and Twitter (2006) are as old as the networks themselves.

Keeping in mind the justified concerns on information privacy, standardization and the degree of accuracy of BD measurement, studies indicate that the use of standard statistics and big data in development can be complementary and integrated within a common framework. In fact, a comparison of the robustness of results when using both types of information on e.g. mapping poverty serves to confirm that big data can potentially bridge the limitations of standard statistics, where appropriate benchmarks on poverty exist (Weeks et al. 2012; Wang et al. 2012).

Source: UN/DESA

ICTs are widely employed for environment and climate monitoring including weather forecasting and in early-warning and disaster recovery communications (UN/ECLAC - EU 2011). ICTs have monitoring and transformative capabilities by strengthening the capacity to collect data about the climate related to temperature, humidity, and precipitation and sea level changes. For example, sensor networks based on the Internet of Things (IoT) technologies connected to wireless (e.g. LTE network) or fixed access technologies. ICTs can also provide defined techniques and methods, utilizing supercomputers to develop climate models and highlight emission trends, which can help to predict potential climate related disasters in the future. Modern disaster prediction, detection and early warning systems based on the use of statistics and ICT are essential for saving lives and build sustainable livelihoods.

The statistical and ICT capacities in many developing countries, particularly countries in special situations, need to be developed and upgraded with the support of the international community. These countries do not have the technical and financial capacities to own mobile devices, in particular smart phones, much less the capacity to use spatial data and environmental and climate change statistics. The LDCs and LLDCs have on average 56 and 65 cell phone subscriptions per 100 population, and 7 and 15 Internet users per 100 people; rural areas are further below these rates. This situation reminds us of the agreed commitment of the international community for a revitalized cooperation to strengthen the development capacities of countries vulnerable to the adverse impacts of climate change.

With the increase in frequency and intensity of **extreme** climate-related meteorological **events** and **natural disasters** there are emerging data needs in countries in special situations, whose fulfilment demand international cooperation. The Sendai Framework for Disaster Risk Reduction recognizes this need by stating, “[To] promote and enhance, through international cooperation […] access to and the sharing and use of non-sensitive data and information, as appropriate, communications and geospatial and space-based technologies and related services; maintain and strengthen in situ and remotely-sensed earth and climate observations; and strengthen the utilization of media, including social media, traditional media, big data and mobile phone networks, to support national measures for successful disaster risk communication, as appropriate and in accordance with national laws” (Paragraph 25c, p.16). Similarly, the Addis Ababa Action Agenda underlines, “A focus on quantitative and qualitative data, including open data, and statistical systems and administrations at the national and sub-national level will be especially important in order to strengthen domestic capacity, transparency and accountability in the global partnership (Paragraph 125, p.58). Therefore, the support of the international community to national efforts to strengthen national and sub-national statistics systems would end up fostering a more even development of statistical capacities and evidence-based policymaking to reduce inequalities exacerbated by climatic hazards.

Geospatial information to reduce gaps in capacity development

Geospatial information mainly originates out of satellite observations. The Committee of Experts on Global Geospatial Information Management (see ggim.un.org) is the intergovernmental mechanism for setting the direction for the production and use of geospatial information within national and global policy frameworks. Geospatial information can be a powerful tool to build resilience to climate change, support inclusive development and improve evidence-based policymaking. For example, geospatial information allows for modelling of many data inputs across many different scenarios to assess the adverse impact of climate change due to sea level rise along the coasts of Small Island Developing States (SIDS). Geospatial information includes profiles of the land, natural hazard, exposure of livelihoods, and location of vulnerable populations (United Nations – Economic and Social Council 2015a). Remote monitoring of the earth by satellite can provide crucial data on deforestation, crop patterns that may indicate potential food shortages, and early warning to climate hazards (UN/ECLAC – EU 2011).

International cooperation on satellite imagery, in particular, has already supported development efforts in different countries. For example, regional cooperation for sharing satellite data and survey measures of poverty levels, together with local placement rules for protected green areas in Thailand had a positive impact on reforestation, consumption and poverty reduction. The intervention also increased local revenue from ecotourism (Greenstone and Kelsey Jack 2015). Likewise, the study by Scaria and Vijayan (2012) underscores the importance of international cooperation on spatial information technology for India's rural development, delivering reliable base line information on natural resources at the regional and micro levels, while supporting an integrated analysis of natural resources inventory and management as well as a strategic plan for sustainable rural development.

Yet, although geospatial information is used in some developing countries, additional capacity building is needed to scale up current initiatives and get access to innovative applications from other parts of the world. Broadly, developing countries have to strengthen statistical infrastructures (e.g. computation and storage), institutional and technical capacities for producing environmental data. For example, in many African countries data and comparable surveys are not available since the proportion of people with e.g. bank accounts, credit cards and social media is low and many countries had not conducted regular surveys. Moreover, only 25 out of 48 African countries had conducted at least two surveys over the past ten years (Beegle et al. 2016).

These limitations shed light on the potential for broader projects and enlarged international collaboration to reduce capacity gaps between and within countries. In this sense, the combination of satellite-generated data with social, economic and demographic information coming from surveys opens the possibility for the analysis of populations with various degrees of vulnerability to natural hazards e.g. floods, storms, droughts. For example, the public-private partnership initiative led by the African Climate Policy Center, the International Research Institute for Climate and Society at Columbia University and hydro-meteorological instrument providers are engaged on linking climate satellite information (physical vulnerability) with demographics (social vulnerability). The digitization of historical data on rainfall and temperature has been calibrated with satellite data to a) generate nationwide gridded data and b) convert point data to spatial coverage (UN/DESA 2015).

International cooperation for access and use of ICT data and statistics

Recent positive applications of ICT in development have enhanced possibilities for scaling up and contribute to the reduction of poverty, economic insecurity and inequalities. Spatial data, in particular, can enable a detailed mapping of populations with various degrees of resilience or vulnerability to the impacts of climate change (Kshetri 2014). Blumenstock et al. (2015) demonstrates that people past history of mobile phone use can be an effective predictor of the socio-economic status of people. For example, the predicted attributes of 1.5 million of individuals living in Rwanda can accurately reconstruct the distribution of wealth of the entire nation and even infer the asset distribution of micro-regions composed of just a few households.

International public-private partnerships may involve governments, NGOs and businesses. For the local private sector, for example, partnerships with internationally funded programmes and NGOs can create benefits through financial support, learning opportunities, risk-sharing and market access. Box 4 below shows an example of international cooperation between international and local organizations and the great potential of using smart phones for development.

Box 4 International cooperation to support the rural poor

The mobile platform *Mobipay* combining agriculture information and financial services, specifically designed for smallholder farmers, has started in Northern Uganda. Based on AgriLife[8], a cloud-based platform, the platform is accessible via a mobile phone and it provides two interconnected services: a) data collection and analysis of farmers' production capability and history, and b) integration point for financial institutions, mobile network operators, produce buyers and their agents to provide more efficient services to distant rural farmers. Farmers are able to use a mobile phone to a) order and pay for inputs like seeds and fertilizer, and b) get paid for their produce.

Mercy Corps has supported the expansion of AgriLife in Uganda and built relationships with other service providers that can be part of the platform to improve reach of rural clients. Mobipay expects to provide services to 10,000 farmers. Farmers are interested on group loans due to the need for collateral, which is usually land. In Northern Uganda, land is often communally owned e.g. clans, so individuals can't use it as collateral. MobiPay is tailoring the AgriLife platform so that group credit scores would be possible, engaging financial institution partners that can provide group lending based on these scores.

Challenges remain such as a) low network coverage and instability of the network in the most remote areas, which can represent lower adoption, b) the high cost of phones (US$20) and calls (US$0.20 per minute), and c) difficulty in charging mobile phones. These factors constrain smallholder farmers from accessing services via mobile, getting on the platform and enjoy economic benefits.

Mercy Corps provides support for the project under a three-year Swiss Agency for Development and Cooperation (SDC) funded program called Agri-Fin Mobile. The programme has simultaneously been rolled out in Indonesia and Zimbabwe by bundling agriculture-related services and delivering them via mobile phones. The target is to raise farmer incomes by 30 percent. Mercy Corps expects that improved crop yields and increased income resulting from a holistic mobile platform will have a significant impact on food security of poor farmers.

Source: Yeoman (2013)

The positive results of the programme above have raised the outlook for further scale up of current initiatives through an enabling environment that promotes climate-resilient development policies. These results also represent a challenge for responding to the capacity development and political commitment needed to support sub-national development of rural and urban areas, and the reduction of inequalities within countries.

[8] The AgriLife platform was developed by a Kenyan-based IT company called MobPay Kenya Ltd.

An illustration of effective multilateral cooperation to support national capacity development efforts and resilience building is the monitoring of forests in tropical countries. The monitoring of forest cover and forest functions provide crucial information to support evidence-based policymaking to conserve, protect and manage forests in a sustainable manner. In particular, for tropical countries and populations whose livelihoods depend from forests, national forest monitoring systems that effectively estimate forest cover, forest cover change and carbon stock change can be of utmost importance. In this sense, the study by Romijn et al. (2015) assessed the status and changes in national forest monitoring and reporting capacities in 99 tropical countries, using the Food and Agriculture Organization of the United Nations (FAO) Forest Resources Assessment (FRA) 2015 data, complemented with FRA 2010 and FRA 2005 data. "Forest area change monitoring and remote sensing capacities" improved considerably between 2005 and 2015. For 54 of the 99 countries, the total tropical forest area that was monitored with good forest area change monitoring and remote sensing capacities increased from 69 percent in 2005 to 83 percent in 2015, which correspond to 1435 million ha and 1699 million ha respectively. This positive effect has been the result of effective use of internationally-free and open source high resolution satellite (remote sensing) data such as Landsat and availability of other techniques for assessing historical forest cover change and improving countries' national forest monitoring.

Moreover, the total tropical forest area that was monitored with good "forest inventory capacities" increased for 40 countries, from 38 percent in 2005 to 66 percent in 2015, which corresponds to 785 million ha and 1350 million ha respectively. "Carbon pool reporting capacities" did not have as much improvement, which indicates the need for greater support on producing accurate emission factors and improved greenhouse gases reporting. The study also revealed that there was a positive adjustment in the net change in forest area where countries with lower capacities in the past had the tendency to overestimate areas of forest loss. The results underlined the effectiveness of capacity building programmes such as those led by FAO and the multilateral initiative REDD+, which financially rewards developing countries for verified efforts to reduce emissions and enhance removals of greenhouse gases through a variety of forest management options[9]. Nonetheless, continued international support to national efforts for investing in capacity building is necessary to enable remaining countries to accurately monitor the tropical forest area with sufficient level of capacity. More country-specific data of carbon stocks are needed to represent the specific biomes and tree species and to have lower uncertainties. In many countries, data for reporting on carbon in different pools come from forest inventories, yet more capacity building and training is needed so countries can actually perform the reporting. Some countries showed a decrease in capacities within a five-year cycle.

On the whole, while many tropical countries had limited capacity in the past to implement national forest monitoring systems, capacity building efforts have been able to strengthen the technical and political skill-sets necessary to implement national forest monitoring at the

[9] REDD+ is a set of guidelines for developing countries on how to report on forest resources and forest management strategies and their results in terms of reducing emissions and enhancing removals of greenhouse gases

institutional level. In building sustainability for the future, countries that are able to maintain their forest monitoring system and regularly update their inventories will continue improving the accuracy and reliability of data and information on forest resources and, therefore, refining policies to further improve forest management.

UNOSAT's support to ICT data access and capacity development

UNOSAT has been one of the leading organizations in using satellite imagery to inform and produce disaster risk and damage images for international public use, while also strengthening capacities in developing countries. In this context, UNOSAT has made available a free crowd-sourcing app, called UN-ASIGN, which is a tool for taking and sharing geo-tagged photos specifically designed to work over low-bandwidth. The photos are automatically mapped, helping towards situational awareness. Individual contributors can see their own photos on Google Maps, while UNOSAT have access to all photos and share those relevant with UN OCHA and other coordination entities. The photos appear in real time as long as the volunteer has a GSM or Internet connection. This tool has been used in Haiti, Pakistan, Nigeria and Thailand.

UNOSAT cooperates in building capacity development by leading training programmes on GIS, earth observations and Disaster Risk Reduction (DRR). For example, UNOSAT works in the Horn of Africa in collaboration with the Intergovernmental Authority on Development (IGAD) to mainstream DRR with an integrated approach to build resilience to climate change and improve disaster management and human security. In the Southeast Asia region, UNOSAT collaborates with the Asian Disaster Preparedness Centre (ADPC) to provide government agencies and stakeholders with geospatial solutions for risk reduction and satellite imagery-based analysis as well as mapping of populations in disaster situations. UNOSAT also partners with the Chadian Ministry of the Hydraulic Urban and Rural (MHUR) in the implementation of the ResEau project, aimed at strengthening national capacities in the fields of geology, hydrogeology and GIS for improved knowledge and policymaking in water resources management throughout Chad (UNOSAT 2016).

UNOSAT also supports capacity development in DRR in Bangladesh. It has trained 16 disaster management professionals representing 13 ministries of the Bangladesh government. The focus has been Geospatial Information Technology for DRR. The training is delivered in collaboration with the Asian Disaster Preparedness Centre (ADPC) in Dhaka, Bangladesh, at the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) office. The in-country training is designed to promote the importance of geospatial information technology applications for DRR policymaking. Active knowledge sharing is emphasized through a mix of lectures and GIS lab exercises combined with round-table discussions and field simulations (Ibid.).

Other international cooperation efforts to support capacity development

Public and private organizations, national and international, have also established partnerships on data systems to facilitate data sharing, with different degrees of open access. For example, the **Megacities Carbon Project** is developing and testing methods for monitoring the greenhouse gas emissions and their impact on populations of the largest contributors to climate change: megacities and their power plants. The project is a federation of research collaboration between international partners with open and transparent data sharing. The Los Angeles (LA) portion of the data portal would be ready for public access at the end of spring 2016. The US National Institute of Standards and Technology (NIST), the National Aeronautics and Space Administration (NASA), the National Oceanographic and Atmospheric Administration (NOAA), and the Keck Institute for Space Studies (KISS) jointly fund the LA component of the project. The California Air Resources Board and the University of California Discovery programme provide in-kind contributions.

The satellite and surface network data, integrated with improved high-resolution emission estimates would provide a robust system for assessing carbon distribution within different populations in megacities and directly improve evidence-based policymaking. Pilot activities are underway in the megacities of Los Angeles and Paris, building on existing research infrastructure and collaborations between the teams involved. Sao Paulo and other megacities are also part of the long-term scope of the project. The goal is to demonstrate a scientifically robust capability to measure multi-year emission trends of carbon dioxide (CO2), methane (CH4), and carbon monoxide (CO) attributed to individual megacities and selected major sectors. After the three-city pilot programme is established, the project may be expanded to include additional cities.

Similarly, the Open Data Platform for Africa portal created by the African Development Bank (AfDB) under its statistical capacity building programprovides free online data to monitor development, at national and sub-national levels. The portal incorporates and disseminates data from national, international and other sources. Users can disseminate data and directly share data content with others through social media. All African countries and nine regional institutions contribute to this platform. This platform also offers capability for data users to access data in machine-readable SDMX (Statistical Data and Metadata Exchange) standard.[10]The AfDB and IMF have partnered together to standardize and streamline the data submission process by leveraging the platform across different agencies (e.g. National Statistical Office, Central Bank, Ministry of Finance) in all African countries. Data consuming organizations can seamlessly collect data from the Platform (African Development Bank 2011). In similar vein, the African Platform for Knowledge and Data sharing on Earth Observation also disseminate free maps, GIS datasets and satellite images to assist monitoring and management of natural resources and agriculture.

[10]The SDMX is an initiative sponsored by seven international organizations to foster standards for the exchange of statistical information (sponsored by the Bank for International Settlements (BIS), European Central Bank (ECB), Statistical Office of the European Union (EUROSTAT), IMF, OECD, UN, and World Bank).

Besides “official” statistics originating with traditional national and international statistical services, there is also a new emphasis on the importance of government statistical services partnerships in the development of new data and data analytic methods for the Sustainable Development Goals, careful to observe the “Fundamental Principles of Official Statistics” and the continuity of data sources. There are good examples of such partnerships in the work of the international organizations and governments in the Inter-Agency and Expert Group on the MDG Indicators, where non-governmental organizations with long experience in specialized fields contributed to the data series used for monitoring implementation, such as the Internal Displacement Monitoring Centre and Refugees International, Audubon International, International Union for the Conservation of Nature, Nature Conservancy International, World Conservation Monitoring Centre, and the World Wildlife Fund. Similarly, as statistical awareness and data-based analytical capacities have increased greatly among civil institutions and non-governmental organizations since the advent of the Millennium Development Goals indicators in 2002, open access to data and availability of user-friendly analytical programs on Internet now play a significant and invaluable role in data development and testing (Johnston 2016).

International cooperation on environment statistics for reducing inequalities

The outcome document of the Rio+20 Conference in June 2012, “The Future We Want” and the 2030 Agenda for Sustainable Development underline the importance of global cooperation on statistics and indicators, particularly of environmental statistics. In this sense, the UN Statistics Division has responded to the challenge by producing an international framework for the development of environment statistics, an Environment Statistics Self-Assessment Tool and a Manual on the Basic Set of Environment Statistics (see box 5 below).

Box 5 International framework for environment statistics

Environment statistics portray key information about the state of the environment and relevant changes through space and time. These statistics make analysis more robust, timely and progressively harmonized at the international level, enabling the production of environmental assessments, state of the environment reports, environmental compendia and indicators; indicators of sustainable development, as well as to facilitate environmental-economic accounting.

The Framework for the Development of Environment Statistics (FDES), including the Core Set of Environment Statistics, addresses the information needs as they relate to the environmental dimension to sustainable development. The FDES lists the most important environment and climate change statistics and provides guidance to countries that are developing national environment statistics programmes. The FDES application to climate change statistics identifies the components, topics and individual statistics needed to inform on each of the sequential stages of climate change, which include: a) drivers and evidence (the most available statistics), b) impacts and vulnerability (available but not enough, particularly of slow onset events), and c) mitigation and adaptation responses (the least available statistics, particularly in key economic sectors).

A Basic Set of Environment Statistics has been designed to be adapted to individual countries' resources, environmental concerns and priorities, and structured in three tiers:

Tier 1 corresponds to the *Core Set of Environment Statistics*, including 100 statistics that are of high priority to most countries and have a sound methodological foundation e.g. monthly average temperature, land cover, coastal area, total forests, precipitation, etc.

Tier 2 includes 200 environment statistics that are of priority to most countries but need more investment in time, resources or methodological development e.g. number and type of shelters in place; urban population living in slums, total urban area, number of people injured by disasters, etc.

Tier 3 includes 158 environment statistics, which are either of less priority or require significant methodological development e.g. wind speed, area of sea ice, amount of plastic waste and other debris in marine waters; area of land under organic farming, etc.

The Core Set of Environment Statistics is intended to foster collection, coordination and harmonization of environment statistics at the national, regional and global levels in the short-term. For a country that faces resource constraints or is at an early stage in developing environment statistics, the *Core Set* can provide guidance in determining priorities. In fact, depending on priorities and resource capacities, countries may produce Tier 2 and Tier 3 statistics in the medium- and long-term respectively.

In 2016-2017, the implementation of the Framework will focus on issues such as a) facilitating and encouraging countries to use the Environment Statistics Self-Assessment tool, b) the development of training material and platforms, and c) the support to training and capacity-building activities.

Sources: http://unstats.un.org/unsd/environment/fdes.htm; Environment Statistics - Report of the Secretary General, Statistical Commission Forty-seventh session 8-11 March 2016, E/CN.32016/27; and http://unstats.un.org/unsd/environment/climatechange.html

To be sure, the production of quality environment statistics needs specific statistical and environmental expertise, scientific knowledge, institutional development capacities, and adequate resources. The development of these capacities is typically unevenly distributed within and between countries. In this context, available statistics and indicators on climate change vary among countries. Interestingly, inadequate development of environment statistics in vulnerable localities affects the provision of information on the impact of climate change, which in turn has adverse consequences for the compilation of environmental sustainability and sustainable development indicators as well as of environmental-economic accounts (UN/DESA 2016).

The development of climate change statistics

Climate change statistics span across a great proportion of the scope of environment statistics. Key environment statistics needed to inform about climate change include atmospheric conditions and change, environmental resource use, forest cover, land use change, energy (intensity, efficiency and renewability), biodiversity, water, waste and extreme events (occurrence and impact).

Using internationally agreed concepts, methods and recommendations at the national level is instrumental to produce effectively described statistical series that can be used to calculate indicators, substantiate analytical reports, and help establish the comparability of statistics among countries. In general, despite the existence of methodological guidance for some stages in the sequence of climate change, developing countries with many competing needs for scarce resources find it difficult to sustain regular production of key climate change statistics. Strengthening statistics by using international recommendations in the statistical domains of agriculture, energy, industry and environment statistics, as well as demographic and spatial statistics is crucial to enable compilation and dissemination of better climate change statistics and indicators.

To guide the production of basic statistics relevant to climate change in different domains, UNSD has produced internationally agreed upon recommendations (e.g., the Framework for the Development of Environment Statistics (FDES 2013), International Recommendations for Energy Statistics (IRES), and International Recommendations for Industrial Statistics (IRIS)), as well as various hands-on guidance manuals. In turn, the United Nations Economic Commission for Europe (UNECE) has produced the Conference of European Statisticians' (CES) Recommendations on Climate Change-Related Statistics, aiming at improving existing official statistics to support climate change analysis and reporting on greenhouse gas emissions under the United Nations Framework Convention on Climate Change (UNFCCC).

There are some stages of the sequence of climate change that need new methodological guidance developed, e.g., adaptation, impacts of climate change (other than extreme events and disasters), and consequences of climate change on ecosystems and health. Given the focus on adaptation of the WESS 2016 on adaptation to climate change, the subsections below do not elaborate on the statistics about the drivers of climate change.

Statistics on evidence of climate change

Key statistics and indicators about the evidence of climate change are relevant at all levels. The available statistics and indicators originate in scientific monitoring stations and cover the global and regional levels, and in some cases, the national level depending on the type of climate change evidence statistics.

At the global level there are agencies that disseminate them. For instance, NASA produces, compiles and disseminates statistics, indicators and maps on the matter, including long series on global surface temperature, Artic sea ice, land ice, sea level and land ice (http://climate.nasa.gov/key_indicators). Further key indicators include sea level rise, global temperature rise, warming oceans, shrinking ice sheets, declining artic sea ice, glacial retreat, extreme events and ocean acidification that are compiled by NASA, based on their own data, the IPCC, NOAA and other global sources (http://climate.nasa.gov/evidence). Infographics depicting key data about CO_2 global concentrations and further climate change indicators can also be found at: http://climate.nasa.gov/climate_resources/136/.

In turn, the NOAA also makes available relevant global level data produced by them and compiled from other sources in their National Climatic Data Center dedicated to monitor and assess the state of the Earth's climate with the purpose of providing decision-makers with data and information on climate trends and variability, offering a wide arrange of climate change indicators (http://www.ncdc.noaa.gov/indicators/).

Statistics on the occurrence and impact of extreme events and disasters

Occurrence and direct impact of extreme events and disasters are usually recorded by the affected countries' authorities and can be transformed in statistics and indicators series. These statistics can be further aggregated into regional and global levels as appropriate.

Most international databases portraying extreme events, disasters and its impact based their statistics on national information, sometimes complemented by their own. The types of statistics required and regularly produced are the type of natural disaster, location, magnitude, date of occurrence and duration. In addition, statistics on hazard-prone areas and on the vulnerability to disasters (i.e., population living in hazard-prone areas), are also relevant.

At the global level, CRED and its Emergency Database[11] provides a series of methodological and conceptual tools for international reference, including the criteria needed to qualify and event as a disaster[12], the definition of disasters[13], their classification and other elements that are useful tools to harmonize the statistical work in this field. Additionally, CRED undertakes data compilation, validation and analysis. EM-DAT provides an objective basis for vulnerability assessment and rational decision-making in disaster situations. For example, it helps policymakers identify disaster types that are most common in a given country and have had significant historical impacts on specific human populations. In addition to providing information on the human impact of disasters, such as the number of people killed, injured or affected, EM-DAT provides disaster-related economic damage estimates and disaster-specific international aid contributions.

Within countries, the most common data sources are administrative records and in some cases maps, aerial photography and satellite imaging produced by national and sub-national authorities responsible for disaster management and assistance, emergency management and response agencies, insurance companies, optical and radar satellite operators for satellite information, as well as seismic monitoring and research centres.

[11] Since 1988 the WHO Collaborating Centre for Research on the Epidemiology of Disasters (CRED) has been maintaining an Emergency Events Database EM-DAT http://www.emdat.be. It was created with the initial support of the WHO and the Belgian Government. It is an international initiative aimed to rationalise decision making for disaster preparedness, as well as for providing an objective base for vulnerability assessment and priority setting. The database is compiled from various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes and press agencies.

Statistics on disaster risk, vulnerability and resilience

Despite their importance particularly in developing countries, statistics and indicators on risk and risk reduction, vulnerability, and resilience to disasters are still in a developmental stage in most countries. Some of the lack of statistical developments is connected to the fact that internationally agreed definitions and concepts on these issues are still under development and that a wide consensus on these variables has not been reached yet. Without clear and unambiguous definitions, the statistical measurement of a variable is very difficult. Although the connections between urban planning, poverty, location of human settlements in risk areas, social and environmental vulnerability and disasters impact is in general well understood, constructing statistics to inform in these relations capturing the complexity of the phenomena is fairly difficult and require significant investment in the international agency community and capacity building and statistical development in the affected countries.

A Global Assessment Report on Disaster Risk Reduction 2013 commissioned by and contributed to UNISDR by a wide range of partners, offers data and geospatial information for countries participating in the initiative. Their information is disseminated through the Risk Data Viewer (http://risk.preventionweb.net), the National Disaster Loss Data Collection Initiative (www. desinventar.net) and Preview-Global Risk Data Platform. This initiative also offers definition about the basic effects which include the sum of losses and adverse effects associated with disasters (http://www.preventionweb.net/english/hyogo/gar/2013/en/home/data-platform.html).

Statistics on impact of slow onset events

Slow onset events such as sea level rise, glacial retraction and increased temperatures slowly but surely impact human lives (i.e., persons displaced), human settlements (i.e., loss of homes), economic assets and livelihoods and ecosystem integrity. The statistics that can measure such impacts are very scarce in general and are usually produced at the global and in some cases national levels. Developing such statistics requires a serious effort by the national statistical systems to be organized and produced. At the same time, internationally agreed definitions and statistical methodologies are to be developed and should thus be part of the statistical development agenda.

Statistics on response to climate change: mitigation and adaptation

Climate change mitigation and adaptation statistics are very relevant at the national and sub-national levels, so that they can substantiate decision making and actions within countries. Nonetheless, climate change mitigation statistics are relatively scarce too as they are difficult to capture statistically, because of the insufficient resources invested in their measurement and the lack of internationally agreed methodological guidance. In the energy statistics domain, production and use of renewables and non-carbon energy sources within the national energy supply is generally available from energy balances and there is also available methodological guidance. In the forest statistics domain, forest cover, afforestation, deforestation and transformation of forest land into agriculture or other uses can be organized and signified as climate change mitigation statistics and indicators.

Statistics informing on actions of climate change adaptation include the existence of programs and institutions for disaster management, and/or its allocated financial and human resources at national and subnational levels. It is often said that the final impact of any given extreme natural event on population and ecosystems will depend on the country's disaster preparedness. Adaptation from slow onset climate changes such as new climate smart agricultural practices are scarce. Despite their importance, these statistics on adaptation are still in a developmental stage and require investment in internationally agreed concepts and methods as well as developing and strengthening statistical capacities to be produced.

Broadly, the development of statistics and indicators relating to SDG 13 on "climate change and its impacts" requires international cooperation on advanced research experience and development of capacities on basic data sources and methods of compilation across a number of fields such as:

(a) Population and demography, including income, occupation and poverty, education, health (United Nations Statistics Division, International Labour Organization, World Bank, United Nations Educational, Scientific and Cultural Organization; World Health Organization, United Nations Children's Fund);
(b) Economic activity in agriculture, fishing and forestry (Food and Agriculture Organization of the United Nations, United Nations Statistics Division, International Labour Organization);
(c) Cartography and geographic information systems (United Nations Statistics Division and Committee of Experts on Global Geospatial Information Management; Food and Agriculture Organization of the United Nations, United Nations Environment Programme);
(d) Meteorology (World Meteorological Organization);
(e) Geology and land use, hydrology, ecology (Food and Agriculture Organization of the United Nations);
(f) Disasters (International Federation of the Red Cross and Red Crescent Societies)[14].

A review of the Intended Nationally Determined Contributions (INDCs) submitted by 150 developing countries and published by the UNFCCC website, also points out to the great interest for strengthening and expanding international capacity development programmes on environment statistics, including climate change statistics, and ICT. Countries in Special Situations (e.g. SIDS, LDCs and LLDC), in particular, face significant resource constraints, limited technical capacities, institutional weaknesses and inadequate coordination among national institutions. Many developing countries are compelled that international cooperation for strengthening their statistical capacities can enhance their own adaptation and mitigation

[14] See Johnston (2016) for a detailed elaboration.

strategies for sustainable development (see Annex 3 with UN agreements on international cooperation on Statistics).

Regional cooperation in early warning systems in Asia and the Pacific

The UN ESCAP has been quite active in supporting a more balanced development of early warning systems for coastal hazards such as tropical cyclones, typhoons, storm surges and tsunamis, while also supporting capacity building programmes in Asia and the Pacific. Box 6 below underscores the importance of regional cooperation to reduce disaster risk, build resilience and enhance the adaptive capacities of vulnerable populations. Partnering with national and international institutions, UN ESCAP has organized expert-group seminars for discussing a broader approach to statistics in the context of climate change and regional ICT capacity building programmes to analyse how communications tools such as spatial data and social media can support resilience building within and between countries.

Box 6 A regional approach to improve access to Early Warning Systems (EWSs)

Effective EWSs are key components of disaster risk reduction strategies and a prerequisite for climate-resilient development. For Asia and the Pacific, a region with a long history of facing a wide range of natural hazards and devastating disasters, regional South-South cooperation has been the right strategic approach for designing and implementing effective early warning systems, as hazards are often trans-boundary in nature and tend to affect vulnerable populations in several countries simultaneously. Countries that share a coastline, mountain range or river often face similar environmental challenges.

In particular, low income countries, Pacific islands and low-lying States that are at high-risk to disasters do not have the technological know-how, neither the financial resources to establish and sustain effective, state of the art end-to-end early warning systems.

Through a Multi-Donor Trust Fund for Tsunami, Disaster and Climate Preparedness, which was established in 2005 following the Indian Ocean Tsunami, UN ESCAP has supported the regional development of end-to-end early warning systems for coastal hazards, including climatic hazards, by harnessing the cooperation of all countries in the Asia and the Pacific region. During the first 10 years of its existence, the Trust Fund has supported 26 early warning projects directly benefitting 19 countries in Asia. Projects have covered a wide range of activities, from risk assessments, mapping and communication, to capacity development, planning and exercises at the regional, national and sub-national levels.

The Trust Fund has also served to support a joint capacity development project led by the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) and the World Meteorological Organization (WMO) since 2011. The project is directed to strengthen the national meteorological and hydrological service (NMHS) in five high-risk countries − Bangladesh, India, Myanmar, the Maldives and Sri Lanka. For each monsoon season there are biannual forums for forecast generators and users of the forecasts. In advance of each monsoon forum, RIMES and WMO work with the NMHS to develop the seasonal forecast and related products, and to train users, such as line ministries, local governments and their partners. At the forums, the users discuss the corresponding preparedness, adaptation and mitigation measures. This model has later been rolled out in several other countries including Cambodia, Lao PDR, Nepal and Pakistan, and there are plans to also extend it to the Pacific.

The Asia-Pacific region is also home to two intergovernmental platforms for addressing the risk of tropical cyclones (known as typhoons if they originate from the West Pacific): the ESCAP/WMO Typhoon Committee (TC) that covers storms emerging from the Western Pacific, and the WMO/ESCAP Panel on Tropical Cyclones (PTC) that covers the Bay of Bengal and the Arabian Sea. Since 2005, both have expanded and strengthened their activities, bringing about closer regional cooperation in early warning. In particular, they have helped integrate the fields of meteorology, hydrology and disaster risk reduction (DRR) − building capacities and developing joint strategies across countries and professional fields. The TC and the PTC undertake original research and pilot projects to further improve the understanding of tropical cyclones and related hazards. One of these projects, implemented jointly by the TC and the PTC with financial support from the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness, led to the development of a regional manual for the establishment of multi-hazard SOPs for early warning.

On the whole, the regional warning systems available provide strategic technological resources that no individual country would have been able to ensure on its own to protect vulnerable populations to the impact of numerous natural hazards, including climatic ones. In this sense, UN ESCAP has been pivotal to facilitate the provision of early warning systems as a regional public good, helping to reduce gaps in DRR and support climate-resilient development.

Source: The box is an edited version of UN ESCAP (2015).

UN ESCAP Regional Drought Mechanism reduces regional inequalities and…[15]

The National Oceanic and Atmospheric Administration (NOAA 2016) defines "four types of drought: 1) meteorological drought, 2) hydrological drought, 3) agricultural drought, and 4) socioeconomic drought. Meteorological drought happens when dry weather patterns dominate an area… [It] can begin and end rapidly. Hydrological drought occurs when low water supply becomes evident, especially in streams, reservoirs, and groundwater levels, usually after many months of meteorological drought. Agricultural drought happens when crops become affected. Socioeconomic drought relates the supply and demand of various commodities to drought". Droughts in the Asia and the Pacific region share most of these characteristics and have been one of the most devastating natural hazards.

Many low- and lower-income countries in the Asia-Pacific region are still reliant on agricultural activities for employment and GDP growth, to which droughts directly affect. Agriculture absorbs over twenty-two per cent of all adverse economic impacts caused by natural hazards, of which eighty-four per cent is caused by droughts. In low- and lower-middle income countries, the agricultural sector represents over 50 per cent of total employment and 40 per cent of total value added, compared to high- and upper-middle

[15] This section is an edited version of a substantive contribution by UN ESCAP.

income countries with only 12 per cent in employment share and 17 per cent in total value added. Persistent or prolonged drought in the region can increase inequalities by adversely affecting water security and food production in the most vulnerable populations. In this sense, droughts can roll back development and steadily increase poverty in a region that is already home to two thirds of the world population and expected to grow to 9 billion by 2050. Nonetheless, although drought is still managed by primarily focusing on the provision of emergency food and water to people affected by natural hazards, countries are starting to recognize the importance of strategic drought risk reduction, early warning, preparedness and long-term risk management, particularly because much of the region is currently experiencing a severe drought triggered by El Niño (UN ESCAP 2015).

Space technology can strengthen early warning, preparedness and long term planning and adaptation of the most vulnerable communities and countries to extreme weather events. For example, signs of drought can be observed from space long before they are visible on the ground to the human eye. Although the Asia-Pacific region has a growing number of spacefaring countries, these technologies are not being used to their greatest potential because of capacity limitations in terms of human, scientific, technological, and institutional resources. Nearly two decades ago the application of space and GIS technology was expensive and unattainable by many countries in the region; nowadays there has been great progress in expanding the accessibility and use of space applications.

UN ESCAP is helping to bridge this gap further by operating as a regional hub for harnessing the latest advances in these technologies. Through its Regional Space Applications Programme for Sustainable Development in Asia Pacific (RESAP), UN ESCAP has implemented the Regional Drought Mechanism for several years. The programme takes advantage of the data, imagery and expertise from the region's spacefaring countries, particularly China, India and Thailand, by sharing it with countries prone to drought, so that they can also benefit from these tools even when they have no space programme of their own. The programme supports and complements other initiatives, including the WMO's Global Framework for Climate Services, by providing detailed, localized forecasts and monitoring that are updated during the growing season; and links to long-term climate scenarios and seasonal climate outlooks[16].

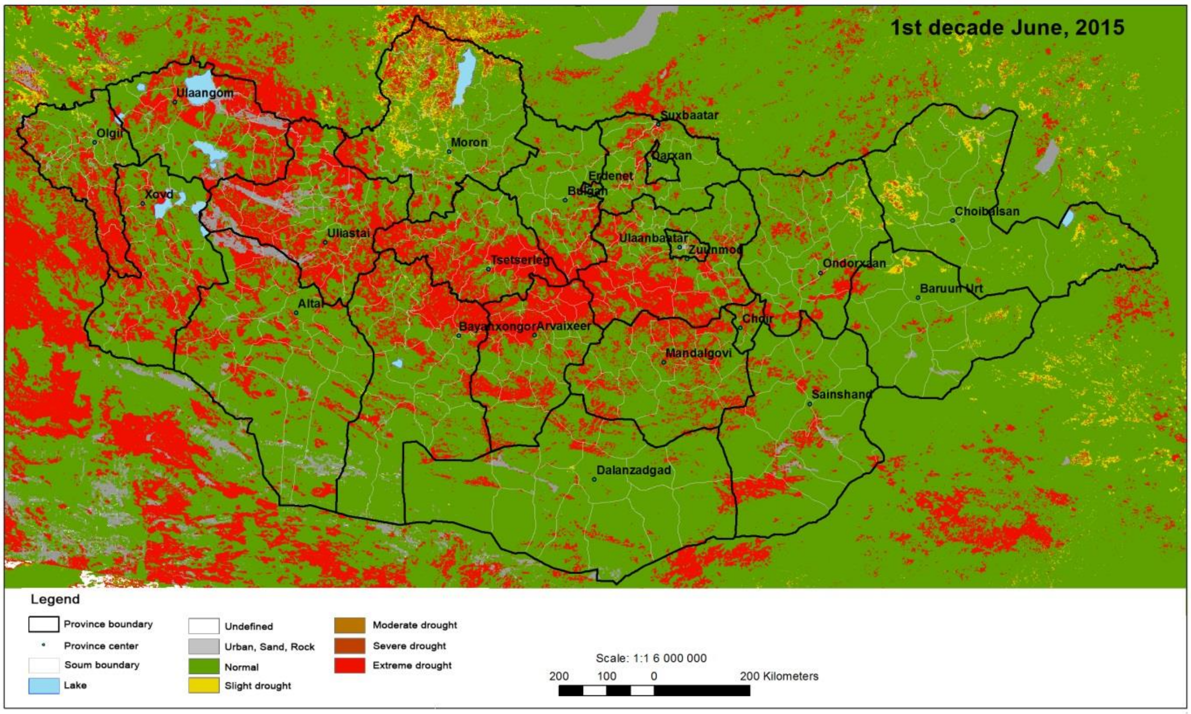
… strengthens capacities within countries

Countries' capacity development programmes are being supported by using space-derived information for monitoring in-season crop stress over large areas and by issuing timely alerts of agricultural drought, allowing rapid response for aid, additional water supplies, and various social support needs. For example, using indicators based on space-derived information and with the help of the National Remote Sensing Centre of India, Sri Lanka has analysed the agricultural drought during the growing season in 2014 by comparing the difference from a baseline drought year (2012) and a normal year (2005). The analysis has served as a baseline for strengthening long-term strategies to reduce national gaps on climate change adaptation, food security and drought mitigation.

[16] See chapter IV for a detailed analysis and simulation of relevant climate-adaptation scenarios.

Along these lines, the Government of Mongolia has been working with the Regional Service Node of the Drought Mechanism in China to develop a monitoring and early warning system for droughts, which it is now autonomously running (see figure 3). From this, Mongolia is further developing space and ground-based indicators, such as forest cover and land condition, to investigate and monitor *dzud* – a drought leading to inadequate pasture or fodder, often followed by a severe winter that typically kills much of the livestock of poor farmers.

Figure 3 Drought in Mongolia



Source: UN ESCAP (2015).

Notes: This map is based on a composite of various indices, including the normalized difference drought index, the vegetation supply water index, and the thermal condition index.
Disclaimer: The boundaries and names shown and the designations used on the map do not imply official endorsement or acceptance by the United Nations.

With medium term warning of possible water shortages, farmers can be alerted to plant alternative crops, initiate water saving measures and find alternative income options. The Regional Service Nodes, which are currently in China and India, provide space-based data, products, services and capacity development to pilot countries such as Afghanistan, Bangladesh, Cambodia, Kyrgyzstan, Mongolia, Myanmar, Nepal and Sri Lanka.

The examples analysed include different kinds, levels and stakeholders' involvement in ICT cooperation, with direct contribution to building resilience and reduction of regional and within-country inequalities. They also enhance the likelihood of wider global cooperation on ICT to improve the evidence-based policymaking in vulnerable countries and populations to the adverse impact of climate change. The engagement of regional and global institutions is central to enhance access to and capacity development in the use of these technologies.

The contribution to DRR and regional warning systems by UN ECLAC

The UN ECLAC has a long history in supporting regional DRR and early warning systems. More recently, the Regional Plan of Action eLAC2015 at the Third Ministerial Conference on the Information Society in Latin America and the Caribbean in Lima-Peru (21-23 Nov 2015) set the goal to "promote cooperation and policymaking in the region for the use of ICTs in natural disasters, and for prevention of and response to climate change and emergencies, based on common standards and best practices, since natural disasters transcend the national sphere." As a regional initiative, the United Nations Economic Commission for Latin America and the Caribbean (UNECLAC) also developed a handbook which can be useful to other countries and regions, "UNECLAC: Handbook for Estimating the Socio-economic and Environmental Effects of Disasters". It evaluates the overall impact of disasters associated with natural hazards and includes a methodology for evaluating this impact. The analysis of disaster impact in terms of damage and losses makes it possible to estimate the impact of disasters on economic growth, on the population's living conditions and on environmental conditions in the region.

Other regional initiatives for cooperation on disaster prevention and response include the Caribbean Disaster Response Agency (CDRA), the Network of Social Studies in the Prevention of Disasters in Latin America (La Red), the Coordination Center for the Prevention of Natural Disasters in Central America (CEPREDENAC), the Programme for Natural Disaster Prevention in Central America (PREVAC) and the Regional Disaster Information Centre for Latin America and the Caribbean (CRID).

More specifically, based on its expertise in assessing the economic and social impact of disasters, UN ECLAC implemented a project to strengthen the capacity of policymakers to understand possible scenarios of disasters related to extreme events during 2012-2013. Floods, earthquakes, hurricanes and tsunamis are some of the natural hazards that typically affect Latin America and the Caribbean. Public officials worked in relevant ministries such as finance, agriculture, environment and social affairs. The project aimed at a) enhancing the understanding on the long-term perspective of risk and cost-benefit analysis of policies to reduce those risks, and b) enhancing the capacity to formulate policy proposals for adaptation to long-term changing hazards and disaster risk reduction. Seminars, short-courses, publications and access to upgraded databases on weather, disaster and climate change information were provided. The project covered the following countries: Argentina, Barbados, Belize, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, and Costa Rica, Cuba, Ecuador, El Salvador, Spain, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, and Uruguay (UN/ECLAC 2014).

The project reached positive results by a) enhancing climate risk management and assessment within institutions through improved methodologies and the design of new tools, b) strengthened links between the government institutions and UN ECLAC, and c) On the whole, the project increased the knowledge of institutional stakeholders on extreme event assessment and cost analysis, although that knowledge has not been institutionalized yet. Greater awareness of extreme events insurance schemes resulted in additional demands for further analysis and discussion on these mechanisms. The tools on disaster impact assessment were well received by policymakers, but increased support is required to facilitate their use in national contexts. The project also contributed to the upgrading of three databases a) weather database, b) disaster impact estimation database, and c) database on the effects of climate change on the coasts of Latin America and the Caribbean. Key lessons learned include a) more attention should be paid to the project formulation stage to ensure that project is not overly ambitious so budget programmed be consistent with knowledge gaps addressed, and b) success of certain activities may generate additional demands that the project cannot satisfy. The way forward may aim at a) continue the capacity building to respond to demand generated for more activities on extreme events assessment, b) create a mechanism for monitoring capacity over the long-term, c) support South-South cooperation links, d) increase formal courses on modelling and fiscal policy in order to mainstream climate change adaptation into public policies (Ibid.).

Regional cooperation in climate information and early warning in Africa

The Intergovernmental Authority on Development (IGAD) of countries in the Greater Horn of Africa notes that the region is prone to the increased frequency and intensity of natural hazards such as droughts and floods, with adverse impact on livelihoods and economic sectors. As a response, the IGAD has set up the Climate Prediction and Applications Centre. This organization provides and supports the application of early warning and climate information for the management of climate-related risks. It also coordinates the development and dissemination of seasonal climate forecasts for IGAD countries, which is part of the Regional Climate Outlook Forum, a process sponsored by the World Meteorological Organization (WMO) in many regions. The Global Framework for Climate Services, another WMO initiative, is directed to build on these and other global, regional and national activities and institutions to develop climate information services for all countries (IPCC 2014, Chapter 21: Regional Context).

Benin is a paradigmatic example of international cooperation to enhance adaptive capacities and build resilience in African countries. Among other countries in the continent, Benin has been adversely affected by changing temperatures and rainfall patterns that have led to more frequent and intense droughts and floods, thus increasing the need for effective adaptation strategies. The 2010 floods in Benin, for instance, killed 46 people, affected 7000,000 people and destroyed infrastructure and thousands of hectares of agricultural produce (Mulobela 2016).

As a result, in 2015 Benin launched an early warning system that feeds into the National Disaster Management Agency (NDMA). Under the leadership of this agency and the support of a multi-country initiative called Climate Information for Resilient Development in Africa (CIRDA)[17], sponsored by the U.N. Development Programme, all meteorological agencies, the national water department, the oceanographic institute and organisations that release the information to the public are working together, eliminating conflicting weather information provided by different agencies in the past. The unified information is used to reduce disaster risk, and to plan a national climate strategy for agriculture, health, energy, water and transportation.

To strengthen observations of meteorological, hydrological and sea conditions, Benin has installed 20 automatic weather stations, 25 hydrological stations to monitor river levels and five oceanographic stations. These stations collect data and transmit it every hour to a central computer server. Given the likelihood of a potentially damaging natural hazard, the NDMA alerts local leaders and authorities in the affected area, as well as the media. The early warning system classifies four levels of risk: green, yellow, orange and red, and warnings are issued for orange and red situations (Ibid.).

On the whole, early warning and timely information on expected extreme weather has supported effective planning and enabled the evacuation of people from risky areas, protect livelihoods, reduce damages to public infrastructure, and save lives.

Closing gaps in ICT data and statistical capacities for climate-resilient development

Building and capitalizing on the progress made by the MDG framework on increasing statistical capacities and improving methodologies and information systems at both national and international levels, investment to improve access to and use of ICT data and environmental statistics would need to be further strengthened in the face of climate change impact on economic, social and environmental aspects of development. Data at the sub-national level, local in particular, can allow effective monitoring by identifying disparities in the availability of statistics and access to basic public goods e.g. data on births and deaths; medicines, water, infrastructures. This would allow governments to focus their policies and programmes on reducing inequalities and enable a more even development. For this endeavor, many developing countries would have to emphasize a closer collaboration between international agencies and country experts (United Nations 2015a).

Indeed, substantive data and statistics gaps remain in several development domains. Inadequate data quality, disaggregation and timely statistics are some of the main challenges for measuring progress and achieving the SDGs. The United Nations (2015a) cites a World

[17] The CIRDA programme supports climate information and early warning system projects in 11 of Africa's least developed countries: Benin, Burkina Faso, Ethiopia, Gambia, Liberia, Malawi, Sao Tome, Sierra Leone, Tanzania, Uganda and Zambia. The programme coordinates with government ministries and national hydro-meteorological services to test new approaches and technologies to enhance evidence-based policymaking and resilience of vulnerable communities.

Bank study reporting that half of the 155 countries lack adequate data to monitor poverty, which affects an accurate counting of the extreme poor. During 2002-2011, fifty-seven countries had none or only one poverty rate estimate; and in sub-Saharan Africa, sixty-one per cent of countries had no adequate data to monitor poverty trends. Similarly, although great progress has been made in the availability of data on indigenous peoples in Latin America, further progress in other regions and high-quality data disaggregated by migrant status, ethnicity and disability are important for more effective policies focused on reducing inequalities within populations. Likewise, since development data tend to have a time lag of at least 2-3 years, real-time information by making use of text messaging technology and satellite observations can allow faster information to respond to crises and take more effective decisions for e.g. precision agriculture and the monitoring of natural hazards (Ibid.). Yet, new data technologies would have to be carefully designed and applied to prevent a bias toward populations who have greater access to them and are better educated, wealthier and men. For example, less than 21 per cent of populations in sub-Saharan Africa have access to Internet.

Looking forward, common international standards would continue to be crucial for building national statistical capacities with the use of consistent concepts, classifications and methods. An integrated framework of indicators will also be needed to effectively identify the interlinkages among economic, social and environmental aspects of development. On the whole, the strengthening of national statistical capacities and modernization of statistical systems would require investment (domestic and foreign) for the adoption of statistical standards, restructuring of statistical production processes, changing institutional arrangements, training of human resources, and facilitation of technical cooperation (Ibid.).

9. Conclusions on international cooperation on adaptation technologies, ICT data and statistics

- International cooperation can be an effective tool to build resilience to climate change by supporting developing countries' efforts to strengthen the production of environment, ICT data and climate change statistics, which can enhance innovation and evidence-based public policy.

- Stronger collaboration between statisticians and ICT data experts can facilitate the transfer of knowledge and prompt the creation of a global framework for national statistical systems with a solid, coherent and integrated set of principles, standardization of methodologies, and production of environment statistics as part of national information systems.

- International cooperation for facilitating transfer and development of adaptation technologies does not automatically lead to lower inequalities. Transformative collaboration, coordination and development of links among the international development community, regional, national and local governments are critical for building long-term resilience and effective capacity development programmes.

- A strategic integrated approach to international cooperation is needed for effective support to national efforts to build resilience to climate change and reduce inequalities. The approach can encompass three types of policy pathways: a) the integration of development with climate policies, b) the integration of local, national and global institutional frameworks, and c) the integration between strategic sectors and development programmes.

- International cooperation is critical for sustained investment in capacity development programmes to improve statistical capacities in countries in special situations as well as to provide wider access to adaptation technologies to vulnerable populations, which can trigger more effective water management, sustainable food production, and reduction of climatic health epidemics.

- The United Nations System has a leading role to play at the global (e.g. UNOSAT, FAO, UN/DESA), regional (e.g. ECLAC, ESCAP) and national levels to build climate-resilient development. It can strengthen coordination and support capacity development programmes, set standards and guidelines on environment and climate change statistics; set a framework for international cooperation on adaptation technologies, and stimulate high-level dialogues for facilitating the transfer of climate technology and resource mobilization to vulnerable countries (e.g. Technology Facilitation Mechanism; Technology Bank and Science, Technology and Information).

- The Paris Accord promises 100 billion dollars per annum as a minimum "floor" for climate finance. By all estimates, the vast majority of this money goes to mitigation activities.

- Considerable barriers to funding adaptation exist. They include: adaptation projects are often public goods, quantifying adaptation impacts is complex, an operational definition of adaptation does not exist, and it is difficult to separate adaptation investment from other types of investment.

- Given that adaptation is similar to a public good and that it is an integrated aspect of "no-regrets" climate policy planning, a strong argument for continued public support to adaptation efforts exists. All the same, public finance will not be sufficient.

- Leveraging incentives for private sector involvement is required, which can include 4 policy levers: 1) international regulations; 2) targeted domestic incentives; 3) improving the domestic enabling environment for private sector activity in general, and 4) self-regulation and voluntary standards from the private sector.

- Partnerships are an intuitive way to scale up climate finance. The theoretical underpinning of partnerships include: acknowledgement of the necessity of different scales of knowledge for adaptation work (highly local, national, and international); the need for feedback mechanisms and reflexive design to engender policy learning; partnerships should ideally include mechanisms for "ratcheting up" the partnership over time towards increasingly ambitious goals.

- Case studies on adaptation projects for water, energy, food security and health offer insight into the components of a successful partnership for adaptation. Case studies investigate adaptation efforts in health, food security, water management and the nexus in between. Many of the case studies include a technology component, which supports adaptation outcomes generally.

- By considering the case studies within the four policy levers, the following principles for developing partnerships to finance climate adaptation include: a) Private sector engagement in adaptation partnerships is possible, but often requires a supporting role from the public sector, b) use of multi-stakeholder partnerships from the international policy level to local groups for implementation, c) active and annual periods of reflection and analysis on the project's outcome to reduce the impacts of unintended consequences and ensure that project adoption is underway, d) technology is a particularly promising avenue for private sector involvement, and e) nexus approach to regulation helps increase the possibility of a win-win outcome.

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