CHAPTER 4

TECHNOLOGY GAPS

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4.1 INTRODUCTION

Technology development, transfer, and diffusion (dissemination and uptake) are priorities on the international agenda of adaptation to climate change. Discussions in the context of the United Nations Framework Convention on Climate Change (UNFCCC) regarding technologies historically focused on mitigation but technologies for adaptation have recently been brought squarely in (UNFCCC 2010). Commitments to scale up efforts on technology transfer were made in 2008 with the Poznan Strategic Programme on Technology Transfer (UNFCCC 2008). This led to the Technology Mechanism in 2010, which aims to "facilitate enhanced action on technology development and transfer to support action on mitigation and adaptation".

The Technology Executive Committee and the Climate Technology Centre and Network (CTCN) implement the Technology Mechanism (see Box 4.1).

Box 4.1: The Climate Technology Centre and Network (CTCN)

The Climate Technology Centre and Network consists of a climate technology centre (CTC) and a network composed of institutions capable of responding to requests from developing countries related to the development and transfer of climate technology. The mission of the CTCN is to stimulate technology cooperation and improve climate technology development and transfer. CTCN assists developing countries in a way that is consistent with their respective capabilities, national circumstances and priorities, and undertakes its work to strengthen the capacity of developing countries to identify technology needs. The CTCN is hosted by UNEP in collaboration with the United Nations Industrial Development Organization.

(see http://unfccc.int/ttclear/templates/render_cms_page?TEM_ctcn)(see http://unfccc.int/ttclear/templates/render_cms_page?TEM_ctcn)

International attention to the role of technologies in addressing adaptation challenges and climate risks is a major motivation for activities in developing countries. These include Technology Needs Assessments (TNAs), emerging activities under the CTCN, Low Carbon and Climate Resilient Development Strategies and National Climate Strategies (see Box 4.3).

Adaptation technology gaps can be defined as the difference between technologies for adaptation actually implemented and a societally set target for implementation of technologies for adaptation. This definition is equivalent to the generic definition proposed in Chapter 2 of this report, which reflects the multidimensional definition of technologies for adaptation that overlaps significantly with the definition of adaptation. This also makes it difficult to measure or quantify the adaptation technology gap separately from the adaptation gap. However, we can identify perceived gaps by the countries based on available technology needs assessments, and requests to technology support mechanisms.

In this chapter, we summarize and analyse key gaps related to technologies for adaptation, drawing mainly on the findings of recent needs assessments, as well as from scientific literature in the field. The chapter begins with a brief summary of how technologies for adaptation are defined, followed by an overview of how technologies can contribute to reducing climate change risks. The chapter continues with an overview of the current landscape of adaptation technology gaps, including countries' priorities and perceived gaps in transfer, diffusion and innovation. The next sections present barriers that have been identified and an enabling framework for the transfer of adaptation technology. It outlines potential targets for adaptation technologies. The chapter has a concluding section.

4.2 DEFINING TECHNOLOGIES FOR ADAPTATION

Adaptation is not merely a matter of making adjustments to technical equipment but also includes organizational and social dimensions. The Intergovernmental Panel on Climate Change (IPCC 2000), in its special report on Methodological and Technological Issues in Technology Transfer, defines technology as "a piece of equipment, technique, practical knowledge or skills for performing a particular activity". A UNFCCC report on the development and transfer of technologies for adaptation to climate change proposes the following definition for adaptation technology: "the application of technology in order to reduce the vulnerability, or enhance the resilience, of a natural or human system to the impacts of climate change" (UNFCCC 2010).

It has become common to distinguish three categories of technologies for adaptation: hardware, software and orgware (Boldt *et al.* 2012, Glatzel *et al.* 2012, Thorne *et al.* 2007). Hardware refers to "hard" technologies such as capital goods and equipment, including drought-tolerant crops and new irrigation systems. Hardware technologies are often expert driven, capital-intensive, large-scale, and highly complex (Sovacool 2011, Morecroft and Cowan 2010, McEvoy *et al.* 2006). They can also be more simple technologies that are readily available, involving traditional and local knowledge, but which for some reason have not been applied by a larger number of users yet. Software refers to the capacity and processes involved in the use of technology, and covers knowledge and skills, including aspects of awareness-raising, education and training. The concept of orgware relates to ownership and institutional arrangements of the community/organization where the technology will be used. Annex B to this chapter provides examples of the different technology categories for various sectors, and different key risks.

With this understanding of adaptation technologies it is clear that technologies are already embedded in many existing approaches to adaptation. For example, ecosystem-based adaptation (EbA) involves a wide range of ecosystem management activities to increase resilience and reduce the vulnerability of people and the environment to climate change. The EbA approach includes various options that can be categorized as adaptation technologies, including protected area systems design, the restoration of key habitats to reduce vulnerability to storm damage, and the establishment of water reservoirs through the restoration of forests and watersheds.

The UNFCCC has identified the role of technologies for adaptation within four different stages of adaptation: information development and awareness, planning and design, implementation, and monitoring and evaluation (Klein *et al.* 2006). Table 4.1 provides an overview of the key stages in adaptation and exemplifies the role technologies have in reducing risks for the coastal zone sector.

Table 4.1: Overview of the role of technologies in the key stages of adaptation in reducing climate risk for the coastal sector

Stage of adaptation	Role of technologies, examples from the coastal zone sector
Technologies to collect data, provide information and increase awareness for adaptation to climate change	Mapping and surveying, Satellite remote sensing, Airborne laser scanning (lidar), coastal vulnerability index, computerised simulation models.
Planning and design	Geographical information systems (GIS) for spatial planning.
Implementation	Dykes, levees, floodwalls, Saltwater-intrusion barriers, Dune restoration and creation, Early-warning systems.
Monitoring and evaluation	Basically the same technologies as in the first stage. Effective evaluation requires a reliable set of data or indicators, collected at regular intervals using an appropriate monitoring system.

Based on Klein et al. (2006)

Adaptation technologies can also be viewed in terms of technological maturity. Here a distinction can be made between traditional technologies, modern technologies, high technologies, and future technologies (Klein *et al.* 2006). Traditional technologies are technologies that have been developed and applied throughout history to adjust to weather-related risks. It can be change of agricultural management practices, the building of houses on stilts or construction of dykes to protect against flooding. Modern technologies are those created since the onset of the industrial revolution in the late 18th century. They make use of new materials and chemicals, and of improved designs. High technologies derive from more recent scientific advances, including information and communication technology, earth observation systems providing more accurate weather forecasts, geographical information systems, and genetically modified organisms. Finally, we can look towards future technologies that are still to be developed, for example crops that need little or no water, or a malaria vaccine.

4.3 THE ROLE OF TECHNOLOGIES IN REDUCING RISKS

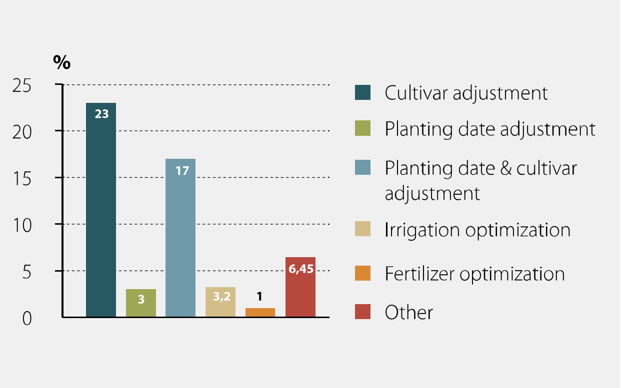
Technologies for climate change adaptation have the potential to play a substantial role in improving social, economic, environmental, and management practices in sectors vulnerable to climate change. It is difficult to assess the extent to which technologies are transferred and diffused, however, in the process of adaptation to climate change. Aspects included in the definition of technology—such as training, capacity building, education, and institutional and organizational aspects of technology— further complicate assessing and quantifying the transfer, diffusion and deployment of technologies and their contribution to risk reduction. Using financial flows could be one (limited) proxy for the comparison over time. Another complicating factor in computing the extent of technology application is that most adaptation technologies are essentially either changes to existing systems or systematic changes that integrate new aspects into current systems.

In the agricultural sector a core challenge for adaptation technologies is to strengthen the ability to produce more food using fewer resources under more fragile production conditions (Lybbert and Sumner 2012). Agricultural production is intrinsically linked with climate in terms of temperatures and precipitation, and even without climate change increasing agricultural productivity requires technological advances. In many developing countries, water availability is projected to decline radically with climate change and population growth in the next few decades (Jiménez Cisneros *et al.* 2014). With changed rainfall patterns and warmer conditions, the future of the agricultural sector in Africa, for example, is even more dependent on improved access to irrigation and improved water management practices and efficiency.

In addition to other adaptation technologies on sustainable water use and management, the efficiency and extension of existing irrigation systems needs to be improved where cost-effective, while, in many cases, new systems need to be installed. In others, land may simply not be arable any longer or there will be a need to introduce new crops based on altered climate conditions.

Figure 4.1 reflects simulated yield benefits from using different adaptation technologies in crop production. These technologies could, either separately or in combination, significantly reduce the impact of climate change on crop production and increase the benefits of positive changes. Box 4.2 provides examples of the use of scientifically developed seeds.

Figure 4.1: Benefits from adaptation technologies - examples from the agricultural sector



Source: Based on Porter et al. (2014)

For the water sector, ensuring adequate water supply under climate change is projected to require significant investment. Yet many of the technology options in the water sector are "no regrets" technologies (Elliot *et al.* 2011) generating net social and/or economic benefits even in the absence of anthropogenic climate change (see Box 4.4). Adaptation technologies addressing issues such as the contamination of drinking water supplies, water resource diversification, and conservation will generally provide benefits even in the absence of climate change.

Box 4.2: New seed technology for agricultural adaptation: experiences from Cameroon, Zambia, and Madagascar

Sustaining agriculture within the context of a changing climate is critical for most African countries given the dependence of large proportions of the population on farming. One common application of technology to agricultural adaptation is the use of scientifically developed seeds—certified, hybrid, or early-maturing to maintain or improve yields.

In Madagascar, rice varieties that mature in four months (as opposed to five or six) have been introduced. They stand a greater chance of reaching maturity before the height of the cyclone season, increasing the probability of a decent harvest and ensuring seed will be available to plant in the following season. The early maturing Open Pollinated Varietal (OPV) rice seeds have the secondary benefit of improved yields: farmers in the Analanjirofo and Antsinanana regions of eastern Madagascar explain that an average annual yield for their traditional seeds would be around 100kg, whereas with the early maturing OPVs it is around 225kg.

In the drought-prone Southern Province in Zambia, the use of early maturing seeds in conjunction with training in conservation agriculture to conserve scarce water resources (such as minimum-till land preparation and mulching) is improving yields and food security. The Least Developed Countries Fund (LDCF)-funded project is in its early stages, but it is explicitly targeting women farmers and therefore contributing towards gender equality as well in the districts participating.

In Cameroon, improved varieties for maize (for example, 8034 and 961414) and cassava have been promoted by farmers' organizations primarily as commercial crops for sale. The combination of greater yields and access to markets brokered by the farmers' organizations has increased incomes and also financial capital, which can act as a cushion in years of poor production due to poor farming weather.

Strong training and ongoing technical support in the use of the new seed technologies is common across all three case studies. New seed technologies are by no means a panacea for agricultural adaptation: improved seed breeds typically require inputs (such as fertiliser and insecticide) to meet maximum yields, which can create a financial barrier; and cultural norms in Madagascar and Zambia are to recycle seeds, whereas certified seeds need to be replaced regularly otherwise yields decline. Additionally, in Madagascar the seed market is very underdeveloped, impeding accessibility for farmers.

These differing examples show that the application of various seed technologies can support agricultural adaptation but that modification for context is required.

There are already many potential adaptation technologies available for reducing the key risks of climate change to existing agricultural systems. These are often modifications to the existing options to accommodate the impact of climate change. Implementing such technologies are likely to have substantial benefits under climate change if systematic changes in resource allocation are considered. Investment in technology-based adaptation (for example seeds, dams, and irrigation) are complicated by the fact that it remains difficult to predict the future impact of climate change, especially on a local scale. Estimating the costs and benefits of adaptation technologies is made more difficult by uncertainties associated with the lack of a consensus in climate change projections and with incomplete information on the path of economic growth and technological change (World Bank 2010). Decisions about investments in adaptation technologies with a horizon of maybe 20, 30 or 40 years—including drainage, water storage, bridges and other infrastructure—will have to be based on unsure information given the degree of variation in climate change projections and other uncertainties, including projections on economic growth. Faster economic growth will put more assets at risk at various levels of society across the world and possibly increase the potential for damage, but as a result of higher levels of investment and technical change, it could also result in higher levels of flexibility and of capacity to adapt to climate change.

4.4 CURRENT LANDSCAPE OF ADAPTATION TECHNOLOGY GAPS

We cannot measure or quantify an overall adaptation technology gap because of the multidimensional definition of technologies for adaptation (see section 4.2) and lack of detailed information on the potential technologies may have to contribute to the reduction of climate risks at an aggregate level. The technology needs assessments and action plans available, however, establish the basis for identifying and analyzing some of the key technology gaps perceived by countries.

Box 4.3: Technology Needs Assessments

Technology needs assessments (TNAs) are a set of country-driven activities that identify and determine the mitigation and adaptation priorities of developing countries. The TNA process involves different stakeholders identifying barriers to technology transfer and measures to address them through sector analyses.
As part of their TNAs, countries have prepared technology action plans (TAPs) and project ideas. A TAP is an action plan selecting one of several options for groups of measures to address barriers to the development and transfer of a prioritized technology. In the context of their TNAs, countries envisage project ideas as concrete actions for the implementation of their prioritized technologies.

More information can be found at: **http://unfccc.int/ttclear/templates/render_cms_page?TNA_home**

Table 4.2 lists the adaptation requests submitted to the CTCN at the time of writing. Given the relatively limited number of requests submitted so far and the lack of geographical and sectoral coverage, the table should not be seen as fully representative of gaps in technologies for adaptation. The types of requests submitted provides a good illustration of the broad perception of what constitutes technologies for adaptation, though, and reflects existing adaptation technology definitions and where technology gaps exist.

Tabel 4.2: Overview of requests for technical assistance on adaptation submitted to the CTCN

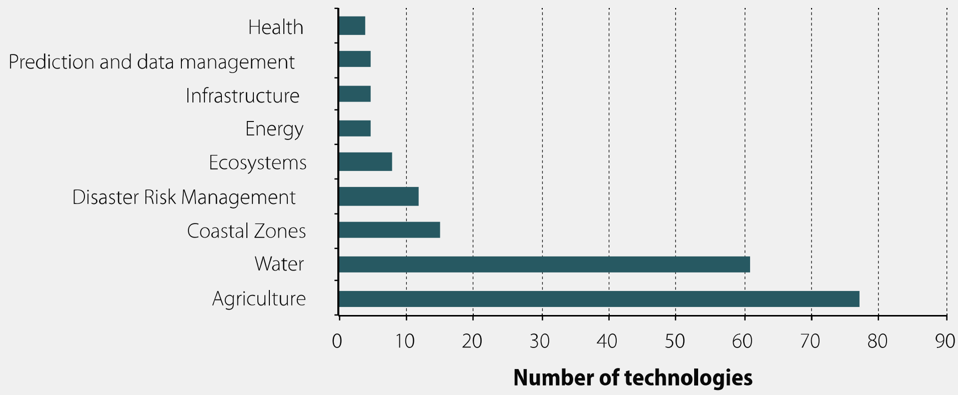
Country	Sector	Request title
Afghanistan	Cross-sectoral	Technical support and advice for the identification of technology needs
Chile	Ecosystems	Design of Biodiversity Monitoring Network in the context of Climate Change
Colombia	Cross-sectoral	Development of a National System of Indicators for Adaptation to Climate Change
Honduras	Ecosystems	Strengthening local capacities at Cuyamel Omoa Protected Area
Ivory Coast	Cross-sectoral	Implementation of an environmental information system which is able to support the selection of a suitable sustainable development policy and promote optimal management of climate change issues
Mali	Cross-sectoral	Strengthening the implementation of climate change adaptation activities and clean development in rural communities in Mali
Pakistan	Agriculture	Propagation of Crop Production Process for Productivity Enhancement
Pakistan	Cross-sectoral	Technical guidance and support for conducting Technology Needs Assessment (TNA)
Syria	Cross-sectoral	Technology Needs Assessment (TNA) for climate change

Source: CTCN (2014)

4.4.1 SECTORS AND TYPES OF TECHNOLOGIES PRIORITIZED BY COUNTRIES

Recent analyses of technology needs assessments for adaptation in developing countries (Trærup and Christiansen 2014, UNFCCC 2013a, 2013b) show that most countries identify water and agriculture as their priorities (see Figure 4.2). This is consistent with findings from earlier technology needs assessments and national adaptation programmes of action (NAPAs) (Fida 2011, UNFCCC 2009).

Figure 4.2: Sector distribution of 192 priority adaptation technologies identified in 25 TNA reports (in numbers)

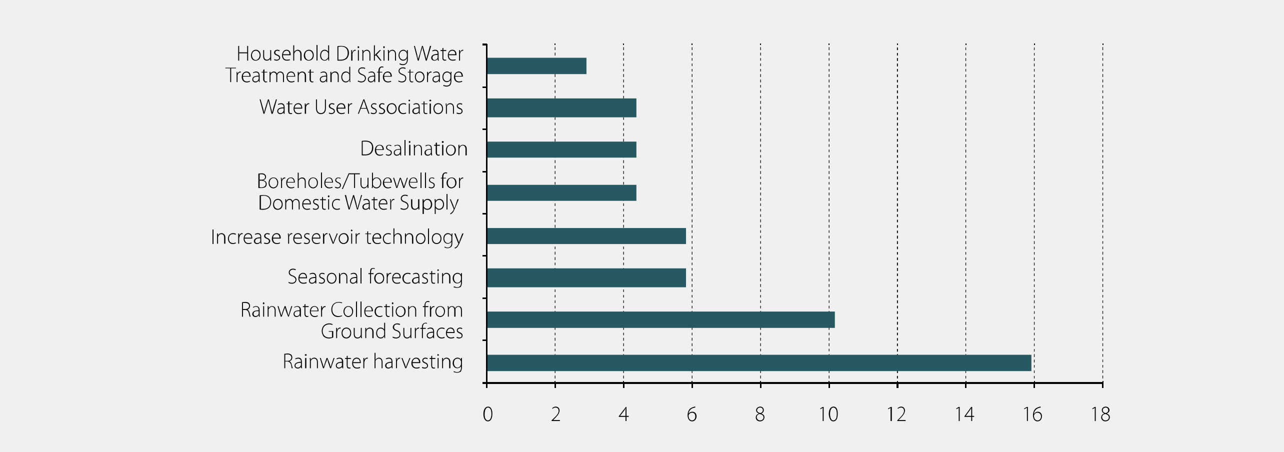


Source: Based on data collected from TNA reports available at: www.tech-action.org

When identified priority technologies within the individual sectors are compared, the relative weight of hardware, software and orgware varies significantly. In particular, the water technologies identified (Figure 4.3) were significantly more 'hardware-intensive' (77 per cent hardware technologies) than, for example, the agriculture sector (36 per cent hardware technologies).

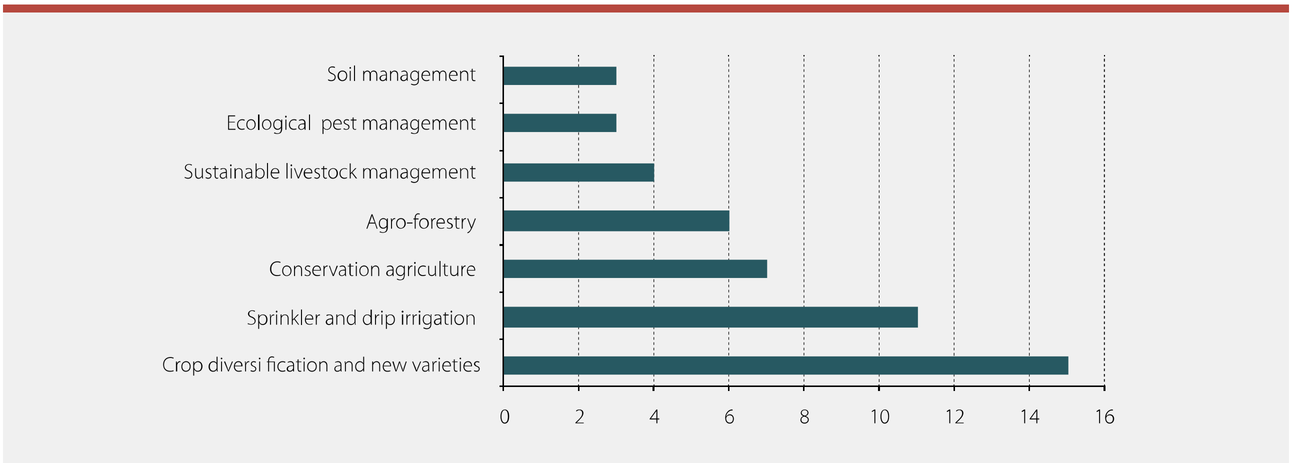
This difference is probably explained by the individual characteristics of each sector: technologies related to water tended to be supply-focused (as with water harvesting and storage from roofs, small dams and reservoirs to store run-off, and with desalinization and the restoration/construction of wells) rather than demand/management-focused (like water-user organizations or integrated watershed management). By contrast, the technologies identified for agriculture (Figure 4.4) tended to be more complex and focused on resource management and integrating aspects of both hardware and software: these include increasing irrigation efficiency through improved management; developing and disseminating drought-resistant crops and cropping systems; implementing integrated agriculture systems such as agro-forestry and mixed farming; and improving extension services and so on. Only rarely were the agriculture technologies identified purely hardware-focused, for example, as investments in modern irrigation systems or terracing, and even then some level of changed practice or knowledge transfer would be an integral part of the technology implementation (although this may not necessarily be stated in the documentation).

Figure 4.3: Percentage distribution of priority adaptation technology needs within the water sector



Source: Based on data collected from 25 TNA reports available at: www.tech-action.org

Figure 4.4: Percentage distribution of priority adaptation technology needs within the agricultural sector



Source: Based on data collected from 25 TNA reports available at: www.tech-action.org

4.4.2 GAPS IN TECHNOLOGY TRANSFER, DIFFUSION AND INNOVATION

To illustrate where the different adaptation technology gaps exist, Table 4.3 depicts the nature of the technology needs countries identified and, thus, implicitly the gaps they have in terms of transfer, diffusion and innovation. The same technologies can appear in several areas acknowledging different gaps in terms of transfer, diffusion, and innovation within the same sector. One country may have efficient and affordable irrigation systems available, while another may need access to more efficient irrigation systems. The table also reflects that, in terms of adaptation, technologies are often familiar and applied elsewhere. For example, water saving technologies well known in one region of a country may be applicable and relevant but not accessible in another region.

Table 4.3: Adaptation technology transfer, diffusion and innovation gaps for selected sectors

Technology gap	Water	Agriculture	Coastal zone	Disaster risk management
International transfer	desalinisation techniques, irrigation techniques	agro-meteorological techniques, water efficient irrigation systems	hazard insurance, salt-resistant crops, building codes, improved drainage, desalination systems, flood hazard mapping, artificial underwater reefs	forecasting, early warning and contingency plans, reconstruction planning
Gaps in technology diffusion and uptake	rain water harvesting techniques, ponds, wells, reservoirs	conservation agriculture, crop diversification, ecological pest management, floating gardens	dykes, seawalls, tidal barriers, development planning in exposed areas, wetland restoration	community based early warning systems, planting mangroves to reduce the risk posed by tidal surges
Technology innovation gaps	increased water use efficiency, desalination techniques, waste water treatment	new crop varieties, bio technology (e.g. drought-tolerant and early maturing food crops/varieties), improved irrigation systems	building codes, early warning systems, flood resistant building materials	tools in meteorological, hydrological and agricultural drought mapping, assessment and monitoring, and early warning systems

Source: Based on data from identified technologies in TNAs available at: www.tech-action.org

4.4.3. GAPS IN TECHNOLOGY BY SECTOR AND TECHNOLOGY MATURITY

Table 4.4 shows the technological maturity of the technologies identified in the TNAs of 25 countries. There is a clear difference in the distribution of technologies between the three categories. Traditional technologies dominate for the agricultural sector; modern technologies dominate for the water, coastal zones, ecosystems, and health sectors; and high technologies dominate for disaster risk management, energy, infrastructure, and prediction and data management. The majority of identified technology gaps are within the category of modern technology. The remaining technologies are distributed close to equally between traditional and high technologies, with slightly more gaps in traditional technologies. Comparing this to an earlier assessment by the UNFCCC (2009), which is reflected at the bottom line of Table 4.4, there seems to be a shift in demand from traditional technologies towards more modern technologies.

Table 4.4: Technological needs by sector and technological maturity

Sectors	Technological maturity			Technologies	
	Traditional	Modern	High	No.	%
Agriculture	55.8	29.9	14.3	77	40.1
Water	1.6	90.2	8.2	61	31.8
Coastal Zones	13.3	80	6. 7	15	7.8
Disaster Risk Management	0	8.3	91. 7	12	6.3
Ecosystems	12.5	75	12.5	8	4.2
Energy	0	0	100	5	2.6
Infrastructure	0	20	80	5	2.6
Prediction and data management	0	0	100	5	2.6
Health	0	75	25	4	2.1
Total, no	47	101	44	192	
Total, %	**24.5**	**52.6**	**22.9**		**100**
Total, % (previous assessment*)	40.6	34.5	24.8	165	

Source: Based on data from 25 countries' reported technology needs in their TNAs.
**Based on UNFCCC (2009)*

4.5 BARRIERS AND ENABLING FRAMEWORKS

A number of barriers remain in terms of the transfer and diffusion of adaptation technologies. Together, these barriers set the stage for exploring the policy responses necessary to support the further development, transfer, and diffusion of technologies for adaptation. The barriers discussed are relevant not only to existing technologies but also to the innovation of future technologies.

For adaptation—irrespective of the sector or technology—almost all the barriers identified in past technology needs assessments fall within certain categories: economic and financial; policy, legal and regulatory; institutional or organizational capacity; and technical barriers to the development and transfer of the technologies countries prioritized (UNFCCC 2013b). Within the category of economic and financial barriers, a major barrier identified by countries was their lack of—or inadequate access to—financial resources (90 per cent). For the policy, legal and regulatory barrier category, the most common barrier was an insufficient legal and regulatory framework (85 per cent). For the institutional and organizational barrier category, the barrier most often reported was limited institutional capacity (90 per cent); while for the technical barrier category, the most commonly reported barrier was system constraints (68 per cent), such as capacity limitation. For example, a Technology Needs Assessment for Lebanon identified some of the key barriers in the agricultural sector as: the high cost of imported patented plant material; the absence of a crediting system; an inappropriate land tenure system; and the shortage of institutional arrangements for subsidies (MoE/URC/GEF 2012).

Lybbert and Sumner (2010) analyzed the policy and institutional changes needed to encourage the innovation and diffusion of agricultural practices and technologies to developing countries, and found that a major barrier to the use of technologies—for example for new seed varieties and crops—occurs at the stage of adopting the new technology where access to and use of new technologies by poor farmers is impeded by several factors. These include: static, poorly functioning or poorly integrated markets; weak local institutions and infrastructure; inadequate or ineffective extension systems; and missing credit and insurance markets. Confirming this, other studies found that it is not the availability of technologies but rather their adoption and diffusion at a local level that poses a challenge for their role in adaptation.

Lack of information presents a barrier to the effectiveness and use of technologies in cases where different groups of stakeholders—involved at different stages of the adaptation planned—need technological information, which is sometimes itself limited and not accessible. Many technology users in developing and least developed countries have few resources to set aside for the purchase of new technologies (Practical Action 2011, Adger *et al.* 2007, Smithers and Blay-Palmer 2001).

It is also evident that the growth of funding for agricultural research has slowed down over time. Despite numerous cost benefit studies reporting on high returns from investment in agricultural research and development (Evenson 2002, Alston *et al.* 2000), there has been a general decline in spending on public sector research and development in agriculture in recent decades (Alston *et al.* 2009). In the United States, public spending on agricultural research and development has fallen to 0.8 percent per year in 2007 from about 2.0 percent in the 1950s (Alston *et al.* 2009).

Current proposals in the area of technology needs assessments show that there is awareness that stand-alone technologies such as physical structures and equipment—are seldom sufficient in themselves but need to be supported by an enabling framework, something recognized in development studies in general.

Box 4.4. Technology Needs Assessment in Small Island Developing States (SIDS)

Mauritius is one of the two SIDS that participated in the first phase of the TNA project. The overarching objective of the TNA project in Mauritius was to improve climate preparedness using an evidence-based approach to better position Mauritius to attract climate finance for technology transfer and the scaling up of proven climate-sound technologies. The scaling up of micro-irrigation (gravity fed drip, mini and micro sprinkler irrigation) among small planters was selected as a "no regrets" technology for adaptation (Deenapanray and Ramma 2014). The most common irrigation systems used for irrigation in vegetable, fruit, and flower production are the drag line, mini-sprinkler and portable/semi-portable sprinkler systems. Due to increasing scarcity of water, however, there is a tendency to shift towards drip irrigation systems that have a higher water efficiency rate (30–40 per cent) than the sprinkler system. Mauritius has had various experiences with drip irrigation systems such as the family drip irrigation system (2001) and the Kenya Agricultural Research Institute (KARI) Drip Kit (2009), both designed for small-scale farming. The latter was evaluated under local conditions and was found to help save on water and on nitrogen fertiliser while improving crop yield by up to 35 per cent, enhancing the income of farmers and reducing the environmental impact of chemical loading.

Using the evidence-based outcomes of the TNA project, the Food and Agricultural Research and Extension Institute (FAREI), has developed a project for scaling up of the micro-irrigation technologies to assist vulnerable small-scale farmers in the drought prone areas of Mauritius.

4.6 POSSIBLE TARGETS FOR ADAPTATION TECHNOLOGIES

As is the case for all adaptation planning, key considerations when setting targets for adaptation technologies include aspects related to the availability of appropriate technologies; access to appropriate technologies in terms of capacity related to financing, operation and maintenance; the acceptability of the technologies to stakeholders (economically and culturally); and their effectiveness in strengthening overall resilience to climate risks (van Aalst *et al.* 2008, Adger *et al.* 2007, Dryden-Crypton *et al.* 2007)

When identifying targets for the transfer and diffusion of adaptation technologies, there is as much a need to distinguish between different timescales—such as when the target should be reached and when required technologies are available and accessible—and levels of certainty and costs, as there is to define any targets for the implementation of other adaptation initiatives. There should be a distinction made as well between "no regrets" options justified by current climatic conditions, and "low-regrets" options made because of climate change but at minimal cost (cost-effective and proportionate).

Considering the existing definitions of technologies for adaptation, introducing "technology approaches" into adaptation and development practice may not necessarily lead to major changes in priorities or in the actual measures implemented compared to those shown in earlier and current adaptation priority assessments such as NAPs, NAPAs, and National Communications.

The broad definition of technologies raises other issues in relation to the work under the UNFCCC (Olhoff 2014). The challenges in clearly distinguishing adaptation technologies from adaptation measures imply there could be risks in driving processes for adaptation under the technology pillar and the work under the adaptation pillar simultaneously. Therefore, there is a need for coordination and the exchange of information between these two pillars of work.

The Cancun Adaptation Framework provides an opportunity for strengthening or establishing global, regional and national institutions and networks, as well as a potential entry point for the coordination of efforts. Along with an increased focus on strengthening or establishing networks—such as the CTCN—for climate technologies, and providing an extensive knowledge management system, this framework will further improve opportunities to setting appropriate targets for adaptation technologies and addressing adaptation knowledge gaps in the countries involved.

4.7 CONCLUSIONS

Experience with technologies for adaptation has clearly shown that the more successful transfer and diffusion of adaptation technologies are those that meet a number of human needs in addition to their provision of climate benefits, and are firmly grounded in the broader socio-cultural, economic, political and institutional contexts (Olhoff 2014, Klein *et al.* 2000). Focus should, therefore, be placed on technologies that serve a variety of purposes above and beyond climate improvement. In addition, it is clear that adaptation technologies are needed across all socio-economic sectors.

In consideration of the role of technology, international technology transfer for adaptation is critical. However, based on recent technology needs assessments, it seems that most technologies are already available and often, though not always, available even within a country but with major barriers remaining to their further uptake (see for example Trærup and Stephan 2014). Therefore, it seems that at this point of time, the most important issue is not technology transfer for adaptation as such but more a matter of accelerating the diffusion and uptake of identified technologies—although there are also situations where specific international transfer is critical, for example in the need for new improved crop varieties, water use efficiency techniques, and monitoring systems. Governments can facilitate the flow of technologies within countries, using measures such as incentives, regulations and the strengthening of institutions. At the same time, as noted by UNFCCC (2009), the development and transfer of technologies should occur mainly in the context of the implementation of adaptation projects and programmes, and the main sources of financing are expected to come from adaptation funding sources, such as the Green Climate Fund.

Research and development have a significant role in adjusting existing technologies to local conditions, and also in terms of innovation in areas where existing technologies—such as insurance solutions, high yielding crop varieties, or water use efficiency appliances—are insufficient to meet fundamental adaptation challenges. The sharing of experiences by countries when it comes to such innovations to promote the transfer, replication and scaling up of technologies will contribute substantially to closing the adaptation technology gap in countries facing similar challenges. Technological change is treated by some as being caused by institutional change (Koppel 1995). In this sense, institutional strengthening is crucial for producing innovations leading to advanced technologies. It is therefore of great importance to increase the mandate and knowledge of existing and new institutions to include the development, transfer and diffusion of adaptation technologies.

The adaptation technology gaps presented in this chapter increase our understanding of countries' needs for technologies in their efforts to reduce the risk to climate change. Nevertheless, more and improved studies on technology options—their ability to reduce climate risks and their associated costs—are necessary for local (national) prioritization.

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