South-South technology transfer

A viable means of adapting to climate change

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Abbreviations and Acronyms

ADB	Asian Development Bank
APAN	Asia Pacific Adaptation Network
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BRIC	Brazil, Russia, India and China
BRICS	Brazil, Russia, India, China and South Africa
CBA	Community-based adaptation
CCA	Climate change adaptation
CBO	Community-based organization
CCS	Carbon-capture and storage
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CIF	Climate Investment Fund
COP	Conference of the Parties
CSO	Civil Society Organisation
CTC	Climate Technology Centre
CTF	Climate Technology Fund
CTCN	Climate Technology Centre and Network
EGTT	Expert Group on Technology Transfer
EST	Environmentally Sound Technology
FDI	Foreign Direct Investment
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GLOF	Glacial Lake Outburst Flood

IPCC	Intergovernmental Panel on Climate Change
IP	Intellectual Property
IPR	Intellectual Property Right
IWRM	Integrated Water Resources Management
LAPA	Local Adaptation Programmes of Action
LDC	Least Developed Country
LDCF	Least Developed Countries Fund
LULUCF	Land use, land-use change and forestry
MDB	Multilateral Development Bank
MDG	Millennium Development Goal
MEA	Multinational Environment Agreement
NAPA	National Adaptation Programmes of Action
NC	National Communication
NCCCC	National Coordinating Committee on Climate Change
NGO	Non-government Organisation
NICRA	National Initiative for Climate Change Resilient Agriculture
NSTT	North South Technology Transfer
NWP	Nairobi Work Programme
OECD	Organisation for Economic Cooperation and Development
PPP	Public-Private Partnership
REDD	Reducing emissions from deforestation and forest degradation
R&D	Research and Development
RTA	Regional Trade Agreement
RWHT	Rainwater Harvesting Technology
SAARC	South Asian Association for Regional Cooperation
SBSTA	Subsidiary Body for Scientific and Technological Advice

SCF	Strategic Climate Fund
SCCF	Special Climate Change Fund
SDC	Swiss Agency for Development and Cooperation
SIDS	Small Island Developing States
SPA	Strategic Priority on Adaptation
SRTT	Special Report on Technology Transfer
SSC	South-South Cooperation
SSTT	South-South Technology Transfer
TAC	Technical Advisory Committee
TCAPP	Technology Cooperation Agreement Pilot Project
TEC	Technology Executive Committee
TM	Technology Mechanism
TNA	Technology Needs Assessment
TNC	Transnational Corporation
TRIPS	Trade-Related aspects of Intellectual Property Rights
TT	Technology Transfer
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific & Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
WGTTT	Working Group on Trade and Transfer of Technology

1. Introduction

Background

Today, climate change[1] is amongst the major environmental concerns for its impacts, which are potentially irreversible are already affecting lives and livelihoods of millions around the world. Accordingly, there is general consensus on the urgency to address the concerns of climate change and the key role that technology can play in climate change mitigation and adaptation. The development and diffusion of 'climate-friendly' or 'climate-smart' technologies has therefore become an issue of policy priority in both developed and developing countries.

There is increasing evidence that the impacts of changing climate across different sectors are a significant threat to food security, water availability, and energy security, amongst others. Moreover, it is also widely accepted that climate change challenges the sustainable growth and dynamism of the economy that countries have achieved in recent years, thereby seriously undermining their future potential for economic development. Note that developing countries in particular are highly vulnerable to the impacts of climate change since large segments of the population in these countries are directly dependent on climate-sensitive sectors for their livelihood, and have only limited capacity to cope with the adverse consequences of climate change. Access to technologies, amongst other factors, which can support or enhance their adaption and mitigation capacities are therefore critical to address climate change concerns and to sustain economic development.

Consequently, technology transfer has been a major component in the ongoing international climate change negotiations. Unfortunately, considering the complexity of the issue, progress has thus far been sluggish. While some positive steps have been taken, it is widely acknowledged that significant challenges still remain in terms of implementation and effectiveness of existing international environmental agreements, and has therefore limited the access of climate friendly technologies for developing countries. Furthermore, in the wake of sluggish economic growth in recent years in the developed countries of the North and the emergence, in contrast, of an economically dynamic "South", the new paradigm of South-South Cooperation among the developing countries is beginning to gain momentum. This Report is an attempt to understand the opportunities and constraints for South-South technology transfer, in the particular context of adapting to climate change and to assess its viability in the specific context of South Asia.

Scope of the Report

1. Highlight the relationship between technology and climate change, with a particular focus on adapting to climate change.

2. Discuss the issue of technology transfer in the context of climate change - the major international policy initiatives on climate change, technology transfer and the access to technologies for climate change adaptation by the developing countries.

[1] According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

3. Explore the phenomenon of South-South technology transfer for climate change adaptation in the context of growing South-South Cooperation, and to evaluate particular initiatives and measures in this regard and more importantly, identify the barriers which obstruct South-South transfer of technologies.

4. Provide national, inter-regional and intra-regional outlook for South-South technology transfer as a means of adapting to climate change in South Asia. In this regard, the three specific questions are addressed by analysing some major initiatives and measures undertaken so far:

    - How critical is the issue of climate change adaptation for the region?
    - Where does the region stand in terms of South-South technology transfer for climate change adaptation?
    - Which are the areas in which South-South technology transfer can help in adapting to climate change?

5. Recommend measures that could be taken to facilitate South-South technology transfer for adapting to climate change in South Asia.

2. Technology in relation to climate change

The relationship between technology and climate change can be understood from two broad perspectives: from the adaptation perspective, technological interventions are made in response to current and predicted impacts of climate change to reduce the vulnerability, and limit the loss and damage from climate change impacts; while from the development perspective, it is broader socio-economic development which fosters technological change which reduce vulnerability to climate change impacts [See Box 1: Adaptation and Development Approaches].

Although the extant literature and ongoing international climate change policy negotiations reflect considerable debate over the relative significance of the two approaches (i.e. adaptation versus development), especially in the case of developing countries, they cannot be seen as distinctly separate from each other, as the two approaches are mutually reinforcing.[2] However, the mutually supportive linkages between adaptation and development cannot be assumed to emerge spontaneously, especially in the context of climate change.

Note that technology is a key linkage between the two approaches, and is the focus of this Report. Technologies in relation to climate change can be categorized into three broad groups: mitigation technologies, adaptation technologies, and observation and monitoring technologies.

[2] For a brief on the debate, see http://ccafs.cgiar.org/blog/adaptation-or-development#.Uu8qSPl_t5c.

Box 1: Adaptation and Development approaches

Adaptation Approach

Technology → Adaptation to Climate Change Impacts → Vulnerability Reduction → Development

Technological change in response to the observed and experienced impacts of climate change on society (including ecosystems) brings about adaptation. This ensures that the vulnerability to the impacts and the risks of loss and damage are reduced. With reduced risk, development can be more sustainable.

Development Approach

Development → Technology → Vulnerability Reduction → Impact Reduction → Adaptation

In this view, development fosters technological change which can help reduce vulnerability to climate change. By reducing the vulnerability, adverse consequences from climate change are also reduced, as there is less sensitivity and exposure to the impacts. This translates into a process of adaptation to climate change.

Source: Adapted from Schipper 2007.

2.1. Technologies for Mitigation

Mitigation as a response to climate change *"…includes strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks"* (IPCC 2007). It can be as complex as a plan involving the development of new technologies for electricity generation, building bicycle paths and walkways, changing management practices and consumer behaviour, or as simple as improving the design of a cooking stove. It also involves protecting the forests and oceans which are natural sinks of carbon, or creating new technologies for storing carbon.[3] Technologies which support mitigation therefore can be broadly divided into two categories: (1) those concerned with controlling, reducing or preventing the emissions of greenhouse gases (GHGs); and (2) those concerned with carbon capture and storage [See Box 2: Climate Technologies].

Mitigation technologies have been at the core of the international technological response to climate change and most of the 'climate actions' taken so far on a global scale have been in this direction with the aim of enabling countries to shift into low-carbon growth paths. The North has historically led the development and adoption of such technologies in sectors such as industry, energy, and transport - the major emitters of GHGs. Therefore, the North has been the traditional source of such technologies, in particular those of the large-scale and industrial/commercial nature. Consequently, the transfer of such technologies is mainly aligned along North-South lines. In recent years, however, countries in the developing South have also built considerable technological capabilities in mitigation. Notwithstanding the significance of such a development on South-South technology transfer for climate change, in line with the scope of this Report, the focus is mainly concentrated on adaptation technologies.

[3] See UNEP http://www.unep.org/climatechange/mitigation/

Box 2: Climate Technologies

Mitigation	low-greenhouse gas (GHG) emission technologies (power-generation, industrial, transport, agriculture, animal husbandry); renewable energy technologies (wind, solar, biomass, biofuel, geothermal, etc.); energy-conservation and energy-efficiency; fuel switching; energy- and material-saving building and construction technologies; transportation technology; recycling technologies; carbon-capture and carbon storage (improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation; techniques and livestock and manure management to reduce emissions; improved nitrogen fertilizer application techniques to reduce emissions; dedicated energy crops to replace fossil fuel use)
Adaptation	water-saving, water-capture and water-reuse technologies; harvesting, storing, conserving, and distributing water; agricultural biotechnology; disease and pest-control technology; soil erosion control; crop management; conservation tillage, nutrient management, rotational grazing and improved forage management, use of cropping rotations and cover crops, establishment of riparian buffers crop variety; crop relocation; improved land management; flood, drought, sea-level rise, agricultural disasters and desertification-control technologies
Observation and Monitoring	climate modelling technologies; automated monitoring and alarm systems; early warning systems; electronics for data logging and alert systems

Source: Compiled from different sources.

2.2. Technologies for Adaptation

Adaptation as a response to climate change includes strategies which help 'systems' (human and natural) to cope with the actual or expected adverse consequences of climate change either by reducing their vulnerability and enhancing their resilience to the climate change impacts. Vulnerability refers to the extent of susceptibility to loss and damage from the adverse impacts of climate change. It depends on the magnitude of the impacts, the sensitivity to the changing climate, and the ability to adapt to such changes. Hence, to be highly vulnerable means being highly sensitive to modest changes in climate along with severely constrained ability to adapt

(Parry et al. 2007, 27). Resilience, on the other hand, is the ability to resist, absorb, accommodate, and recover from the adverse impacts in a timely and efficient manner.

A less discussed aspect of adaptation to climate change includes the exploitation of the beneficial opportunities that emerge from changing climate. Such opportunities may include for example, a longer growing season in the higher altitudes enables one to grow additional crops, while a warmer temperature benefiting certain crop varieties.[4]

Note that adaptation, in contrast to mitigation, is inherently contextual, taking into account context-specific features which include geographical, physiological and socio-economic conditions. Also, adaptation can be considered under different time frames – the immediate, short-term and long-term. Adaptation could be 'anticipatory' (also referred to as 'proactive') that takes place before the impacts of climate change are actually felt, or could be 'planned' - a deliberate decision based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state (Parry et al. 2007).

Consequently, the range of technologies for climate change adaptation is phenomenally immense, and can be classified into two broad categories: adaptation technologies for the human system; and adaptation technologies for the natural system (See section 4.6).

This approach can be seen in the work done by international development organisations, like the United Nations Development Programme (UNDP). These technologies have the goal of building and strengthening the 'adaptive capacity' defined as the ability to cope with the adverse consequences and even to take advantage of opportunities from climate change impacts.

2.3. Technologies for Observation and Monitoring

Even before any strategy can be formulated in response to climate change impacts, an effective response has to be grounded on observation, monitoring and interpretation of the climate-induced changes on the particular system under consideration. Technologies for this purpose includes those which help in generating information and building the statistics based on different types of surface observations (e.g. air temperature, precipitation, etc.), atmospheric and marine measurements operating at different scales, from global to local level, to help in formulation, implementation and evaluation of the responses made to climate change impacts.

The significant role played by such technologies in the prediction of extreme weather events and in disaster risk management is well known. But against a broader picture of adapting to climate change, they are relevant in the context of identifying and interpreting the risks arising from changing climate.

3. Climate change technology transfer and developing countries

Technology transfer (TT hereafter) has been variously defined from different perspectives and although it is well known that it is implemented through bilateral and multilateral agreements, as

[4] See for example, a study on rice cultivation from Madagascar at http://www.cirad.fr/en/research-operations/research-results/2012/the-beneficial-effects-of-climate-change-on-rice-in-madagascar

well as international commitments and market-based mechanisms, there is much less understanding and not global consensus on the TT process, in terms of its practice and the policies or measures undertaken to facilitate the transfer.[5]

In the context of climate change, TT is often misunderstood as it has a range of meanings and interpretations. For some, it is simply a transfer of 'hardware' from one country to another. However, the definition of TT as proposed by the Intergovernmental Panel on Climate Change (IPCC)[6] refers to a broad set of processes covering the flows of know-how, experience and equipment amongst different stakeholders such as governments, private sector entities, financial institutions, non-government organisations (NGOs) and research/educational institutions (IPCC 2000). It encompasses diffusion of technologies and technology cooperation across and within countries. Importantly, TT also comprises the process of knowledge transfer as it helps to understand, utilize and replicate the technology made available and to adapt it to local conditions. Although this broad and inclusive definition has methodological and operational complexities, such a definition is essential from an adaptation perspective [See BOX 3: Technology Transfer].

Box 3: Technology Transfer

> … a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions.
>
> …"transfer" encompasses diffusion of technologies and technology cooperation across and within countries.
>
> …comprises the process of learning to understand, utilize and replicate the technology, including the capacity to choose it and adapt it to local conditions and integrate it with indigenous technologies.

Source: IPCC 2000.

The process of TT therefore includes both 'hard' technologies such as capital goods, hardware, equipment, setting up infrastructure as well as 'soft' technologies such as knowledge of methods and techniques which enable hard technologies to be efficiently applied. For instance, pilot demonstrations of specific technologies, modelling climate scenarios, and building the capacity of institutional stakeholders involved in the process of adapting to climate change are some examples of soft technologies.

In the development literature, in addition to hard and soft technologies, the use of technologies that give communities access to knowledge and information, for instance, through networks on

[5] See Gehl Sampath and Roffe 2012.

[6] The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988.

how to cope under adverse conditions and to make informed decisions also bear significantly on adaptive capacity.

Adaption is thus, much more than the application of a particular technology. It is "an ongoing and reiterative process that includes information development, awareness raising, planning, design, implementation and monitoring" [7] and reduces vulnerability to risks from climate change which requires not only having access to technology, but also having the mechanisms, expertise and other resources that are needed to make the technology useable and sustainable.

In the broad and inclusive definition of TT described above, the process of 'transfer' depends on a number of social, economic, political, legal and technological factors. The process of TT or the 'pathway' will therefore depend on the sector, location and even the type of technology involved. For example, the process of TT may be different for the industrial sector and the agricultural sector, for the Least Developed Countries(LDCs) and the high-income countries, for indigenously developed technologies and those developed at research laboratories, and for 'close to market' technologies and for technological innovations which are still in the development phase. In practise, TT is therefore essentially complex and multi-faceted in nature and there is no one 'blueprint' applicable in all situations.

Nonetheless, TT certainly involves key stages, starting from the identification of needs, choice of technology, assessment of conditions of transfer, agreement, implementation, evaluation and adjustment to local conditions, to replication (IPCC 2000). It is also generally understood that for TT to be successful, access to information, availability of a wide range of skills, technical, business, management and regulatory, as well as a sound economic policy and regulatory frameworks are essential (*ibid*).

The international position on access to technology and supporting technology transfer to developing countries can be traced back to 1992 Rio Declaration (Chapter 34.18 of Agenda 21). The issue emerged in the context of 'environmentally sound technologies' (ESTs) for sustainable development, and was concomitantly adopted in the United Nations Framework Convention (UNFCCC). Two years later, UNFCCC developed a global climate change policy framework and emphasised the role of technologies in relation to climate change. In the following sub-section, we look at some of the major international policy initiatives in this regard, an overview of which is presented in Table 1 (See Appendix 1).

3.1 The international policy initiatives on climate change technology transfer

Recognizing that stabilizing the concentration of GHGs in the atmosphere is critical to address the global threat posed by climate change[8], UNFCCC (Article 4.5) urged Annex I countries[9] to enable other Parties, particularly non-Annex I countries[10] to implement the provisions of the Convention by promoting, facilitating and financing, as appropriate, the transfer of or access to

[7] http://unfccc.int/ttclear/sunsetcms/storage/contents/stored-file-20130620104821216/backgroundPaper.pdf.

[8] Refer to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

[9]Annex I countries include developed country parties to the Convention and are the member of the Organization for Economic Cooperation and Development (OECD).

[10] Non-Annex I countries include are developing country parties to the Convention.

ESTs and technological know-how. This commitment was followed by the Kyoto Protocol (1997) which established the Clean Development Mechanism (CDM) to allow the transfer of emission-reduction (otherwise referred to as 'clean') technologies from the developed countries to the developing countries. Since CDM became operational in 2006, the transfer of mitigation technologies have been in areas such as electricity generation, fuel switching, industrial applications, renewable energy and energy-efficiency, among others, as described in Box 2. A share of the proceeds from CDM activities is stipulated under the Kyoto Protocol to be used to assist vulnerable developing countries with climate change adaptation.[11]

Additionally, a Technology Transfer Framework for effective action towards increasing and improving the transfer of ESTs and know-how as per UNFCCC's objective emerged as part of the Marrakesh Accords in 2001. This framework had five key themes: (i) technology needs assessment; (ii) enabling environments; (iii) technology information; (iv) capacity building; and (v) mechanisms for technology transfer. Four sub-themes to facilitate the support of financial, institutional and methodological activities were added later to under the mechanisms for technology transfer theme: (i) Innovative Financing; (ii) international cooperation; (iii) endogenous development of technologies; and (iv) collaborative research and development.

More recently, the Bali Action Plan in 2007 charted a new course in the negotiating process through long-term cooperative action and had five main components: shared vision, mitigation, adaptation, technology and financing. Subsequently, the Copenhagen Accord committed financing by developed countries for adaptation and mitigation projects in developing countries, with priority given to the Least Developed Countries (LDCs).

The primary focus of the UNFCCC in promoting national and international cooperation has been on reducing the volume of GHG emissions while working to lower the cost of reducing GHG emissions. Until recently, the transfer of ESTs has therefore essentially meant transfer of mitigation technologies from the North to the South to meet the long-term global goal. The flow of funding and other resources, including capacity-building support by developed countries and international organisations to the developing countries, consequently, has mainly been in the area of mitigation.

As the financial mechanism of UNFCCC, the Global Environment Facility (GEF), setup in 1991, is the largest funder of projects addressing climate change concerns. It is a partnership among 178 countries, international institutions, NGOs and the private sector, and is considered to be one of the largest public sector technology transfer mechanisms in the world (GEF 2008). Its activities have centred on deployment and diffusion of energy efficient, renewable energy, and sustainable transport technologies. Similarly, the Green Climate Fund (GCF) is another financial mechanism under the UNFCCC which was setup in 2010 to support developing countries to prepare and implement mitigation actions.

Additionally, a number of bilateral and multilateral funding mechanisms funded by donors from public and private sectors, along with various NGOs are also involved. The Climate Investment Funds (CIF) for example, administered through country-led programmes and investments by the

[11] This share is 2% of CDM proceeds (http://www.gendercc.net/policy/topics/adaptation.html)

African Development Bank, Asian Development Bank (ADB), European Bank for Reconstruction and Development (EBRD), Inter-American Development Bank, International Finance Corporation (IFC) and the World Bank include two financing instruments, namely the Climate Technology Fund (CTF) and the Strategic Climate Fund (SCF) to support climate action efforts by developing countries. Under the SCF, there are three programmes: (i) the Forest Investment Programme (FIP); (ii) the Programme for Scaling-Up Renewable Energy in Low Income Countries (SREP); and (iii) the Pilot Programme for Climate Resilience (PPCR).

Although there are no studies that assessment the effectiveness of UNFCCC led initiatives in facilitating the transfer of technologies from North to South, it is clear that very little consideration has been given to adaptation technologies. Despite the mandate under the Convention, the international policy response and action so far is limited, whether in terms of funding, technology transfer or capacity building.

With particular reference to adaptation, it was the Nairobi Work Programme (NWP) undertaken by the UNFCCC in 2005 which explicitly stated the objective to help countries improve their understanding and assessment of the impacts of climate change and to make informed decisions on practical adaptation actions and measures. Since then, there has been some progress in building a database of adaptation experiences, technologies, tools and methodologies.

Following the NWP, the Cancun Agreement (December 2010) launched the Adaptation Framework and created the Adaptation Committee to facilitate the implementation of adaptation activities through technical support and guidance; as well as to strengthen, consolidate and enhance the sharing of relevant information, knowledge, experience and good practices at the local, national, regional and international levels, taking into account, as appropriate, traditional knowledge and practices to promote synergy and strengthen engagement with national, regional and international organizations, centres and networks, in order to enhance the implementation of adaptation actions, in particular in developing country Parties.[12]Steps to further the implementation of the Cancun Adaptation Framework, including working out the modalities and guidelines for countries in formulating their national adaptation plans, were outlined at the Durban Climate Change Conference in 2011. The following year, the Doha 'Climate Gateway', emphasising the need for technological support to developing countries, set out a timetable to adopt a universal climate agreement by 2015 that is to come into effect in 2020.

The new Technology Mechanism at the Cancun Agreements is considered a departure from the conventional UNFCCC approach based essentially on capacity building and technology needs assessments as it addresses "a 'dynamic' arrangement geared towards fostering public-private partnerships; promoting innovation; catalysing the use of technology road maps or action plans; mobilizing national, regional and international technology centres and network; and facilitating joint R&D activities."[13] Under this mechanism, a Climate Technology Centre and Network (CTCN)[14] was setup in 2013 to help developing countries access technologies related to climate change through both North-South and South-South partnerships.

[12] See http://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf#page=5

[13] http://unfccc.int/focus/technology/items/7000.php

[14]It includes a consortium of organisations from around the world: the Asian Institute of Technology in Thailand; the Bariloche Foundation in Argentina; South Africa's Council for Scientific and Industrial Research; India's The

Importantly, to finance climate change adaptation efforts, the GEF has recently adopted a Strategic Priority on Adaptation (SPA) initiative, and together with the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF), the GEF is funding projects on adaptation within which TT is a major component. Specifically, the LDCF finances the preparation and implementation of projects under national adaptation plans by the LDCs.

Clearly, a number of international initiatives on climate change exists, some of which specifically aims to facilitate TT to address climate change concerns. Now, the focus is beginning to move away from dealing with technology transfer from a narrow, closed perspective to a wider, systemic perspective, geared towards promoting innovation and technology development. Given such a scenario, the big question is where global actions and efforts to facilitate TT to developed countries have been effective in improving developing countries' access to climate change adaptation technologies.

3.2 Access to climate change technologies by the developing countries

As described earlier, with mitigation at the centre of international climate policy negotiations driven by the global perspective on climate change, the North has historically taken a lead role, whether related to funding, capacity building or the actual transfer of technology. Thus far, common pathways for North-South technology transfer include government assistance programmes, direct purchases, licensing, foreign direct investment (FDI), joint ventures, cooperative research arrangements and co-production agreements, education and training, and government investment. Accordingly, in order to facilitate TT to the developing South, numerous approaches in use include compulsory licensing, patent pools, patent databases and structured voluntary licensing "mechanisms." However, it has been argued that these approaches are partial solutions at best, while some of them could even be potentially detrimental to developing countries (Cannady 2009).

Moreover, despite numerous international commitments, it is generally acknowledged that the transfer of climate change related technologies to the developing countries has been limited (see for e.g. Khatiwada 2012; CIEL 2008). In the context of CDM, for example, the projects are found to have been either too small-scale or the processes too convoluted to deliver technology to the extent required for rapid climate change mitigation and adaptation. CDM projects also appear to be concentrated in a small group of countries in Asia and Latin America whereas African countries and some parts of South East Asia seem to be neglected (Khanal 2008). Considering the failure of past global initiatives to facilitate the transfer of climate change related technologies to developing countries, at the UNFCCC's Bali Conference in December 2007, developing countries refused to take on specific emission reduction obligations in the post-Kyoto period. Also note that, in light of the failure of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) Article 66.2[15], the general perception is that the developing countries cannot rely on the North for access to technologies.

Energy and Resources Institute; Environment and Development Action in the Third World in Senegal; The Tropical Agricultural Research and Higher Education Centre in Costa Rica; and the Kenya-based World Agroforestry Centre as well as organisations in Denmark, Germany and the United States.

[15]This refers to the obligation on the part of the North (the developed countries) to provide incentives for technology transfer.

Along with the failure of North-South TT, the current economic slow-down and financial crises in the developed countries has placed further constraints on the flow of technologies from the North to the developing countries. Concurrently, a global shift of economic power to the South has occurred. Along with the larger countries like China, India, Brazil and South Africa which are most visible in the South, smaller countries like Chile, Ghana and Mauritius have also made rapid advances in recent years. They have gradually built up significant technological expertise and financial resources, and are emerging as leading global providers in manufacturing, services and agricultural sector globally. Notably, the positive growth spillover from the larger South countries has led to expanding cooperation between the developing countries in the South in many areas, including but not limited to TT.

Against the backdrop of a 'new' international order, we explore in the following section the potential of South-South cooperation to make up for the failure of North-South TT and address the specific technological needs of developing countries in the context of climate change.

4. South-South Technology transfer and climate change

4.1 Growing South-South Cooperation and technology transfer

The new reality of a global South—where rising high- and middle-income developing countries have the expertise, skills, finance and resources to support growth and development in the less developed developing countries including the LDCs—has positioned South-South Cooperation (SSC) as a key tool of development and foreign policy for the countries in the South, and has also garnered strong international support. In recent years, development forums[16] have reaffirmed the high potential of SSC and Triangular Cooperation[17] in addressing shared development challenges more relevant to developing country contexts.[18] According to the latest Human Development Report 2013 which focuses on the large number of developing countries which have emerged into dynamic major economies, much of this transformation is being driven by new trade and technology partnerships within the South itself.

Interestingly, the growing interest in the potential of SSC is not a recent phenomenon. In fact, a Special Unit for South-South Cooperation had actually been set up in UNDP as way back as in 1978 whose mandate is to promote, coordinate and support South-South (and Triangular) Cooperation on a global and UN system wide basis. Moreover, since 2008, a Task Team on South-South Cooperation (technology transfer-SSC) has also been established by the OECD Development Co-operation Directorate (DCD-DAC), and is a southern-led platform co-chaired by Colombia and Indonesia with active support from the World Bank Institute and regional platforms in Asia, Africa and Latin America and the Caribbean.

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[16]For example, the *G20 Summit in Cannes*, the *UN South-South Cooperation Summit in Nairobi*, the *Development Cooperation Forum of the Economic and Social Council* (ECOSOC), the *Fourth High Level Forum on Aid Effectiveness of the Organization for Economic Cooperation and Development* (OECD) *in Busan.*

[17]Triangular Cooperation involves two or more developing countries in collaboration with a third party, typically a developed country government or organization, contributing to the exchanges with its own knowledge and resources.

[18] See http://wbi.worldbank.org/sske/sske/about-knowledge-exchange.

Notwithstanding the regional variation which is observed in the South, such as a much higher level of cooperation among the South East Asian countries or the Latin American and Caribbean countries in comparison to the South Asian countries, the overall trends in the South signify a higher degree of inter-connectedness among the developing countries in recent years. The share of export of capital goods and intermediate goods, for example, from developing countries to LDCs has increased in comparison to those from developed countries to LDCs. In addition to the increasing trends observed in South-South flows of finance, trade and foreign direct investment (FDI), cooperation at other levels in international relations has also been positive. The emergence of BRICS [Brazil, Russia, India, China and South Africa] and its growing agenda are pointers in this direction.

Now what does this increased SSC mean for TT?

Ever since the Buenos Aires Plan of Action for Promoting and Implementing Technical Cooperation among Developing Countries was put in place in 1978, the significance of South-South technology transfer (SSTT) has been recognized, and technical cooperation among Southern countries has been taking place, more so in recent years in response to new demands arising from the transformation of production and consumption patterns.

As described earlier, there are different pathways along which TT generally takes place, both market-mediated and non-market mediated, such as direct purchases, licensing, FDI, joint ventures, cooperative research arrangements and co-production agreements, education and training, government direct investment, etc.

Recent empirical evidence on development assistance used as proxy between southern partners show that TT so far has been mainly in soft infrastructure in the form of capacity building programmes, and bigger initiatives with potentially larger pay-offs, such as collaboration in the area of science and technology are only beginning to emerge (Dhar and Joseph 2012). On the other hand, the latest Technology and Innovation Report 2012 from UNCTAD, aptly titled *Innovation, Technology and South–South Collaboration*, notes that exchanges between developing countries accounted for 55 percent of global trade in 2010, as compared to 41 percent in 1995, and the process is already leading to appropriate technology diffusion, TT and innovative capacity.[19]

4.2 South-South technology transfer for climate change adaptation

In the context of climate change, evidence for SSTT is more noticeable in the transfer of mitigation technologies under the Clean Development Mechanism (CDM). Countries like China, India and Brazil which have made significant investment into renewables, instituted carbon markets and begun using innovative technology to address issues such as deforestation and air quality have taken the lead in this direction. Such progress has benefitted other developing countries by making available technologies that are more appropriate and cost efficient. Importantly, it has provided business opportunities in Certified Emission Reduction (CER)

[19]See UNCTAD/PRESS/PR/2012/35
http://unctad.org/en/pages/PressRelease.aspx?OriginalVersionID=104andSitemap_x0020_Taxonomy=20;

markets, which from an economic perspective is seen as a win-win solution for both parties (Aggarwal 2011).

There is an increasing level of small-scale SSTT particularly in the case of clean and renewable energy technologies such as biofuel and wind energy (Krishna 2009), waste-to-energy technologies such as biogas digesters and 'jatropha' fuels between countries like Nepal, India, Bangladesh and China,[20] biomass gasification power generation system transfer between India and Thailand, and solar projects from India to Kenya and Ethiopia (Goswami and Gregoire-Wright 2013). However, it has also been observed that the increase in investment on research and development (R&D), as well as transfer and patenting of clean technologies is limited to few fast growing developing countries.[21]

There are also some successful instances of SSTT in disaster risk management and climate change observation and monitoring, mainly between India and other developing countries, both within and outside South Asia, as with Myanmar in the wake of Cyclone Nargis (Goswami and Gregoire-Wright 2013).

Although, as described above, some progress has been made in South-South transfer of climate technologies, it has been observed that the high potential of SSTT in adapting to climate change is yet to be fully explored (Corvaglia 2010).

4.3 Impediments to South-South transfer of climate technologies

At a general level, it is widely acknowledged that globally there are significant constraints in the form of domestic and external barriers to TT. The limited number of available studies on TT—which largely focus on North-South cooperation and are centred on mitigation technologies—point to political, economic, institutional, policy and legal obstacles.

In the context of this study, two questions emerge: (i) do the same North-South barriers also hold for South-South technology transfer?; and (ii) are the barriers different for adaptation technologies?

In order to answer these questions, we need answers first to questions such as: Who owns the technology? What is the mode of technology transfer? Who is transferring the technology? What type of technology is being transferred?

It has been observed that multinational corporations (MNCs) produce, own and control the bulk of the world's modern technology (Kathuria 2011). They are also responsible for most of the technology transferred, especially when connected with FDI. In the context of climate change, this observation holds true for mitigation technologies, in particular those intended for large-scale industrial/commercial purposes. In contrast, most adaptation technologies are publicly funded, with limited private sector engagement.

[20] See http://www.unep.org/SOUTH-SOUTH COOPERATION/case/casefiles.aspx?csno=63

[21] http://www.scidev.net/en/science-and-innovation-policy/south-south-cooperation/policy-briefs/measuring-progress-on-technology-for-development-1.html

Clearly, an underlying explanation can be found in the fact that adaptation technologies are distinctly different from mitigation technologies in many ways. First, most of the adaptation technologies which are proven to be effective or successful are impact and context-specific. Hence the transfer of adaptation technologies to a different country is fraught with uncertainty, among other cross-country barriers. Therefore, although adaptation technologies may be drawn from a greater range, they are neither easily identifiable nor easily transferred.

Second, since adaptation technologies are mainly of 'public good' nature with no market, it is left to the governments to work on their provision and transfer. Thus, both market and institutional failure become impediments to the process of transfer.

Another important inhibiting factor is the contentious issue of intellectual property rights (IPRs). Although intellectual property rights were conceived to promote the innovation and diffusion of technologies, it is not clear how effective they have been in facilitating TT to developing countries. While some studies have shown that IPRs have a positive impact on TT,[22] others have shown that they provide no incentives for TT.[23]Although there is no comprehensive study yet on the potential impact of IPRs and access to the different categories of climate-related technologies by developing countries, it has been suggested that "the general dynamics of IP and transfer of technology are likely to remain valid in the climate change context"(ICTSD 2009). In the context of climate change related technology, IPRs are even seen as an obstacle to TT, particularly to LDCs since they lack the capacities that are prerequisite to facilitate TT under the IPR regime.

But the proponents of IPRs have argued that the flexibilities under the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS), especially the provisions which include exceptions to patent rights and compulsory licensing, overcome some of the constraints arising from protection of IPRs. Such flexibilities provide developing countries the critical policy space, especially relevant in the context of climate change adaptation, when there is a need to adapt the acquired technology to the local context. Nonetheless, whereas some have found TRIPS flexibilities as potentially effective for facilitating TT for climate change adaptation in developing countries, others have found several shortcomings (Srinivas 2012; Foray 2009). Many point to the significant challenges such as institutional reforms and regulatory incentives that are required in both countries involved in TT.

Additionally, the market-based approach to the process of TT is also a major concern. While developing countries require significant access to technologies on concessional or grant terms, the market-driven process does not favour the low-income developing countries. Studies have shown that market-based technology transfer mechanisms such as FDI or joint ventures are ineffective in meeting the needs and demands of LDCs (see Foray 2009). The UNFCCC has recognised that LDCs, for example, those in the African region and small island developing states have 'specific needs and special situations' when it comes to TT. Thus, mechanisms normally found useful in other contexts may be inadequate and even counterproductive for such countries (ICTSD 2009). In the particular case of adaptation technologies, which in many cases do not have a market, the potential for their transfer through market-based mechanisms is questionable.

[22]See for e.g., Maskus 2003.

[23] See for the debate, ICTSD 2009.

The lack of adequate institutions and policy/regulatory infrastructure to initiate the process of TT, and the limited capacity to mobilise resources for the purpose is another major impediment for TT in developing countries. As we noted earlier, effective transfer of technology requires skills and resources to identify context specific technologies appropriate to the adaptation needs. Regrettably, only few of the developing countries have the infrastructure and capacity to undertake such an endeavour.

Moreover, once climate change risks are identified, choosing the right technology and planning a strategy for TT requires access to a large amount of finance. While funding options have increased through the involvement of the private sector and international financial institutions (World Bank, ADB, etc.) and the other multilateral development banks (MDBs) and international mechanisms like GEF, the Climate Investment Funds and the Green Climate Fund (described earlier in section 2), the emphasis is primarily on mitigation, especially in renewable energy supply and improved energy efficiency. Private sector flows are limited in sectors like agriculture, forestry, human health or coastal zone management. Despite the commitments made at UNFCCC COP15 in Copenhagen in December 2009 to balance funding between adaptation and mitigation, estimates suggest that only one-fifth of climate finance supports adaptation in developing countries. Further, planned resource allocation is significantly less than what is necessary to address the urgent need to adapt to climate change (Tessa and Kurukulasuriya 2010).

5. A regional outlook: South Asia and South-South climate technology transfer

South Asia includes eight countries: Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan and Sri Lanka. It occupies only 2 percent of the world's land mass but it is home to about 20 percent of the world's population making it both the most populous and the most densely populated geographical region in the world. Apart from India, Pakistan, Sri Lanka, and Maldives, the other four are classified as LDCs.

5.1 Urgency of adaptation and mitigation in South Asia

On account of its diverse topography, susceptibility to natural disasters, widespread poverty and a high proportion of population dependent on climate-sensitive resources for livelihood, South Asia is among the most vulnerable regions in the world to climate change (Cruz et al. 2007).

There is mounting evidence that the effects of climate change are already being felt in South Asia on human as well as natural systems manifested as water shortages, low crop yields, increased salinity, inundation of low lying cities, soil erosion/coastal erosion, increased incidence of vector-borne diseases, extreme weather events, and loss of endemic species, among others. With the region's population poised to rise by another 650 million people by 2050[24], the additional demands on increasingly scarce resources like water and land and also inadequate infrastructure can only exacerbate the adverse consequences of climate change.

[24] http://www.prb.org/Publications/Datasheets/2013/2013-world-population-data-sheet/world-map.aspx

Clearly, the impacts of climate change in the region are felt on many fronts: agriculture and food security, water availability, more frequent occurrence of natural disasters like flooding, droughts, tidal surges, and cyclones which cause extensive damage to assets and infrastructure (roads, ports, railway and telecommunications), human lives and human health, and biodiversity.

According to the latest Climate Change Vulnerability Index (CCVI)[25] which ranks 193 countries in terms of climate-related risks to population, business and governments over the next 30 years, Bangladesh is most at risk to climate change impacts, followed by India (20th) and Pakistan (24th). The index is based on the assessment of countries' vulnerability to: (i) exposure to extreme climate-related events including sea level rise and future changes in temperature, precipitation and specific humidity ; (ii) the sensitivity, in terms of population patterns, development, natural resources, health, education, agricultural dependency and available infrastructure; and (iii) the adaptive capacity of a country to combat the impacts of climate change which encompasses R&D, economic factors, resource security and the effectiveness of government. Additionally, at a sub-national level, among the 50 cities mapped by CCVI, Dhaka in Bangladesh, and Mumbai and Kolkata in India rank among the top five cities which face 'extreme risks'.

Notwithstanding the variation in vulnerability of the different South Asian countries to climate risks, and the nature, extent and intensity of climate change impacts felt by the different countries in the region, there is no denying that climate change has multidimensional implications for the millions in the region who depend on climate-sensitive sectors for livelihood and food security. It follows therefore that it is the ability of these highly vulnerable countries to adapt to climate change impacts and minimize the direct impact of extreme events on the economic infrastructure which is crucial not only to confront climate risks currently faced and to take advantage of changing climatic conditions, but also to sustain long term economic growth. Adaptation to climate change impacts (as well as mitigation) is subsequently of paramount significance for the region. An overview of climate change impacts and adaptation needs by country is presented in Table 2 [See Appendix 1].

It is imperative to ask then to what extent South Asian countries have adopted adaptation as an approach to reduce loss and damage from climate change. Additionally, taking note of all climate change initiative and strategies undertaken by countries in the region, and the nature of the technological dimension embedded in them is also equally important.

5.2 Country Analysis: Initiatives, Strategies and Practices

Following the mandate of the UNFCCC and the directives of the IPCC, countries are committed to address climate change in two ways: (i) by implementing national programmes for mitigation and adaptation; and (ii) by taking climate change into consideration in their development strategies.

From an adaptation perspective taken in this Report, implementation of national programmes such as the National Communications to the UNFCCC, the National Adaptation Programmes of Action (NAPAs), and the National Climate Change Strategies and Plans, are notable efforts for

[25] See for details: http://maplecroft.com/portfolio/new-analysis/2013/10/30/31-global-economic-output-forecast-face-high-or-extreme-climate-change-risks-2025-maplecroft-risk-atlas/

climate change adaptation. The National Communications and the NAPAs provide an overview of the specific country's vulnerability to climate change by sector and set the context for adaptation policy options, and identify priority adaptation actions and projects. Currently, these programmes are under various stages of implementation in South Asian countries.

An overview of national policy initiatives in relation to climate change and the technology dimension is presented in Table 3 (See in Appendix 1).

In **Afghanistan**, the National Environmental Protection Agency (NEPA) supports the sustainable development of natural resources through the provision of effective environmental policies, regulatory frameworks and management services that are also in line with the Afghanistan Millennium Development Goals (MDGs). Afghanistan's National Capacity Needs Self-Assessment (NCSA) and NAPA have identified desertification, biodiversity loss and climate change as priority areas.

Bangladesh is at the forefront of addressing climate change but there are large gaps in the understanding of how populations in vulnerable locations are affected and what they can do about it. In 2005 the government finalised NAPA, which identified key adaptation needs. This was followed by the National Climate Change Strategy and Action Plan in 2008 which was revised in 2009. This comprehensive strategy addresses the climate change challenges in Bangladesh through six thematic areas: (i) food security, social protection and health; (ii) comprehensive disaster management; (iii) infrastructure; (iv) research and knowledge management; (v) mitigation and low carbon development; and (vi) capacity building and institutional strengthening.

With active support from multilateral development agencies, the Bangladeshi government has taken several initiatives on adaptation in key priority sectors—agriculture and food security, coastal zones and marine ecosystems, water and energy, and public health. It also has a Strategic Programme for Climate Resilience, which has been developed as a broad-based strategy for achieving climate resilience at the national level in the medium- and long-term.

Bhutan's NAPA puts emphasis on integrating climate change risks into the national planning process. The overall strategy is laid down by the National Environment Commission (NEC) which also facilitates the implementation of 'integrated' adaptation projects requiring several agencies to closely cooperate. The climate-related concerns identified include drought/water scarcity, extreme weather events, flood, land degradation and deforestation.

In **India**, the government released its first National Action Plan on Climate Change (NAPCC) in 2008, which outlines existing and future policies and programmes aimed at addressing adaptation and mitigation issues. It identified eight core 'national missions' running until 2017 emphasising India's overall goal of maintaining high economic growth while also addressing climate change.[26] These include solar, energy efficiency, sustainable habitat, Green India (REDD and LULUCF), water, Himalaya ecosystems, agriculture and strategic knowledge of climate change. The NAPCC

[26] See for details, "National Action Plan on Climate Change Government of India" available at http://www.c2es.org/international/key-country-policies/india/climate-plan-summary.

is being implemented through State-level Action Plans on Climate Change (SAPCCs), which are currently being drafted by the different States.

In **Maldives**, the NAPA (2008) focuses on adaptation needs which strengthen agricultural production, and increase food security and the resilience of local food production through enhancing the capacity of farmers and local communities. In 2011, Maldives endorsed a Strategic National Action Plan (SNAP) that integrates Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) recognising the links between climate change, natural hazards and disasters.

In **Nepal**, several initiatives related to climate adaptation at local and community level are already underway. The Nepal Risk Reduction Consortium formed in May 2009[27] supported the government in developing a Disaster Risk Reduction Action Plan building on the National Strategy for Disaster Risk Management (NSDRM). In addition, NAPA was launched in 2010 with focus on six themes—agriculture and food security, forests and biodiversity, water resources and energy, climate-induced disasters, public health, and urban settlements and infrastructure. The NAPA also has two cross-cutting themes: livelihoods and governance, and gender and social inclusion. Together with NAPA, a local adaptation plan of action (LAPA) has also been developed with an aim to act at a more localised level. Till date, projects identified include those addressing the effects of climate change on hunger and poverty reduction, and on mainstreaming disaster risk reduction into cross-sector planning.

In **Pakistan,** the Initial National Communication on Climate Change (2003) identifies many of the country's urgent needs for adaptation. Its national climate change policy was launched recently in March 2013. The government has established a Global Change Impact Studies Centre with a focus on modelling-based research to assess impact, develop adaptation measures, and provide feedback to policy makers.

In **Sri Lanka,** the government has placed emphasis on adaptation measures targeted at key sectors, and is actively supported by multilateral development agencies. Its National Climate Change Adaptation Strategy (NCCAS) focuses on both adaptation and disaster risk management options for key sectors, including agriculture/food security. At the national level, the government has recently developed a National Climate Change Adaptation Strategy for 2011–2016. This is built around a strategic framework with five main components, which includes minimizing the impact of climate change on food security, among others.

From the overview of climate change related national strategies, policies and actions in South Asian countries, one can argue that while Afghanistan, Bhutan and Maldives are in very early stages of their adaptation plans, comprehensive adaptation plans are underway in other South Asian countries. In the latter, some progress has been made, but the mainstreaming of climate change adaptation and embedding technology needs into development policies is still inadequate. Although climate change concerns in key areas like agriculture, food security, disaster risk reduction and environment, emphasise adaptation to climate change impacts and the need for an urgent response, the implementation so far at country level is very limited. In relation to the agriculture sector, for example, all South Asian countries recognize the need for agriculture to be

[27]It is a consortium of ADB, IFRC, UNDP, UNOCHA, UNISDR, and World Bank.

'climate resilient' and the importance of identifying new varieties of crops and alternative cropping patterns. However, there has been no significant adaptation efforts at the national level and, in many cases, only a limited amount of resource have so far been committed (Wiseman and Chhetri 2011). This is particularly of concern in light of more current understanding of the magnitude of the climate change challenge faced by the region. It is increasingly becoming clear that the consequences from climate change impacts are transboundary with severe implications for food and water security, and threaten regional poverty eradication efforts.

5.3 Intra-regional Dimension

Interdependence in the region

Notwithstanding the disparities in economic power and resources among the eight South Asian countries, there is a growing sense of interdependence among them.[28] The significant increase in trade and the proliferation of bilateral and regional trade agreements, and South-South international investment agreements (IIAs) are evidence to growing intra-regional interdependence. Also, developing countries have become home countries for FDI flows in the past decade, and firms/companies in developing countries are emerging as world´s major transnational corporations (TNCs).[29] Since the late 1990s, both FDI inflow and outflow into South Asia have grown significantly, especially in India, Pakistan, Bangladesh and Sri Lanka.

Going beyond these positive trends in South-South trade and investment, in the context of climate change, it is important to consider how and to what extent South-South cooperation facilitates TT within the region so as to make it a viable means of adapting to climate change in the region.

The information on the extent of TT between the countries in relation to addressing climate change concerns or impacts in the region is scarce. As the Technology and Innovation Report 2012 puts it, "Technology and innovation are both difficult to assess within economic transactions, and there is no single indicator that measures them holistically" (UNCTAD 2012, 3). This is more so when we consider the broader definition of TT (described earlier in section 2) as it not only includes the transfer of technologies, but also the building of technological capacity and enabling its replication in the local context.

However, available data on proxies used as indicators for technological capacity and innovation in general shows that although as a region, South Asia is much lower in global ranking when compared with other neighbouring countries such as China, Iran and Thailand (Adhikari 2012b), significant progress has been made within the region, mainly by countries like India and Sri Lanka. Meanwhile, other South Asian countries technologically inferior to India and Sri Lanka, and some argue that it is this 'technology divide' which could drive TT in the region, especially when indigenously developed technologies are not available, since "South-South TT has the advantage of low cost of transfer coupled with fast diffusion and adaptation" (Kathuria 2011).

[28] See for example Kharel 2012 who notes the advances made in regional economic cooperation in South Asia.
[29] http://unctad.org/en/pages/PublicationArchive.aspx?publicationid=424

Role of India

Within South Asia, India occupies a pivotal position with respect to TT and cooperation because of its relatively advanced technological capabilities and economic strength. In global climate negotiations, India has been proactively engaged with climate change issues, arguing for a global agreement on "climate-friendly" technology which is driven by technological needs of developing countries rather than the technological agenda of industrialized countries.[30]

Importantly, India's geographical and cultural proximity offers tremendous scope in terms of acquisition, adoption, assimilation, and adaptation of technologies developed and operated in India for other countries within the region. It has been observed that "cultural similarities enable better adaptation of technologies and thus, a more sustained operation. Subsequently, based on the experience gained, local capacity to further expand the delivery of technology can be built" (UNEP 2009).

Given that India has bilateral and/or multilateral trade agreements with all the countries in the region, such agreements can be used to facilitate the transfer of climate technologies. It has been argued that "India's leverage would be in the form of offering the most cost-effective, quick and convenient transport and communication services to its neighbours".[31]

There are successful instances of SSTT initiated by India through the network of institutions in India such as the Energy and Research Institute (TERI) and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), as well as specific government-funded programmes. These include, for example India's technology cooperation with Maldives for deploying mitigation and adaptation measures for climate change as well as capacity building of key stakeholders on climate change related issues. Another successful instance is the cooperation with Nepal for conversion of waste agricultural biomass into energy, and drought- and flood- resistant seeds (Pandey et al 2012). Also, in the inter-regional arena, India has partnered with countries in Africa and also China in climate change adaptation and mitigation actions by bringing together research institutes to enhance and strengthen South-South learning processes and capacity building, holding training sessions and workshops for stakeholders from government, not-for-profit organizations and other stakeholder groups. While poverty alleviation and economic development continues to be the country's priority, India is taking considerable steps to address climate change issues internationally as well as nationally.

Role of SAARC

Recognizing that South Asia is particularly prone to climate change and natural disasters, the South Asian Association for Regional Cooperation (SAARC) has emphasized the need for effective regional cooperation in the context of sustainable development. At its successive Summits, the agenda of cooperation being pursued by the Member States has given priority to environment, natural disasters and in recent years to climate change.

[30] http://www.worldwatch.org/node/6302

[31] http://www.business-standard.com/article/opinion/shyam-saran-building-bridges-in-south-asia-111111600025_1.html.

In the context of climate change, the Thimphu Statement on Climate Change, issued at the 16th SAARC Summit in 2010, outlines the "deep concern about the adverse effects of climate change and its impact on the region, particularly on the lives and livelihoods of the 1.6 billion people of South Asia" and recognizes that "effective responses, both on mitigation and adaptation should be formulated and implemented at regional and international levels."[32] The Thimphu Statement also raises the issue of enhancing South-South cooperation on TT, which includes technology needs assessment and capacity development, as well as an assessment of barriers to technology development for adaptation and mitigation options.[33]

Among SAARC's major intergovernmental initiatives in the context of climate change are the 'Monsoon Initiative' to assess vulnerability due to changes in monsoon patterns and the 'Climate-related Disasters Initiative' to integrate adaptation with disaster risk reduction; both initiatives are closely linked to agriculture and food security concerns in the region. For instance, the Colombo Statement on Food Security is directed at implementing a "people-centred" short- to medium-term regional strategy with collaborative projects to increase food production, to develop and share agriculture technologies, and to manage climatic and disease-related risks in agriculture, among others and is also committed to provide technical and policy support to such projects. Similarly, the SAARC Disaster Management Centre (SDMC) set up in October 2006 at the premises of the National Institute of Disaster Management in New Delhi aims to provide policy advice and facilitate capacity building services including strategic learning, research, training, system development and exchange of information for effective disaster risk reduction and management in South Asia.

Notwithstanding the plethora of initiatives, in terms of implementation, the progress can only be described as slow, particularly in relation to climate change (Majaw 2012, Sterrett 2011). The reasons often cited range from lack of regional coordination of national climate change strategies and plans, to lack of adequate financial mechanisms.

Role of CSOs and NGOs

The influence of Civil Society Organisations (CSOs) and NGOs on creating international links, capacity building and on issues of governance has been steadily increasing over the years. On the ground experience from the implementation of projects and action plans across the region show that these organisations play a key role in improving stakeholder engagement by ensuring effective participation, cooperation and communication, and facilitating compliance and enforcement.

In South Asia, a number of such organisations and their networks have emerged, and are involved in climate change related action.[34] Notwithstanding the problems of accountability with some of them, they are active on national, regional and international stage. In the 'hyper connected' world that we live in today, these mediating organisations are significant stakeholders in the process of TT, and could be channelized to facilitate TT in the region.

[32] http://www.saarc-sec.org/userfiles/ThimphuStatementonClimateChange-29April2010.pdf

[33] http://saarc-sdmc.nic.in/pdf/publications/climate/chapter-2.pdf

[34] For example, the Climate Action Network South Asia (CANSA) is a network of 60 NGOs from Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka (http://www.cansouthasia.net/)

Clearly, the increasing interconnectedness among the countries in the region through trade, finance and networks of organisations offers opportunities and scope for successful intra-regional transfer of knowledge, practices and technologies for adaptation to climate change impacts, especially when the local contexts are similar. An instance of successful intra-regional SSTT leading to better natural resource management and rural development is seen in the African context, where cooperation in transferring technologies between the North and the West Africa regions has helped them successfully combat desertification.

5.4 Inter-regional Dimension

Looking beyond South Asia, it is clear that in the context of the financial and economic crisis engulfing the North, and the rapid growth in other South regions (East Asia, West Asia, South East Asia, Africa, and the Latin Americas), TT between South Asia and other countries of the South is all the more relevant. Four clusters of Southern countries have emerged as providers of regional and sub-regional South-South development cooperation (SSDC); and include growing economies as well as those are diversifying their assistance and undertaking mutually beneficial interregional activities (Corvaglia 2010). The increase in South-South trade, investment and financial flow has resulted in positive growth spillovers, particularly between close trading partners; to a certain extent, this has offset the slackening demand from developed countries in recent years (HDR 2013).

In the specific context of climate change, particularly in mitigation technologies, countries in the South like China, Brazil, and Mexico have built up significant technological expertise and are now active on the regional and global stage seeking to expand South-South relations. In the South-South Cooperation Exhibition held at the Rio+20 Conference, successful initiatives were showcased which included actual projects on solar energy funded by India, Brazil and South Africa partnership for rural areas in Guinea-Bissau, and sharing of knowledge and skills for projects on supplying electricity to rural areas of Afghanistan by India facilitated by UNDP. Moreover, in the area of disaster risk management, the Rio+20 outcome document has reaffirmed the international community's commitment to the Hyogo Framework of Action (HFA) and the significance of regional cooperation in the implementation of the HFA, *albeit* in the context of sustainable development and poverty eradication.

Role of China

A recent report entitled "The Critical Decade" published by Australia's Climate Commission, which examines global action on climate change describes China's achievements in the renewable energy sector as "extraordinary".[35] China has created vast technological capabilities in renewable energy industry which include solar, bio gas, wind and other sectors such as reforestation.

Under the South-South cooperation programme, China is also significantly engaged in technology cooperation and transfer with the developing countries (Aggarwal 2011), and already has dominant presence in Africa, the small island developing countries and many LDCs. It has also developed technologies in hydro power, solar heating and solar photo voltaic systems which are

[35] http://www.newscientist.com/article/dn23464-china-leads-in-climate-changes-critical-decade.html?cmpid=RSS|NSNS|2012-GLOBAL|climate-change#.Uu0kQxB_t5c

especially appropriate in many developing and least developed countries (Dhar and Joseph 2012). Moreover, China has set up financial instruments, like the China-Africa fund which is especially aimed at encouraging Chinese firms to invest in renewable energy projects in Africa. It has also set up institutions such as the International Centre on Small Hydro Power with three sub-centres in India, Nigeria and Colombia to engage in the process. The Centre provides training to engineers from 50 countries, technical consultations, feasibility studies, equipment supplies and installation in more than 30 countries (Dhar and Joseph 2012).

Without a doubt, China is gaining ground as a leader in climate technologies.[36] The government of China is working closely with the United Nations Educational, Scientific & Cultural (UNESCO) in updating the 'Applicable Technology Manual: South-South Cooperation on Science and Technology to Address Climate Change' to promote the sharing of information and transfer of technology related to climate change among developing countries.[37] The Manual contains a complete set of applicable technologies in agriculture, forestry, energy conservation and new energy developed by China. [38] Clearly, there are lessons to learn from its successful experience in these areas through which it has brought about its own rural transformation. Leveraging South-South cooperation to bring the benefits of such technologies and enhance the capabilities of developing countries in response to climate change is especially relevant for South Asia.[39] Cooperation with China to address climate change could be through policy study and planning, technology research, development, transfer and dissemination, technical training and/or capacity building.

In the context of South Asia, China has established a partnership with India to combat climate change by strengthening their bilateral dialogue and practical cooperation on adaptation and mitigation measures.[40] In the area of adaptation in particular, China and India have agreed to cooperate on (a) Evaluation of adverse impacts of climate change and vulnerability; (b) Adaptation-related polices, measures and technologies; and(c) Adaptation-related capacity building activities. China also enjoys the observer status in SAARC, which can be leveraged to facilitate greater regional cooperation in SSTT.

Role of other regions

With regard to climate change, many countries in Latin American and the Caribbean like Mexico, Colombia, Panama, Uruguay, El Salvador and Honduras are active on the regional and global stage. These countries have developed infrastructure, institutional and operational capacities to expand South-South relations. For instance, Brazil has created vast technological capabilities in biomass energy which could have significant implications on South Asia if such technologies are transferred to the region.

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[36] http://www.newscientist.com/article/dn23464-china-leads-in-climate-changes-critical-decade.html?cmpid=RSS|NSNS|2012-GLOBAL|climate-change

[37] http://www.unescobkk.org/news/article/south-south-cooperation-in-climate-change-adaptation-and-technology-transfer/

[38] http://www.actc.com.cn/UpLoadFiles/Attached/file/20120605/20120605105916_4745.pdf

[39] 'Leveraging South-South cooperation' bySir Fazle Hasan Abed and Kanayo F. Nwanze, Sunday, July 15, 2012.http://www.thedailystar.net/newDesign/news-details.php?nid=242091 (accessed on 21.10.2012)

[40] http://moef.nic.in/downloads/public-information/IndiaChina%20Agreement%20on%20Climate%20Change.pdf.

A recent analysis of the CDM (Aggarwal 2011) shows that China, India, Brazil and Mexico have emerged as the four major CDM-active countries in the South, along with Malaysia, Vietnam, Thailand and Indonesia. They have built up significant capacities in clean technologies and in turn have created opportunities for SSTT, mainly to LDCs.

Although it is difficult to generalise how successful the transfer of adaptation technologies will be between South Asia and the other regions, there are lessons to be learnt from the successful instances of SSTT, and the nature of the process which can be used to leverage SSTT on a global scale. To aid the purpose, some inter-regional initiatives on climate technology are presented in the following sub-section.

Other inter-regional initiatives

Jointly hosted by the ADB and the United Nations Environment Programme (UNEP), the **Climate Technology Network and Finance Centre** in Manila, Philippines aims to foster knowledge sharing and public-private partnerships, and develop institutional capacity and climate technology policies in Asia and the Pacific; and thus holds potential for SSTT of adaptation technologies in South Asia.

The **Bay of Bengal Initiative for MultiSectoral Technical and Economic Cooperation (BIMSTEC)** is an inter-regional initiative that involves cooperation between five countries in South Asia (Bangladesh, Bhutan, India, Nepal and Sri Lanka) and two countries from South East Asia (Myanmar and Thailand). One of its 13 priority sectors of cooperation, i.e. environment and natural disaster management is led by India. Moreover, BIMSTEC has setup a Technical Support Facility (TSF) and members have signed a Free Trade Area Framework Agreement in order to stimulate trade and investment through collaborations and partnerships within the countries, although the focus is on micro, small and medium scale enterprises. At the different Ministerial Meetings held by BIMSTEC, regional cooperation in technology transfer has been emphasized *albeit* not from a climate change perspective.

The **Asia-Pacific Partnership (APP) on Clean Development and Climate** initiated by ASEAN[41] is an inter-regional response to climate change. Currently, India is a member of the larger East Asia Summit which includes ASEAN Plus Three (namely China, Japan, and South Korea), Australia and New Zealand. APP has established eight government/business taskforces through its Work Plan which includes cleaner fossil energy, renewable energy, distributed generation, and power generation and transmission.[42]

Another initiative, the **Regional Climate Change Adaptation Knowledge Platform for Asia (Adaptation Knowledge Platform)**[43] has been launched by the Stockholm Environment Institute (SEI), the Swedish Environmental Secretariat for Asia (SENSA), UNEP, the Asian Institute of Technology (AIT)/UNEP Regional Resource Centre for Asia and the Pacific (AIT/UNEP RRC.AP) and is supported by the Swedish International Development Cooperation Agency (SIDA). The

[41] Association of Southeast Asian Nations (ASEAN) comprises Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

[42] http://www.asiapacificpartnership.org/.

[43] http://www.climateadapt.asia/about-us.

platform's objective is to support research and capacity building on climate change adaptation, policy making and information sharing among the countries in Asia so that they can adapt to the challenges of climate change. The knowledge sharing system includes generation of new knowledge and the synthesis of the existing and new knowledge to facilitate adaptation processes at local, national and regional levels, while the geographical scope of the knowledge platform includes South Asia (Bangladesh, Bhutan, Nepal and Sri Lanka), South East Asia (Indonesia, Malaysia and the Philippines) and the Greater Mekong Sub-Region (Cambodia, China PR, Lao PDR, Myanmar, Thailand and Vietnam) in the first phase (2009-2012). It is currently collaborating with the Asia Pacific Adaptation Network (APAN) on the implementation of selected activities in South and Southeast Asia which include developing a portal on Climate Change Adaptation in Asia and the Pacific, and organizing the Asia-Pacific Climate Change Adaptation Forum. The platform also provides technical support on sharing of knowledge on climate change adaptation and is currently supporting the South East Asia Network of Climate.

Recently, developing countries (Bangladesh, Cambodia, Ethiopia, Kenya, Mozambique, Gambia and Zanzibar) initiated the **Government Network on Climate Change Mainstreaming and Development**[44] to put climate change adaptation at the centre of national policy planning. It is a network for policymakers and planners in countries at risk from climate change to share information and collaborate.

Among other inter-regional initiatives are those undertaken by international development agencies, like UNDP to support South-South Cooperation. Launched in 2005 by the UNDP in India, the '**Solution Exchange**' initiative provides a platform for exchange of knowledge and ideas among developing practitioners across 13 thematic areas including climate change. There is also an emerging interest on the part of traditional donor agencies, such as the Australian Agency for International Development, the Canadian International Development Agency, the German Agency for Technical Cooperation, the Japan International Cooperation Agency and the United States Agency for International Development, to support South-South capacity building under North-South-South triangular arrangements or through sponsoring third country training programmes.

All mentioned initiatives and the growing global interest to support South-South capacity building offer opportunities for sharing of knowledge and ideas leading to TT in climate technologies to and within South Asia.

5.5 Climate Technology and SSTT in South Asia: Constraints

The discussion above shows that there are certainly initiatives in place to support transfer of mitigation technologies in sectors such as energy, transport and industries driven by financial flows between the countries. The discussion also highlight the potential for increased South-South Cooperation to facilitate the diffusion of adaptation technologies in South Asia especially in those sectors that are crucial to sustain livelihoods and the natural ecosystems but are under threat from climate change. However, it is necessary to note that such opportunities for transfer of climate change adaptation technologies is not with challenges. But while the impediments to

[44] http://www.iied.org/developing-nations-put-climate-change-adaptation-centre-planning (accessed 28April)

TT against a broader picture have already been highlighted in section 3.3, the region specific impediments to the transfer of adaptation technologies to South Asia must be identified to effectively and efficiently address the regional issue of TT for adapting to rapidly changing climate.

While South Asia is particularly vulnerable to the adverse effects of climate change, the countries also lack the means and capacities to acquire and use scientific knowledge as well as more cost-effective and applicable technologies. The overriding priority for all the countries has been economic growth and development to improve the livelihood options for the population. Consequently, available resources and policies are mainly geared towards reducing poverty and alleviating the concerns arising directly from population pressure and rapid urbanisation. As mentioned earlier (section 4.2), the development approach predominates current policy scenario in the region. Nevertheless, the consensus is increasing that adapting to climate change is critical to sustaining the progress made so far and adaptation technologies contribute to addressing the dominant concerns, directly and indirectly by increasing the resilience of the large groups of population and the key sectors which support the economies.

However, unlike the case of mitigation, where the technologies are mainly owned and transferred by MNCs and facilitated by international organisations or governments, most of the adaptation technologies that are proven to be effective for adapting to climate change are based on project/community level adoption of such technologies. Unfortunately, the knowledge on the demand and supply of affordable, practicable, low-maintenance, effective and environment-friendly technologies for climate change adaptation (and mitigation) is fragmented. Since most of the research and policy dialogue so far at national and international levels has focused primarily on mitigation, there is only limited understanding of adaptation and the process of technology transfer that can facilitate it.

From an assessment of climate impacts, identification of adaptation priorities for the development and transfer of climate adaptation technologies involves various stakeholders from the technical personnel, scientists, government officials, NGOs, funding agencies, to the end-users themselves. A significant barrier to intra-regional process of TT stems from a lack of coordination among these diverse stakeholders and their capacity to effectively participate in the different stages of TT process. Unless changes in climate governance take place at all levels—local, community, national, regional and global—scope for effective TT will remain limited.

Although a number of funding initiatives are in place, with various adaptation funds undertaken by multilateral funding institutions, the planned resource allocation is still "significantly short of seriously addressing the urgent challenge of adapting to climate change" (Tessa and Kurukulasuriya 2010). Moreover, access to climate finance is limited (Ciplet et al. 2012), which tends to dampens the initiatives on technology transfer for climate change adaptation and its successful implementation. Also, limited engagement of private sector investment in adaptation technologies is another constraint; many have called for incentives, not necessarily market-based, to speed up the process of private sector engagement.

Even when funds are available, a major impediment to technology transfer is the lack of adequate institutions and policy/regulatory infrastructure needed to initiate the process of TT. Apart from a

general lack of political will, it has been suggested that the cornerstone for the failure of TT has been institutional—"There is little or no understanding of the specific institutional mechanisms needed to ensure effective technology transfer, at the national level in developing and industrialized countries, and at the multilateral level to connect differing national actors and achieve multilateral mitigation and adaptation goals" (CIEL 2008). Additionally, South Asian countries also lack adequate information, skills and resources required to identify appropriate technologies for implementation at the local level.

Although some of the constraints to SSTT are likely to be country-specific, a closer look at NAPA projects in four South Asian LDCs, the National Action Plans of non-LDC countries in South Asia, and case studies based on projects undertaken by international and national development organisations reveal that there also exist certain constraints, which are shared across the region. These include:

- insufficient information on current and predicted impacts of climate change by sector, groups (including women) and communities;
- lack of awareness of existing and emergent technologies which are appropriate and cost-effective as part of the solution to adaptation (and mitigation);
- lack of coordination among different stakeholders;
- poor regulatory institutions and lack of political will; and
- lack of financial resources.

These common constraints suggest that the transfer of adaptation technologies, unlike mitigation technologies, is not likely to take place through market-based or commercial approaches. We need to consider new ways of thinking about TT which capitalises on the region's strengths. Therefore, unlike the approach taken for mitigation technologies, non-market-based approaches may have to be taken for transfer of adaptation technologies. The notion of 'technology commons'[45] has been advanced which need to be explored further.

The contextual nature of adaptation technologies and their diversity also implies there could be other barriers, opportunities and policy challenges which have not been understood so far. Trans-border networks or creating inter-country connections to fill the gaps in the understanding[46] will require partnerships as well as a "synergy between local and traditional knowledge with 'scientific' knowledge, and a broad discussion of technologies and practices suitable to a particular context" (Sterrett 2011, 5).

5.6 Climate Technology and SSTT in South Asia: Areas of Cooperation

If the barriers to TT could be removed, which adaptation technologies are relevant for the region? In order to answer this, we review briefly the adaptation needs by country in the region presented earlier in Table 2.

[45] http://www.scidev.net/global/climate-change/news/seminar-highlights-distrust-in-tech-transfer-pledges.html>

[46] See ISET (2008) for the knowledge gaps and research issues on climate adaptation in Asia.

In the particular case of LDCs (Afghanistan, Bangladesh, Bhutan and Nepal), the projects identified by NAPAs provide a good starting point since they point to the key areas where TT would be most beneficial. A list of the projects in order of priority as identified by the countries is shown in Table 4. Together with the national climate action plans from India, Maldives, Pakistan and Sri Lanka, it is clear that there are areas of cooperation where SSTT can potentially improve the adaptive capacity for the region as a whole.

Since adaptive capacity is contextual, technological interventions for climate change impacts also have to be context-responsive. The process of TT has to be built around a specific context and the stages should involve identification of particular technological needs, matching those needs with the available, appropriate and cost-effective technologies across the region, and facilitating the transfer across boundaries.

In order to expand on the areas of technological cooperation in the specific context of adapting to climate change in South Asia, all relevant technologies are included under three broad categories (described earlier in section 1.2): (i) those relevant to impacts on human system; (ii) those relevant to impacts on natural systems; and (iii) those relevant to monitoring and observation of climate change.

5.6.1 Technologies for Adaptation in the Human System

An overview of the technologies described in this sub-section is provided in Table 5 (See Appendix).

Agriculture and food security

Objective for SSTT

- minimise losses to productivity and production
- increase local adaptive capacity and ensure livelihood and food security

Nearly 70 percent of population in South Asia directly depend on agriculture (including fisheries and forestry)—the sector most at risk to climate change—for their livelihood. As shown in Table 2, the impacts of climate change on agriculture are mainly through changes in precipitation level, water availability (flooding and drought), sea-level rise, salinization of soil and increasing pests and diseases, all of which affect agricultural production (and fisheries), both in terms of yield and the total output. Moreover, in South Asia, the consequences of climate change on agriculture are predicted to become severe on the rural poor (Oxfam 2009a, Oxfam 2009b).

Adapting to climate change is therefore crucial for rural farming communities, and is also equally important for the overall food security of the region. Climate technologies which minimize the production losses help increase the adaptive capacity of the farmers, water efficient irrigation techniques, and crops resistant to drought, flood and/or pests are all crucial for adaptation. In the context of semi-arid areas, interventions may include crop diversification, pest management, stress-resistant crops and seedlings, and creation of freshwater reservoirs; these are particularly pertinent in the case of smallholder farming and the subsistence nature of agriculture which predominate the region's agriculture landscape.

Accordingly, intra-regional and inter-regional TT in South Asia holds prospects for minimising the adverse impacts of climate change on yields and food production, thereby improving the socio-economic well-being of the millions engaged in small-scale agriculture in the region. A joint programme—International Fund for Agriculture Development (IFAD) and Food and Agriculture Organization (FAO)—directed at agricultural policymakers in Cambodia, China, India, Indonesia, Nepal, Pakistan, Sri Lanka and Vietnam is currently under way in this direction. At the regional level, SAARC's Colombo Statement on Food Security also places emphasis on the development and sharing of agriculture technologies, and the management of climatic and disease-related risks in agriculture through collaborative projects.

The need for TT to South Asian countries is put into perspective by NAPA projects listed in Table 4, which show that agriculture (fisheries and forestry) related concerns in Afghanistan (project 2), Bangladesh (projects 10-14), Maldives (projects 6 and 9) and Nepal (projects 1, 2, and 5) have a significant technological component. Fortunately, there already exists many agriculture adaptation technologies in the South, and successful SSTT for climate change adaptation is not limited to fiction; Bangladesh for instance, transferred technologies related to the production of high-quality rice seeds to improve agricultural yields to countries in Asia and Africa. Therefore, there are ample opportunities for intra-regional TT related to agriculture adaptation technologies.

However, in the context of agriculture, technology transfer, as we discussed earlier (section 2) does not just imply access to machines, hardware and equipment, but also to 'soft' technologies—skills, knowledge and practices—at different stages of production cycle, right from planting/sowing to post-harvest operations. Therefore, in addition to the building of irrigation canals and other agricultural infrastructure, it is also necessary to build the technical capacity of key stakeholders and institutions, specifically technical staff, local farmers, community-based organizations and NGOs.

Note that adapting to climate change is not just about minimising losses in agricultural productivity and production, but exploiting the opportunities presented by climate change; for instance, include 'new' crops into the production basket. In practice, adapting to climate change actually means making a better use of natural resources and managing them to cope well under adverse conditions.

Water resources management

Objective for SSTT

- availability of sufficient water to maintain agricultural production in times of water shortages or droughts
- minimise losses in agricultural productivity in times of excess rainfall
- control erosion and flooding during periods of excessive rainfall
- access to safe drinking water
- ensure livelihood and household food security

Water resources management continues to be a major intervention area in NAPA projects (refer to Table 4) in Afghanistan (projects 1 and 2), Bangladesh (project 2), Bhutan (project 6), Maldives (project 3) and Nepal (projects 1 and 8). Such priority is likely because South Asia is most

vulnerable to water shortages (or excesses) affecting all sectors—agriculture, industry and human health.

In areas where farmers are primarily dependent on rain-fed agriculture, rainwater harvesting technologies (RWHT) are considered critical to help the local farmers adapt to rapidly changing climate since unpredictable weather patterns are leading to water shortages and threating the livelihood of the farmers. By collecting excess water, treating it and storing it as part of a wider water supply strategy during dry months, farmers can provide water for irrigation as well as for domestic/household consumption. These water conservation technologies also have environmental benefits such as in controlling soil erosion and reducing the intensity of flooding during periods of excessive rainfall.

Other technologies based on RWHTs which are associated with small-scale irrigation development used in other parts of the region and beyond include[47]:

- Micro-catchment runoff farming water harvesting systems
- Macro-catchment runoff farming water harvesting systems
- Floodwater harvesting runoff farming (also called large catchment water harvesting or spate irrigation)

Some of these techniques and their localized variants are successfully practiced by farmers in Bhutan. Transfer of such technologies to other parts of South Asia which has similar geo-physical conditions can be potentially useful in adapting to climate change.

Furthermore, when the impact of climate change is on the availability of freshwater resources, as in Maldives, for example, where storm surges lead to flooding and salinization of groundwater, and destruction of the rainwater storage tanks and water catchment areas (as it happened during the December 2004 tsunami), increasing the capacity for rainwater harvesting and storage in the island communities and protecting rainwater storage facilities from impacts of flooding and storm surges becomes a priority adaptation measure. In this case, technologies to ensure appropriate designing of water storage facilities, and desalinisation technologies to provide emergency freshwater are critical.

Taking entire watersheds into account, the integrated water resource management (IWRM) approach integrates climate change impacts into management of the water resources. Technological interventions in irrigation (channels, drip and borehole types, etc.) as well as changing crop patterns to flood-resistant or drought-tolerant crops, and land management techniques are a part of this approach. The local geo-physical conditions (topography, soil characteristics and hydraulic conductivity, among others) determine the particular technologies which could be used for water resources management.

There exist a global initiative for supporting South Asian countries address water related challenges and promote IWRM[48]called the 'Global Water Partnership-South Asia (GWP-South

[47] This section from Bhutan NAPA.

Asia)'.[49] The initiative currently covers Bangladesh, Bhutan, India, Pakistan, Nepal and Sri Lanka, and the countries are linked to the network through the respective Country Water Partnerships (CWPs). Such an initiative makes the sharing of knowledge on water related technologies feasible. Transfer of technologies in the form of knowledge and practices, which lead to new or improvements over old designs, are relevant to the goal of minimising water losses and making efficient use of water under the threat of climate change.

Infrastructure/Disaster risk management

Objective for SSTT

- predict disasters and minimise losses/damage
- effectively intervene in disaster relief and reconstruction
- build climate-resilient infrastructure systems

Rising sea levels, extreme weather events, and the increasing incidence and severity of disasters (landslides, flood, drought, cyclones, etc.) have significantly affected South Asia. Moreover, there is evidence that increasingly more communities will be at risk to climate change impacts in the region (Parry et al. 2007). A recent Report states that extreme weather linked to climate change is increasing, which is likely to cause more disasters and undermine the progress achieved so far in poverty alleviation, especially in South Asia and Sub-Saharan Africa (ODI 2013). Among the 11 countries most at risk of disaster-induced poverty, three are from South Asia—Bangladesh, Nepal and Pakistan.

In times of disasters, as we have learnt from recent disasters across the region and beyond such as Typhoon Phailin which struck eastern India, and Cyclone Haiyan which devastated parts of South East Asia, technological interventions can make an enormous impact on the relief and reconstruction efforts.[50] Often, the degree of coordination when conducting relief efforts (emergency health care, medical aid, food distribution, shelter, transport and communication) determines the loss of lives and damages incurred, while the resilience of the infrastructure determines the vulnerability of the communities to climate change induced disasters.

Landslide prone areas in Bhutan and Nepal, and flood prone areas in Bangladesh, India and Pakistan, for example, suffer from immense human casualties, property and infrastructure damage, and loss of agriculture land and standing crops when struck by disasters. Thus, a well-managed and coordinated relief strategy is required to meet the exigencies, among other things such as food and medicine reserves and a distribution network to operate efficiently, all of which is made possible by access to needed technologies. Moreover, technologies are also required for

[48] IWRM is the coordinated development and management of water, land and related resources in order to maximise economic and social welfare without compromising the sustainability of ecosystems and the environment (GWP-SAS).

[49] founded in 1996 by the World Bank, the United Nations Development Programme (UNDP) and the Swedish International Development Cooperation Agency (SIDA) http://www.gwp.org/en/gwp-south-asia/

[50] http://world.time.com/2013/11/12/how-india-prevented-catastrophe-when-it-was-hit-by-a-massive-storm-last-month/.

restoration of infrastructure such as houses, power transmission facilities, bridges, irrigation channels amongst others.

In order to cope with the vulnerabilities from climate change induced disasters, it is imperative to have access to those technologies which complement a broader disaster-management strategy. Possible the technological interventions include: (i) mapping of areas vulnerable to climate induced disasters; (ii) disaster prevention such as early warning systems, cross drainage, embankment, land management, erosion control; (iii) communication and transport infrastructure; and (iv) disaster-resilient infrastructure.

In the context of NAPA projects (Table 4), Bhutan requires installation of a flood warning station on the Pho-chu river basin, mapping of the Pho-chu area according to geological, geotechnical and hydro-geological aspects, and analysing soil samples (priority NAPA project 8). Similarly, Maldives NAPA Priority Project 8 (see Table 4) emphasises the building of climate-resilient structures to improve the adaptive capacity of the island communities to climate change impacts, while in Bangladesh (projects 1, 4 and 5) and Nepal (projects 4 and 5), technological interventions form a part of the responses identified to increase the resilience of the communities affected by climate induced disasters.

In the particular case of South Asia, natural disasters have disproportionately adverse consequences for the marginalised and vulnerable groups, mainly women for climate change can amplify existing inequalities and reinforce the disparities they face.[51] There is ample research[52] now to suggest that the technological needs of men and women are different, considering that the two play different roles in the society. Unfortunately, women often have only limited stake in TT because of unequal access to social, economic or political capital which tend to favour the men. Since it is important to include all key stakeholders for effective TT, the gender dimension needs to be included in the entire process.

5.6.2. Technologies for Adaptation in the Natural System.

Technologies for adapting to adverse impacts of climate change on the natural system are aimed at the biological and physical environments. They are categorised into three areas: (i) biodiversity and ecosystem management; (ii) sustainable land management; and (iii) disaster risk management. An overview of these technologies is provided in Table 6 (See in Appendix).

Biodiversity and Ecosystem Management

Objective for SSTT
- protect and conserve biodiversity and diverse ecosystems in South Asia

South Asia's vast geographical size spans across rich and diverse ecosystems—mountain, forest, wetland, freshwater and coastal, and underpins socio-economic status of majority of South Asia's poor and vulnerable. Sadly, the region's ecosystems are under threat from the impacts of climate

[51] See Saxena 2012b for a discussion on the gender dimension of climate change.

[52] http://www.gendercc.net/policy/topics/technology-transfer.html.

change. The consequences range from a loss of biodiversity to the destruction of ecosystems and extinction of species.

In Maldives for example, protection of coral-reef diversity is a priority listed under NAPA Project 11 (Table 4). Although the direct cause of the coral reef destruction is waste water pollution, and not climate change, the project details reveal that climate-induced disasters often damage the sewerage system which lead to wastewater pollution. In this case, the technological interventions identified include wastewater treatment and disposal systems. Similarly, in the case of Sri Lanka, protection of the mangroves to maintain wetland diversity and the shorelines is a priority which requires specific interventions designed for the particular purpose.

Sustainable land management (SLM)

Objective for SSTT
- restore degraded soils
- control soil erosion

Sustainable Land Management (SLM) techniques, especifically in the case of farmers, pastoralists and those dependent on forests, not only help in improving the capacity of the land-users to adapt to climate change by increasing the land productivity and minimising loss in yields (as we saw earlier in relation to agriculture and food security), but they can also contribute to sustaining 'land' as natural capital.

In practice, SLM techniques integrate environmental and economic benefits. They are also integral to the IWRM approach described earlier in relation to water resources management.

Disaster risk management (natural system)

Objective for SSTT
- prevent disasters
- protect coastlines

Disaster management related technologies are often a part of integrated national coastal zone management strategies. The 'living shorelines' approach focuses on an innovative set of bank stabilization and habitat restoration techniques to reinforce the coastline, minimize coastal erosion and maintain coastal processes (Tessa and Kurukulasuriya 2010).

In Bhutan, climate change has increased the risks of glacial lake outburst floods (GLOFs) from massive lakes created by receding glaciers. As listed under its NAPA Projects (project 2 in Table 4), the technological interventions include installing pumps to artificially lower the water levels of lakes below dangerous thresholds, and installing an automated monitoring and alarm system.[53] In the case of Maldives, the stability and survival of coral reefs which support the country's economic base (tourism and fisheries) and the livelihood of the majority of the population are under threat from predicted climate change, particularly the risks associated with the sea surface

[53] The GEF (through the LDCF) is funding measures in this direction.

temperature rise and sea level rise (Maldives project 11, Table 4). This provides another instance where technological intervention could provide a solution.

5.6.3 Technologies for Climate Change Observation and Monitoring

Objective for SSTT

- assess extent of vulnerability to climate impacts
- help prepare and monitor adaptation strategies

From an adaptation perspective, even before formulating and implementing adaptive strategies or measures, the first step is a credible assessment of vulnerabilities at local, national and regional levels. Technologies on observing and monitoring changes related to climate (rainfall pattern, river flows, etc.) are critical to effectively adapt to climate change.

In agriculture and food security, technologies which can provide accurate, timely and local information on climate change related events like floods, storms, droughts, etc. are critical to reduce the vulnerability of farming communities to the adverse impacts of climate change. In certain cases, it has been observed that the use of relatively simple technologies such as handheld sirens and FM radios to broadcast early warnings can significantly increase the capacity of communities to withstand the shocks.[54]

In disaster management, technologies are particularly useful to assess the vulnerability of communities and ecosystems to climate change induced disasters. In the case of landslide or flood prone areas, topographical surveys along with landslide and flood susceptibility maps are critical, and will require technologies related to data collection, analysis and dissemination. Additionally, the use and application of models such as Dynamic Interactive Vulnerability Assessment (DIVA)—an interactive software/web tool—that enables users to simulate socioeconomic changes and adaptation on coastal systems, Geographic Information System (GIS) technology for monitoring and responding to coastal erosion, and early warning systems for floods and storm surges can be highly effectively tools in disaster management.

It has also been argued that sharing of such tools and technologies is cost-effective, particularly when they may be used for infrequent but catastrophic events like a tsunami. A study has shown that a shared early warning system for tsunami around the Indian Ocean would be nearly 50 times cheaper than if each country developed and operated its own separate system.[55] However, along with the actual installation of observation and monitoring equipment, the transfer of knowledge and understanding to build the capacity of local communities to use and benefit from all accessible technologies is also vital.

Therefore, regional adaptation to climate change requires access to technologies, which as described above, could range from those used in the initial stages of identifying climate change risks and opportunities, preparing short- term and long-term strategies for risk management in key sectors, reducing the impacts from extreme weather events to building capacity of key

[54] From a briefing note by Practical Action (UK), "Technology for adapting to climate change" available at http://practicalaction.org Accessed February 25, 2013.

[55] http://www.unescap.org/idd/Pubs/ThemeStudy2013/CHAPTER-7.pdf.

stakeholders at local, community, national and regional levels. SSTT is potentially significant in this respect since the technologies developed by developing countries will be more accessible and application to other developing countries, especially if the countries involved are regional counterparts.

6. Conclusion

The two concurrent developments, one within the region (of greater economic cooperation) and the other outside the region (the financial crisis engulfing the North and increasing South-South links) have created a scope for substantial South-South cooperation, including in TT. The global political environment has become favourable for greater South-South cooperation. And considering South's vulnerability to climate change and its significant transboundary impacts, SSTT can enable countries in the South to explore opportunities to improve their adaptive capacity to climate change. SSTT is also a viable means of reducing loss and damage from climate change, and has the potential to increase the "development dividend" i.e. the social and developmental benefits that are associated with adaptation measures.

Today, there is general consensus that SSTT framework for climate change adaptation and the framework for mitigation have to be designed differently. The latest round of climate talks under the UNFCCC held in Bonn in April 2013 has reaffirmed the growing urgency to accelerate existing climate action to stave off the worst effects of climate change and discuss options towards the 2015 global climate agreement. As the Human Development Report 2013 (UNDP 2013) rightly argues, although the world has achieved the main poverty eradication target of the Millennium Development Goals, unless we deal with climate change, all of those advances may be reversed. "Business-as-usual development is clearly not sustainable in the context of the reality of climate change" (Dhar and Joseph 2012).

Adapting to climate change is a shared global challenge and by engaging in South–South collaborations, countries in South Asia can have access to technologies from a wider portfolio, thus providing them additional flexibility when choosing the technologies that are most appropriate and applicable in South Asian conditions.

7. Recommendations

Given the significant potential for SSTT in climate change technologies, SSTT must be consciously promoted, and countries need to collaborate as partners to share knowledge, experience and expertise on climate change adaptation and mitigation. The vulnerability to current and predicted impacts of climate change cuts across all development challenges in South Asia.

The convergence of multiple inter-related issues arising from the more immediate challenges like economic growth, poverty eradication and livelihood security, along with those issues related to climate change, pose a threat to South Asia's development gains as well as the region's future socioeconomic prospect.

Regrettably, there is no significant regional initiative directed towards addressing the formidable challenge of adapting to climate change. Hence, there is an urgent need to generate a new agreement of cooperation between South Asian countries to facilitate transfer of adaptation technologies and to develop a comprehensive regional Climate Change TT framework.

At the country level, state and local officials also have to be actively involved in the process of SSTT. The government has to create an enabling policy environment which facilitates multi-stakeholder partnerships, removes the barriers to technology transfer and promotes transfer of adaptation technologies. It has been suggested that the state should offer incentives for attracting larger flows of private finance into the development and diffusion of adaptation technologies.

A possible starting point at the SAARC level could be the establishment of 'South-South Technology Centre for Climate Change Adaptation' with the following agenda:

- map, document, analyse and identify currently available and emergent technologies for adaptation to climate change by location, sector and nature of impact;
- create multi-stakeholder partnerships across the region;
- leverage financial resources from various sources, both public and private, to facilitate the transfer of technologies; and
- match capabilities with needs to address the 4Ds of TT–development, demonstration, dissemination and diffusion of technologies by exploring new ways of approaching SSTT in South Asia.

Building on the multi-lateral cooperation that already exists, the South-South Technology Centre for Climate Change Adaptation could act as a nodal point for South Asian countries to identify technology needs and to facilitate the preparation and implementation of technology projects and strategies that support action on adaptation (and mitigation); a regional pooling of resources may facilitate the process.

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Appendix 1 (Table 1-6)

TABLE 1: Climate Change Technology Transfer in International Agreements

Rio Declaration 1992	Chapter 34.18 of Agenda 21
UNFCCC 1992	Article 4: the North (Annex 1) countries to provide support, including financial resources, transfer of technology and capacity building to developing (non-Annex 1) countries "Parties to give full consideration to the positive and negative impacts of the implementation of response measures to mitigate climate change on society and on all vulnerable groups, in particular women and children;" Article 4.5 Article 4.1 (c) -mitigation
Kyoto Protocol 1997	Article 10 –mitigation Clean Development Mechanism (CDM) – project based mechanism to allow for the transfer of emission-reduction (or 'clean') technologies from the North to developing countries
Marrakesh Accords [COP7]	Technology Transfer Framework -- 5 key themes: Technology Needs Assessment Enabling Environments Technology Information

	Capacity Building Mechanisms for Technology Transfer: Innovative Financing, International Cooperation, Endogenous Development of Technologies, and Collaborative Research and Development [these sub-themes added later]
Expert Group on Technology Transfer	
Nairobi Work Programme (NWP) 2006 [COP 12]	Subsidiary Body for Scientific and Tevhnological Advice (SBSTA) – IMPACTS, VULNERABILITES and ADAPTATION
Bali Action Plan 2007 [COP 13]	technology transfer as a key element leading up to 2012 and beyond refocuses the work of the UNFCCC's Expert Group on Technology Transfer See UNFCCC Conference of the Parties Decision 3/CP.13
Poznan Strategic Program (COP 14) December 2008	1. Conduct technology needs assessments (TNAs); 2. Establish pilot priority technology projects linked to TNAs; and 3. Disseminate GEF experience and environmentally sound technologies that have been successfully demonstrated
TRIPS Agreement (WTO)	Article 66.2 mandates developed country Members to 'provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to least

	developed country Members in order to enable them to create a sound and viable technological base'.[from ictsd2009infonotes: Box3]
Copenhagen Accord 2009	priority to LDCs
Cancun Agreements [COP 16] Dec2010	Cancun Adaptation Framework (CAF): adaptation to be addressed with the same level of priority as mitigation. parties committed "to reduce vulnerability and build resilience in developing country Parties, taking into account the urgent and immediate needs of those developing countries that are particularly vulnerable' Technology Mechanism Green Climate Fund
GEF's Long-Term Program on Technology Transfer. 2010	1. Support for Climate Technology Centres and a Climate Technology Network 2. Piloting Priority Technology Projects to Foster Innovation and Investments 3. Public-Private Partnership (PPP) for Technology Transfer 4. Technology Needs Assessments (TNA) 5. GEF as a Catalytic Supporting Institution for Technology Transfer
Durban Platform for Enhanced Action 2011	advancement of CAF
UN Climate Change Conference Doha 2012 (COP 18)	commitment to achieve a new global framework in 2015

Source: compiled from multiple sources

Table 2: Climate Change Impacts and Adaptation Needs in South Asia

Country	Impacts	Adaptation Needs
Afghanistan	untimely and heavy rainfall, drought, desertification land degradation; frost and cold spells	crop and water management; efficient irrigation practices; climate-tolerant cultivars; soil conservation; flood evacuation support; R & D and institutional capacities for vulnerability assessments; institutional networks for monitoring, collection and maintenance of datasets for climate research
Bangladesh	floods; salinization of land and water resources; cyclones and storm surges; landslides; drought	R & D for climate-tolerant cultivars; natural protective coastal structures & coastal afforestation; studies on future storm surge patterns; enhanced computational and modeling capacities; early warning systems; vulnerability assessments in health, forestry & biodiversity; strengthening and documentation of community based adaptation
Bhutan	flash floods; landslides; GLOFs	R & D for regional climate modeling and impact assessments; climate resilient infrastructure; early warning systems; expanding the network of climate monitoring stations; assessment of rate of glacial melt and GLOF formation; enhance adaptive capacities of farming communities

India	droughts, floods, cyclones, storm surges, destruction of ecosystems (wetlands, mangroves)	crop and water management; efficient irrigation practices; climate-tolerant cultivars; soil conservation; flood evacuation support; R & D and institutional capacities for vulnerability assessments; institutional networks for monitoring, collection and maintenance of datasets for climate research integrated impact assessments; research in glaciology, human health, forestry, biodiversity & urban issues; build capacities of institutions and human resources at all levels, including public awareness
Maldives	cyclones, droughts and floods extreme weather events) coastal erosion destruction & damage to marine ecosystems (coral reefs and fish catch) Human health impacts (vector-borne , water-borne)	network of stations and measuring points for sea level, SSTs & salinity, and enhance early warning facilities; technologies for desalination; land-use planning (including citing of critical infrastructure) and consolidation considering the topographic variations; research studies and monitoring of coral growth and response to SLR and changes in SST; awareness creation among land use planners, civil society, sharing of best practices between islands

Nepal	glacial melt, flash floods, GLOFs, landslides	climate modelling capacities, R& D; early warning systems, building institutional, infrastructural and human resource capacities; livelihood diversification; assessments of climate change on the hydropower producing units
Pakistan	Floods and droughts Cyclones landslides and avalanches. Water stress Coastline ersion Biodiversity loss	water resource conservation and management, maintaining and expanding reservoir capacity, trengthening of embankments for controlling sediment flows; R& D on climate-tolerant cultivars, coastal erosion control, institutional coordination and building international networks for strengthening research capacities
Sri Lanka	Droughts, Extreme rainfall events, floods, coastal erosion, landslides Biodiversity loss	Climate-tolerant cultivars (coastal agriculture), monitoring of changes in sea level, early warning and health & surveillance systems, watershed management, need for institutional capacity building and training at all levels

Source: modified from Nair 2011.

TABLE 3: South Asia and Climate Change: National Policy Initiatives

AFGHANISTAN		
Climate Change Policy	NAPA	NAPA (2009) [*jointly developed with National Capacity Needs Self- Assessment (NCSA*)]
	National Strategy/Plan	no plan yet [*country recovering from decades of war and civil strife; focus on reconstruction & development*]
BANGLADESH		
Climate Change Policy	National Communication to UNFCCC	Initial National Communication in 2002
	NAPA	NAPA (2005) [updated 2009]
	National Strategy/Plan	Bangladesh Climate Change Strategy and Action Plan (BCCSAP) (2009) *food security, social protection and health; comprehensive disaster management;* *infrastructure; research and knowledge management; and capacity building and institutional strengthening*

BHUTAN		
Climate Change Policy	National Communication to UNFCCC	Initial National Communication in 2000
	NAPA	NAPA (2006)
INDIA		
Climate Change Policy	National Communication to UNFCCC	Initial National Communication in 2004 Second National Communication under development
	NAPA	Non-LDC
	National Strategy/Plan	• National Action Plan on Climate Change (NAPCC) (2008) *eight core "national missions", which include:* *solar energy; enhanced energy efficiency; sustainable habitat; water; sustaining the Himalayan eco-system;* *Green India; sustainable agriculture; and strategic knowledge for climate change* • Implemented through State-level Action Plans on Climate Change (SAPCCs), currently being drafted by the different States.

MALDIVES		
Climate Change Policy	National Communication to UNFCCC	Initial National Communication in 2001
	NAPA	NAPA (2008) [*Maldives moved out of LDCs in January 2011*]
	National Strategy/Plan	Strategic National Action Plan (SNAP) (2011) *integrates climate change* *adaptation and disaster risk reduction*
NEPAL		
Climate Change Policy	National Communication to UNFCCC	Initial National Communication in 2004
	NAPA	NAPA (2010) complemented by Local Adaptation Plans of Action (LAPA) *bottom-up, local approach*
PAKISTAN		
	National Communication to UNFCCC	Initial National Communication in 2003
	NAPA	Non-LDC

Climate Change Policy	National Strategy/ Plan	Report of the Task Force on Climate Change (2010) National Climate Change Policy (NCCP) launched in 2013 specific emphasis on water, food, energy and national security issue
SRI LANKA		
Climate Change Policy	National Communication to UNFCCC	Initial National Communication in 2000
	NAPA	Non-LDC
	National Strategy/Plan	National Climate Change Adaptation Strategy (NCCAS) 2011-2016 (2010)

Source: compiled from different sources

TABLE 4: NAPA projects by country (the LDCs)

COUNTRY	Order of Project Priority	PROJECT TITLE	PROJECT SECTOR	SECTOR COMPONENT (S)
Afghanistan	1	Improved water management and use efficiency	Water Resources	Water management
Afghanistan	2	Community based watershed management	Terrestrial Ecosystems	Water management, Land Rehabilitation, Agriculture
Bangladesh	1	Reduction of Climate Change Hazards through Coastal afforestation with community participation	Coastal and Marine Ecosystems	Coastal Zones
	2	Providing drinking water to coastal communities to combat enhanced salinity due to sea level rise	Water resources	Water Resource development

	3	Capacity building for integrating Climate Change in planning, designing of infrastructure, conflict management and landwater zoning for water management institutions	Education and Capacity Building	Capacity-building
	4	Climate change and adaptation information dissemination to vulnerable community for emergency preparedness measures and awareness raising on enhanced climatic disasters	Education and Capacity Building	Awareness raising and Capacity building
	5	Construction of flood shelter, and information and assistance centre to cope with enhanced recurrent floods in major floodplains	Cross sectoral	Terrestrial ecosystems, water resources, infrastructure and early warning system
	6	Mainstreaming adaptation to climate change into policies and programmes in different sectors (focusing on disaster management, water, agriculture, health and industry).	Cross sectoral	Mainstreaming and policy Adaptation
	7	Inclusion of climate change issues in curriculum at secondary and tertiary educational institution.	Education and Capacity building	Education
	8	Enhancing resilience of urban infrastructure and	Infrastructure	Infrastructure: urban and industry

		industries to impacts of climate change		
	9	Development of eco-specific adaptive knowledge (including indigenous knowledge) on adaptation to climate variability to enhance adaptive capacity for future climate change.	Education and Capacity Building	Education and Public awareness
	10	Promotion of research on drought, flood and saline tolerant varieties of crops to facilitate adaptation in future.	Food security	Agriculture
	11	Promoting adaptation to coastal crop agriculture to combat increased salinity	Food security	Agriculture
	12	Adaptation to agriculture systems in areas prone to enhanced flash flooding (North East and Central Region).	Food security	Agriculture
	13	Adaptation to fisheries in areas prone to enhanced flooding in North East and Central Region through adaptive and diversified fish culture practices	Food security	Fisheries
	14	Promoting adaptation to coastal fisheries through culture of salt tolerant fish special in coastal areas of Bangladesh	Food security	Fisheries
	15	Exploring options for insurance to cope with enhanced climatic disasters.	Insurance	Insurance to cope with climatic disasters

Bhutan	1	Disaster Management Strategy- planning for food security and emergency medicine to vulnerable communities	Early warning and Disaster management	Disaster management
	2	Artificial Lowering of Thorthormi Lake	Terrestrial Ecosystems	Wetland Ecosystem
	3	Weather Forecasting System to Serve Farmers and Agriculture	Early warning and Disaster management	Early warning
	4	Landslide Management & Flood Prevention (Pilot Schemes in Critical Areas)	Terrestrial Ecosystems	Land Rehabilitation/ erosion control
	5	Flood Protection of Downstream Industrial and Agricultural Areas	Terrestrial Ecosystems	Land Rehabilitation/ erosion control

	6	Rainwater Harvesting	Water resources	Rainwater
	7	GLOF Hazard Zoning (Pilot Scheme-Chamkhar Chu Basin)	Early warning and Disaster management	Early warning system
	8	Installation of Early Warning System on Pho Chu Basin	Early warning and Disaster	Early warning system
	9	Promote Community-based Forest Fire Management and Prevention	Terrestrial Ecosystems	Forest ecosystem
Maldives	1	Integration of Future Climate Change Scenarios in the Safer Island Strategy to Adapt Sea Level Rise and Extreme Weather Risks Associated with Climate Change	Cross sectoral	Disaster management and capacity building
	2	Coastal Protection of Safer Islands to Reduce the Risk from Sea Induced Flooding and Predicted Sea Level Rise	Coastal/Marine ecosystems	Coastal zones

	3	Enhance adaptive capacity to manage climate change related risks to fresh water availability by appropriate technologies and improved storage facilities	Water resources	Fresh water
	4	Coastal Protection of Male' International Airport to Reduce the Risk from Sea Induced Flooding and Predicted Sea Level Rise	Infrastructure	Coastal Protection Infrastructure
	5	Enhance adaptive capacity to manage climate change related risks to fresh water availability by appropriate wastewater treatment technologies	Early warning and disaster management	Fresh water
	6	Increase the resilience of local food production through enhancing the capacity of farmers, local communities to address food security issues caused by climate change and climate variability	Food security	Agriculture
	7	Improve the health status of the population by the prevention and management of vector-borne diseases caused by changes in temperature and flooding due to extreme rainfall	Health	Prevention and control of vector borne diseases
	8	Improve resilience of Island communities to climate	Infrastructure	Building design

		change and variability through sustainable building designs		
	9	Investigating alternative live bait management, catch, culture and holding techniques in the Maldives to reduce vulnerability of the tuna fishery sector to the predicted climate change and variability	Food security	Fisheries
	10	Improve the design and construction of access infrastructure in Maldives to increase the resilience of access infrastructure and island beaches to climate change	Infrastructure	Improvement of design and construction
	11	Increase resilience of coral reefs to reduce the vulnerability of islands, communities and reef dependant economic activities to predicted climate change	Coastal/Marine ecosystems	Coastal zones
Nepal	1	Promoting community-based adaptation through integrated management of agriculture, water, forest and biodiversity sector	Cross-sectoral	Agriculture, Water resources, Forestry
	2	Building and enhancing adaptive capacity of vulnerable communities through improved system and access to services related to agricultural development	Agriculture	Food security

	3	Community-based disaster management for facilitating climate adaptation	Early warning system and disaster risk management	Disaster risk management
	4	GLOF monitoring and disaster risk reduction	Early warning system and disaster risk management	Disaster risk management
	5	Forest and ecosystem management for supporting climate-led adaptation innovations	Terrestrial ecosystems	Forest ecosystem
	6	Adapting to climate challenges in public health	Health	Public health
	7	Ecosystem management for climate adaptation	Terrestrial ecosystems	
	8	Empowering vulnerable communities through sustainable management of water resources and clean energy supply	Water resources	Water management

	9	Promoting climate smart urban settlement	Education, capacity-building	Urban settlement

Source: Index of NAPA Projects by Country (UNFCCC)

[As of January 2010 Maldives is no longer a LDC].

TABLE 5: Technologies for Adaptation in the Human System

Agriculture & Food Security	Water Management	Disaster risk management	Human health
Weather forecasts and seasonal climate information	Demonstration of small-scale innovative techniques for climate-resilient harvest, storage, conservation, and distribution of water	Improvement of drought early warning systems and coordination of food and forage banks	Climate and statistical models developed to monitor and track the effects of climate on malaria and dengue
drought-tolerant crop varieties dry- land farming (such as dry seeding, minimum tillage, etc.	Upgrade of irrigation facilities to promote efficient usage of available water resources	Reduced risks of glacial lake outburst floods (GLOFs) through artificial lowering of lake levels and automated monitoring/warning system	

Training of adaptation experts for agricultural extension services	Development and implementation of integrated water management frameworks for rational prioritization of limited resources climate-resilient techniques for harvesting, storing, conserving, and distributing water; prevention of groundwater seepage, and new water treatment techniques	Increased coverage of existing early warning system and improved flow of early warning information to vulnerable coastal communities	Increased capacity and understanding among local health professionals through pilot implementation of preventive and responsive public health programs specifically targeting climate change- induced illnesses

Source: adapted from multiple sources

Table 6: Technologies for Adaptation in the Natural System

Ecosystems	Sustainable land management	Disaster risk management
Pest management technologies introduced into sustainable forest management to combat severe pest problems caused by decreasing rainfall	Soil erosion and soil loss prevention	Planting /conservation of protective mangroves
Dissemination of alternative energy technology to reduce human stresses on important mangrove ecosystems, previously used for firewood collection	Part of IWRM	Installation of breakwater/ sea walls at key vulnerable coastal locations
Updating of coastal zoning and fisheries management based on detailed analysis of saline front changes induced by climate change	Assessment of soil erosion and land degradation	Improvements in human and technical capacity (such as GIS technology) for monitoring and responding to coastal erosion

Source: adapted from multiple sources