Global Water Partnership South Asia

apan asia pacific ADAPTATION NETWORK

TECHNICAL REPORT:
CLIMATE CHANGE ADAPTATION IN WATER MANAGEMENT FOR FOOD SECURITY:
RECENT DEVELOPMENTS IN SOUTH ASIA

Global Water Partnership South Asia (GWP-SAS)
under Asia Pacific Adaptation Network (APAN)
March 2013

Technical report: Climate change adaptation in water management for food security: Recent developments in South Asia

Suggested Citation
IGES, GWP South Asia. 2013. Technical report: Climate change adaptation in water management for food security: Recent developments in South Asia. Hayama, Japan: IGES.

How to obtain the digital copy: The full report can be electronically downloaded from www.asiapacificadapt.net.

ACKNOWLEDGEMENT

This technical report was prepared by the Global Water Partnership South Asia (GWP-SAS), the Asia Pacific Adaption Network (APAN)'s thematic node for water. We would also like to extend our sincere gratitude to the Ministry of Environment, Japan (MoEJ) and Asian Development Bank (ADB) for funding this report.

EXECUTIVE SUMMARY

The objectives of this research report is to provide an update of the climate change adaptation in water management for food security in South Asia, particularly focusing on Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. As a region as well as individual countries, the focused area represents one of the most vulnerable regions of the world to climate change.

The study shows that there is a substantial recognition and awareness of the impacts of climate change in the sub region at the top political policy making level. Several development in the climate change adaptation process had taken place in the recent past; many of them in the policy making and strategy development. All the six countries have developed climate change adaptation policies. As the climate change has a pronounced impact on the sustainable development in the region, the report assesses the incorporation of its impacts to the development policies in water, agriculture and disaster management fields, and brings out the strengths and weaknesses.

The financial needs of the sub-region to withstand the impacts of climate change appear to overweigh the inputs. However, an accurate assessment of the needs and inputs, though could be a complicated matter, is highlighted as a need.

There are considerable advances in the technological development related to climate change adaption in the region. Several of them relate to forecasting climate related parameters, which would help to be more resilient to climate induced hazards. In the light of the predictions that South Asia will experience a significant reduction of food production, the countries have given much attention to developing drought and flood resistant crop varieties as well.

Overall, the seriousness of the challenges of climate change to sustainable development of the region is accepted at the higher political levels. However, it can be seen that many of the challenges have regional dimensions, and therefore, regional cooperation can have a tremendous positive impact on the resilience of the region to climate change, through helping to achieve the unrealized potential in water resources development. The funding situation does not match the magnitude of the impact of climate change, and as a result, there are marked deficits in the research and technological outputs. As the communities are an integral part of both the problem and the solution, mobilizing them as investors in the field of climate change adaptation is as important as creating awareness among them regarding the climate change. Improved data collection, management and dissemination would be very useful to achieve the R&D potential of the region. The building of capacities among policy makers, technologists and the communities falls short of the region's requirements, and a more intensive discussion on this subject is required.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 The Context

South Asia is a region with limited land and water resources to support its huge population, totalling about 1.5 billion. Land resources, extending over about five million km2 are being further limited by the topography in countries such as Nepal and Bhutan, soil conditions and aridity in countries such as Pakistan, and the large proportion of disaster-prone areas in countries such as Bangladesh. There is water scarcity in some countries already, and some other countries are approaching the limits of sustainable use of water resources due to increasing population and pollution.

Investments by the national governments in water resources development and agriculture have helped to alleviate poverty and improve the food security. However, the sustainability of such investments is doubtful due to impacts of climate change. It is observed that the reservoir capacity is being limited due to high intensity rains, landslides, and soil erosion. There is a substantial spatial variation of the rainfall trends as well, with some areas having declining trends and other areas having increasing trends. In addition, a large proportion of people have been elevated above the poverty lines, only temporarily. This results in a huge population vulnerable to variations of water availability, thus threatening the sustainability of poverty alleviation initiatives. Most threatened in the agriculture sector are the rain-fed farmers and the farmers dependent on small reservoirs and small diversion schemes.

The sub-region of South Asia is a highly complex area with many contrasts affecting the climate variability as well as adaptation capacity. However, there are common features such as high rural population, dependency on agriculture and incidence of poverty. Water plays a key role in adaptation to climate change, agricultural productivity and poverty alleviation. In addition, water security is an essential prerequisite for peace and harmony in the region.

When the several statements of SAARC summits related to climate change are analyzed, it appears that climate change is recognized as a serious challenge to sustainable development and the contribution of poverty, illiteracy and social inequities to increase the vulnerability of the people is understood. South Asia has made considerable advances in the field of policy making to address such challenges. These developments serve as a good foundation for adaptation strategies. However, inadequate policy support is observed in certain challenge areas. Whenever water policies are available, sometimes the phenomenon of climate change is not well integrated to the policy framework, especially in the development policies. This would increase the vulnerability and contribute to the future water stress.

There are country-specific peculiarities that affect the vulnerability. In India and Bangladesh, the difference between Total Annual Water Resources and Internally Renewable Water Resources is significant. Especially in the case of Bangladesh,

this difference results in a situation where the bulk of the water resources are not within the control of the country. While the major river system that supplies water to Bangladesh is Ganges-Brahmaputra-Meghna system, only 7% of the catchment area lies within Bangladesh. While Bangladesh is considered as a flood-prone country and 22-30% of the country is affected by floods every year, in the dry season (November through May), the country faces water scarcity(Khan, 2012). Therefore, high per-capita water availability can sometimes be misleading, and higher values do not necessarily indicate a lack of water stress.

Several countries are considered as disaster prone. The floods have, in recent times caused devastation in countries with high per-capita water availability such as Bangladesh and Bhutan, as well as countries with low per-capita water availability such as Pakistan.

1.2 The Major Threats

The Himalayas constitute a major water source area for the region, but it is a highly threatened ecosystem in the world. In the mountains, climatic conditions vary more sharply with elevation and over shorter distances than they do with latitude. For example, mean temperature decline about 10 C per 160 m of elevation, compared with about 10 C per 150 km by latitude (Hartmann, 1994). Hence, the effects of climate change are expected to intensify with a high degree of spatial variation in the mountain areas. Such climatic characteristics contribute to the vulnerability of mountainous countries such as Nepal and Bhutan. IPCC's climate models for South Asian sub-continent predict that Bhutan's annual average temperature is likely to increase by 1° C from 2010 to 2039 and by 2°C from 2040 to 2069. It is also expected that the largest warming will take place at higher altitudes in Bhutan. On the basis of analysis of maximum temperature data from 49 stations in Nepal for the period of 1971 to 1994, Shrestha et al (1999) reported warming trends after 1977 ranging from 0.060C to 0.120C per year in most of the Middle Mountain and Himalayan regions, while the Siwalik and Terai (southern plains) regions show warming trends less than 0.030C per year. A more recent study shows that the average temperature trend in Nepal from 1975 to 2006 is 0.0270 C per year in comparison to the global trend of 0.017o C per year for the similar period. This shows that the average temperature in Nepal is increasing by 1.6 times the global average (Sharma, 2011).

One of the most conspicuous impacts of climate change that has been observed in the past years is the retreating glaciers and formation of glacial lakes, which poses serious threats to human lives and livelihoods downstream from glacial lake outburst floods (GLOF). The reduction in snow and glacier cover from a small amount of climate change reduces the albedo effect and increases the surface temperature, causing a positive warming feedback in the local environment (Meehl, 1994). The changes in heat waves, glacier retreat, and/or permafrost degradation will affect high mountain phenomena such as slope instabilities, movement of mass, and glacier lake outburst floods (IPCC, 2012). The glacial

retreat in Nepal ranges up to 20 m/year resulting to the growth of glacial lakes by six-fold (CNCCC, 2007) with possible "Vertical Tsunami". The GLOF induced disasters might claim the lives and properties in the downstream including public property and infrastructure. The Himalayan ecosystem which is an important resource for the densely populated Gangetic plain and its vulnerability to climate change might increase conflict amongst neighbours.

- Different studies carried out on the climate change projection, mainly based on different climate models, have predicted changes in precipitation over the entire Nepal for different time periods. Based on Regional Climate Model (RegCM3) output for A2 scenario, Karmacharya et al (2007) have indicated a decrease in monsoon precipitation in most part of Nepal for period from 2039-2069.
- Currently, Bhutan also faces the impacts of climate variability with extreme weather events such as windstorms, changes in precipitation patterns, increasing temperatures and so forth. Impacts from these incremental changes over the years are expected to be more obvious in the coming decades and the severity of these impacts will primarily depend on the vulnerability of communities, livelihoods and infrastructures.
- In India the combined pressure of urbanization, economic development and industrialization would only be intensified by the risk of climate change. India is predicted to be the most populous country in the world around the middle of this century and this combined with high degree of spatial and topographical variation will make designing the adaptation measures more complex.
- In Pakistan, the energy crisis is further magnifying the water shortages with prolonged unscheduled bouts of electricity load shedding. Past neglect of investments in infrastructure and general erosion of quality and mandates in water institutions is showing up in the form of slower response to emerging water insecurity (PWP, 2012).

The sub region has substantially invested in storage reservoirs which would reduce the adverse impacts of variations of rainfall and water availability. However, forest cover in several countries of the sub region is very low and unplanned exploitation of natural resources results in severe soil erosion and sedimentation. In addition, the rising temperatures and associated high evaporation would further reduce the storage potential.

1.3 The unexploited potential

Despite threats and the vulnerabilities of the region, there is a potential to address the issues, which is yet to be exploited. Some examples are:

- There is untapped hydropower potential in countries such as Nepal and Bhutan. While Bhutan's topography enhances the vulnerability to disasters, the same topography can facilitate hydropower production. But less than 2 percent of Bhutan's hydropower potential has been achieved. Similarly, the hydropower potential in Pakistan is reported to be exceeding 100,000 MW with 60,000 MW considered feasible in the Indus River alone (World Bank, 2011; and WAPDA 2010). Unsustainable energy use is a major contributor to

the climate change and exploiting the hydropower potential could help both climate change mitigation and adaptation efforts.

- South Asia is the cradle of several ancient civilizations. Water has played a major role in developing and sustaining such civilizations. As such, there is a wealth of local knowledge which can be useful in the adaptation efforts, which is yet to be fully exploited.
- The region has placed a high value on the education of masses. As a result, there is a vast resource of academics, scientists and technologists who could be useful to enhance the adaptation capacity of the population and the relevant institutions. However, there is no regional strategy to share such academic resources.

As such, it can be seen that the sub-region has the potential to develop the water resources in such a way that it can reduce the vulnerability to climate change as well as to develop the economy. However, regional cooperation is essential to achieve this goal, and it can transform the political will to strategies and work plans.

1.4 Food Security and Climate Change Linkages

IPCC's fourth Assessment Report, using global climatic models predict that crop yields could decrease up to 30% or more in South Asia, considering physiological effects of CO2 concentration. These estimates apparently do not take into account the crop losses due to water-related disasters and unpredictable rainfall. In addition, there could be a loss of productivity due to ill health of farmers. For example, heat stress and changing patterns in the occurrence of disease vectors affecting health are expected to increase the endemic morbidity and mortality due to diarrhoeal diseases and the abundance and/or toxicity of cholera in South Asia (UNFCC, 2007). Therefore, it is likely that a substantial part of climate change impacts will be transferred to South Asia's large rural and poor population as food insecurity.

In Bangladesh, production of rice and wheat might drop by 8% and 32%, respectively, by the year 2050 (Faisal and Parveen, 2004). India is considered to be the second largest producer of wheat and the national productivity of wheat is about 2708 kg/ha (which year data?). In Haryana, higher night temperatures during February and March in 2003-04 which were 3° C above normal, resulted in the decline of wheat production from 4106 kg/ha to 3937 kg/ha (which year data?). According to a study done by the Indian Agriculture Research Institute, increased temperatures and decreased radiation will lead to decreased rice productivity in the North Eastern region. Sudden events such as the floods in Tihar Desert in 2006 and relatively slow events like the incursion of sea water into inland Orissa over the last two decades has decreased the regional food production. The onset of the summer monsoon in India is getting delayed and disturbed. This affects crop cycles and cultivation in rain-fed areas. Monsoon delays and failures inevitably lead to a reduction in agricultural output, thereby deepening food insecurity (Ranuzzi and Srivastava, 2012).

Bhutan is a least developed country with a population of nearly 700,000 that relies heavily on subsistence agriculture, hydropower generation and tourism revenues. Food security is an important theme cutting across different sectors affected by the degree of food availability, access, and utilization. Current food security strategies address the links between sustainable development, poverty reduction and the promotion of food security in food insecure areas (WFP 2012).

Agriculture plays a dominant role in the Bhutanese economy engaging nearly 69 per cent of the total population. Production is generally based on traditional methods of farming with low-level purchased inputs such as seeds and chemical fertilizers. Although, the sector contributes only one third of GDP, it does constitute the majority of income, employment, and food security to most Bhutanese, particularly the poorest (World Bank, 2011). Of the total 7.8 per cent arable land in the country, an estimated 21% are irrigated, 43% are rain-fed, nearly 27% are used for shifting cultivation, approximately 8% are used for orchards and 1% are kitchen gardens. With a small population, landholdings are fairly evenly distributed but fragmented with more than half (55.4%) per cent of the faming populating owning less than 3 acres each. Rice, maize, wheat, potatoes and a few cash crops such as apples, citrus and cardamoms are grown all over the country.

Therefore, at the national level, food security is constrained by the small percentage of arable land, subsistence nature of farming, low productivity and small size of land holdings. Bhutan is not self-sufficient in terms of food production and has been a net food importer, particularly of grains (FAO 2012). This is compounded by a shrinking farming population with rural-urban migration leading to farm labour shortage, rapid fragmentation, loss of prime agricultural land to urbanization and hydropower, crop depredation by wild animals, crop pests and diseases heightening the status of food insecurity in the country (BhWP, 2012).

Pakistan is already witnessing serious water shortages, with negative impacts on crop yields, rotation, crop calendars and cropping intensities in irrigated areas (PWP, 2012). Food security features high on the government agenda. A recent study by Sustainable Policy Development Institute, 2010 identified 44 districts in Pakistan being food insecure out of which 10 are located in the Baluchistan province (Sulheri et al. 2009). Climate change likely to aggravate the situation as cereal yields could decline by as much as 50% in Indo Pak sub-continent as indicated by Nelson, (2009) of the International Food Policy Research Institute. Shifts in cropping patterns in response to rising temperatures and international price fluctuations are also impacting markets and farmer decisions in South Asia. Ensuring food security is the core principle behind the development of the agriculture, fisheries and irrigation sectors in Sri Lanka's national development agenda. This thrust is further bolstered by the emphasis on nutrition in the health sector. Agriculture accounts for a little over 20 percent of GDP and provides nearly 70 percent of the rural employment (Aheeyar, 2012). More than half of Sri Lanka's food grain production is dependent on irrigated rice. Irrigation

is the major user of fresh water consuming over 90 percent of the total annual captured water.

Rice is the staple food of the majority Sri Lankans and provides a livelihood for almost two million farmers. More than 30 percent of the total labor force is directly or indirectly involved in the rice sector. Rainfall, temperature, and day lengths are key determinants of the growing seasons, type of agricultural practices and yield levels. Rainfall plays on important role in agriculture as any shortages or excess of rainfall gives way to a reduction in yield. Therefore, climate change undoubtedly would trigger serious impacts on the country's food insecurity and vulnerability patterns. This has been highlighted in the recent study of ESCAP (2010) as Sri Lanka is to be one of the hotspots of food insecurity in the Asia-Pacific region.

Most Sri Lankan crops, and particularly rice, are produced at the top end of the optimum temperature range for cultivation, meaning that the anticipated increases in temperature could have a profound effect on yields. Estimates suggest that rice yield could be reduced up to 6% for 0.1 - 0.5°C temperature rise (Vidanage and Abeygunawardena, 1994; Practical Action, undated). However, major climate change impacts for rice cultivation are from changes in rainfall amount and distribution. The combined effect of higher temperatures and less rain is projected to lead to a greater than 11 percent loss in revenue from paddy by 2050 (Munasinghe Institute, 2010).

2. STRATEGIES AND POLICIES IN SUPPORT OF CLIMATE CHANGE ADAPTATION (CCA)

2.1 Partnership in global programmes

All the countries in South Asia are signatories to the United Nations Framework Convention on Climate Change (UNFCC). This is further proof that all the countries have recognized that climate change exists as a problem, and being signatories they are bound to act in the interest of human safety, even in the face of scientific uncertainty. All South Asian countries are Annex II countries, which implies that they need support for climate change activities over and above the financial support received from developed countries for general development activities. National Adaptation Programmes of Action (NAPAs) are being implemented in all countries and several projects are being implemented with external support under NAPAs (APAN, 2011).

However, not all the countries have ratified the Kyoto protocol, Afghanistan being the exception.

2.2 Treaties and Regional Cooperation

Some initiatives such as the SAARC platform have been used to initiate discussions and they have resulted in several actions. As a result of SAARC initiated studies of early 1990s, the SAARC Plan of Action on Environment was

adopted in 1997, which advocated the establishment of Regional Centers of Excellence. The studies influenced the establishment of the SAARC Meteorology Research Centre (SMRC) in Dhaka in 1995, the SAARC Coastal Zone Management Centre (SCZMC) in Male in 2004, the SAARC Disaster Management Centre (SDMC) in New Delhi in 2007, and the SAARC Forestry Center has come into the existence in Bhutan 2008.

The SAARC platform produced several joint statements and declarations, as well. Examples include the SAARC Declaration on Climate Change of 2007 made by the SAARC Council of Ministers, at their Twenty ninth Session held in New Delhi, the SAARC Environment Ministers Declaration on Climate Change made in Dhaka in 2008 and The Thimphu Statement of 2010 made by the SAARC Heads of State climate change. The Dhaka Declaration on Climate Change of 2008 agreed to initiate and implement programmes and measures to protect the lives and livelihood of people from impacts of climate change, through ensuring food, water and energy securities. This resulted in the adoption of the SAARC Action Plan on ClimateChange of 2008. The SAARC Workshop on Climate change and Disasters (2008) held in Kathmandu noted that South Asia has perennially been a disaster-prone region and two thirds of the disasters occurring in the region are climate related. The Workshop produced a Road Map for Implementation of SAARC Action Plan on Climate Change by SAARC Disaster Management Centre for the period 2009 – 2011.

The SAARC Heads of State recognized the region's dual challenge of addressing the negative impacts of climate change and pursuing socio-economic development in the Thimphu Statement of 2010. The urgent and compelling nature of the need for a regional response to meet the resulting challenge was noted and it was agreed that the region could benefit from cooperative regional initiatives and approaches, exchange of experiences, knowledge, transfer of technology, best practices to address the challenges posed by climate change. Accordingly, the Heads of the States agreed to undertake an action programme consisting 16 activities to face the challenge, addressing needs such as advocacy, awareness, research and knowledge transfer.

The region has several major rivers that flow across political boundaries. The Indus river in the western part of the region originates from Tibetan Plateau and flows across India and Pakistan. The Ganges-Brahmaputra-Meghna river system in the eastern part of the region is shared by India and Bangladesh. Brahmaputra basin is shared by Bhutan as well. Mahalkali river in Nepal (known as river Sarda in India) is shared with India. From time to time, bi-lateral treaties have been signed between the countries to share and develop water resources. The major treaties include the Indo-Pakistan Indus Treaty (1960), the Indo-Nepal treaties regarding the Kosi (1954), the Gandaki (1959), and the Mahakali (1996), and the Indo-Bangladesh Ganges Treaty (1996). (Uprety, The Kosi Treaty have been amended subsequently.

These treaties have helped to substantially improve the regional cooperation in water resources management. However, in the face of climate change, the

need for circumvent the implementation challenges, making institutional arrangements for implementation and improving the coverage have been highlighted.

Bangladesh shares the waters of 54 trans boundary/common rivers with India. The Indo-Bangladesh Joint Rivers Commission (JRC) deals with sharing and management of trans-boundary river waters (Khan, 2012).

2.3 National adaptation strategies, policies, plans and programmes

2.3.1 National Policies and Action Plans

The Bangladesh climate change action plan (BCCSAP): The Bangladesh climate change action plan (BCCSAP) is a 10 year program (2009-2018) to build the capacity and resilience of the country to meet the challenges of climate change. The development strategy underlined by the plan has a pro-poor, climate resilient orientation and low carbon emphasis. The strategy is based on adaptation to Climate Change, mitigation of climate change and technology transfer.

The first part of the BCCSAP provides the background on physical and climatic contexts, core socio-economic realities and policies in the country and the consequent rationale for a strategy on climate change. The thrust of the strategy is on sustainable development, poverty reduction and increased well-being of all vulnerable groups in society with special emphasis on gender sensitivity. The second part provides a set of programs based upon six pillars or broad areas of intervention. (MOEF, 2008). The six pillars are -

- food security, social protection and health;
- comprehensive disaster management;
- infrastructure development;
- research and knowledge management;
- mitigation and low-carbon development; and
- capacity building and institutional strengthening.

The BCCSAP sums up Bangladesh's current thinking on desirable activities to build climate resilience into the economy and society of Bangladesh through adaptation to climate change as well as mitigation for a low carbon development path (Khan, 2012).

The National Adaptation Programme of Action (NAPA) for Bangladesh recognizes the importance of addressing environmental issues and natural resource management with the participation of stakeholders in bargaining over resource use, allocation and distribution (BCAS, 2008).

National Adaptation Programme of Action in Bhutan: Bhutan's first National Adaptation Programme of Action (NAPA) was completed in 2006. It identified nine priority actions to respond to urgent and immediate needs to adapt to

climate change. With the main objective of enhancing adaptive capacity to prevent climate-change induced GLOF disasters in Bhutan, three adaptation priority activities namely (i) artificial lowering of Thorthormi lake, (ii) pilot GLOF hazard zoning , and (iii) installation of early warning system began implementation in 2008 with the expected outcome of reducing climate change induced risks and vulnerabilities from GLOF in three vulnerable districts of Bhutan.

Six other priority actions including (iv) disaster management strategy, (v) planning for food security and emergency medicine, (vi) weather forecasting, (vii) landslide management and flood prevention (viii) flood protection downstream areas and (ix) community-based forest fire management and prevention were implemented at varying degrees with financial support from the Royal Government of Bhutan and other donor communities.

A review of the key adaptation needs after the first NAPA for Bhutan was carried out based on historical information on climate related hazards, past adaptations to climate change and climate variability engaging all stakeholders. The updated NAPA document includes eight priority actions related to primary and vulnerable sectors such as human health, water resources and renewable energy, agriculture, natural disaster, infrastructure and institutional capacity building. These are:

- Landslide Management and Flood Prevention
- Disaster Risk Reduction and Management – planning disaster management interventions and providing emergency medical services to vulnerable communities
- Enhancing National Capacity for Weather and Seasonal Forecasting in Bhutan
- Application of Climate Resilient and Environment Friendly Road Construction (EFRC) Nationwide to the National Engineering Institutes
- Community-based Food Security and Climate Resilience
- Flood Protection of Downstream Industrial Area
- Rainwater Harvesting and Drought Adaptation
- Community-based Forest Fire Management and Prevention

The National Action Plan for Climate Change of India: The National Action Plan for Climate Change in India has 8 missions which include:

a. National solar mission-which aims to promote the development and use of solar energy for power generation to making it competitive with fossil-based energy options.

b. National Mission for Enhanced Energy Efficiency, which recommends mandating specific energy consumption decreases in large energy-consuming industries,

c. National Mission on Sustainable Habitat, which aims at promoting energy efficiency in urban planning

d. National Water Mission, which sets a goal of a 20% improvement in water use efficiency

e. National Mission for Sustaining the Himalayan Ecosystem, which aims to reduce melting of the Himalayan glaciers

f. Green India Mission, which plans to expand the forest cover from 23% to 33%
g. National Mission for Sustainable Agriculture, which promotes the climate change adaptation in agriculture
h. National Mission on Strategic Knowledge for Climate Change, which plans to enhance the climate–related knowledge and adaptation and mitigation technologies (Pandhve, 2009)

The National Action Plan on Climate Change provides a direction for changes at the national level in policy, planning, and public-private partnerships, and lays out a global vision for modifying longer time trends for sustainable development (Dev and Sharma, 2010).

Climate Change Policy development in Nepal: Some of the policy measures that have been implemented to date demonstrate that Nepal has started to participate in addressing climate change. For instance, formulation NAPA (2010); Climate Change Policy (2011); National Framework on LAPA (2011); Agricultural Development Strategy (2012) and their implementation can help minimize the adverse impacts of climate change on water and agricultural sectors and help attain the water and food security at the national at the national level.

As Nepal is one of the Parties to the UNFCCC, it is her obligation to implement Convention provisions. For this, necessary instruments, including methodology and framework for addressing and combating the impacts of climate change on water and food security should be developed. Although the GoN has accorded a high priority to resolving different environmental problems by formulating comprehensive set of policies, plans, and programs; only recently, very few instruments have addressed the climate change issues. Uncertainties in climate projections, inadequate knowledge, lack of reliable data and information remain an important constraint for effective anticipatory planning for a developing country like Nepal in order to address the on-going and emerging threats of climate change.

Climate Change Policy, 2011 is the first comprehensive policy framework of Nepal addressing climate change. This policy was prepared in the wake of global climate change awareness and the need for urgent responses to protect people, properties and resources from the adverse impacts of climate change.
The vision of the policy is to spare the country from the adverse impacts of climate change by considering climate justice, through the pursuit of environmental conservation, human development, and sustainable development¬¬ -all contributing toward a prosperous society (GoN, 2011(a)).
The specific objectives of the policy includes

i. Establishing a Climate Change Centre as an effective technical institution to address issues of climate change and also strengthen existing institutions;
ii. Implementing climate adaptation-related programmes and maximize the benefits by enhancing positive impacts and mitigating the adverse impacts;
iii. Reducing GHG emissions by promoting the use of clean energy, such as hydro-electricity, renewable and alternative energies, and by increasing energy efficiency and encouraging the use of green technology;

iv. Enhancing the climate adaptation and resilience capacity of local communities for optimum utilization of natural resources and their efficient management;
v. adopting a low-carbon development path by pursuing climate-resilient socio-economic development;
vi. developing capacity for identifying and quantifying present and future impacts of climate change, adapting to climate risks and adverse impacts of climate change; and
vii. Improving the living standard of people by maximum utilization of the opportunities created from the climate change-related conventions, protocols and agreements.

One of the most remarkable aspects of this Climate Change Policy of Nepal is that it provides for climate justice concept, a new concept for Nepal. The policy document mentions that the local communities will be entitled to at least 80% of the total climate change funds which will be channelled through activities at the grassroots level.

The Policy also highlights that the detailed impacts of climate change on agriculture and water resources has yet to be assessed. In relation to agriculture and food security, the Policy has strategy and working policy of introducing agriculture and disaster insurance in climate change-affected areas.
In a nutshell, the Climate Change Policy, 2011 provides multiple opportunities to initiate climate change activities in Nepal. Policies and strategies formulated and laws enacted before 2010 don't contain provisions that address climate change concerns. At present, several projects have been developed to implement community-based climate adaptation actions including GLOF and flood, however Nepal has no previous experience in climate change adaptation and therefore, the current activities are more related to compliance to the UNFCCC, institutional strengthening including development of coordination mechanism, promotion of climate adaptation, and benefiting from Convention provisions, and awareness raising (Uprety, 2011).

The goal of the Nepal Climate Change Support Programme (NCCSP) is to enable Nepal's poorest and most vulnerable communities to adapt to the effects of climate change, by supporting local level adaptation programme in the most climate vulnerable districts of the Mid and Far Western regions of Nepal. This program will assist the Government of Nepal to implement its Climate Change Policy, 2011 and develop and implement necessary strategies.

National Adaptation Programme of Action of Nepal: The Government of Nepal endorsed National Adaptation Programme of Action (NAPA) in 2010, which was prepared through a broad-based consultative process. The document provides more focus on providing information, knowledge, skills and technology to the most vulnerable communities living in fragile and climate vulnerable districts across Nepal. The actions are targeted to increase community's adaptive capacity through livelihoods support, improved governance, collective

responses, improved service delivery mechanisms, and access to technology and finance.

Particularly, in terms of agriculture and food security, the NAPA highlighted that the vulnerable subsistence farming economy is facing risk due to changes in the reliability of stream flow, more intense and erratic rainfall and impacts of flooding. The document also accepts that the potential loss of some local crops due to climate change is posing threat to food security. The NAPA has promoted a watershed and landscape level approach dealing with issues related to food security, biodiversity loss, water scarcity, energy use, settlements, disease outbreak, and governance (MoE, 2010).

As NAPA is a broad-based adaptation programme, the Government of Nepal has also issued a National Framework on Local Adaptation Plan for Action (LAPA) in November 2011. The LAPA provides opportunities to assess site-specific climate vulnerabilities, and prioritize and implement most urgent and immediate adaptation options in the spirit of NAPA (GoN, 2011(b)). The LAPA equally provides opportunities to integrate adaptation options into planning process at different levels and also adaptation actions in sectoral plans. As of now, Nepal is the only country who has developed LAPA framework to implement field level adaptation actions with people's participation, and internalize adaptation into planning processes.

National Climate Change Policy in Pakistan: Pakistan has completed a draft National Climate Change Policy on the basis of the recommendations of the Prime Minister's Task Force on Climate Change. The policy sets out strategies to include climate change perspectives into plans and programs of all major ministries and to ensure climate proofing of high priority sectors (water, agriculture, forestry, industry and health) by paying attention to mitigation and adaption requirements with fast track actions post floods 2010 that served as a wakeup call for Pakistan to organize its resources and institutions to address climate change. Pakistan has also prepared the draft National Action Plan in the light of 2012 approved climate change Policy. However, with the devolution of certain subjects like health, education, agriculture and environment to the provinces under the 18th constitutional amendment-much of the burden to interpret climate change policy will fall on the provinces that have to develop their own micro versions of the policy and address the core issues of climate changes relevant to their provinces.

National climate change policy of Sri Lanka: National climate change policy of Sri Lanka has been developed by the Ministry of Environment to provide guidance and directions for all the stakeholders to address the adverse impacts of climate change efficiently and effectively (Ministry of Environment, 2012). The objectives of the policy are to:

- Sensitize and make aware the communities periodically on the country's vulnerability to climate change.
- Take adaptive measures to avoid/minimize adverse impacts of climate change to the people, their livelihoods and ecosystems.

- Mitigate greenhouse gas emissions in the path of sustainable development. Promote sustainable consumption and production.
- Enhance knowledge on the multifaceted issues related to climate change in the society and build their capacity to make prudent choices in decision making.
- Develop the country's capacity to address the impacts of climate change effectively and efficiently.
- Mainstream and integrate climate change issues in the national development process.

2.3.2 Incorporation of Climate Change into the development policies

It can be seen that while there is uniformity regarding the recognition of climate change as a major challenge, the approaches to incorporate climate change into policies differ across the countries. Agencies and institutions dealing with water and agriculture already carry out activities supportive of climate change adaptation. Considering the vast amount of natural resources managed by such agencies and institutions, it is important that water and agriculture agencies make specific provisions in their policies to climate change adaptation, within a broad national policy framework. As the major part of clime-induced disasters are water-related, it is equally important to discuss how the disaster management policies incorporate climate change.

Several countries have already incorporated climate change impacts in their project formulation and planning. There are many projects and programmes carried out by the governments, which have not been designed as climate change adaptation as the primary objective, but nevertheless contribute to climate resilient communities. For example

- encouragement of private sector participation in irrigation and other agro-activities
- improving input supplies, improved crop varieties and good quality seed, fertilizers and pesticides, and credit,
- improving agricultural support services,
- increased mechanization,
- better plant protection and the adoption of integrated pest management (IPM)
- better maintenance of soil fertility,
- crop diversification with minor crops and horticultural crops for export, and
- enhanced development of farmers groups and associations (BWP 2011).

The development policies should give due recognition to the contribution of these activities to community resilience, by incorporating climate change adaptation into development policies. A country-wise assessment is given below:-

Bangladesh

The National Water Policy of Bangladesh formulated in 1999 is a forward looking document that has taken into consideration all the important aspects for

improving the water resources management and protection of environment comprising of water rights, water pricing guidelines, decentralized water management and the role of women in water management. Although climate change does not feature in it, the more recent policy documents indicate the major implication of climate change for the water sector. Following this national policy, National Water Management Plan of Bangladesh was drafted during 1999-2000. However, it is felt that both the policy and the plan should take further consideration of the advance conditions of changing climate (Khan, 2012).

- Bangladesh Water Development Board (BWDB) is planning and designing all its water sector projects to cater to the effects of climate change. The projects include river bank erosion control, Coastal embankment and polder management. Some of these projects are now being financed from the Climate Change Trust Fund as well as Climate Change Resilience Fund.
- In order to help accretion of more land in the south/coastal belt, BWDB is preparing and Estuary Development Project and preparing a Delta Development Plan for the year 2100.
- The different Agricultural Research Institutes of the country are now busy in developing more flood tolerant, drought tolerant, Salinity tolerant varieties of rice and other food crops.
- The National Water Management Plan is being revised and updated in the light of the Climate Change impacts. An Integrated Coastal Zone Management Policy (ICZMP) has been prepared to addresses the climate change aspects adequately.
- Climate change is considered in designing and implementing small scale water resources development projects and urban as well as rural Infrastructure Development.
- The Government has recently embarked upon an ambitious program of capital dredging in the main rivers as well as some other important medium rivers to improve the drainage system of the country.

Bhutan

Bhutan's commitment to conservation, development and management of its water resources are evident within the Water Policy and Water Act of 2011, developed in collaboration with Bhutan Water Partnership. It recognizes water as valuable natural resources crucial to socio-economic and ecological wellbeing and promotes conservation and protection of water resources in an efficient and sustainable manner. The policy documents accord the highest priority to drinking, sanitation and irrigation, and recognizes the importance of allocating adequate water to the agricultural sector to achieve overall national food security.

The National Food and Nutrition Policy: This policy is a framework to guide decentralized food security planning at the district and sub-district levels based on pro-poor growth with the overall goal of increasing food security in Bhutan in a sustainable way. Five major program objectives and related outcomes were identified to contribute to the overall goal.

- Increase crop and animal production through development of improved varieties, breeds, and management technologies.
- Improve food accessibility by all consumers regardless of geographic positions through establishment of distribution, storage and road infrastructure; disease surveillance and forecasting systems; promotion of off-season vegetable cereal grains production; and sustainable harvesting non- wood forest products (NWFP).
- Improve cropping sequences and farming systems to diversify and enrich household nutrition consumption habits including diversification of food source, promotion of safety measures and advocacy and education.
- Regulate food and feed supply in the local markets to make food items available and affordable by consumers at all times through appropriate policy measures on food security and climate change; pest and disease surveillance and forecasting systems, and food price regulation.
- Enhance information sharing, exchange of plant and livestock materials, and Institutional Building in the agriculture sector (livestock and Crops).

India

There are several national policies in India that have a bearing on climate change adaptation. India's National Water Policy (2002), which was being updated in 2012, has taken into account the issues in disaster-prone areas. It has laid emphasis on inter-basin transfers, artificial recharge of ground water and desalination of brackish or sea water, rainwater harvesting, reforestation etc which complements the climate change adaptation measures. However, inadequate linkage with environmental, natural resources management and disaster management policies are seen as a drawback (IWP, 2012). But, the updated policy NWP recognizes the commercial aspects of water management and corporate involvement in policy implementation, and this may have implications on disaster management, health, and power generation. The other policies that could contribute to climate change adaptation are the National Forest Policy of 1988 and the National Environment Policy of 2006 (IWP, 2012).

The National Food Security Bill of India attempts to address issues like increase in investments in agriculture, including in research & development, ensuring remunerative prices, credit to farmers, crop insurance, etc. It also points out incentivizing decentralized procurement including procurement of coarse grains, augmentation of adequate decentralized modern and scientific storage etc which if effectively implemented can mitigate food insecurity catalysed by climate change. IWP (2012) notes that IWRM principle and approaches have been agreed upon but few examples exist where it is implemented in entirety.

Nepal

Nepal has undertaken a number of environment related measures as a part of its policy to achieve sustainable development path. The principles of sustainable development have formally been integrated into Nepal's national planning processes by developing sustainable development agenda in 2003, incorporating the spirit of Agenda 21. Beginning with the Eighth-Plan (1992-1997), the environment agenda continued through the Ninth Plan (1997-

2002), the Tenth-Plan (2002-2007) and into the Interim Plan (2007-2010). Hence, these polices apart from making the process to attain the goals of sustainable development also address the climate change concerns as well. The Government has issued the Three Year Plan (TYP) (2010-2012) which has broad-based objectives of promoting green development, making development activities climate-friendly, mitigating the adverse impacts of climate change, and promoting climate adaptation. The TYP also has objectives of mitigating urban pollution and protecting rural natural beauty.

The Nepal Agricultural Development Strategy 2012 has noted that the on-going abrupt changes in the climatic phenomenon are beyond the experience of the farmers in Nepal. The majority of the farmers are reliant on rain and they prepare their cropping calendar based on their past experience about the intensity and the time of rainfall. But, the emerging situation of climate related natural hazards undermines their agriculture productivity, adding to risk of poverty, food insecurity and conflicts. The agriculture dependent livelihood activities of farmers are frequently exposed to a variety of natural disasters such as floods, landslides, cold spells, heat waves, drought and epidemics. Besides climate change, the strategy also considers rapid population growth, shrinking farm size and unplanned agriculture in vulnerable areas as factors to add pressure on agriculture.

The strategy predicts that the change in hydrological flows both due to glacial retreat and more variable precipitation are expected to have impacts on many irrigation systems which will affect agricultural production leading to increasing levels of malnutrition. So, the Strategy focuses on putting efforts to increase the productivity of irrigated agriculture though the impacts are likely to be far less on irrigated fields than on rain-fed. The Strategy also mentions that the current climate change coping strategies such as growing instead of grain crops; rain water harvesting and erosion control measures are not sufficient to manage the future expected changes in climate. In addition to these, the Strategy highlights the application of disasters risk reduction approaches such as flood mitigation and soil erosion control by use of bio-engineering.

Nepal has formulated a number of strategies and action plans that have an impact on the climate change adaptation. Some of them are described below:

National Strategy for Disaster Risk Management of Nepal was adopted in 2009 with a long-term vision to establish the disaster–resilient community in the country. The mission of the Strategy is to mainstream Disaster Risk Reduction (DRR) into development.

Water Induced Disaster Management Policy of Nepal was formulated in 2006 for the management of water-induced disasters. The policy is in line with the principle of integrated water resource management (IWRM) and has the following objectives:
i. To minimize the loss of life and property arising from water-induced disasters
ii. To conserve rivers, river basins, and water-related environments for the

sustainable use of natural resources

iii. To reclaim river banks and flood-affected areas for rehabilitation of landless people and carry out other socioeconomic activities;

iv. To develop or strengthen institutions for the management of flood-affected areas and the control of water-induced disasters; and

v. To streamline the role of local and central government institutions, non-government organizations, community organizations, and private institutions that are involved in the management of rivers.

The National Water Plan which has IWRM as one of the principal themes was adopted in 2005. It is a framework to guide, in an integrated and comprehensive manner, all stakeholders for developing and managing water resources and water services. The broad objective of the Plan is to contribute in a balanced manner to the overall national goals of economic development, poverty alleviation, food security, public health and safety, decent standards of living for the people and protection of the natural environment.

The Plan makes it mandatory to involve popular participation in all its decision-making processes. The formation of users group in each sub-sector activity and sub-basin committee(s), which is one of the key components of the NWP, will ensure popular participation in the integrated water resources development and management in the country.

The National Agriculture Policy of Nepal (2004) has no specific provisions for including likely impacts of climate change on agriculture sector though having an objective of conservation, protection and utilization of natural resources, environment and biodiversity.

The Irrigation Policy was adopted in 2003 with the objective of expanding year-round irrigation services, developing user group's institutional development for sustainable management of irrigation systems, and strengthening required institutional capabilities. However, the policy has neither realized the impacts of climate change on the water availability and the damages to the irrigation system due to extreme climatic events nor has envisaged the need of adaptation measures to overcome such impacts. Nevertheless, the policy has identified the trans-basin water transfer, use of ground water, rainwater harvesting and development of storage projects as some measures to overcome the water scarcity which are considered now as tools for adaptation.

The Water Resources Strategy of 2002 has the objective of strengthening water resources development in Nepal. It aims to contribute the national goal of significantly improving the living conditions of Nepali people in a sustainable manner. The Strategy recommends the establishment of a Himalayan Climate Change Study Centre under the Department of Hydrology and Meteorology so as to strengthen mandate to provide information and warning systems.

The Natural Disaster Relief Act (1982) and the Local Self-Governance Act, 1999 provide the legislative framework for disaster management.

Sustainable Development Agenda for Nepal (2003) aims to expedite the poverty reduction process and provides to its citizens and successive generations the broader opportunities in the social, economic, political, cultural and ecological development. This document lacks direct address to climate change related food and water security issues but promotes the need for 'zero' emission for pollution control.

Sri Lanka

The policies acknowledge water as vital resource for the development of all the sectors. This is recognized in national policies such as in the Mahinda Chinthana 2010, Haritha Lanka Programme and Randora National Infrastructure Development Programme. Mahinda Chinthana has noted the need for the agriculture sector to be commercially viable and optimizing the water use through modern irrigation techniques as a critical aspect of development.

National Physical Planning Policy and Plan (2006-2030) address 'water resources development' including protection of catchments, water resources and tanks, in order to improve water quality and ensure adequate supply of water for different uses, viz; domestic, agricultural, industrial and power generation activities. The policy specifies the certain principles and strategies to achieve these objectives.

Sri Lanka however does not have a comprehensive water resources management policy. Adaptation to climate change has not received high priority as a policy issue in the water sector of Sri Lanka, as policy makers are pre-occupied with other developmental priorities (AHEEYAR, 2012). Adaptation strategies are largely being dealt in isolation from other developmental issues, though there is a need to link the existing policies on climate risk with development policies, and to mainstream climate change adaptation into development planning (ADBI, 2010). This is further elaborated by Senatne et al (2009), that although farming communities involved in agriculture, forestry and water sectors continuously adapt to variability in climate on voluntary basis, projections on global climate change indicate that future variations of climate parameters could exceed the adaptive capacity of communities unless facilitated by well-designed policy supports by the government.

When the situation is summed up, it can be seen that there are some serious attempts to incorporate the CCA into the development framework. However, there are a few concerns to be addressed. There does not seem to a uniform strategy in these incorporation attempts, and there appears to be a need to learn from each other and develop a regional strategy for the purpose of incorporating CCA into development framework. Countries may have to guard against having too many strategies and programmes with similar and duplicating objectives, to avoid fragmentation of efforts and to enable synergy. Similarly, there is a gap between the policy principles and their application through strategies. For example, IWRM principle and approaches agreed upon but few examples exist where it is implemented in entirety.

2.4 Institutional Framework in support of CCA

There are some differences among the status of the acknowledgement of climate change as a problem incorporating to national policies and actions. Different models have been employed in the policy making and strategic planning. In India, the Prime Minister's office has taken the lead in preparing the National Action Plan for Climate Change with the participation of relevant Ministries developing their own mission under the larger umbrella of national mission. Pakistan has established a Ministry of Climate Change. In several other countries, the Ministries of Environment have adopted the major role in climate change related activities including policy formulation. However, several of the natural resources management and development activities are handled by agencies in charge of agriculture and irrigation, who conduct climate change adaptation activities as well. Ministry of Agriculture, Irrigation and Livestock of Afghanistan, Ministry of Food and Disaster Management in Bangladesh, several government departments and agencies in the water and agriculture fields in Pakistan, carry out climate change related activities. The Departments of Irrigation and Agriculture in Sri Lanka are having responsibilities towards flood management and drought management respectively.

Bangladesh: The relevant ministries and agencies along with civil society and the business community will be responsible for implementing the various components of the BCCSAP. The implementation of the BCCSAP will be financed through Government's own resources and external support that may be available from the development partners as well as the specific international funds created for the purpose. The Ministry of Environment and Forests will be responsible for coordinating activities under the Action Plan (MOEF, 2008). The government established a Climate Change Cell (CCC) to build capacity and to mainstream climate change issues to promote climate-resilient development in Bangladesh in 2004. The aim is to develop a uniform methodology for all vulnerable areas and to complete resulting bottom-up Climate Change Risk Reduction Plans (CCRRP) (Khan, 2012)

India: The National Action Plan for Climate Change was announced by the Prime Minister's Office in 2008. It is a comprehensive a Action Plan, which encompasses many sectors that are affected by climate change. This approach highlights the recognition of climate change impacts at the highest levels of Indian Government. The Ministry of Environment has set up a coordination unit for the implementation of this action plan.

Pakistan: Pakistan has recently created the Ministry of Climate Change and Disaster Management to give impetus to the importance of the climate changes taking place in the country and to address the issues of adaptation and mitigation at the highest level of policy formulation (PWP, 2012).

Sri Lanka: Sri Lanka, as a signatory to the United Nations Framework Convention on Climate change, has undertaken the first greenhouse gas inventory in 1995 and established a separate Climate Change Division within the Ministry of

Environment. A centre for Climate Change Studies (CCCS) was also created at the Department of Meteorology. First National Communication on climate change was made in 2000. Sri Lanka has ratified the Kyoto protocol in 2002. Subsequently two national Clean Development Mechanism (CDM) study centres were established at University of Peradeniya and University of Moratuwa. However these two centers are not functioning fully due to lack of capacity which normally required for the smooth functioning of an institution. Ministry of Environment and National Resources has conducted a thematic assessment of existing capacity to address climate change by preparation of National Capacity Needs Self Assessment Action Plan. Second national communication on climate change was published in 2012 (AHEEYAR, 2012).

However, the absence of a governing policy for the institutions involved in water resources management is a major hindrance in sustainable management of water resource in the country. Further, there are no laws governing excessive water extraction which is considered to be a potential problem for water management in the future (Ministry of Environment, 2010a, Imbulana et.al, 2010). Although many of the laws are strong, their implementation remains inadequate. Water Resources Board is planning to introduce some legal instruments to monitor, control and regulate groundwater extraction in the country. A ten year plan has been prepared to identify the groundwater sources, monitor the quality variation and water table fluctuation (Aheeyar, 2012).

There is a concern about implementing policies. For example, IWP (2012) observes that IWRM principle and approaches are agreed upon but few examples exist where it is implemented in entirety.

2.5 International and National CC Financing Mechanisms

There is general agreement that poorer countries will be harder hit by the impacts of climate change. However, these countries will find that it is difficult to make the required investments to improve their resilience, especially to implement the structural solutions. An initial step in mobilizing such investments is to make a realistic estimate of the investments required for adaptation to climate change.

The Global Climate Risk Index (GCRI) 2010, covering the period 1990-2008, assesses Bangladesh as the most vulnerable country to extreme climate events. It further estimates that, on an average 8,241 people died each year in Bangladesh, while the cost of damage was US$ 1.2 billion per year and loss of GDP was 1.81% during the period. To finance the climate change action plan of Bangladesh, a National Climate Change Fund with 45 million dollars of its own cash, which will focus on adaptation initiatives have been established (Khan, 2012). Under the Trust Fund, projects from both government and non-government organizations (NGOs) would be accepted for undertaking projects on adaptation with the climate change for a maximum period of two years. For the government projects, maximum 250 million taka (3.57 million U.S. dollars)

would be allocated from this fund, while the highest allocation for any project by NGO would be 50 million taka (about 714,000 U.S. dollars)(MOEF, 2008). Another Fund, namely Bangladesh Climate Change Resilience Fund (BCCRF) has been established by the government with contribution from development partners. So far US$ 125 million has been received for the BCCRF and another US$ 113 million has been pledged. Managed by a committee headed by the Ministry of Environment and Forest, Projects have started to be implemented with allocations from this fund. However, both funds are too little to address the massive cost of adaptation infrastructures needed for protection against sea level rise, floods and storm surgest.

The water sector development projects of Bangladesh have mainly focused on flood control and drainage, irrigation, riverbank erosion control, delta development and land reclamations. The projects involved construction of infrastructure facilities like small and medium sized barrages, cross-dams, regulators, sluices, canals, embankments and sea-dykes along the coast and rivers. The Dhaka city protection embankment in this respect has been partially completed. Over the last 12 years, the Government of Bangladesh has spent about US$ 1.5 billion as investment for development of flood control, irrigation and drainage. In addition, the government has set up a major research fund for innovative research in agriculture. The presently allocated amount stands at about US$ 70 million.

Pakistan completed the National Economics and Environmental Development Study (NEEDS), 2011 that provides a first cut at the mitigation and adaptation costs Pakistan faces (Khan et al, 2011). The estimated annual costs of adaptation 5-14 billion US $ with an average figure of around $ US 10 billion annually. This cost is likely to decline over next 30 years provided the necessary investments to adapt to climate change takes place in sectors of water, energy, health, agriculture and Forestry/biodiversity. At present a US $ 4 million project under GEF is being implemented by ICIMOD and partners on studying GLOF related phenomenon in Hindu Kush region of Pakistan.

Pakistan is basing its future investments in water in the light of adaptation and mitigation costs proposed in the NEEDS study. The Climate Change Adaptation Fund proposed at the Durban UNFCCC meeting 2011 is an important source of financing adaptation related projects. Similarly, Pakistan is approaching World Bank and ADB for additional financing to support hardware and software related investments in water sector and keenly seeking assistance for its large water infrastructure and maintenance financing.

Indirect impacts of the climate change can complicate the process of assessing the investments required for climate change adaptation. The Government of Bangladesh has noted that changes in the climate will push away people now living in the coastal areas to floodplains and dry areas in the northwest to become climate/environmental refugees, making millions of people vulnerable to poverty and hunger. Many of those displaced persons would ultimately migrate to urban areas thereby doubling the urban population in the near

future that would contribute to political and socio-economic instability. The issue is really grave as it would ultimately result in large scale displacement and even cross-border migration (BWP, 2011). Available estimates suggest that a 1.0 meter sea-level rise will inundate 15-20% of Bangladesh in the coastal region. The existing coastal embankments cannot stop the sea water intrusion into rivers and increased salinity further inland, rendering the affected land unfit for agriculture or for any other economic use. Also, livelihoods, water security, health security and even human security will be severely threatened. The impacts may cause the displacement of up to 30 million people by the mid-21th century (Khan, 2012). Given the extreme scarcity of land and limited adaptive capacity, social tensions may arise in the country. Therefore, the transfer of resources and technologies to enable Bangladesh to undertake appropriate adaptive and rehabilitative activities is a necessity.

Overall, the need for a comprehensive assessment of the financing needs of the region for CCA, including the direct and indirect impacts of climate change, can be observed. It has to be noted that some of the indirect impacts of climate change are addressed by other development activities which sometimes do not come under climate change adaptation strategies. Considering the multiplicity of the development programmes and strategies, making an accurate assessment of the net financial needs for CCA would be complicated and time-consuming, but would be vital to enhance the resilience to climate change.

In addition to raising funds for CCA, there has to be a focused investment of such funds. IWP (2012) makes two observations regarding the focus of adaptation investments:

- Imbalance in Hardware vs. software investments leading to skewed distribution of resources and poor understanding of economic and social impacts of water distribution and lagging information on impacts on poverty, equity and income distribution
- Too much emphasis on engineering solutions as opposed to utilizing a multidisciplinary approach to water problem solving.

While the inadequacy of external support to the region is emphasized, inability to engage in domestic resource mobilization by encouraging domestic banking institutions to invest in water works continues as a hindrance to water sector infrastructure development (IWP, 2012).

3. IMPLEMENTING ADAPTATION VIA TECHNOLOGY

3.1 Weather forecasting

A reliable, timely, accurate weather warnings and forecasts are heavily felt in the water and agriculture sector. Agricultural system managers and policy makers look forward to such information for seasonal planning.

Bangladesh, recognizing impacts of the climate change has been making all out efforts to improve its Flood Forecasting and Warning system as well as cyclone warning system. In terms of giving advance warning on floods, Bangladesh

Water Development Board (BWDB) with the application of more modern techniques is planning to decrease the lead time of warning from 72 hours to 24 hours for the major river floods, and at least 6 hours for the flash flood prone areas. Regional cooperation for providing real time rainfall and river water level data of the upstream hydrometric stations on the trans-boundary rivers is required to achieve the objectives.

The drought forecasting capacity of Bangladesh is not strong. Relevant research organizations are trying to evolve appropriate drought forecasting systems in the country but in this case too, the regional cooperation is essential to achieve the objectives (Khan, 2012).

Bhutan's hydro-meteorological network has 24 River Gauging Stations, 90 Meteorological Stations, 9 Sediment Sampling Stations and 15 Flood Warning Stations, which are maintained and operated by the Department of Hydro-met Services (DHMS). While most of these stations are exclusively located in the central and southern parts of Bhutan, data from the manually operated existing systems are often limited.

The project on enhancing national capacity for weather and seasonal forecasting in Bhutan aims to resolve some of the technological shortcomings by installing Automatic Weather Stations, Automatic Water Level Station and automatic gauge and discharge stations in selected gewogs or sub districts. This is expected to allow real time link to the National Weather and Flood Forecasting and Warning Center located in the capital city. The data generated is expected to help provide improved weather and climate forecasting information for disaster management, land and water resource managements and the local communities in general (Source: Draft NAPA, 2012).

The Government of Karnataka, India set up a Drought Monitoring Cell in the year 1988. This institution has taken a lead in monitoring and managing the recurring drought situation in the state on a scientific basis. It has become a success in terms of knowledge management and decision support system (source: Drought Manual, 2009, AGRICOOP and NIDM).

A facility of Agricultural drought assessment using space technology inputs, has been operational in India since 1989, through a project 'National Agricultural Drought Assessment and Monitoring System (NADAMS)'. NADAMS provides near real-time information on prevalence, severity level and persistence of agricultural drought at state/district/sub-district level. Currently, the project covers 13 states of India, which are predominantly agriculture based and prone to drought situation (source: www.dsc.nrsc.gov.in/DSC/Drought/index.jsp)

Climate change impact assessment and adaptation studies require predictions from climate models. To plan for adaptation some important changes are required in the features provided by current climate models. For example climate predictions are needed at finer spatial resolutions than are currently available from the global climate models. Also, future scenarios of climate need to go

beyond predictions on temperature and precipitation. Along with these primary variables, the impact and adaptation community would benefit from knowledge on secondary variables such as heating degree days that combines information on available temperature range over the growing period of agricultural crops, heat index, starting and ending days of seasonal monsoon rainfall, storm surge etc (Patwardhan, 2010)

In Sri Lanka, improving weather forecasting and information dissemination has been identified as one of the adaptation strategies to ensure food security under changing climate scenario (Ministry of Environment, 2010b). Department of Meteorology is currently operating 20 Meteorological stations and 350 rainfall stations throughout the country. Meteorological stations collect three hourly data while rainfall stations records 24 hour rainfall data. The department has digitized daily values of rainfall, maximum and minimum temperature since 1861. However, more important three hourly data is yet to be digitized. In addition 33 Automatic weather systems are linked to the central monitoring station via satellite transmission and 20 automatic rainfall gauging stations are placed in landslide prone areas and linked to Central monitoring system via cellular telecommunication network (Aheeyar, 2012).

Department of Agriculture in Sri Lanka also operates Agro-Meteorological network to collect weather data twice a day in agro-climatic zones. These data are being continuously shared with Meteorological Department. Department of Agrarian Development has installed rain gauges in 320 Agrarian development centres and it is planned to install in the rest of the centres very soon. Rainfall data is used for local level planning and decision making. Hydro-meteorological network maintained by Irrigation department consisted of 69 hydrometric stations in 17 river basins, 16 river gauging stations and 11 evaporation pans. The information collected is used by department to issue flood warning. Improvements for Hydro-meteorological network and modelling is planned to forecast flood. Therefore the country have fairly extensive network of metrological information. Department of Meteorology in Sri Lanka and the universities have formed a joint committee to find out the methodology to provide weather forecast in short term and medium term to be able to make decisions for farmers and other relevant people in their activities appropriately. In addition, the major research institutions located in the region have initiated several actions to monitor and forecast climatic variations relevant to water resources and agriculture such as drought monitoring and early warning. South Asia Drought Monitor is one of such tool developed by IWMI. It uses freely available satellite data to monitor ground vegetation as an indication of drought progression. Reporting in near real time, the system currently covers Afghanistan, Pakistan and western parts of India. With further improvements, including building in weather forecasts, this could provide an effective early warning system for droughts, allowing early action to reduce impacts. (Climate, agriculture and food security: A strategy for change, CGIAR, 2009)
Severe Weather Forecasting Demonstration Project (Swfdp) of WMO aims to contribute to capacity-building and to help developing countries be resilient to weather-related hazards. Global-scale products, as well as data and information

provided by other regional centres, are integrated and synthesized by a designated Regional Specialized Meteorological Centre (RSMC), which, in turn, provides daily guidance for short-range (days 1 and 2) and medium-range (out to day-5) on specified hazardous meteorological phenomena (e.g. heavy rain, strong winds, etc) to participating National Meteorological Centres (NMCs) of the region. SWFDPs have been implemented in other parts of the world and WMO is considering a regional project for South Asia (WMO, 2012). The WMO is also planning to combine agro-meteorological data with crop, pest, and disease models.

However, the access to data and dissemination of data is not properly institutionalized (Aheeyar, 2012). A comprehensive assessment of the research and technology needs of the region would be useful to propose a gap-filling oriented strategy.

3.2 Infrastructure development engineering design techniques

Water infrastructure is widely accepted as means to adapt to climate change. However, there are limitations:

- South Asia is a heavily populated region. Large scale water infrastructure requires displacement of people and encroachment of the already depleted and vulnerable ecosystems.
- Furthermore, increasing temperatures resulting in more evaporation, low water conveyance and water use efficiencies limit the achievement of expected benefits.

As such, there is a need for innovative solutions to improve water use and conveyance efficiency, optimize the selection of water storage solutions and improve on the hydrological planning. There is a need to revisit design parameters as hydrological return periods for different types of structures and some countries have already responded to the need.

Technological needs in Bangladesh:- Being one of the most vulnerable countries in the world to climate change, Bangladesh has invested heavily in flood control, drainage, and irrigation projects, often combining the objectives in making them multi-purpose. The Bangladesh Water Development Board (BWDB) constructed hundreds of kilometers of flood embankments both inland and along the coastal belt of Bangladesh, coupled with thousands of appurtenant structures like regulators, flushing sluices etc. Besides, BWDB has constructed a large barrage project across the river Teesta in the north-west of country for irrigating more than a million hectares of land. Feasibility and detailed Engineering studies are rapidly progressing for another large multipurpose project across the river Ganges called the Ganges Barrage Project. The Water Sector Improvement Project is concerned with the future operation, maintenance and rehabilitation of some of the existing projects, while Small Scale Water Resources Development project has a strong bottom up participatory approach. Some NGOs are taking up flood proofing schemes for

raising homesteads in vulnerable areas and community flood shelters etc, on a limited scale.

In Bangladesh, all the communication, housing and settlement and water sector infrastructures are now being designed and implemented under the flood proofing concept so that they are not inundated by increased flood heights. The roads, rail-way tracks are being further raised to put them above the inundation depths. The heights of old flood protection embankments as well as sea dykes and appurtenant structures are being gradually raised. But paucity of funds is a major constraint in this respect.

All dwelling houses are going to be progressively equipped with rain water harvesting systems. More small scale water conservation undertakings are also in the offing. Some of these projects are being funded by the climate change trust fund as well as climate change resilience fund. River erosion control projects of BWDB are being designed to be more robust and effective.

The Estuary Development Project plans to offset the negative impacts of sea level rise and to accrete more new land along the Coast in the south. Water Resources Planning Organization (WARPO) is going to update and revise the National Water Management Plan to face the impacts of Climate Change. BWDB has also embarked upon an ambitious program of Capital Dredging in the main rivers as well as some other important medium rivers to improve the drainage system of the country.

Technological needs in Bhutan: Some of the technological measures to improve efficiency and availability of water for the primary water users have been identified as follows:

a. Water storage facilities

- Build reservoirs for drinking water supply in both urban and rural areas
- Build irrigation water storage structures
- Encourage multipurpose mini hydropower schemes so that the water from the reservoir/tail race can be used for municipal areas.

b. Eco-efficient design, construction, operation and maintenance

- Regular maintenance in the system to prevent loss of water due to breakages, leakages and illegal tapping of water
- Promote water efficient fixtures such as water saving sanitary fittings
- Reduce water use through metered charging, progressive charging, fair water pricing, water saving equipment

c. Improve Irrigation Infrastructure to increase availability of water for crop and animal production

- Improve on-farm water management to enhance productivity of water i.e. more crop per drop
- Construct new irrigation schemes for potential crop and animal production sites

- Reconstruction and renovation of irrigation systems (lining, better maintenance) to reduce water loss (by as much as 50%) and apply advanced water-saving methods of irrigation
- Introduce rain and groundwater harvesting techniques in appropriate areas
- Introduce drip and sprinkler irrigation facilities in places where high value crops are grown
- Installation of GLOF technical early warning systems with associated awareness-raising

3.3 Agricultural Practices and Irrigation Management

In Bangladesh, traditional practices such as pond excavation, retention of rainwater in mini ponds are providing supplemental irrigation in many places. Private and government supported shallow and deep tubewells are also facilitating irrigation with subsidy in fuel and electricity. Rubber dams are being implemented in increasing numbers in some small rivers for supplying irrigation water. Farmers are practicing moisture conservation through 'mulching' by straw, water hyacinth, rice husk, polythene etc. Some are following alternate Wetting and Drying method for rice cultivation. Alternative adaptation practices such as multiple cropping systems and homestead gardening etc. are also been encouraged.

Climate change is inducing change in the fertilizer management in Bangladesh. Increase of atmospheric carbon dioxide reduces the nitrogen uptake by plants or crops. To cope with the situation use of USG (Urea Super Granule) in wetland rice cultivation is promoted. Use of organic matter or organic manure is being popularized to increase water holding capacity of the soil.

Research organizations in Bangladesh have been active producing drought tolerant, saline tolerant: ans flood tolerant rice varieties. Floating vegetable cultivation on water hyacinth mass (heap) are considered to be practiced in low lying areas which for major part of the year remain submerged.

To meet food security objectives of Bhutan, the national food security roadmap recognizes the role of developing and institutionalizing surveillance and forecasting systems for crops and livestock including:
- Agro-climatic zones including wet tropical and mid and high altitude
- Emerging livestock animal diseases
- Pest and diseases in maize, rice, potatoes, vegetables and fruits

Pakistan has on-going work on on-farm water management and greater attention is being given to raised bed furrow crop cultivation in all major crops e.g. cotton, maize and sugarcane with estimated water savings of over 30% compared to the traditional flood irrigation. New machinery implements that allow zero tillage agriculture in form of rabi drills and dry sowing of rice is becoming popular in wake of water stresses whereby farmers are looking at low cost alternatives to save water. Minimum crop water requirements have been proposed by some institutions such as IUCN in Baluchistan. Major attention

is also being given to re-discover traditional techniques of sub surface water storage like Karez and a renewed interest in such localized solutions is emerging in Baluchistan and KPK provinces.

The main aim of Indo Swiss Collaboration in Bio-Technology is to develop products and biotechnological processes, which have an impact on poverty reduction and sustainable management of natural resources in India, and to build capacities of Indian institutes and to promote international R&D partnerships.

3.4 Research

Pakistan has taken up actions by placing a Global Impact Study Center (GCISE) established in 2002 to undertake research and impacts of climate change in Pakistan and the region. The center has published a series of reports based on down scaling of Global Circulation Models and has implemented several projects with focus on climate change and its influence on water resources (Iqbal, 200). Several Universities (e.g. Agriculture University, Faisalabad) are engaged in crop-livestock research to better understand impacts of climate change on farm productivity and research new technologies that are better adaptable to global warming induced rising temperatures. Research on major and minor crops for heat tolerance and disease resistance is underway. A new climate change cell with greater emphasis on crop agro meteorology modelling and cross cutting disciplinary research is being undertaken at University of Faisalabad.

Research on adaptation at the grass roots level is being undertaken by LEAD, Pakistan; World Wildlife Fund, Pakistan and IUCN, Novib-Oxfam and a number of NGO's that are focusing on livelihoods, poverty reduction and climate change linkages.

An agency of Pakistan working on upper atmospheric research is heavily engaged in monitoring impacts of aerosols on weather systems and considerable research is focused on impacts of high altitude weather systems and aerosols on the formation of fog and its impacts on productivity and health. The National Institute of Oceanography is concentrating its efforts on measuring sea level rise from climate change aberrations on the coastline of Sindh and Baluchistan. Likewise the Lahore University of Management Sciences in collaboration with WWF is recently engaged with research on adaptation strategies with greater focus on deltaic region of Sindh and the Indus River Basin (Mustafa and Reid, 2012). In 2011-12 the Harvard University under its International Water Initiative carried out several studies on the Indus Basin and also provided several international students to work on the Indus system for M.S. and Ph.D. thesis work (PWP, 2012).

An MSC level course on Environmental Economics and Climate Change has been initiated at the Pakistan Institute for Development Economics in Islamabad and the Higher Education Commission of Pakistan in 2012 has issued instructions to all its national and provincial curricula development bodies to start integrating

climate change perspective from schooling to advanced education into all education programs. There is much discussion on providing funds to support PhD thesis research and creation of centers of excellence in the hotspot universities to bring the academia in direct contract with problem to propose solutions.

LEAD, Pakistan has included Water and Climate Change impacts as a major theme for its Cohort 17 program (2012) and 20 LEAD fellows are being trained from middle to high level positions in public and private sector to assume leadership roles to address water and climate change impacts on Pakistani society and help devise future programs.

Water stands out as the fundamental sector that is likely to be adversely be impacted from Climate Change. Asia Pacific Network has supported several studies on water including the Impact of Climate Change on Water Resources in South Asia (APN, 2005). This study documents the water resources of South Asia and also highlights future research scenarios with respect to water and meteorology and has strong scientific basis and draws on international literature. Much of the forecasting research for water is carried out by the Pakistan Meteorological Department, WAPDA, Water Resources Institute (NARC, Islamabad) and often supervised and utilized by the Indus River Systems Authority. The latter is the major repository of rim station data for the nation and serve as regulatory body for allocation of water according to the 1991 Apportionment Accord.

The Ministry of Water and Power of Pakistan completed two studies focusing on water, hydropower and impacts of climate change (Amir and Tariq, 2011). This information is being used to plan future water works in the light of climate changes and challenges facing Pakistan.

Very high genetic variation among indigenous rice varieties in Sri Lanka is an indicator of the potential for varietal improvement for adaptation (Aheeyar, 2012). The need for development of different age groups of paddy (short term and long term varieties) to suit unpredictable rainfall regimes is recognized by the Department of Agriculture in Sri Lanka and several New Improved Varieties with varying yield have been developed. Although high yielding rice varieties are cultivated in almost all the areas, they are environmentally unsustainable due to high fertilizer and water requirements. Fertilizer use has raised more than four-fold after green revolution, but yield has only doubled (Aheeyar, 2012). Overall, the extent of paddy lands has increased since the establishment of peace in Sri Lanka, due to the cultivation of a large extent of abandoned paddy lands in the Northern and Eastern Provinces and implementation of fertilizer subsidy.

However, these technologies should be transferred to farm level and farmers should be convinced to accept the developed technology. Herath (2012) reveals that, most of the newly developed rice varieties in Sri Lanka are not popular among farmers and majority of the farmers are using the varieties developed about 15-20 years ago. Currently the highest percentage of rice area is planted

with old varieties released before ten years. There are empirical evidences to show inadequate seed stock and lack of access to new improved varieties at rural levels (Aheeyar et.al 2012 and 2006). Therefore the sustainability of these interventions has to be studied in the light of climate change.

Some of the technologies used at present in the Food Sector of Sri Lanka, which have an impact on the water management are;
o Soil and water conservation
o Reduction of land degradation in agriculture areas
o Promoting quality seeds and planting material
o Promotion of organic and bio-fertilizers
o Promotion of organic farming
o Development and improvement of post harvest technologies
o Promotion of inland aquaculture

Walawe left bank extension project of Sri Lanka used several new construction and management strategies to increase the water distribution efficiency. The Project employed a system facilitating the re-use of the return flow. The project has introduced innovative 'dual canal system' considering the two different soil types in the upland and low land. One canal is designed exclusively for paddy and other one is for other field crops. The technique aimed at promotion of cultivation of other field crops by using water more efficiently. A new method of paddy cultivation called 'parachute' method was introduced, which requires lower amount of water and produce higher yield. A comprehensive evaluation of these technologies is required to replicate the lessons.

Concrete lining of sub canal systems has been included in some new rehabilitation projects to reduce the conveyance losses. The success of such technologies has to be compared with the use of gabion walls, dry rubble packing, using clay and geo-textiles for similar purposes. Solar powered drip irrigation technology is another innovative and environmental friendly technology introduced to Sri Lanka, though the level of success is low.

3.5 Research needs

A number of research needs have been identified in Sri Lanka, some of which may be relevant to other countries as well. Weerakoon and De Costa (2009) suggest that, the negative impacts of the temperature and scarcity of water would be less for wet zone paddies, maximum efforts must be devoted towards achieving the full potential from wet zone rice cultivation in Sri Lanka. The anticipated problems for wet zone paddy cultivation are increased sea level rise and inundation due to high intensity rainfall. A shift in biotic pressure on the rice crop by emerging new bio types of both pest and disease and different weed population in rice field is predicted. It has been found that climate change has significantly affected the cultural practices, seed paddy broadcasting and harvesting of rain-fed paddy farmers (Ministry of Environment, 2004).
The combined effects of temperature and relative humidity at the reproductive stage of rice plant plays major role in determining yield level and quality of

rice. Therefore breeding programmes to identify cultivars that can withstand higher temperature and relative humidity during spikelet development stage is necessary as an adaptation strategy. Looking into the possibility of adjusting the cropping calendar to avoid unsuitable weather conditions is another option (Rathnayake et al, 2009).

There is also possibility of increasing cropping intensities by proper management of irrigation water.

There is an obvious gap between the research priorities and resources allocations in the non-paddy crop sector of Sri Lanka. Impacts of climate change on certain fruit species are many fold; namely, advances blossoming of fruit trees, extended growing season, and increasing pest population, which ultimately effect in productivity. However, no systematic research has been initiated to identity these issues to increase productivity and profitability and also to develop suitable adaptation strategies (Heenkanda and Pushpakumara, 2009). Several priority research areas are proposed to identify appropriate adaptation strategies for fruit crops such as potential shift of fruit growing areas, changes in flowering and fruiting phonology and stigma receptivity, changes in fruit yield and fruit qualities, and identification of new fruit species and varieties.

Being a rain-fed plantation crop, coconut can be adversely affected by prolonged dry spills associated with high temperature (Ranasinghe, 2009). Projections on coconut yield suggest that, production after year 2040 may not be sufficient to cater local consumption (Peiris et.al, 2004). Genotype and Environmental interactions based screening techniques and yield related physiological parameters are proposed to be applied successfully in the screening for drought tolerance in coconut, which is one of the approaches to increase adaptability to inevitable changes of climate (Nainanayake, 2009).
A number of field crops, including coarse grains, grain legumes, oil seeds and condiments are grown on rain-fed upland areas in the Dry Zone. The production of these crops will also be adversely affected by fluctuations in rainfall. The effect of enhanced CO2 levels in the atmosphere may be favourable for some field crops. However, the yield levels of some other field crops may reduced due to elevated CO2 (Malawiarachchi et.al, 2009). De Silva (2009) shows that irrigation requirement for chilli and tomato would increase by 18% and 14% respectively in the dry zone under A2 scenario of climate change.

Most of the horticultural crops cultivated in the up country wet zone require specific climatic conditions for high quality production and higher productivity. However, the recent past data indicates the tendency for changes in climatic conditions leading to considerable loss in production (Nugaliyadda, 2009). Therefore, new varieties should be developed to overcome this problem. Emergence of new pest and diseases were also reported in potato farming due to changes in temperature and prolonged dry condition (ibid).
In countries like Pakistan and India, where there is much dependence on glacier melt and snowfall in Hindu Kush mountainous regions, rapidly melting glaciers are a matter of grave concern (ICIMOD, 2010 and Planning Commission of

Pakistan 2008). Paradoxically, countries with rather limited water storage capacity like Pakistan (12.6 MAF) were at a comparative disadvantage when outflows of water exceeded 55 MAF during the mega-floods of 2010. Lacking such storage can further aggravate water security in South Asia. Much research is needed to quality the true economic consequences of using such huge volumes of water. The often cited justification of allowing such large volumes to the sea for environmental health must be weighted with opportunity cost in terms of water security.

Research and development in water resources management and climate change adaptation appears to be inadequate. One reason for this situation is the inadequacy of funds. Inadequacy of agro-meteorological data as well as constraints to access such data have been highlighted (GWP Nepal, 2012).

3.6 Innovations by Civil Society

A literature survey reveals that there are many small scale interventions by the civil society that contribute to climate change resilience. Despite the scale of innovations, they reflect on the needs of the society. Many of the innovations are related to power and energy requirements, which are becoming expensive due to heavy reliance on fossil fuels as a source of energy. Water lifting devices operated by human labour and renewable energy sources such as solar and wind power, are fairly common innovations. Another subject area communities seem to be interested in is the bio gas generation.

Climate change is defined as a result of unsustainable energy use. Therefore, such micro level innovations will eventually have an impact on climate change mitigation as well as adaptation. However, policy, technical and financial support is required to make these innovations have a sustained impact on community resilience to climate change.

4. ARE THE STAKEHOLDERS WELL-EQUIPPED FOR CCA – GROWING CAPACITY BUILDING NEEDS?

4.1 Communities

Communities are important for climate change adaptation in South Asia, not just because they are vulnerable to the impacts, but they have the capacity and potential to positively contribute to the adaptation process.

- Communities are better aware of localized impacts of climate change, such as groundwater occurrence and recharge, drying up of springs etc.
- Adaptation options have to be acceptable to the community. For example, social and cultural norms influence the selection of income diversification options, use of waste water for irrigation, etc.
- People live in less productive and vulnerable areas due to various reasons including poverty. Therefore, mitigation measures to address climate induced disasters have to be compatible with local social and economic realities.

- Some of the climate change impacts are not readily understood or foreseen by scientific observations. Aspects such as increased production costs due to declining groundwater table are already experienced by the communities,
- An individual's resilience to climate change is restricted by social, religious and cultural constraints. Women encounter several of them. A resilient community would require the empowerment of the most vulnerable people.
- A major part of South Asian agriculture is managed by smallholder farmers, who are vulnerable to floods, droughts and irregular rainfall. Efficient and climate-smart agricultural practices will not only improve the farmers' adaptation capacity, but would help to reduce greenhouse gas emissions from unplanned expansion of agriculture.
- The economies of South Asia are stressed to meet the rising costs of adaptation. In this situation, involvement of the communities is seen as getting to "release of social capital". Examples can be found where the community organizations are motivated to protecting forests, and conserving water sources, when provided with adequate awareness. Similarly, people have adopted solutions such as rainwater harvesting which can reduce the high capital cost of large scale water resources development and maintenance of infrastructure.

The following case studies demonstrate the opportunities to utilize the traditional knowledge in the capacity building for climate change adaptation:

There are around 2,000 traditional rice varieties in Sri Lanka. Many are very high in nutritional value and have medicinal properties, and most are resistant to extreme drought conditions, diseases and pests. However, the new-improved varieties became popular, due higher yields and the promotional campaigns. Salt-affected soils are one of the problems encountered by coastal farmers of Hambantota District in Sri Lanka. A Regional Rice Research Institute had developed two salinity resistance rice varieties, but these varieties were poorly accepted by the farmers, due to the low quality of rice according. Therefore, Practical Action South Asia pilot tested several traditional varieties among ten selected farmers and found out the most suitable varieties for salinity through participatory process. A huge demand was created in the area for these traditional salt tolerant varieties after the intervention (AHEEYAR,2012).

Tennakoon (1986) have described number of traditional wisdom and knowledge farmers had in climate forecasting in Sri Lanka. The main clues to predict a drought in the offing were; blowing of weak wind with constant change in direction, appearance of sky, sunshine and heat, misty and cold weather during the few hours before sunrise and unusual behavior of animals and plants. early nesting of weaver birds (Carpenter birds) in September, High frequency of black crow nests with multiple eggs in September, the appearance of Swallows (Vehi Lihiniya) flying very low in September or early October, excessive flowering and fruiting in Mi (Marsa perrottetiana) in August –September are indicators of heavy rain during the rainy season. Conversely, the detection of beehives more frequently in old ant hills than in upright hollow trunks, the flowering of 'Tala' (Corypha umbraculifera) , excessive bearing of wood apple, Katu keliya,

Eraminiya, Damba and mora during August- September are considered as signs of a drought in the making. Traditional communities have made several adjustments during the signs of rainfall failure such as mixed planting/sowing in chena cultivation, sowing chena before irrigated paddy cultivation, short duration paddy cultivation, staggered cultivation and bethma cultivation.

Considering the above, it is vitally important to learn from traditional knowledge and practices for climate change adaptation, which would help to mobilize community and formulate acceptable strategies.

Several climate change and related policies recognize the role played by the communities in climate change adaptation:

- The National Adaptation Programme of Action (NAPA) for Bangladesh recognizes the importance of addressing environmental issues and natural resource management with the participation of stakeholders in bargaining over resource use, allocation and distribution (BCAS, 2008). The government established a Climate Change Cell (CCC) to build capacity and to mainstream climate change issues to promote climate-resilient development in Bangladesh in 2004. The aim is to develop a uniform methodology for all vulnerable areas and to complete resulting bottom-up Climate Change Risk Reduction Plans (CCRRP).
- India's National Action Plan on Climate Change emphasizes on raising the public awareness on climate change and community based disaster management
- The goal of the Nepal Climate Change Support Programme (NCCSP) is to enable Nepal's poorest and most vulnerable communities to adapt to the effects of climate change, by supporting local level adaptation programme in the most climate vulnerable districts of the Mid and Far Western regions of Nepal. This program will assist the Government of Nepal to implement its Climate Change Policy, 2011 and develop and implement necessary strategies.

4.2 Capacity Building among vulnerable sectors of the society

The social economic and political constraints can make some sectors of the society more vulnerable than other sectors. Women are normally the custodians of children and cultural norms sometimes decide their dress, which reduce their mobility during extreme events. They are further constrained in opportunities to be trained in activities such as swimming. Their limited access to resources such as income and land can increase their exposure as well as decrease their adaptive capacity both during and following disasters.

In many parts of the region, the responsibility for fetching water, household cleanliness etc usually falls on women and girls. The decreasing quality and quantity of drinking increases their burden.
Several climate change policies recognize the role of women in climate change adaptation:

- Bhutan recognizes that knowledge in climate change and preparedness for its impacts among the local communities, schools and institutes may be achieved through developing appropriate outreach tools, engaging local communities in designing programs and integrating in school curricula. The roadmap for National Food Security of Bhutan notes the role of education and the need for strategic planning on raising awareness of communities on the impacts of climate change on food security. Bhutan's water policy recommends that, due to the central role of women as managers and users of domestic water, they shall be involved in planning, development and management of water resources programs.
- The Climate Change Policy of Pakistan recognizes both the vulnerability of women to climate change impacts, and their contribution in the management of natural resources. As such, the policy recommends to incorporate the women's role into the decision making process on climate change mitigation and adaptation initiatives, and to utilize local and indigenous knowledge, particularly held by women, in developing climate change adaptation measures.

In general, the improvement in adaptive capacity refers to either increment in financial resources, reduction in poverty, provision of diversified income sources, better governance, social and political capital and even equitable flow of resources (Smithers and Smit, 1997; Yohe and Tol, 2001). As such, a considerable effort is required to convert policies into strategies and implementable programmes (IWP, 2012).

4.3 Action on Capacity Building among policy makers and managers

At the trans-boundary level, Bhutan identifies the need to institutionalize mechanisms to share climate change information- data on rainfall, temperature, water and satellite images. Exchange of information on pest and diseases may be vital for control and prevention across the borders.

Some of the activities carried out under Research and capacity development for Climate Change in Bhutan are as follows:

- Developing capacity of technical staff and awareness of climate change for local government (Dzongkhag and Geog level) and for civil society.
- Providing seed capital to develop research proposal and small studies on climate change in Bhutan relevant for decision making, capacity development and awareness creation in Royal University of Bhutan (RUB) and other relevant institutions. Supporting researchers and students to study climate change science in neighbouring countries with strength in this field
- Developing capacity of technical staff and decision makers in the most relevant line ministries, commissions and governing bodies (BhWP,2012)

Improving the capacity in the meteorological and hydrological services in Bhutan are carried out in the following fields:

- Collection and management of climate data, analyzing weather data and improving the coverage of monitoring stations and developing climate models and forecasting.

• Early warning and hazard forecasting for the agriculture sector as well as other sectors and urban centres
• Regional networking (e.g. SAARC/SACEP, ICIMOD and ADPC) including participation in climate change projects with regional institutions.

4.4 Capacity development for Agriculture Sector in Bhutan

- Supporting research and improvement of crop management, including selection of crop varieties and introduction of crops better adapted to climate change by the Renewable Natural Resources (RNR) Research Centres in order to reduce farmers" vulnerability to water and temperature variability and their capacity to adapt to and reduce climate change risks.
- Improving the management and the utilization of land and water resources including pilot development on efficient and low-cost water harvesting to reduce vulnerability to variability in water availability for agriculture.
- Building on the traditional knowledge in rural areas on coping mechanisms in the agricultural sector.
- Implementing integrated watershed management, including forest rehabilitation in vulnerable locations, particularly in upper catchments, e.g. through pilot development in selected sensitive upper watersheds with vulnerable downstream sites.

Some of the capacity building activities in India are as follows:

- The National Cyclone Risk Mitigation Project seeks to minimize vulnerability in the cyclone hazard prone States and Union Territories of India and make people and infrastructure disaster resilient, in harmony with conservation of the coastal eco-system.
- A project entitled "Climate change adaptation in rural areas of India" executed with the Ministry of Environment and Forests (MoEF) in the lead role and commissioned by the German Federal Ministry for Economic Cooperation and Development, for the term 2009-2014
- The Asian Development Bank has initiated several infrastructure and capacity building projects on environmental sustainability Karnataka and Assam
- The project Strengthening Adaptation Capacities and Minimizing Risks of Vulnerable Coastal Communities in India (AdaptCap)in Andhra Pradesh and Tamil Nadu is financed by the European Commission.
- The Asian Disaster Preparedness Centre (ADPC) provides on-demand technical assistance for Asian Cities Climate Change Resilience Network (ACCCRN) partners during city-level project design and implementation phases (IWP, 2012)
- The National Initiative on Climate Resilient Agriculture (NICRA) project in India has selected 100 most vulnerable districts of 27 States and one Union territory (Andaman & Nicobar Islands) to transfer climate resilient technologies to the grassroots level. The approach is to focus on demonstration of available climate resilient technologies.Tthe focus is on promoting secondary agriculture and encouraging entrepreneurial talent (e.g., custom hiring of seed sowing drills, tractor, etc) (IWP, 2011).

Pakistan has taken up the issue of capacity building extensively with extensive workshops, conferences, media workshops and district level capacity building

exercises undertaken in the past several years. The climate change debate took impetuous from the 2010 and 2011 mega floods that have impacted over 20 million people.

4.5 Dissemination of information

The methodologies for dissemination of information vary from location to location, corresponding to the characteristics, preferences and traditions of the community. Rickshaw adverts to create mass awareness have been practiced in some parts of Bangladesh. In India, it is reported that government initiatives are planned to increase the number of farmers having access to weather and crop forecasting from about three million in the beginning of 2012 to about 10 million by the end of 2012. In Pakistan's Punjab Province, a traditional practice of storytelling was revived for raising awareness in climate change and mobilizing community members to undertake adaptation measures. In some areas the radio or television could have better access to farmers.

UNDP, with the support of Climate Change Secretariat of Sri Lanka has developed a "one-stop-shop" web based data base (Sri Lanka climate change adaptation portal) which include the results of the stocktaking/scoping assessment exercise and include the list of key publications, research papers, case studies, Relevant Projects, Briefs, Policy papers, etc covering different sectors including Water and Agriculture sectors (Aheeyar 2012).

Improved communication: The methodologies for dissemination of information vary from location to location, corresponding to the characteristics, preferences and traditions of the community. Rickshaw advertisements to create mass awareness have been practiced in some parts of Bangladesh. In India, the government initiatives are planned to increase the number of farmers having access to weather and crop forecasting from about three million in the beginning of 2012 to about 10 million by the end of 2012. A traditional practice of storytelling in Pakistan's Punjab Province, was revived for raising awareness in climate change and mobilizing community members to undertake adaptation measures. In some areas the radio or television could have better access to farmers.

A new channel on Agriculture, radio and mass media information dissemination and nation wide mobile phone network along with a user friendly Pakistan Meteorological Department Website is providing much needed information to communities. An innovative project on engaging grass root populations in Community Based Adaptation in 5 districts in Sindh and Punjab has been initiated (PWP, 2012).

4.6 Capacity building requirements of the sectoral institutions

IWP (2012) notes that, a major challenge in Capacity Building is to disseminate a sufficient quantity of fundamental research outputs and useful technologies

in time for adaptation to develop. The information necessary could be different depending on the regions and sectors considered. There should be a good understanding and convergence between the public sector and the private sector. The public sector should disseminate general information on climate scenarios, impacts and adaptation at a minimal cost since this information can be considered as a public good. The private sector (with the eventual collaboration of public institutions) could provide more detailed analyses by region or by sector, since these analyses require a specific effort and have a significant marginal cost (Hallegatte et al, 2011).

Accordingly, IWP (2012) points out that while the Institutions are pivotal in implementing adaptation strategies, they could be subject to increasing pressures as a result of climate change. For example, the conflicts in water distribution among users may become aggravated due climate change. Among the technical problems, the current hydrological safety factors could have to be changed considering the increase of extreme events. Therefore, the capacity building needs of the sectoral institutions should take the future scenarios and additional demands on capacity building created by them into account. BhWP (2012) also notes that the national capacity in terms of institutional, human and financial resources to deal with climate change and its impacts on water resources and food insecurity is insufficient.

4.7 Policy and institutional support to improve the current situation in Capacity Building

Policy and institutional support for incorporating the communities into the climate change adaptation process is important for several reasons. For example, temperature increases and erratic rainfall pattern requires farmers changing their planting and harvesting periods. While farmers are aware of such changes at the micro level, macro-level water releases, access to credit, machinery and infrastructure should be in place for them to implement such changes. Furthermore, reduction in production due to direct impacts such as floods and droughts, as well as indirect impacts such as crop diseases and pest attacks can drive the communities away from agriculture, thus upsetting the national food security targets.

Water services including irrigation and drinking water require close cooperation between the service provider and the consumer, to be effective and efficient. Even though there is willingness by both parties to co-operate, there has to be a catalyst to bring them together, initially. This need has been demonstrated in the GWP experiences in Wainganga river basin in Maharashtra, India and water supply to Biratnagar in eastern Nepal.

Therefore, providing policy and institutional support to incorporate local knowledge and communities to climate change adaptation process is important from a national and regional point of view. Policies and institutions should

vulnerable and excluded groups enter into the mainstream, as well as external resources for adaptation.
However, whether the policies adequately enable such community and social organizations to actively contribute to enhance the resilience of communities is not clear. In several countries the community organizations for managing drinking water and sanitation are less developed than the organizations for managing irrigation water. The role of the NGOs is not clearly defined in several climate change or water policies. Several policies consider the communities as the beneficiaries of climate change adaptation process and not as a group of potential investors in the form of social capital. The current approach inhibits learning from local knowledge, best practices and local and traditional solutions to climate change impacts.

However, the current status of capacity building among the institutions in water sector to address the needs of climate change adaptation requires a more intensive discussion among the stakeholders. Some of the questions that may need answers are:

- Are our capacities adequate to address the requirements and expectations of national policies and national strategies on climate change?
- What are the public expectations, and are our responses adequate?
- Is there sufficient policy support to improve the capacities of the water sector institutions dealing with food security?
- Do we have sufficient links with local universities, to develop our capacity?
- Are we linked with global climate change adaptation networks? Do we get the required information from them?
- Do we have sufficient regional or global training programs? Are we using the expertise available within the region in an optimum manner?
- What specific subject areas are more relevant for having training?
- What can we do to improve the collaboration among institutions to improve the adaptation capacity? (local, regional and global level)

5. CHALLENGES FACED IN THE REGION

5.1 Financial resources

For Bangladesh, the regional support in co-operative basin management of the international river water resources traversing through the country is vital for sustainable development. The subject areas that require cooperation include preparation and dissemination of accurate and timely flood and drought forecasts in the Ganges, Brahmaputra, Meghna river system to save the life and livelihoods of millions of people (Khan, 2012).

The funds that can be nationally generated for climate change adaptation in many of the South Asian counties, especially Bangladesh, fall short of the requirements. Least Developed countries including Bangladesh are now facing a scenario of declining Official Development Assistance (Khan, 2012) and this need to change. The observation made by IWP (2012) show that there should

be a good focus in the utilization of funds that are already generated. makes two observations regarding the focus of adaptation investments.

5.2 Research technology gaps

Access to climate data, their management, and forecasting and modelling capacity are constraints to Climate Change Adaptation, especially in countries such as Nepal and Bhutan. Most meteorological and hydrological stations are located in inner and southern part of Bhutan, and require manual recording. Data are not collected for the northern higher mountains ranges. Given Bhutan" s complex mountain topography, the existing network of meteorological and hydrological stations does not sufficiently reflect disparities in temperatures, precipitations, and flows over short distances. Modelling of the scenarios of climate change in Bhutan is yet to be undertaken. There is also insufficient and proper vulnerability and adaptation assessment carried out (BhWP, 2012) (Source, Strategizing Climate Change for Bhutan, 2009)

In Bhutan, water-related data are insufficient. A comprehensive inventory of water resources and aquatic ecosystem still needs to be conducted. An inventory of Ground water sources is still at the basic level. Institutional building, technology transfer, technical expertise and infrastructure strengthening are among the important requirements to be addressed.

IWP (2012) makes similar observations regarding limited modeling capacity iamong academia and identifies that as a major gap in the overall analytical framework to plan water resources.

IWP (2012) notes that the public investments in research and development on infrastructure for increasing climate adaptation in the agriculture sector needs to be improved. The National Commission on Farmers there is a knowledge gap in the existing technology. Therefore, extension becomes crucial for improving agricultural productivity. In view of the high variability in agro-climatic conditions, particularly in unfavorable areas, research has to become increasingly location specific (Dev and Sharma, 2010).

IWP, (2012) notes the need for a detailed evaluation of the technologies and procedures employed for assessment of geological or hydrological conditions relevant to water. For example the current district-wise assessment of groundwater development does not take into account the long-term trends, as the latest methodology suggests. A region might have experienced long term decline or rise in water levels; but a few years of abnormal precipitation (either drought years or wet years), may change the trends in the short run. Hence, assessment of over-draft conditions should integrate hydro-dynamics, i.e., the way groundwater levels behave (Dinesh Kumar, Sivamohan, Narayanmoorthy, 2010).

The potential future impacts of groundwater over-exploitation in a particular region on India's food security depend on: the relative contribution of well

irrigation in that region to India's food security; the degree of over-exploitation of groundwater in the region; and the degree of vulnerability of the region (Dinesh Kumar, Sivamohan, Narayanmoorthy, 2010). Database for water in India is incomplete, and there are restrictions on the public scrutiny of information, resulting in inadequate transparency.

5.3 Weak linkages, data exchange coordination and communications among stakeholders

Khan (2012) states that a communication network amongst the South-Asian countries for free flow of all types of climate change related data and paucity of adequate funds minimally required to implement the adaptation measures are immediate requirements in climate change adaptation.

Insufficient coordination among stakeholders is a major in Bhutan and this has resulted in agencies working in isolation. This has resulted in lack of synergy, and duplication and waste of resources. The coordination of information sharing and dissemination is a cross-sectoral issue, which is crucial for an integrated and holistic response to climate change at national and regional levels. In view of the limited human and financial resources to ensure the optimal utilization of these resources as well as progressive advancements in areas of water and climate change, it is important to identify the most effective mechanisms of collaboration and minimize duplication.

5.4 Policies and Institutions

Although there are commendable advances in the policy making related to climate change, several policy gaps can be identified in the region.

IWP, (2012) identifies that the policies that promote demand side management of water use and conservation is a weak link in the Indian policy framework. As such, a user has hardly any incentive to use water efficiently. The absence of appropriate pricing policy for groundwater use has resulted in the over-exploitation of ground water. In spite of a model bill for ground water use suggested by the Government of India, no meaningful progress has been made at the State (sub national) level to enact proper laws for use of ground water. A few States such as Maharashtra have attempted to bring ground water laws and, there too, a direct involvement of community or water users' association is either missing, or minimal (IWP, 2012).

Indian policies place immense importance on the building of buffer-stock, since the frequency of floods and drought has increased in the recent past thus putting a strain on food security. However, there is major mismatch between water supply and water demand for agriculture in India. Eastern India extending over Bihar and eastern UP, which is part of the Gangetic alluvium, is abundant in both surface water and groundwater. this region continues to be a net importer of food grain (Amarasinghe et al., 2004), and is agriculturally very backward (Evenson et al., 1999). This limit mainly comes from poor land availability due to

very high pressure on land; very little additional land that can be brought under irrigation; high degree of land fragmentation; poor public investments in rural infrastructure including irrigation and electricity; ecological constraints due to floods; and overall lack of institutional and policy reforms in agriculture sector (Dinesh Kumar, Sivamohan, Narayanmoorthy, 2010).

IWP (2012) points out that the Institutional reforms in water sector, which have been agreed upon, have not been implemented or they are implemented at a slow pace. Local knowledge and historical rights and entitlement sharing are not given the due consideration with preference for "imported" approaches that may lack the ability to implement in South Asia. Virtual water concept, allocation decisions based on the value of the crops and the knowledge and support for water conservation technology are some of the other policy isues in India, that need attention.

Outdated regulatory frameworks and legislation in water and agriculture are impediments to address fundamental issues of water apportionment and distribution at the grass roots level, often leading to conflicts. As the climate change can aggravate water conflicts, such constraints have to be removed on a priority basis.

Water availability for agriculture will be influenced by long term climate change, but the sectoral allocations, to a large extent are determined by the changes in demand due to socio-economic changes in the society. With lower technological and capital stocks, the agriculture sector in Nepal is unlikely to withstand additional pressures imposed by climate change without a concerted investment response.

Aheeyar (2012) identifies four major gaps that act as barriers for formulating viable adaptation policies to face impacts of climate change. They are; information gap, lack (or necessity) of an integrated agenda for action, coordination and resource mobilization gap. Effective adaptation in these sectors would be determined by the success of overcoming these major gaps. Therefore, researchers, academics and policy makers should focus their attention on measures that could help overcome these four gaps.

6. CONCLUSIONS

It is essential to design policies in such a way that they take into account the uncertainties associated with the climate change. Disaster planning and risk reduction strategies must incorporate measures to deal with the new challenges of climate induced disasters. In the agricultural sector, in addition to addressing the physiological response of plants and animals, policies should also seek to improve how production and distribution systems cope with fluctuations in yields due to climate change.

It is well accepted that as the adaptive capacity of the country decreases, its vulnerability to climate change increases, leading to a greater cost of associated impacts. So there is a need to assess the national level adaptive capacity, strengthen institutional and human capacities to implement existing policy measures, document what worked and what did not, and develop and implement climate-friendly strategies. Attention should be given to strengthen institutional arrangements and institutionalizing knowledge generation and information sharing.

Uncertainty in climate change projections is a significant barrier to developing a long-term adaptation strategies and working policies. The Governments have a role to play in preparing communities to adapt to climate change through policy, procedural guidelines and financial and institutional support. It is necessary to document what worked and what did not, document traditional adaptation practices and replicate them in appropriate climate vulnerable areas. Adaptation policies and the necessary conditions for these policies to be implemented must be identified with the communities in a participatory manner.

There are also concerns about the value of information that is generated and how it could be made meaningful for actual decision making across a variety of farmers skill levels and agro-ecological zones. In counties like Pakistan, there is substantive generation of information and data bases are being created along with Water Portals that provide information on key water parameters. Despite such improvements in infraction the institutional linkages and investments in management information systems for use at different levels of decision making appear to be a major constraint. Effective utilization of water statistics in policy decision making remains an outstanding issue for most South Asian countries. Even data that are collected are seldom put to practical use to arrive at rational and well-reasoned decision making frameworks (PWP, 2012).

It is noted that some institutions in Sri Lanka created to address CCA do not function well due lack of physical and human resources. The stakeholder technical coordination committees do not conduct meetings in regular manner. There are large volume of data and information available with different departments without proper use for decision support system. For example as pointed out by Zubair (2002), despite advances in the capacity to predict the evolution of the El Niño–southern oscillation (ENSO) phenomenon and advances in understanding the influence of ENSO on rainfall in tropical regions such as Sri Lanka, there has been limited use of climate predictions for agricultural decision-making (Zubair, 2002).

It is also observed that some countries do not have a specific policy for climate change related data management, sharing, access to information and networking. Individual institutions that maintain climate change related data, information and networks; share and access this information informally as there is no policy on information and data exchange. These individual databases are not open to outsiders as they are not networked. Improved data collection, management and dissemination would be very useful to achieve the R&D potential of the region.

REFERENCES

• "Some recommendations for Drought Prone Areas"- A brief Handout from the Local Govt. Engineering Department, Govt. of Bangladesh, Dhaka, July, 2012.

• "Steps to be taken for Mainstreaming Climate Change issues in Bangladesh" – A handout of DAE, Dhaka, 2012

• ADB, 1994. Climate change in Asia. Sri Lanka Country Report. Asian Development Bank. Colombo.

• ADBI, 2009. Post event Statement. Regional Workshop on Mainstreaming Climate Change Adaptation into Developmental Planning, Tokyo, 14 -17 April 2009, Available at http://www.adbi.org/event/2886.regional.workshop.climate.change.adaptation/, accessed on 29th July 2012

• ADBI, 2010. Summary of Proceedings, Regional Workshop on Strategic Assessment for Climate Change Adaptation in Natural Resource Management, 8-11 May 2010, Colombo, Sri Lanka

• Agrawala, S.; Raksakulthai, V.; Alast, M.; Larsen, P.; Smith, J.; and Reynolds, J. 2003. Development and Climate Change in Nepal: Focus on Water Resources and Hydropower, Paris, Organization for Economic Co-operation and Development (OECD), 64p.Retrieved from- http://www.oecd.org/dataoecd/6/51/19742202.pdf

• Aheeyar, M.M.M. 2012. Climate change adaptation in water management for food security: Recent developments in Sri Lanka-A review of Existing Knowledge and Information, Report for APAN prepared by the AHEEYAR.

• Aheeyar, M.M.M. and Bandara, M.A.C.S. 2012. Impacts and Lessons of Small Irrigation Rehabilitation Project Implemented by Dry Zone Livelihood Support and Partnership Programme, Ministry of Agriculture. Battaramulla (Un Published).

• Aheeyar, M.M.M.; Bandara, M.A.C.S. and Padmajani, M.T. 2012. Assessment of Solar Powered Drip irrigation Project- Phase 1 Implemented by the Ministry of Agriculture, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo (Forthcoming)

• Aheeyar, M.M.M.; Bandara, M.A.C.S. and Padmajani, M.T. 2012. Crop Production in Anicut Schemes in Walawe Basin, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo (Forthcoming)

• Aheeyar, M.M.M.; Henegedara, G.M. and Rupasena, L.P. 2006. Cost of Production of Paddy Cultivation in Kurunegala and Kegalle District, Research Report No. 115, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo.

• Alford, D. 1992. Hydrological Aspects of the Himalayan region. ICIMOD Publication, International Centre for Integrated Mountain Development, Kathmandu.

• Anon, 2000. Sri Lanka Water Vision 2025: Framework for Action, Sri Lanka National Water Partnership Colombo.

• Azmy, S.A.M., P. de Alwis, and N. H. Dassanayaka. 1993. Water Quality in the Irrigation Network of the Mahaweli H System. Colombo, Sri Lanka: Annual Scientific Sessions of National Aquatic Resources Agency.

• Banda, Jayathilaka P.M. 2010. National Report on Climate Change Related Information Networking, Education, Training and Public Awareness and Capacity Building, A Report Prepared for the Climate Change Division, Ministry of Environment, Battaramulla.

• Bangladesh, Rio+20: National Report on Sustainable Development, Published by Ministry of Environment and Forest, Government of Bangladesh, Dhaka, May, 2012.
• Beniston, M. 2003. Climatic Change in Mountain Regions- A Review of Possible Impacts. In: Climate Change, Vol. 59, pp. 5-31
• Bhutan Water Partnership (BhWP), 2012. Climate Change Adaptation in Water Management for Food Security: Recent Developments in Bhutan
• Chandrapala, L. 2009. Climate Change and Sri Lanka, Seminar on Climate Change and Food Security, Ministry of Disaster Management and Human Rights, Colombo, Sri Lanka.
• Chandrasekara, A.I., Wettasinghe, A. and Amarasiri, S. 1985. "Pesticide Usage by Vegetable Farmers", Annual Research Conference, ISTI, Gannoruwa, Sri Lanka.
• Chaulagain, NP. 2007. Impacts of Climate Change on Water Resources of Nepal: The Physical and Socioeconomic Dimensions. Doctoral Thesis, University of Flensburg, Germany.
• CNCCC, 2007. China National Report on Climate Change. China National Committee on Climate Change, Beijing.
• Communication from the Regional Coordinator on outline of the report on "Climate Change Adaptation: recent developments in South Asia" from the GWP-South Asian Regional office, Colombo, 2012.
• CWP Report from Bangladesh Water Partnership (BWP) entitled "Bangladesh Water Agriculture and Climate Change", Dhaka, 2012
• Dahal, R.K. and Hasegawa, S. 2008. Representative rainfall thresholds for landslide in the Nepal Himalaya. In: Geomorphology, Vol. 100, pp. 429-443.
• De Silva C.S., 2009. "Climate Change Effects on the North-East Monsoon and
• De Silva, C.S., Weatherhead, E.K., Knox, J.W. and Rodriguez-Diaz, J.A.. 2007. "Predicting the impacts of climate change – A case study of paddy irrigation water requirements in Sri Lanka". Agricultural Water management, 93 (1-2): 19-29.
• Deliberations in the 'Consultation Meeting' of Bangladesh Water Partnership (BWP) on "Climate Change Adaptation in Water Management for Food Security: Recent Developments in South Asia", held on 14 July, 2012 at Dhaka.
• Dharmakeerthi, S. 2010. Evaluation of Agrochemical Use of Vegetable Farmers in Matale District, In Abeyratne, F. and Weligamage, P. (ed.), Proceedings of the Fourth Annual Research Forum of Sri Lanka Economics Association, PGIA, Peradeniya.
• Dry Zone Agriculture in Sri Lanka", Proceedings of the 1st National Conference on Climate Change & Its Impacts on Agriculture, Forestry and Water, 10-11 Sept. 2009, Kandy, Sri Lanka.
• Ebi, K. L.; Woodruff, R.; Hildebrand, A.; and Corvalan, C. 2007. Climate Change-related Health Impacts in the Hindu Kush–Himalayas. In: EcoHealth, Vol. 4, pp. 264–270.
• Eriyagama, N.; Smakhtin, Chnadrapala, L. and Fernando, K. 2010. Impacts of Climate Change on Water Resources and Agriculture in Sri Lanka: A Review of Preliminary Vulnerability Mapping, Research Report 135, International Water Management Institute, Colombo
• GoN, 2011 (a). Climate Change Policy, 2011. Government of Nepal, Ministry of Environment, Kathmandu.
• GoN, 2011 (b). National Framework on Local Adaptation Plan for Action. Government of Nepal, Ministry of Environment, Kathmandu.

• Hartmann, D.L. 1994. Global Physical Climatology. Academic Press, San Diego.
• Heltberg, R.; Siegel, P.B.; and Jorgensen, S.L. 2009. Addressing Human Vulnerability to Climate Change: Toward a 'no-regrets' Approach. In: Global Environmental Change, Vol. 19, pp. 89-99.
• Herath S. and Ratnayake, U.R (2004) "Monitoring rainfall trends to predict adverse impacts: a case study from Sri Lanka (1964–1993)", Global Environmental Change, Elsevier, Vol.14, pp 71-79
• Herath, R.M. et al, 2012. Adoption of New Rice varieties in Sri Lanka, Paper has been accepted for Publication in Sri Lanka Journal of Agrarian Studies. (Forthcoming)
• Hettige, V. (u.d) Adapting to Climate Change in Sri Lanka, Available at practicalaction.org/media/download/6619.
• Hoek W. Van der, Konradsen F, Athukorala K, Wanigadewa T. 1998. Pesticide poisoning: a major health problem in Sri Lanka, Social Science & Medicine, Vol. 46, Issue 5, Pp 495-504.
• Imbulana, K.A.U.S., Neupane, B., Wijesekara, S. Aheeyar, M.M.M. et-al (Ed.). 2010. Sri Lanka Water Development Report 2010, UNESCO and Ministry of Irrigation and Water Resources Management
• India Water Partnership (IWP) 2012. Climate Change adaptation in water management for food security: Recent developments in South Asia, A Draft Report prepared for APAN.
• IPCC 2007. Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, (eds.) B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 23p.
• IPCC, 2007. Climate Change 2007: Climate Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Intergovernmental Panel on Climate Change Fourth Assessment Report, Intergovernmental Panel on Climate Change, Geneva
• IPCC. 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation - Summary for Policymakers. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. World Meteorological Organisation, Geneva.
• IWMI, 2007. Comprehensive Assessment of Water Management in Agriculture. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International Water Management Institute.
• Jayakody, S. 2009. Laws to tighten pesticide use, Available at http://www.lankanewspapers.com/news/2009/10/48621.html Accessed on 20th December 2010
• Jayatillake, H.M., Chandrapala, L., Basnayake, B.R.S.B. and Dharmaratne, G.H.P. (2005). Water Resources and climate change, Proceedings Workshop on Sri Lanka National Water Development Report, (eds. Wijesekera, N.T.S., Imbulana, K.A.U.S, and Neupane, B.) World Water Assessment Programme. Paris, France
• Jayawardane, H.K.W.I,; Sonnadara, D.U.J.; Jayawardane, D.R. 2005. Trends of Rainfall in Sri Lanka Over the Last Century, Sri Lanka Journal of Physics, 6: 7-17.
• Jianchu, X.; Shrestha, A.; Vaidya, R.; Eriksson, M.; and Hewitt, K. 2007. The Melting Himalayas-Regional Challenges and Local Impacts of Climate Change on Mountain

Ecosystems and Livelihoods, ICIMOD Technical Paper, International Centre for Integrated Mountain Development, Kathmandu, 15p.
• Karmacharya, J; Shrestha, A.; Rajbhandari, R. and Shrestha, M.L. 2007. Climate Change Scenarios for Nepal based on Regional Climate Model RegCM3 (Final). Department of Hydrology and Meteorology, Kathmandu, Nepal.
• Kawai, M. 2009. Opening Remarks made at the Regional Workshop on mainstreaming Climate Change Adaptation into Developmental Planning, 14-17 April Asian Development Bank Institute, Tokyo, Japan
• Kumarasinghe, N.C. 2009. Effects of Climatic Conditions on Sugarcane Cultivation Systems in Sri Lanka. Paper presented at the 1st National Conference on Climate Change & Its Impacts on Agriculture, Forestry and Water,10-11 Sept. 2009, Kandy, Sri Lanka
• Manawadu L. and Fernando, N. 2008. Climate Changes in Sri Lanka, Available at http://archive.cmb.ac.lk/research/bitstream/70130/1100/1/Manawadu_CLIMATE%20CHANGES%20IN%20SRI%20LANKA.pdf, accessed on 15th August 2012.
• Meehl, G.A. 1994. Influence of the Land Surface in the Asian Summer Monsoon – External Conditions versus Internal Feedbacks. In: Journal of Climate. Vol. 7, pp. 1033-1049.
• Ministry of Agriculture & Lands and Ministry of Irrigation & Water Management - MAL&MIWM. 2003, Proposal for Granary Area Programme, Sri Lanka
• Ministry of Environment 2010. National Climate Adaptation Strategy for Sri Lanka-2011-2016, Ministry of Environment, Battaramulla.
• Ministry of Environment 2010a. Sector Vulnerability Profile- Water, Supplementary Document for the National Climate Adaptation Strategy for Sri Lanka-2011-2016, Ministry of Environment, Battaramulla.
• Ministry of Environment 2010b. Sector Vulnerability Profile: Agriculture and Fisheries, Supplementary Document for the National Climate Adaptation Strategy for Sri Lanka-2011-2016, Ministry of Environment, Battaramulla.
• Ministry of Environment and Natural Resources (2004). Climate Change in Sri Lanka- Project Terminal Report Vol, 1, Environmental Economics and Global Affairs Division, Ministry of Environment and Natural Resources, Battaramulla.
• Ministry of Environment, 2011. Second National Communication on Climate Change. Ministry of Environment, Battaramulla.
• MoE, 2010. National Adaptation Programme of Action. Ministry of Environment, Kathmandu
• MoE, 2011. Status of Climate Change in Nepal. Ministry of Environment, Kathmandu.
• MOPE 2004. Nepal: Initial National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change, Ministry of Population and Environment, Kathmandu, pp.1-42.
• Nainanayake A. D. 2009. Screening Coconut Germplasm for Drought Tolerance – An Approach for Adaptation to Climate Change, Paper presented at the 1st National Conference on Climate Change & Its Impacts on Agriculture, Forestry and Water,10-11 Sept. 2009, Kandy, Sri Lanka
• National Planning Department, (2006). Mahinda Chintana: Vision for a New Sri Lanka, Ministry of Finance and Planning, Colombo.

• NCVST 2009. Vulnerability through the Eyes of the Vulnerable- Climate Change Induced Uncertainties and Nepal's Development Predicaments. Institute for Social and Environmental Transition-Nepal (ISET-N, Kathmandu) and ISET (Boulder, Colorado) for Nepal Climate Vulnerability Study Team (NCVST), Kathmandu.
• Sharma, K.P. 2011. Climate Change trends and Instances of Socio-economic Effects in Nepal. Jalsrot Vikas Sanstha (JVS) Nepal and Global Water Partnership (GWP) Nepal, Kathmandu.
• Shrestha et al. (1999)
• Shrestha, A.B.; Wake, C.P.; Mayewski, P. A.; and Dibb, J. E. 1999. Maximum Temperature Trends in the Himalaya and its Vicinity: An Analysis Based on Temperature Records from Nepal for the Period 1971 – 94. In: Journal of Climate, Vol. 12, pp. 2775-2789.
• Uprety, B.K., 2011. Climate Change: Living with the Threats. In: Image Nepal, Bi-monthly Travel Magazine (August-September), Kathmandu.

CA – there are issues that are particular to your country, but there are also issues which are common across the region;

- facilitate access to adaptation finance and technologies;

Asia Pacific Adaptation Network (APAN)
IGES Bangkok Regional Centre
604 SG Tower 6th floor
161/1 Soi Mahadlek Luang 3,
Ratchadamri Road, Pathumwan,
Bangkok 10330, Thailand
Tel: +66 (0)2 651 8794-99
Fax: +66 (0)2 651 8798
e-mail: info@asiapacificadapt.net
Website: www.asiapacificadapt.ne7

Global Water Partnership South Asia (GWP-SAS)
International Water Management Institute,
127, Sunil Mawatha, Pelawatta,
Battaramulla, Sri Lanka
Tel: +94 11 2880000 ext. 3301
Fax: + 94 11- 2786854
e-mail: p.dissanayake@cgiar.org
Website: www.gwpsouthasia.org

ADB IGES RRC.AP 環境省 Ministry of the Environment SEI UNEP