Global Water Partnership South Asia

ASIA PACIFIC ADAPTATION NETWORK

Technical report on Issues related to Water and Agriculture in South Asia

Prepared by GWP South Asia for the Asia Pacific Adaptation Network

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IGES is an international research institute conducting practical and innovative research for realizing sustainable development in the Asia-Pacific region.

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1. Background

1.1. General Description

As defined by the South Asia Association of Regional Co-operation (SAARC), South Asia consists of Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri Lanka. The sub-region is the origin of several religions of global importance and ancient civilizations, and therefore is rich in cultural heritage and traditions. It is also the home to about one-fourth of the world's population, supported by an inequitable share of natural resources demonstrated by having only about 4 percent and 4.5 percent (UNEP, 2008) of the world's lands and annual renewable water resources, respectively.

Within this small surface area, there is a variety of geographical features, such as glaciers, rainforests, valleys, deserts, beaches and grasslands that are normally found in much larger continents. It is surrounded by three water bodies — the Bay of Bengal, the Indian Ocean and the Arabian Sea, and it is bounded in the north by Himalayan range of mountains.

1.2 Regional Co-operation

The South Asian Association for Regional Co-operation (SAARC) was founded in 1985 and it is dedicated to economic, technological, social, and cultural development of the region. The SAARC has identified agriculture and rural, biotechnology, culture, energy, environment, economy and trade, finance, funding mechanism, human resource development, poverty alleviation, people to people contact, security aspects, social development, science and technology; communications, and tourism as areas of co-operation(saarc-sec.org, 2012).

The SAARC Environment Ministers' Dhaka Declaration on Climate Change -2008 recognized the effects of climate change on the region's agricultural production, and the limitations they impose on development options for the future. It also noted the serious risks to the livelihoods and the negative effects on the achievement of the Millennium Development Goals (MDGs). The Declaration recognized that sustainable development is the best and most appropriate way to address the threat of climate change.

The SAARC Action Plan on Climate Change (2009-2011) adopted in 2008, identifies seven thematic areas of co-operation. They include adaptation, mitigation, technology transfer, finance and investment, education and awareness, management of impacts and risks, and capacity building for international negotiations (saarc-sec.org, 2012).

The Thimphu Statement on Climate Change at the 16th SAARC Summit in 2010 agreed to commission inter-governmental initiatives addressing the subject areas of shared oceans and water bodies, mountain ecosystems, evolving monsoon pattern, and climate-related disasters. It also noted that South Asia would benefit from cooperative regional initiatives and approaches, exchange of experiences and knowledge, transfer of technology, and the best practices to address the

challenges posed by climate change. The Statement also agreed to set up an intergovernmental experts group on climate change to develop clear policy direction and guidance for regional co-operation (Thimphu Statement on Climate Change, 2012).

Therefore, it can be seen that the gravity of the climate change impacts has been understood and the need for co-operation within the region and exchange of knowledge are recognized.

1.3 Economy

The South Asian Association for Regional Co-operation (SAARC) is an economic co-operation organization in the region.

In 2009, Asia and the Pacific accounted for one third of the global GDP. However, this larger region is dominated by China which comprises 37 percent of Asia-Pacific's GDP and Japan comprising about 17 percent. India in the South Asian sub-region is the third with 15.6 percent or 5.2 percent of the global GDP (ADB, 2011).

However, South Asia is considered as a comparatively poor region in the world. In 2005, 39 percent of the South Asian population were living with less than US$ 1.25 per day, though the percentage dropped from 49 percent in 1990 (UN 2011). Poverty is reflected in many indicators related to health. There is a shortage of good quality food and poor feeding practices (UN, 2011). The underweight prevalence among under-five children, at 43 percent, is the highest in the World. It is noted that the nutrition has to be given the highest priority if the MDGs are to be achieved.

The UN report on the MDGs notes that the progress in combating child malnutrition is bypassing the poorest in South Asia, and there is no meaningful improvement among the children in the poorest households, between 2005 and 2009. While the proportion of underweight prevalence fell from 52 to 43 percent, the proportion among the poorest 20 percent fell by 64 to 60 percent only. Furthermore, children in the developing regions are twice likely to be underweight if they live in rural areas more than urban areas. The record of under-five mortality rate is also not impressive; despite gains in the recent years, there were 69 deaths per 1,000 births in Southern Asia, which is the second highest in the world.

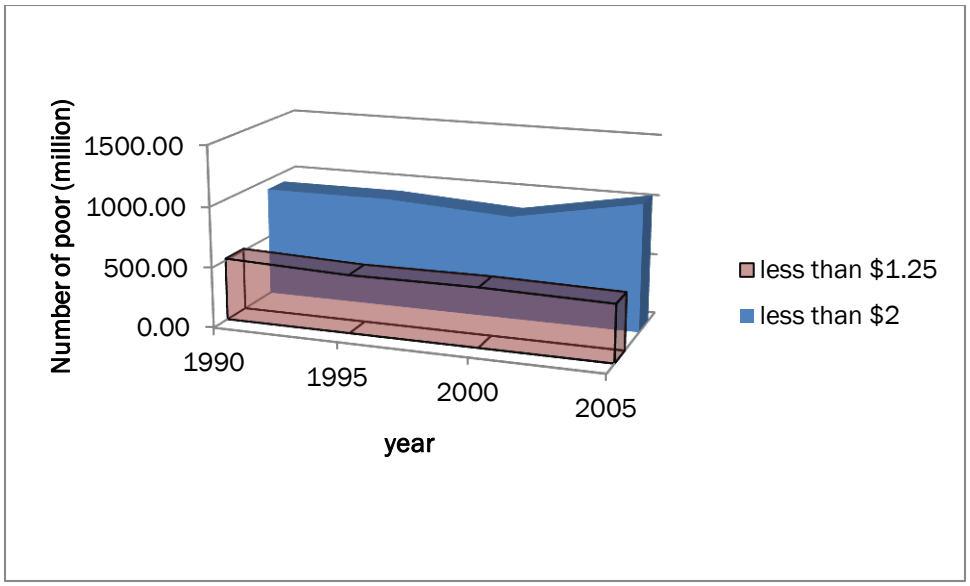

Figure 1. Dynamics of poverty in South Asia

Note: The values refer to Bangladesh, India, Nepal and Pakistan. When the exact value of the number of poor corresponding to the year was not available, the nearest year or an interpolated value was taken. Source: World Bank, 2010

The Figure shows that the poverty alleviation efforts have been successful in lifting the poorest people to better living conditions. However, most of them appear to have entered the next vulnerable category of living with less than US$ 2 per day, and the number of people in that category appears to be growing. If the livelihoods of latter are affected, it is likely that they will fall back to the poorest category.

There is a temporal dimension in poverty, especially income poverty. Explaining the concept of dynamic poverty, JBICI (2002) defines chronic poverty as a state where a household's income is constantly below the poverty line. The transient poverty is defined as a state where the income is above the poverty line but there is a possibility of the household temporarily falling below the poverty line. The study carried out by JBICI in Sri Lanka shows that availability of irrigation infrastructure and adequate water supply lower the incidence of poverty, particularly the chronic poverty. Income peaks are related to the water availability, and when there is double-cropping there are two income peaks for the year (JBICI, 2002). Accordingly, when the expected water supply is not received, agriculture-based rural incomes fall below the poverty lines temporarily.

1.4 Commonalities and contrasts

South Asia is an ethnically diverse region; with more than 2,000 ethnic entities with populations ranging from hundreds of millions to small tribal groups (Wikipedia, 2012). The South Asian countries have many similarities with regard to culture and tradition. It is generally regarded as a poor region in the world, and the majority of thepeople lives in rural areas. Therefore, poverty alleviation and rural development are given prominence in the national development agendas.

Table 1. Climate change-related parameters in South Asia

Country	Area Km^2	Population millions	Population density Per km^2	GDP/Capita US$ (2009)	Adult literacy 2004	Annual per capita water availability m^3	Area covered by forests %
Afghanistan	652,230	26.1	40	1352	28.0*	2,709	2.1
Bangladesh	144,000	146.2	1015	1593	43.0*	8,370	11.1
Bhutan	38,390	0.7	18	5167	--	114,134	69.1
India	3,287,260	1182.1	360	3266	61.0	1,603	23.0
Maldives	300	0.3	1000	6730	96.3	95	3.3
Nepal	147,180	28.3	192	1261	48.6	7,642	25.4
Pakistan	796,100	166.5	209	2700	49.9	1,064	2.2
Sri Lanka	65,610	20.7	316	4747	90.7	2,200	28.8

* For 2000-04. Source: Mujahid-Mukhtar, 2008

Sources: ADB, 2011; UNDP, 2006; FAOSTAT, 2011; AQUASTAT, 2011

But, as shown by Table 1, it is also a region of contrasts. Himalayan glaciers feed several of world's great rivers such as the Ganges, Indus, Brahmaputra - on which hundreds of millions of people depend for their livelihoods and basic human needs such as drinking and sanitation. But in Sri Lanka and the Maldives, water resources solely depend on rainfall for replenishment. Groundwater is a major source of water in countries such as India, Pakistan and Bangladesh, but surface water dominates in Sri Lanka. Literacy, which plays a major role in creating awareness, varies widely among the South Asian countries. Relevance of issues such as trans-boundary water sharing is little for the island states, while sea water level rise is not an immediate concern for Bhutan, Nepal and Afghanistan. Per-capita water availability, population density and the rate of population increase are relevant parameters having a large degree of spatial variation.

As such, while co-operation is vital to address the challenges of climate change, strategies to meet the challenge would be sometimes country-specific, and even area-specific.

2. Agriculture in South Asia

More than 70 percent of the world's irrigated areas is in Asia (Siddiqi, 2010). In South Asia, about 70 percent of the population, and about 75 percent of the poor, live in rural areas. Increase of agricultural productivity has helped improve food security and increase rural wages in this

region. Corresponding to agricultural growth, the rural poverty rate has declined significantly (World Bank, 2011).

Most of the rural people depend on both irrigated and rain-fed agriculture, livestock, fragile forests, and sometimes on casual and migratory employment. The contribution of agriculture to the national GDPs is small and declining, but the sector employs a very significant number of people.

Country	Agriculture contribution to GDP / percent	Rural population / percent	labor force employed in agriculture / percent	Agricultural Area / percent	Irrigated area / percent
Afghanistan	31.6	77	70.0	58	3.4
Bangladesh	18.6	72	48.0	65	35.1
Bhutan	17.4	65	59.4	15	1.0
India	19.0	70	56.0	55	18.9
Maldives	5.6	60	12.0	30	--
Nepal	32.8	81	66.0	30	8.0
Pakistan	21.2	64	45.0	33	25.0
Sri Lanka	12.8	85	33.0	40	8.9

Sources: FAOSTAT, 2011; ADB, 2011; CIA, 2012 and World Bank, 2011

Except in Maldives, the role of agriculture in South Asian countries is notable. In Bhutan, the low percentage of areas allocated for agriculture is due to the topography. Therefore, it can be seen that agriculture plays a very significant role in national economies and rural livelihoods in South Asia. The Maldives is an exception, but it constitutes a very small percentage of the population.

Over the years, the growth of agriculture has slowed down in many countries. There is a growing demand for high-value crops, cultivation of which would enhance the rural livelihoods. However, the high-value crops require assured water supply to minimize the economic risk, and low-value crops such as rice have a considerable impact on domestic food security.

3. Climate and water resources

3.1 Climate

The climate of South Asia varies considerably across the space, from tropical monsoon in the south to temperate in the north. The variation of climate is influenced by changes of altitude, the proximity to the sea coast, and the seasonal impact of the monsoons. The monsoonal climate prevails over most parts of the region, characterized by being humid during summer and dry during winter. It favors the cultivation of jute, tea, rice and various vegetables (UNEP, 2008).

Accordingly, the average rainfall varies from 2,700 mm per year in Bangladesh to about 300 mm in Afghanistan and Pakistan. However, annual rainfall exceeding 5,000 mm is experienced in central Nepal, Southern foothills of Bhutan, (APN-GCR, 2004) India and Sri Lanka. The Ministry of Water Resources in India notes that precipitation in India varies from a low of 100 mm in western Rajasthan to over 11,000 mm in Cherrapunji in Meghalaya (MWR, 2008).

The South Asian economies are heavily dependent on water, especially the monsoonal patterns and water supplies from glaciers and snowmelt.

3.2 Exploitation of natural resources

Except for Bhutan and Nepal, the per-capita water availability in the region is less than the world's average, with water use in this region being limited mainly to the agriculture sector. Almost 95 per cent of the withdrawn water is consumed by the agriculture sector, a much larger proportion than the average global agricultural water use (70 percent). In contrast, the region generally exhibits very limited water use in the industrial and domestic sectors. The percentage of the population with sustainable access to improved sanitation facilities in South Asia is 39 percent (compared to the world's average of 59 percent) (UNEP, 2008).

In South Asia, the percentage of surface and groundwater withdrawal as a percentage of internal renewable water resources is 58 percent (UNEP, 2008). Therefore, the region is close to the threshold level of 60 percent which is defined as "water scarcity is approaching" situation, and not too far away from the threshold of 75 percent, above which the sustainable limits of water withdrawal are exceeded.

The rural poor are at a disadvantage to access clean drinking water as well. Access to improved sanitation in Southern Asia increased to 36 percent, but remains as the second-lowest in the world. The positive point is that the gap between the rural and urban population in accessing improved sanitation appears to be reducing, though the urban residents in South Asia is 2.2 times more likely to use the improved sanitation facility than the rural residents (UN, 2011).

3.3 Climate change and adaptation challenges

IPCC Fourth Assessment Report (Parry et al, 2011) notes that the water and agriculture sectors are likely to be the most sensitive to climate change-induced impacts in Asia. While rice production in Asia is predicted to drop by 3.8 percent by the end of the 21st century, larger reduction in the yields is to be experienced in South Asia. Due to glacial melt, river runoff will initially increase but would decrease later due to loss of ice resources. Over-exploitation and salinity intrusion will further reduce groundwater resources in South Asia.

South Asia produces substantial food grain; India was the second highest cereal producer in Asia in 2005 (Parry et al, 2005). But the sub-region is also considered as the least food-secure sub-region considering the proportion of undernourished. Climate change is expected to increase the rice prices by 29 percent to 37 percent, compared to a no-climate-change case, resulting in a dramatic increase in childhood malnutrition. The Agricultural GDP would drop particularly in South and Southeast Asia resulting in an increase of poverty. When a combination of a group of indicators representing

exposure, sensitivity and adaptive capacity are considered, Afghanistan, Bangladesh, India and Nepal are among the most vulnerable countries to climate change in Asia-Pacific (ADB, 2009).

South Asia has generally been a disaster-prone region. The western parts of the Indian sub-continent including the deserts in Punjab, Thar Desert in Pakistan, Rajaputna desert and Gujarat State of India are considered drought-prone. About 263 million people in India live in drought-prone areas that are considered to extend over about one-third of the country. Floods have been experienced in India, Pakistan, Bangladesh, Nepal (APN-GCR, 2004) and Sri Lanka, some of which have been devastating. About 60 percent of the landmass of Bangladesh is considered flood-prone and about 25 percent is flooded every year. An increase of extreme flood events has been experienced in the recent years in Bangladesh (APN-GCR, 2004).

Glacial lakes which form by melted ice result in Glacial Lake Outburst Floods (GLOF) in the higher mountain areas of Bhutan, India, Nepal and Pakistan. Such events are highly unpredictable and damaging. Studies also have shown an increase of extreme rainfall in many of the countries, including Pakistan (APN-GCR, 2004).

Both floods and droughts heavily devastate the agriculture, resulting in its negative growth sometimes, and affecting a vast number of people who depend on it. Long-standing floods and droughts reduce the plant growth and productivity of crops such as rice. On the other hand, high-value crops cannot be grown in flood-prone areas due to the high financial risk, reducing the opportunities for commercialization of agriculture. Floods destroy livestock as well.

Gender issues are an important dimension in climate change adaptation, particularly in South Asia. This importance is, in many ways, linked to heavy dependence on agriculture as a livelihood. Women play a significant role in agriculture, and when the urbanization and availability of off-farm employment increase, women have to increase the inputs to agriculture. Women play key roles in drinking water supply and sanitation at the domestic scale. As such, the vulnerability of women to the impacts of climate change is high.

However, the adaptation and coping capacity of women could vary among the countries. The Gender Development Index shows a considerable variation from Sri Lanka to Afghanistan. Similarly, the female literacy rate is much lower than male literacy rate in most of the countries except Maldives and Sri Lanka (Mujahid-Mukhtar, 2008). Gender parity index for gross enrolment ratio in primary, secondary and tertiary education (i.e. school enrolment ratio of girls to that of boys) were 95, 89 and 74 percent, respectively. It shows an improvement from 1999 to 2009 but lags behind the targets. The share of women in non-agricultural paid employment has also improved in South Asia from 1990, but still only 22 percent (UN, 2011). Apparently, the inadequate access to education limits the women's ability to disengage from water-intensive low-skilled livelihood

4. Country profiles

4.1. Afghanistan

4.1.1. Agriculture and water

Afghanistan extends over 652,230 km^2, out of which about 78,000 km^2 (12 percent) is arable (FAOSTAT, 2011). About 80 percent of the area is either mountainous or desert area (ADB, 2003). As such, the land that can be used for productive activities is limited. The forest cover is limited to about 2 percent and has gradually reduced over the years. The main reasons for the shrinkage of forest cover are the demand for fuel wood and illegal logging.

About 13,000 km^2 is rain-ed. The estimated area under irrigation varies from about 26,000 (Qureshi, 2002) to 32,000 km^2 (FAOSTAT, 2011), which is about 4 to 5 percent of the area. But the irrigated agriculture provides for about 85 percent of all of the agricultural outputs (ADB, 2003). The agriculture sector contributes about half of the GDP as well (World Bank, 2011). The country has a population of about 32 million, of which 77 percent live in rural areas (FAOSTAT, 2011). The majority of rural population is small subsistence farmers who live off small plots of land. Therefore, management of water resources is a vital factor for the economic growth, for maintaining the rural livelihoods, and for meeting the people's needs for food and fiber.

The climate of Afghanistan varies from arid in the South and Southwest to semi-arid in most other parts of the country. The high mountain ranges of Hindu Kush and Pamir are moderately humid and covered by permanent snow and glaciers at altitudes above 5,000 m. A few locations in the northern slopes of Hindu Kush above 1,000 m altitude receive sufficient rainfall for rain-fed agriculture. But in most of the areas, the climate is not favorable for such type of agriculture. Without irrigation the arid to semi-arid areas cannot support any agricultural activity (Qureshi, 2001).

The snow on the high mountains such as Wakhan, Hindu Kush and Baba are the major sources of water. More than 80 percent of the country's water resources originate in the Hindu Kush mountain ranges at altitudes above 2,000 m, which function both as a natural storage of water in winter and a source of perennial flow through snow melt in summer.

Amu Darya, Helmand River, Kabul River, and Harirud and Murghab rivers are the major rivers of Afghanistan. The waters of these rivers are shared with Iran, Pakistan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. The Amu Darya, one of the longest rivers in Central Asia, flows into the Aral Sea. The Harirud-Murghab River representing approximately 12 percent of Afghanistan's water resources flows into Turkmenistan. The Helmand River, shared between Afghanistan and Iran, is the longest of Afghanistan's rivers. It originates in the Hindu Kush mountain range, and flows to Iran. The Kabul River originates in the West of Kabul city, and flows east past Kabul and Jalalabad, north of the Khyber, then pass into Pakistan, and joins the Indus River. The Kabul River Basin and tributaries represent approximately 26 percent of the water resources in Afghanistan.

4.1.2. Water-related Issues and challenges

Afghanistan went through a period of civil strife which naturally affected the growth and development. As such, challenges faced by Afghanistan are similar to many other countries that have experienced wars and conflicts.

- Poverty is one of the major challenges to food and water security. According to the data from the National Rural Vulnerability Assessment, almost half of the rural population in 2003 had food expenditures less than that required to purchase adequate calories (2100 calories/person/day) (World Bank, 2011).

- Less than 50 percent of the irrigated areas are used to grow double cropps. Irrigation system efficiency is around 25 percent, but there is a potential for improvement. While involving the community in management is an option, it has been observed that the irrigated area can be expanded (ADB, 2003) provided that resources including water are available.

- Only about 15 percent of the runoff contributes to groundwater, which has strategic importance in drought management. Policy improvements are needed to manage groundwater better.

- Livestock raising, which plays an important role in the rural economy is facing sustainability challenges. Severe overgrazing and the recent drought have contributed to decline of the livestock population (World Bank, 2011).

- About 30 percent of the country's available water resources are currently being used. Water use efficiency and productivity are very low. Irrigation and rural water supply infrastructure have deteriorated due to strife, drought, and lack of maintenance.

- The country's limited forest resources (about 2 percent of the area) is depleting due to logging, using for firewood, overgrazing by livestock and the recent droughts. Reduction in forest and ground cover on the hillsides has led to floods, widespread soil erosion, and reduced water retention in aquifers.

- Inadequacy of physical infrastructure, necessary regulatory framework, and skilled staffs in public and private institutions are constraints to build a modern and competitive agricultural sector (World Bank, 2011).

- Inadequate coordination among water management policies and institutions, inadequate recognition of climate change as a national priority and aspect needing policy coverage and inadequate research and development structure reduce the adaptation capacity.

4.2. Bangladesh

4.2.1. Agriculture and water

Bangladesh extends over 147,570 km^2, out of which land area comprises 134,000 km^2. The country has a fairly large area under water bodies. About 79,000 km^2 (60 percent of the land) is arable. The agricultural land is estimated at about 70 percent of the land area (USAID, 2010).

Population of Bangladesh was 146 million in 2010. Out of this, 72 percent lives in rural areas (ADB,

2011). The GDP per capita was US$ 1,677 in 2010 (ADB, 2011). 48 percent of the total employed was in agriculture in 2008 (ADB, 2011). The rural economy constitutes a significant component of the national GDP, with agriculture (including crops, livestock, fisheries and forestry) accounting for 21 percent and the non-farm sector, which is also driven primarily by agriculture, for another 33 percent (World Bank, 2011). Rice, Jute, wheat, sugarcane, potato, pulses, tea, and tobacco are the principal crops of Bangladesh. Crop diversification programme, credit supply, extension of work and research and input distribution policies by the government are yielding positive results (Khan, 2012).

Annual precipitation in Bangladesh is 2,666 mm which provides a precipitation volume of 384 km^3. The total internal renewable water resources are 105 km^3. But when the volume of water entering and leaving the country is considered, the total renewable water resources are estimated at 1,227 km^3 (AQUASTAT, 2012), resulting in annual per capita water availability of 8,370 m^3.

There are more than 230 rivers in Bangladesh; 57 of them are transboundary rivers or international water courses (Khan, 2012). Bangladesh is the terminal floodplain delta of three large rivers - Ganges, Brahmaputra and Meghna (World Bank, 2011). Brahmaputra river basin splits into two branches: the larger branch flowd south as the Jamuna (Jomuna) and flows into the Lower Ganges, or Padma. Another branch curves the Southeast as the lower Brahmaputra and flows into the Meghna. Both paths eventually flow out into the Bay of Bengal (Ahmed, S. undated)

Climate of Bangladesh can be classified as tropical monsoon. The four main seasons are pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November) dry season (December-February). About 80 percent of the total rainfall occurs in the monsoon (AQUASTAT, 2012).

4.2.2. Water-related Issues and challenges

- About 53 percent of the rural population in Bangladesh is classified as poor. Among other reasons are the country's vulnerability to water-related natural disasters (World Bank, 2011) inequitable land distribution and small land-holding size by the rural poor (USAID, 2010), making poverty alleviation and meeting the related MDG targets very challenging tasks. In turn, poverty reduces climate change adaptation capacity of the people.
- Being a densely populated country increases vulnerability of Bangladesh, making re-location from unsafe areas difficult.
- The rapidly growing population and increased urbanization have caused the cultivated areas to decline at a rate of 1 percent per year. High cropping intensity ranging about 175 percent implies that growth in the agriculture has to result from intensification, diversification and value addition (World Bank, 2011). However, increased irrigation efficiency is also an option.
- The water resources are dependent on glacial melt. Warming is expected to change the river flows with increased flows and floods in the short term and reduced flows and droughts in the long term.
- Water resources are also heavily dependent on the transboundary rivers. The country is located in the terminal floodplain delta of three large rivers (World Bank, 2011). About 90% of the

- catchment areas of the above mentioned three rivers lies outside Bangladesh. 80 percent of the river flows comes during the four monsoon months (Khan, 2012). While increased extraction in the upstream reduces the dry-season flows to Bangladesh, more than 90 percent of flood-causing flows are attributed to the transboundary rivers (Khan, 2012). About 20 to 30 percent of the country is flooded every year. This causes serious damage to the infrastructure, crops and overall economy.
- About two-thirds of the land area is less than 5 meters above sea level (APAN, 2012). It is predicted that sea level will rise by 62 cm in 2080 due to climate change, inundating about 4,700 km^2. Increased rainfall and storm surges will inundate more lands. Agriculture contributes to about 30% of the GDP in the coastal areas, which will be affected due to climate change (Khan, 2012).
- River bank erosion is a major problem in rivers such as Brahmaputra/Jamuna and Ganges/Padma. Increased peak discharges due to climate change are predicted to increase the problem (Khan, 2012).
- There are non-climate related phenomena such as over-extraction of groundwater for irrigation that are complimentary to low-lying nature of the land, resulting in salt water intrusion to groundwater. Arsenic contamination of groundwater is a major concern, and over-exploitation is considered as one contributing factor. Although the government is trying to increase the surface water utilization, flat topography and alluvial soils reduce surface water storage options (Khan, 2012).
- The Government of Bangladesh has made large investments to protect against floods and cyclones. However, issues such as public and private roles and community participation in disaster management, environmental protection, and institutional reforms are among the issues to be addressed (World Bank, 2011).
- Several factors mentioned above make Bangladesh highly vulnerable to floods, droughts and sea level rise. Climate change is expected to make the situation worse. Among the phenomena that affect agriculture include the projected changes of river flows, inundation resulting from inadequate surface drainage, sea level rise, salt water intrusion, and increased occurrence of floods (USAID, 2010). Location-wise, coastal and flood plain agriculture are the most vulnerable. The contribution of agriculture to the GDP and the employment opportunities in agriculture will reduce due to climate change.

4.3. Bhutan

4.3.1. Agriculture and water

The Kingdom of Bhutan spreads over an area of 38,394 km^2, out of which about 3.3 percent is arable. The agricultural land is estimated at 5,630 km^2 or 15 percent of the total land. The agricultural land in Bhutan is under increasing competing demand from urbanization (World Bank, 2011). It is a landlocked country.

Population of Bhutan was 734,000 in 2011. Out of this 65 percent lives in rural areas (FAOSTAT, 2011). The GDP per capita was US$ 5167 in 2009 (ADB, 2011).

The total annual renewable water resources are estimated at 65 km^3 and per-capita annual water resources are 106,000m^3.

The climate of Bhutan is influenced by the western winds originating in the Bay of Bengal. The monsoon period is from June to early September, preceded by light showers in pre-monsoon from April to May. Occasional downpours occur during the post-monsoon period from October to November and the rest of the year is generally dry.

Bhutan has a subtropical climate in the southern foothills which are hot and humid during monsoon and chilly during winter. The annual precipitation ranges from 2500 to more than 5000 mm. The climate is temperate in the middle valleys or inner hills with a cold winter and hot summer, and the precipitation ranges from 1000 to 2500 mm. The alpine climate in the northern part of the country is cold throughout the year with precipitation ranging from 500 to 1000 mm.

The AmoChhu (Toorsa), Wang Chhu (Raidak), PunatsangChhu (Sunkosh) and DrangmeChhu (Manas) are the major rivers in Bhutan, and they drains into the India. Nyera Ama Chu, Jomotshangkha Chhu and Shaar Chhu are smaller river basins. The large rivers are characterized by steep longitudinal gradients and narrow steep-sided valleys. Some of the rivers are fed by the glacial lakes. The occasional outbursts of such lakes result in extensive floods and damage in the downstream. During the dry season, the major source of water for the rivers is the snowmelt, and groundwater recharge is low due to topography-influenced nature of the river flows (Climate change – resources, 2012).

4.3.2. Issues and challenges

- The agricultural land in Bhutan covers only 7.8 percent of the country, which is under increasing competing demand from urbanization. The current level of food production is generally sufficient for an adequate per-capita food consumption level. But the subsistence agriculture intensifies land scarcity issues, and therefore diversification and commercialization of agriculture is needed.
- Bhutan has adopted strong conservation ethics and there is commendable commitment. However, soil erosion, deforestation, and overgrazing are common, especially in densely populated areas. There is a need to involve the communities and private sector in agriculture and natural resources management (World Bank, 2011).
- Climate change can aggravate the issues such as erosion. Already the sediment in rivers affects the output and economic life of the hydropower plants. In addition, melting of glaciers and Glacial Lake Outburst Floods (GLOF) occurrence are increasing, resulting in water-related disasters. Low capacity of river flow regulation (NEC, undated) would increase the adverse impacts.
- Climate change impacts on water resources would adversely affect agriculture as well. Risks include possibility of extinction of traditional crop varieties, loss of soil fertility due to erosion of topsoil and loss of cultivable lands due to flash floods, landslides and loss in crop yields due to hailstorms (APAN, 2012).
- Bhutan has a huge hydropower potential, but less than 2 percent is developed (NEC, undated). Financial resources and sustainable development with dueregard to environment, climate change induced flash floods and sedimentation are the challenges to improve hydropower development.
- The National Environment Commission (undated) notes that “high per-capita availability of water at the national level is in stark contrast to local water scarcity”. This local water scarcity is related

- to the terrain, and has to be resolved with investment in water infrastructure and local solutions such as rain-water harvesting.
- Changing lifestyle, increased demand from agriculture, urbanization and water pollution which are common to the region are challenges to Bhutan as well.
- Other challenges include the need to strengthen water-related research and improved collaboration among regional experts in all water-related subjects.

4.4. India

4.4.1. Agriculture and water

India, the largest country in the sub-region, extends over 3,287,260 km^2. About 1,581,450 km^2 or 48 percent is arable. The agricultural land is estimated at 55 percent of the total land.

Population of India was 1,241.5 million in 2011. Out of this, 70 percent lives in rural areas (FAOSTAT, 2011). However, the fast economic growth in India is expected to increase the urban population creating pressure on agriculture (IWP, 2012). The GDP per capita was US$ 3,535 in 2010.

The climate varies from monsoonal in Uttar Pradesh, Madhya Pradesh, Bihar and West Bengal to arid in Haryana and Rajasthan in the West.

Slightly different estimates of India's water resources are available from different sources, and two sources are cited below:

Table 2. Estimates of water resources of India

Parameter	Source: Ministry of Water Resources (MWR), India	Source: AQUASTAT
Precipitation mm/year		1083
Precipitation volume km3	4,000	3,560
Surface water entering the country/year km^3	500	635
Total internal renewable water resources/Annum km^3		1,446
Total renewable water resources/Annum km^3 (Actual)	1,869	1,911
Annual TRWR/per capita	1,581	1,616

Due to various constraints of topography anduneven distribution of resources over space and time, it has been estimated that only about 1123 km^3 including 690 km^3 from surface water and 433 km^3 from groundwater resources can be put to beneficial use (MWR,2009)

Being the largest country in the sub-region, there are vast differences and variations with regard to the water resources across the country. Amarasinghe et al, (2004) divides India's land area into 19 major river basins. The per-capita water resources in these basins vary from 240 m^3 in the Sabarmati basin to 17,000 m^3 in the Brahmaputra basin. Irrigation withdrawals are estimated to be

more than 80 percent of the total withdrawals. The Ganga-Brahmaputra-Meghna drainage area is the largest of the 19 major basins and covers about 34 percent of the country.

Climate change impacts on Water Resources:

There are substantial spatial differences in the projected rainfall changes. The maximum expected increase is 10 to 30 percent and it is expected to occur in the central India. Surface air temperature shows comparable increasing trends by as much as 3 to 4° C towards the end of the 21st century. The warming is widespread over the country, and relatively more pronounced over the northern parts of India. (MWR, 2009)

National Action Plan on Climate Change

The Prime Minister's Office in India documented the National Action Plan on Climate Change in June 2008 (http://bcsd.teri.res.in/documents/pdf/napcc.pdf). There are eight National Missions which form the core of the National Action Plan, forming a long-term and integrated strategy to address climate change. Among the eight missions are the National Water Mission which aims to ensure integrated water resource management to make water use more efficient, the mission for sustaining the Himalayan Ecosystem for sustaining and safeguarding the Himalayan glacier and mountain ecosystem, and the national mission for sustainable agriculture aiming to devise strategies to make the Indian agriculture more resilient to climate change.

The share of agriculture is about 19 percent of India's GDP (CIA, 2012). However, this indicator does not adequately reflect on the importance of agriculture in the economy and politics of India. India's Green Revolution of the 1970s enabled the country to achieve self-sufficiency in food-grains and stave off the threat of famine. Agricultural intensification in the 1970s to 1980s saw an increased demand for rural labor that raised rural wages and, together with declining food prices, reduced rural poverty (World Bank 2011).

4.4.2. Issues and challenges

- About 70 percent of the population lives in rural areas, a large number of whom are poor. Most of the rural poor depend on the rain-fed agriculture and fragile forests for their livelihoods (World Bank, 2011). Combined with high population density, this exerts pressure on the ecosystems.
- Since the beginning of the new millennium, there has been a slowdown in agricultural growth which is a major cause for concern. India's rice yields are low compared to some of the major rice- producing countries. While the productivity is fairly high in sugarcane, potato and tea, improvements are possible for most other agricultural commodities (World Bank, 2011), which will reduce the demand for water.
- India's economy is closely tied to its natural resource base and many livelihoods are based on sectors such as agriculture, forestry and fisheries which are climate-sensitive. Climate change could alter the distribution and quality of India's natural resources and affect the livelihoods.

- Many river basins in India are predicted to face water-stress conditions due to climate change. The reasons are change in rainfall-runoff patterns and alterations to snow and glacier melt contributions to river flows (APAN, 2012). Eventually, the impacts would transfer to agriculture.
- While it is known that climate change would increase the variability of rainfall, temperatures and occurrence of floods and droughts, the spatial variation of such changes are not easily predictable. To address the anticipated water stress, larger water storage is necessary (IWP, 2012).
- Water quality concerns would add to the water stress. IWP (2012) notes that water quality in Ganges river system is particularly badly affected due to high population density, high-intensity agriculture, loss of forest cover and reduced river flows.
- Institutional arrangements for water resources management are required to be improved. MWR (2009) recognizes this need and recommends setting up legally-empowered basin authorities representing all stakeholders, including Governments and departments of the Government, water users and consumers.
- There is a need to improve efficiency of individual irrigation system for optimum use of developed water resources, and to reduce non-beneficial water uses such as evaporation/evapo-transpiration of the swampy areas. Improvements to drainage systems in water-logged areas are required as well. MWR (2009) recommends benchmarking and annual performance evaluation of the irrigation systems on an annual basis, participatory management and eventual transfer of downstream sections of irrigation systems farmers.
- Demand-side management of water needs to be improved. Poorly planned groundwater development, absence of a pricing policy in groundwater exploitation, lack of incentives to use water efficiently and inadequate involvement of water users in enacting groundwater legislation result in inefficient use and over-exploitation of the resource. IWP (2012) notes that price structure of groundwater use for irrigation is *ad-hoc*, irrational and perverse. Over-exploitation of groundwater is already resulting in a fall of groundwater levels (MWR, 2009).
- The contribution of rain-fed area to food security and poverty alleviation is significant (IWP, 2012). About 65 percent of the net cultivated area is rain-fed, and this area contributes to 45 percent of rice production. Therefore, rain-fed agriculture and related livelihoods are more vulnerable to change of rainfall pattern. High-intensity rainfall and floods would increase the risk to high-value and horticultural crops, affecting both national and individual economies (APAN, 2012). Methodologies to improve the availability of water and water use efficiency in rain-fed cultivation are important (IWP, 2012).
- In addition, rainfall in India is concentrated in less than forty days per year, on average. Less than 30 percent of rainfall is harvested. Therefore, rainwater harvesting is crucial for water and food security and the required technology is available within the country (IWP, 2012).
- It is noted that the settlement of inter-state water disputes takes a very long time. MWR (2009) recommends implementing the reforms to settlement process.
- There is a need to improve the institutional arrangements in the water sector. It is recommended to internalize the climate change concerns in the current institutional structure with necessary modifications (MWR, 2009).
- Modified programmes for data collection, capacity building, working procedures and research are required to accommodate the climate change concerns.

- Among the other issues related to water management, inequitable allocation of water and deteriorating irrigation infrastructure, it is noted that many states lack the incentive, policy, regulatory, and institutional framework for efficient, sustainable, and equitable allocation of water. The existing infrastructure has rapidly deteriorated as operations and maintenance are given lower priority (World Bank, 2011).
- There is a need to improve research and development, concentrating on integrated research on water and climate change (APAN, 2012)

4.5. Maldives

4.5.1. Agriculture and water

The Maldives is an archipelago of 1,190 islands located in the West of India (World Bank, 2011). The total land area is less than 300 km^2, out of which about 90 km^2 (30 percent) is agricultural land (FAOSTAT, 2011).

The estimated population in the Maldives is about 300,000 residing on 198 inhabited islands. The population density in the country is 977 per km^2; one of the highest in the world.

Maldives receives an annual rainfall of 1,972 mm. Accordingly, the total annual renewable water resources are estimated at 0.03 km^3 (300 million m3), which consist mainly of groundwater. The per- capita annual water resources are 95 m^3.

Among the South Asian counties, the Maldives are comparatively natural resource-poor. However, they have achieved good economic growth. The per-capita GDP was US$ 8016 in 2010 (ADB, 2011). These economic achievements have been complemented by improved living standards such as high literacy, low maternal and child mortality, declining poverty levels, and improvements in service delivery (World Bank, 2011). Poverty levels are also low.

The role played by agriculture in the Maldives is small. Agriculture contributed to only 5.6 percent of the GDP in 2009 (CIA, 2012). The agriculture sector employed 12 percent of the total labor force in 2006 (ADB, 2011).

4.5.2. Issues and challenges

- Agriculture presently accounts for less than 3 percent of the GDP. Most of the domestic agriculture demand is met through imports: the ratio of food imports to domestic food production is 10:1. While some islands contain sufficient soil and water conditions to support increased agricultural production for certain horticultural products, fishing is still seen as the traditional livelihood opportunity.
- Global warming could lead to an average sea level rise and especially low-elevation small island states such as Maldives. The potential impacts include coastal flooding, increased storm damage, and contamination of fresh water by salt water. Given that most islands in Maldives have less than a two-meter average elevation, even a moderate rise in sea level could submerge many islands in the longer term (World Bank, 2011)

- One of the severest and most damaging effects of improper resource management is soil erosion which, on atolls, depletes an already scarce resource. Soil erosion occurs to a large extent on the islands' shorelines and in areas of agricultural activity (Zuhair, undated).
- The agricultural systems in the Maldives consist of a mixture of traditional and new practices. One of the problems is to find an agricultural system that is both productive and sustainable (UNESCAP). For example, at present, the majority of agricultural activities in Maldives rely on sunken wells and manual watering for crop irrigation. That procedure prevents over-exploitation of water resources.
- The decline in land productivity in the Maldives is the result of overuse of soil resources and reliance on external inputs, which reduce the productivity. Over-cropping with limited crop rotation or fallow periods has resulted in depletion of soil organic matter and nutrients on some islands.
- Although not a serious problem yet, the islands have a potential to be affected by water-logging and build-up of salinity. Pollution and intrusion of salt water is an emerging problem due to population increase, agricultural and industrial activities.
- The low level of organic matter in the soils is conducive for leaching of pesticides and fertilizers into the groundwater.
- However, in some islands mechanized irrigation systems such as pumps are used to draw water from a number of sunken wells through large hoses. Water application is not efficient as a substantial part of water is evaporated. There is a need to find more efficient irrigation methods (Zuhair, undated)

4.6. Nepal

4.6.1. Agriculture and water

Nepal extends over 147,180 km^2, out of which about 23,570 km^2 or 16 percent is arable (FAOSTAT, 2011). The agricultural land is estimated at 42,100 (29 percent of the total land). Population of Nepal was 30.5 million in 2011. Out of this 81 percent lived in rural areas (ADB, 2011).

The GDP per capita was US 1,255 in 2010. The agriculture sector contributed to 33 percent of the GDP (CIA, 2012) and employed 66 percent of the total labor force (ADB, 2011). Contribution of rice alone, to the GDP is about 16 percent. Three main reasons for making Nepal one of the most vulnerable countries to climate change impacts include fragile mountain ecosystem, extreme variability of climatic pattern and poverty. High dependency of the economy on agriculture increases the vulnerability of the people to the impacts of climate change (Sharma, 2010).

The total annual renewable water resources of Nepal resulting mainly from annual precipitation of about 1,500 mm, are estimated at 210 km^3 (AQUASTAT) and per-capita annual water resources are 6,892 m^3. The climate can be described as monsoonal - about 75 percent of the total annual rainfall occurs during the monsoon period of June – September (ICID, www.icid.org/v_nepal.pdf). A part of the precipitation falls as snow at elevations above 5,100 m in summer and above elevations of 3,000 m in winter. There are more than 6,000 rivers, and they drain into the Ganges River. The country can be divided into five river basins, which are from West to East:

- Mahakali River Basin, which is shared with India;
- Karnali River Basin;
- Gandaki River Basin;
- Kosi River Basin, with the upper catchment located in China; and
- the southern river basins (AQUASTAT, 2012)

Agriculture is the principal source of food, income, and employment for the majority of thepopulation, especially the poor. Therefore, agricultural productivity enhancement is very important for poverty reduction (World Bank, 2011). Domination of low-value cereals and subsistence production in agriculture are constraints to improve the incomes of the farmers.

4.6.2. Issues and challenges

- The observed changes in climate, especially rainfall, are similar to the other parts of the sub-region. They include increased frequency of extreme rainfall events, overall decrease in annual rainfall in arid and semi-arid regions, decreasing snow cover and groundwater levels, drying-up of springs, delayed or unreliable rainfall pattern, these are some of the observations (Sharma, 2010). The river flows that are dependent on glacial melt are expected to change, with increased flows and floods in the short-term and reduced flows and droughts in the long-term.
- Climate change is expected to increase the risk of Glacial Lake Outburst Floods (GLOF).
- As expected, such variations in climate have resulted in increased occurrences of flood, drought, and landslide. Such events will contribute to loss of soil fertility and cultivable lands, and would result in a decrease in crop yields and agricultural productivity, affecting traditional crop varieties as well.
- Drying up of sources, decreased surface and groundwater flows and pollution have negative effects on meeting domestic water supply needs of the increasing population. Such changes to water availability have contributed to additional burden on women and children to fetch water for domestic needs, collection of firewood and fodder. Similarly, the demand for water from the allied sectors such as hydropower, industry, drinking water and sanitation is increasing, resulting in completion for water.
- Poorly-managed watersheds increase the stress and decrease sustainability of water resources. Other factors affecting vulnerability include weaknesses in technological capacity, infrastructure, policy and institutional arrangements.
- Improvements in climate and weather-related data management and efficient information flow at national as well as regional levels is required (Sharma, 2010).
- There is a need for stronger incorporation of climate change impacts and adaptation measures to the national policies and planning process (NAPA,). The commitment in translating water resources policy into investment, planning and prioritization at the national, regional and local levels is inadequate. There is also a need for water regulations to implement the water policies

- when prepared. In general, the policy, regulatory and institutional framework is inadequate (GWP Nepal, 2012).
- Improvements are needed in research and development, capacity building and awareness creation among communities. Similarly, a planned effort in optimizing water uses through Integrated Water Resources Management (IWRM). Technical and social measures to make irrigation systems more efficient through research and innovations are much needed.
- Full irrigation potential has not been achieved in Nepal. Less than 40 percent of cultivable land is irrigated and the annual value is only 17 percent. The potential is estimated at about 67 percent. Institutional problems and inadequate resources for operations and maintenance affect achieving the potential (World Bank, 2011). Landslides, soil erosion and flash floods may further deteriorate the irrigation infrastructure.
- Change in lifestyles, rapid urbanization and increased water pollution are the other critical issues which limit the water availability for agriculture, but the demand on agriculture, horticulture and livestock production is increasing.
- The attention on intensification, diversification and value addition in agriculture to meet the shortfalls in agricultural production is inadequate.
- Limited capacity and funding shortfalls in agricultural research and development is hampering adaptation. Inadequate agro-meteorological data and limited access to available data are adding to these problems (GWP Nepal, 2012).
- Climate change has not been adequately addressed in the sectoral policies such as drinking water, irrigation and hydropower.

4.7. Pakistan

4.7.1. Agriculture and water

Pakistan extends over 796,100 km^2, out of which about 203,470 km^2 or 26 percent is arable. The agricultural land is estimated at 262,000 km^2 or 33 percent of the total land (FAOSTAT, 2011).

Population of Pakistan was 176.75 million in 2011. Out of this, 64 percent lives in rural areas (FAOSTAT, 2011). The GDP per capita was US$ 2,791 in 2010 (ADB, 2011). The contribution of the agriculture sector to the GDP was 21.2 percent (CIA, 2012), and the sector employs about 45 percent of the total labor force. Growth of the agriculture sector is linked to poverty reduction and both show fluctuating trends.

The topography of Pakistan is highly variable, with the far North reaching the Himalayas. The Northern Highlands include parts of Hindu Kush, Karakoram and the Himalaya's ranges including the second highest peak in the world Mount Godwin Austen (AQUASTAT, 2012). The southern, western, and coastal regions are lowland plains of the River Indus. Topography influences the climate; with sub-zero temperatures in the far North and high temperatures in the low- lying Southeast. The northern regions on the southern side of the Himalayan Mountains receive rainfall of up to 200 mm per month, and the rest of the country receives very little rainfall throughout the year (McSweeney et al, undated).

Annual precipitation in Pakistan is 494 mm resulting in total annual renewable water resources (actual) estimated at 230.8 km^3. The per capita annual water resources are 1,305 km^3.

The major river in Pakistan is the Indus. The Indus basin spreads over more than 566,000 km^2, or 71 percent of the territory. The river has two main tributaries, the Kabul on the right bank and the Panjnad on the left bank. The flow in Panjnad is contributed by Jhelum, Chenab, Ravi, Beas and Sutlej rivers (AQUASTAT, 2012). Pakistan's economic and social wellbeing is built on this river system despite the scant average annual rainfall in the basin. Over the years, Pakistan has harnessed the Indus River to bring 35.7 million acres under irrigation to cultivate land in otherwise desert conditions, thus creating the world's largest irrigation system. This irrigated agriculture system accounts for a quarter of the country's GDP, two-thirds of the employment and about 80% of the exports (Ali, 2012).

In addition to the Indus basin, there are two other hydrological units:

- The Karan desert in the West of Balochistan in the West extending over 15 percent of the land. The Mashkel and Marjen rivers are the main water sources in this part of the country, which discharge into the Hamun-i-Mashkellake in the Southwest; and
- The arid Makran coast along the Arabian Sea in the Southwest spreading over 14 percent of the land. The major rivers are Hob, Porali, Hingol and Dasht.

However, the river flow outside the Indus Basin are flashy in nature, do not have a perennial supply and accounts for less to 5 km^3 of water resources per year, emphasizing the role of the Indus river in the water resources of Pakistan. About 56 percent of the Indus basin lies in Pakistan, and the rest in China, Afghanistan and India.

Glacier melt, snowmelt, rainfall and runoff constitute the river flows. Water resources are inextricably linked with climate and highly sensitive to climate change impacts (GOP, 2011).

Agriculture is central to human survival and is probably the human enterprise most vulnerable to climate change. Considering agriculture's contribution to the GDP, the share in labor force, and to the export earnings of the country such impacts could be heavily felt. It is greatly affected by short term climate variability and could be harmed significantly by long-term climate change (GOP, 2011).

4.7.2. Issues and challenges

- Monsoonal rainfall and Indus river flow which depend on glacier melt are the main water sources for Pakistan. These sources are predicted to be adversely affected by climate change, and in combination with increased evaporation due to increased temperatures, water stress in Pakistan is likely to increase (APAN, 2012).
- Projected recession of Hindu Kush-Karakoram-Himalayan (HKK) glaciers due to global warming and carbon soot deposits from transboundary pollution sources, threatens water flows into the Indus River System (IRS). This results in increased siltation of major dams caused by more frequent and intense floods (GOP, 2011).
- The capacity of the agriculture research and development system has declined. Better technology for rain-fed areas and livestock is needed. Livestock has been the fastest growing sub-sector, and now comprises almost half of the agricultural GDP (World Bank, 2011).
- Pakistan so far has not developed the capacity to fully utilize rain water. Presently it is estimated that not more than 20-25% of rain water is harvested with current practices (Ali, 2012).

- Irrigation plays an important role in rural economies, which can be made more efficient. In addition, some irrigation infrastructure shows signs of degradation. Water distribution within and among irrigation systems is required to be more equitable. Inter-provincial water allocation, storage management and water scheduling are among the water management functions needing improvement.
- Water logging, salinity, pollution and land degradation are becoming significant (World Bank, 2011), and these issues usually aggravate with climate change and affect rural economies.
- Pakistan has a large proportion of soils which is unsuitable for agricultural practices; the major factors contributing to the poor soil conditions include soil salinity and sodicity, water logging, and soil contamination with heavy metals and metalloids. The contamination of agricultural lands is increasing by irrigation with sewage water that contains toxic metals and application of pesticides and herbicides. This is affecting the agricultural productivity and the environment by reducing the area under cultivation and generating health problems (Ali, 2012).
- Low rainfall, poor drainage, ancient marine deposits, saline groundwater, and evaporation and transpiration combine to soil salinity. The expansion of irrigation and agriculture contributes to accumulation of salt. As the water resources are almost fully exploited, any salt/sediment/water imbalance of the Indus system will severely threaten the food and water security (Ali, 2012).
- Reduced water availability is expected to drastically reduce cereal (such as wheat and rice) production. Increased temperature resulting in enhanced heat and water-stress conditions particularly in arid and semi-arid regions would reduce agricultural productivity (GOP, 2011), as well.
- In the southern Pakistan yields of major cereals are predicted to decline by 15-20 percent, but in the northern area minor improvements in yield due to increased duration of growing period are expected.
- Impact of increasing temperatures on crop yield can sometimes be compensated by increased CO_2 concentrations. However, the negative impacts could outweigh the positive impacts and the studies show that heat stress would affect the crop yields, especially wheat, cotton, mango and sugarcane (APAN, 2012).
- Livestock production is predicted to decline by 20-30 percent. Rangelands will be over-stressed from prolonged droughts and shifting human and livestock populations around riverine areas and in mountainous regions. This will reduce tree and shrub cover, which is only 5.2 percent at present. Inland fisheries are expected to be reduced as well. (IUCN and Ministry of Environment, 2010).

4.8. Sri Lanka

4.8.1. Agriculture and water

Sri Lanka extends over 65,610 km^2, out of which about 12,500 km^2 or 19 percent is arable. The agricultural land is estimated at 26,400 km^2 and it comprises 40 percent of the total land (FAOSTAT, 2011). Imbulana et al (2010) estimate the agricultural land excluding the forest area as 28 percent of the total area.

Population of Sri Lanka was 20.7 million in 2010. Out of this, 85 percent lives in rural areas. It is a densely-populated country with about 320 persons per km^2.

The GDP per capita was US$ 5,098 in 2010. The agriculture sector contributed 12.8 percent of the GDP (CIA, 2012) and employed 33 percent of the labor force in 2010 (ADB, 2011). The contribution of agriculture to the GDP and as a source of employment is decreasing, but it remains a socially, politically and economically important sector.

Rainfall is the only form of precipitation. The annual rainfall of 1,860 mm produces the total annual renewable water resources of estimated 45 km^3 and per-capita annual water resources are 2,175 m3. The country is divided into a wet zone and a dry zone by the 2,000 mm annual rainfall isohyet. The dry zone extends to about 80 percent of the country (Manchanayake and MaddumaBandara, 1999). When averaged over the country, the rainfall is somewhat evenly distributed over the year, with 55 percent occurring in the two monsoon periods and the remainder in inter-monsoon periods. However, the dry zone receives the bulk of rainfall during December to January.

There are 103 distinct river basins on the island, with considerable variation in characteristics and potential for development. 16 out of the 103 rivers are classified as wet-zone rivers and carry approximately half of the annual runoff from streams (Arumugam, 1969). Mahaweli River is the largest of all the rivers with a basin area of 10,448 km^2 (about 16 percent of the country). Its water resources are diverted to several other river basins in the dry zone and the land benefited from Mahaweli is therefore greater than the basin area.

4.8.2. Issues and challenges

- Sri Lanka has a tradition of water resources management dating back to several centuries. However, recent attempts to frame a comprehensive water resources management policy have not been successful. Although sub-sectoral policies have been developed, an integrated approach to the water problems is not in place.
- Pollution of water bodies is an issue growing in significance. Urban, industrial and agricultural wastes contribute to the problem. Concentration of pollutants increased during the dry periods and climate change is expected to influence pollutant concentration. Over-extraction of groundwater, especially for agriculture, depletes the resource and increases the pollutant concentration (Iqbal, 2010 and Imbulana et al, 2010). In addition, farmers of the dry zone are affected by a kidney disease, which is suspected to be caused by Cadmium in water, and such issues also affect the agricultural productivity.
- Increasing trend of one-day heavy rainfall events contribute to soil erosion and damages the water infrastructure (Iqbal, 2010)
- Although the annual rainfall does not indicate alarming trends, there isareduction of rain during the seasons that bring rain to the dry zone. Available information indicates an expansion of the dry zone. Such changes would increase water demand in the dry zone, where the bulk of the irrigated land is located (Imbulana et al, 2010).
- As the irrigated agriculture utilizes more than 90% of the developed water resources, increasing the water use efficiency will substantially relieve the stress on water resources. As

such, there is a need to improve water and land productivity through efficient farming methods, appropriate technology, efficient conveyance and sustainable management of infrastructure, with due attention to the Integrated Water Resources Management (IWRM) (SLWP, 2012)

- River flows are already under pressure in some major rivers due to demand from hydropower, irrigation and domestic sectors. The erratic rainfall, increased rainfall intensity, reduced rainfall in upper catchments and extreme climatic events can aggravate the situation (Iqbal, 2010).
- There are considerable changes to the rainfall patterns including the delay of rainfall seasons, affecting timely cultivation and harvesting of crops. There is a need for long-term weather forecasting system with special attention to agricultural needs (SLWP, 2012).
- Current institutional arrangements for dealing with extreme events are reactive and relief-oriented rather than strategic and enabling, with little provision for inclusion of climate change adaption in the normal, pre-planned, development agenda (SLWP, 2012).
- A substantial investment has been made in water storage reservoirs, which could increase the adaptation capacity to varying river flows. However, deforestation, associated soil erosion and sedimentation reduce the capacity of the reservoirs.
- In the light of the above cited observations, a master plan for water resources is imperative for planning, development and operation of the facilities in a coordinated manner.
- Poverty in the agriculture sector reduces the adaptation capacity of the rural community. World Bank (2011) attributes the rural poverty to weaknesses in strategy and policy. Among the causes are the "top-down," supply-driven" planning process, weak prioritization of expenditures in agriculture, and under-performing programmes. Lack of clarity in the roles and responsibilities of the central government agencies and provincial councils (to whom many responsibilities have been devolved) poses challenges for water resources management.
- Climate change-induced disasters, such as floods and droughts, destroy the crops. To recover from such situations, availability of good quality seed in sufficient quantities is important. The current storage capacity of seed and buffer stocks are not sufficient to meet the challenges of climate change, and this affects crops such as rice, maize and cowpea.
- Rising trends of temperature are observed in Sri Lanka as well. Such changes are expected to adversely affect plantation crops such as tea, affecting substantially the economy and rural livelihoods (Iqbal, 2010)
- While the major irrigation has more impact on the national economy, there are the small-scale irrigation systems called minor tanks and anicuts which support a large number of rural people in their livelihoods and basic water needs. These systems are more vulnerable to the changes of climate because they depend heavily on local rainfall and stream flows and have little or no storage capacity.

- A considerable population is also engaged the in rain-fed agriculture, though less dependent on it as a livelihood. Rain-fed agriculture makes a notable contribution to the national food production, and it could be the most vulnerable sub-sector within agriculture.

5. A synthesis on major issues related to water at the sub-regional level

5.1 Challenges

South Asia is a region with limited land and water resources to support its huge population. The limitations are compounded by the topography in countries such as Nepal and Bhutan, soil conditions and aridity in countries such as Pakistan, and disaster-prone areas in countries such as Bangladesh. The region is approaching the limits of sustainable use of those meager resources as well.

Investments by the national governments in water resources development and agriculture have helped alleviate poverty and improve the food security. However, the sustainability of such investments is doubtful due to the impacts of climate change. It is observed that the reservoir capacity is being limited due to highly intensive rains, landslides, and resulting soil erosion. In addition, a large proportion of the people have been elevated above the poverty lines only temporarily. This results in a huge population being vulnerable to the variations of water availability, thus threatening the sustainability of the poverty alleviation initiatives.

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. The most threatened in the agriculture sector are the rain-fed farmers and the farmers who depend on small reservoirs and small diversion schemes.

There is the necessary political recognition of the impacts of climate change, and the special vulnerability resulting from poverty, illiteracy and social inequities, which serve as goodfoundations for adaptation strategies. However, inadequate policy support is observed in several countries including Afghanistan and Sri Lanka. Whenever water policies are available, sometimes the phenomenon of climate change is not well integrated into the policy framework, especially in the development policies. This would increase the vulnerability and contribute to the future water stress. There are improvements needed in the water regulations as well.

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. Therefore, high per-capita water availability can sometimes be misleading, and higher values do not necessarily indicate a lack of water stress.

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.

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. 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.

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).

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

5.2 The Way Forward

Other than for the island states, regional co-operation in climate change adaptation is essential for addressing the challenges of climate change. The data and information exchange and access, at the national and sub-regional levels has to be improved a lot. Any regional strategy in adapting to climate change should have a focus on the common social, economic and political priorities, while keeping the flexibility to address the country-pecific peculiarities. The strategies should pay special attention to factors that aggravate the challenge, such as illiteracy, diversity, economies, and gender disparities.

Increased storage would undoubtedly improve the adaptation capacity and resilience to climate change impacts. But considering the heavy population density and topographical factors, surface water storages are not always feasible. IWP (2012) recommended that underground water aquifers provide the best possible storages, and recharging such aquifers through water harvesting systems and flood waters etc are required. Other options include rainwater harvesting, of which the potential is not fully utilised. Other solutions being considered include inter-basin transfers from surplus to deficit (IWP, 2012). Considering social and economic costs of such solutions, they may have to be country- specific. But in the case of the transboundary rivers, the importance of river basin master plans has been highlighted.

Water quality is already a concern in several countries such as India and Bangladesh. As this situation can worsen due to climate change, serious attention is required to address the issue. The suggested methodologies include avoiding over-exploitation and preventing pollution (IWP, 2012).

The countries are at various stages of policy formulation. Incorporation of climate change into development and sectoral policies is very important for creating the resilience to impacts of the climate change.

However, policies, infrastructure and regional co-operation may not be sufficient to stave off the challenges of climate change. The benefits of such interventions should reach the individual. High incidence of poverty, malnutrition, illiteracy and inadequate access to resources can retard the flow of benefits to the grassroot level. Considering such social and economic factors together with the large proportion of people vulnerable to seasonal variation of access to water, there is a need for increasing the resilience of the communities.

Research and development have the potential to make a significant contribution to climate change adaptation. Some of the areas where research and development could contribute include:

- Increasing the efficiency of rain-fed cultivation;
- development of drought-resistant crop varieties (IWP, 2012);
- Technologies to increase groundwater storage and recharging;
- Eliminating the ocial, economic and technological constraints to achieve the potential in rainwater harvesting; and
- Variations of the rainfall pattern including onset of monsoonal rains, and changes to the intensity and frequency of occurrence of such rains.

However, research and development is highly dependent on the availability of good quality data and easy access to such data by the scientists. Funds for research have been identified as a constraint as well. These issues have to be dealt with at the national as well as regional levels.

References

- ADB, 2003. Rebuilding Afghanistan's Agriculture Sector. ADB South Asia Department. Manila, The Philippines. 12 Dec 2011 <www.adb.org)
- ADB, 2011. Key Indicators for Asia and Pacific. Mandaluyong City, Philippines: Asian Development Bank. 10 Dec 2011. <http://www.adb.org/Documents/Books/Key_Indicators/2011/pdf/Key-Indicators-2011.pdf>
- Ahmed, S. undated. The Status and Challenges of Water Infrastructure Development in Bangladesh, Country Paper. 05 Dec. 2011. <www.ecowaterinfra.org>
- Ali, K. 2012. Report of Pakistan Water Partnership (PWP). (outcome of the consultations with Implementing Partners in water, agriculture and climate change)
- Amarasinghe, U. A.; Sharma, B. R.; Aloysius, N.; Scott, C.; Smakhtin, V.; de Fraiture, C. 2004. Spatial variation in water supply and demand across river basins of India. Research Report 83. Colombo, Sri Lanka: International Water Management Institute.
- APN-GCR (Asia- Pacific Network for Global Change Research) 2004. Water Resources in South Asia: An Assessment of Climate Change -associated Vulnerabilities and Coping Mechanisms. 14 Feb 2012. <http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2004 /2004_02_CMY-Muhammed_.pdf>
- AQUASTAT, 2011. 06 Dec. 2011 <http://www.fao.org/nr/aquastat>
- Asian Development Bank (ADB) 2009. Building Climate Resilience in the Agriculture Sector in Asia and the Pacific. Executive Summary.ADB. The Philippines
- Bhatti, A. M., Suttinon P. and Nasu, S. 2009. Agriculture Water Demand Management in Pakistan: A Review and Perspective. Society for Social Management Systems. 20 Dec. 2011. <http://management.kochi-tech.ac.jp/PDF/ssms2009/sms09_172.pdf>
- Climate change – Resources. 2012. Securing the Natural Freshwater Systems of the Bhutan Himalayas. 02 Feb 2012. <http://www.bhutanclimatesummit.org.bt /paper /Water_Paper_ Bhutan.pdf, 2011>
- Demographic Yearbook (DYB), 2009. United Nations Statistics Division. 18 Dec 2111. <http://unstats.un.org/unsd/demographic/products/dyb/dyb2.htm>
- FAOSTAT, 2011. FAO Statistical Yearbook. 20 Dec 2011. <faostat.fao.org>
- GWP Nepal, 2012. Consultation Meeting with National Implementing Partners/Focal Points Working on Water, Agriculture and Climate Change Sectors. GWP Nepal (unpublished)
- ICIMOD , 2010. Climate change impacts on the water resources of the Indus Basin Capacity building, monitoring and assessment for adaptation. 12 Jan 2012. <http://books.icimod.org/uploads/tmp/ icimod-climate_change_impacts_on_the_water_resources,_of_the_indus_basin:_.pdf>
- Imbulana, K.A.U.S., Wijesekera, N.T.S., Neupane, B.R. Aheeyar, M.M.M. and Nanayakkara, V.K. (Eds). 2010. Sri Lanka Water Development Report. MI&WRM, UN-WWAP, UNESCO, HARTI and University of Moratuwa, Sri Lanka, Paris and New Delhi.

- Iqbal, MCM, 2010. Vulnerability and Adaptation Assessment, Climate Change Division of the Ministry of Environment and Natural Resources, Sri Lanka. 05 Jan 2012. <http://www.climatechange.lk /SNC /snc_index.html>
- IUCN and Ministry of Environment, Government of Pakistan. Undated. Climate change vulnerabilities in agriculture in Pakistan. 20 Jan 2012. <http://cmsdata.iucn.org/ downloads/pk_cc_agr_vul.pdf>
- IWP (India Water Partnership) 2012. Report on Consultation Meet on "Water, Agriculture and Climate Change". Organized under GWP-South Asia & Asia Pacific Adaptation Network On 9th February, 2012. Institute for Human Development, New Delhi
- Khan, T.A. 2012. CWP Report from Bangladesh Water Partnership (BWP)
- McSweeney, C. , Newand M., Lizcano, G., Undated. UNDP Climate Change Country Profiles-Pakistan. 21 Dec. 2011. <http://country-profiles.geog.ox.ac.uk>
- Ministry of Water Resources (MWR), 2008. Government of India, Ministry of Water Resources. National Water Mission under National Action Plan on Climate Change. Comprehensive Mission Document Volume – II. New Delhi. 15 Jan 2012. <india.gov.in/allimpfrms/alldocs/15658.pdf>
- National Adaptation Programme of Action (NAPA), undated. Climate Change and Agro-biodiversity in Nepal: Opportunities to include agro-biodiversity maintenance to support Nepal's National Adaptation Programme of Action (NAPA). Nepal
- National Environment Commission. (NEC), undated. Bhutan Water Vision and Bhutan Water Policy. National Environment Commission. Royal Government of Bhutan.
- Parry, M.L. Canziani, O.F. Palutikof, P.J. van der Linden and Hanson, C.E., Eds. 2011. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In Climate Change 2007: Impacts, Adaptation and Vulnerability. 20 Jan 2012. <http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2 _report_impacts_adaptation_and_vulnerability.htm>
- Qureshi, A.S. 2002. Water Resources Management in Afghanistan: The Issues and Options. Working Paper 49. IWMI
- saarc-sec.org, 10 Feb 2012. http://www.saarc-sec.org/areaofco-operation/cat-detail.php?cat_id=54
- Sharma, K.P. 2010. Climate change trends and instances of socio-economic effects in Nepal. Jalsrot Vikas Sanstha (JVS) and Nepal Water Partnership
- Siddiqi, Y. 2010. Water-Food-Energy Nexus: At work in South Asia. 16 Jan 2012. <http://www. Adb.org/water/articles/2010/ Water-Food-Energy-Nexus.asp>
- SLWP (Sri Lanka Water Partnership). 2012. Consultation with Implementing Partners. Unpublished report.
- Thimphu Statement on Climate Change. 20 Feb 2012. <http://www.saarc-sec.org/ userfiles /ThimphuStatementonClimateChange-29April2010.pdf>
- United Nations (UN), 2011. The Millennium Development Goals Report 2011. United Nations. New York. 22 Jan 2012.<www.un.org/millenniumgoals/11_MDG%20Report_EN.pdf>
- United Nations Environmental Programme (UNEP), 2008. Freshwater under Threat, South Asia. Nairobi, Kenya. 25 Jan 2012. <www.unep.org/pdf/southasia_report.pdf>

- USAID, 2010. Bangladesh Country Profile. USAID Country Profile for Bangladesh. USAID. Bangladesh.
- Wikipedia, 29 Jan 2012. <http://en.wikipedia.org/wiki/South_Asia>
- World Bank and Global Facility for Disaster Reduction and Recovery (GFDRR). 2011. Vulnerability, Risk Reduction, and Adaptation to Climate Change. Pakistan. 28 Jn. 2012. http://sdwebx.worldbank.org/ wb_gfdrr_climate_change_country_profile>
- World Bank, 2005. Bangladesh Country Water Resources Assistance Strategy. Bangladesh Development Series – paper no 3. The World Bank Office, Dhaka. 02 Feb 2012. <http://siteresources.worldbank.org/BANGLADESHEXTN/Resources/Final_Water_CAS-print_version.pdf>
- World Bank, 2010. South Asia Economic Update 2010, Moving Up- Looking East, Advance Edition. The World Bank. Washington DC. 27 Jan 2012. <http:// siteresources.worldbank.org /SOUTHASIAEXT/Resources/223546-1269620455636>
- World Bank, 2011. Agriculture in South Asia. 15 Jan 2012. <http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/ SOUTHASIAEXT/EXTSAREGTOPAGRI/>SAARC. 2012. Thimphu Statement on Climate Change. 10 Feb 2012. <http://www.saarc-sec.org/userfiles/ThimphuStatementonClimateChange-29April2010.pdf>
- Zuhair, M. undated. Sustainable Agricultural Development Strategies for the Least Developed Countries of the Asian and the Pacific Region, Maldives. Prepared by M. Zuhair, Deputy Director of Agricultural Services, Ministry of Fisheries and Agriculture, Male. 14 Jan 2012. <http://www.unescap.org/rural/doc/sads

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