



Agriculture Adaptation Practices in South Asia

Case of Nepal

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List of Abbreviations

ADS:	Agriculture Development Strategy
APN:	Asia-Pacific Research for Global Change Network
BCCSAP:	Bangladesh Climate Change and Action Plan Strategy
CBO:	Community Based Organization
CCAFS:	Climate Change, Agriculture and Food Security
CCTT:	Climate Change Technology Transfer
CGIR:	Consultative Group on International Agriculture Research
FDI:	Foreign Direct Investment
GDP:	Gross Domestic Product
GFCF:	Gross Fixed Capital Formation
GHG:	Greenhouse Gas
GLOF:	Glacial Lake Outburst Flood
INGO:	International Non-governmental Organization
IPCC:	Intergovernmental Panel on Climate Change
IPM:	Integrated Pest Management
IPR:	Intellectual Property Rights
IRRI:	International Rice Research Institute
ISET:	Institute for Social and Environmental Transition
ITPGRFA:	International Treaty on Plant Genetic Resources for Food and Agriculture
NAPA:	National Adaptation Programmes of Action
NGO:	Non-governmental Organization
NIDS:	Nepal Institute of Development Studies
NREGA:	National Rural Employment Guarantee Act

R&D: Research and Development

SAARC: South Asian Association for Regional Cooperation

SALT: Sloping Agriculture Land Technology

TRIPS: Trade Related Aspects of Intellectual Property Rights

UNIFEM: United Nations Development Fund for Women

UPOV: Union for the Protection of New Varieties of Plants

WTO: World Trade Organization

1. Introduction

This study is about different agricultural¹ adaptation practices followed by farmers in Nepal to address evident climate change impacts and the dissemination of these practices across other South Asian countries. Though many of these adaptation practices are autonomous, and are likely to be widely used as the impact of climate change intensifies, there is not much research or policy dialogue on this issue since most research and policy dialogue is focused on planned adaptation. Therefore, research across a number of related areas to better understand the drivers of autonomous adaptation would benefit the entire South Asia region in the fight against climate change.²

Agriculture is a complex system encompassing many resources as well as different components of the ecosystem (for example land, water, air, bio-diversity, forest, and socio-economic system). Importantly, agriculture can be affected by climate change in a multiplicity of ways either directly or indirectly. In order to understand how farmers are coping with climate change impacts and identify their adaptive strategies and practices, it is important to first review how climate change has and will affect agriculture; this will in turn have implications on the technology that is suitable to enhance the adaptive practices of farmers and to examine the possibility of sharing of such technology/practices across South Asia. Accordingly, this report will first discuss the climate change impacts being experienced in Nepal and its actual/possible effects on agriculture. The second section will present the agriculture adaptive practices, followed by discussion on the status of co-operation in sharing of experiences with regards to adaptive practices across South Asian countries and identification of technology for adaptation that is being shared or acquired. The last sections will identify impediments on sharing of such practices and technology, while the concluding chapter will provide pertinent recommendations for enhancing the sharing of adaptive practices across South Asian countries.

Though further analysis is necessary, it is now widely believed that Hindu Kush-Himalayan region is one of the hotspots of climate change (Maplecroft 2011; IPCC 2007). Temperature rise in the Himalayan region—much of which lies in Nepal—has been very high in comparison to the global

¹ Here “agriculture” is meant to include all primary production activities that help to produce food and fibre for subsistence as well as commercial purpose. Therefore, crops, trees, fruits, vegetables, animal production, apiculture, floriculture, forestry, pasture, soil and water management for production of food, and processing, marketing and distribution of food are included under agriculture.

² ISET (2008a) *Enabling Adaptation to Climate Change for Poor Populations in Asia Through Research, Capacity Building and Innovation*, Report for the Adaptation Study Team to the International Development Research Centre, co-ordinated by ISET, Kathmandu, Nepal: ISET.

average rise in temperature³, and is expected to have a severe impact on South Asian countries, Nepal in particular. Considering that the Himalayas are the major source of water in the region, and are also essential to preserve the balance between monsoonal rain pattern and the water drainage system, rising temperature could upset the whole hydrological cycle in South Asia. Additionally, changing climate will negatively affect the entire ecosystem and biodiversity, which will have direct implications on the different ecosystem services they provide to the people living in the Himalayan region. Since a large proportion of population still depend on primary production (agriculture, forestry, fishing and use of natural resources) as a main source of livelihoods, climate change could also alter their livelihood patterns. More importantly, climate change impacts could force the people to alter the way they interact with the environment and manage available resources in order to sustain their livelihoods.

Given that agriculture in Nepal is rain-fed and climate sensitive, the sector is highly vulnerable to climate change in comparison to other economic sectors. With more than 75 percent of the total labour force still dependent on agriculture, the agriculture sector contributes to about 38 percent of the national gross domestic product (GDP) and is still of primary importance to the livelihood of millions. Although a rise in temperature could have some positive effects, increased agriculture yield for instance, most of the benefits will only be short term and will be outweighed by the negative consequences of rising temperature on the ecosystem. Moreover, the agriculture sector in Nepal is becoming more and more feminized. Gender division of labour is highly skewed, especially when agricultural, pastoral and wage labour is combined with household, community and casual labour. This is mainly due to high rates of men's out-migration to urban cities, towns and cross-border destinations in the region and beyond. Recent research on the 'feminization' of agriculture and natural resource management illustrates that women carry out 6.3 to 6.6 times more agricultural work than men (Pravettoni 2011; Nellemann et al. 2011). Due to the possible impacts of climate change on agriculture, researchers are concerned not only on how it will adversely impact the rural economy but also how women will suffer more as they are on the frontline experiencing these impacts. On the other hand women, due to their skills and experiences, may also be able to develop different adaptation practices to the changing climate.

In recent years, climate change impacts have been felt by farmers directly. In effect, farmers are currently trying to adapt to these changes under their own initiatives, with financial/technical support from various research and donor organizations. Farmers who use traditional farming practices and dependent on traditional knowledge have noticed changes in crop cycles, encroachment by invasive species and new pests, and changes in soil moisture among others. In many cases, farmers

³ Temperature rise has been 0.06 degree Celsius per year as against the 0.013 degree Celsius globally in the last few decades. IPCC (2007) even projected that all glaciers in the Himalayas could disappear by 2035 (a claim which was revised later on, but the broader conclusion still remains true).

have also developed their own indigenous know-how on how to tackle these changes. Historically, farmers in Nepal have been climate resilient despite following sustainable farming practices. In this context, it is also important to understand more about those sustainable practices that were resilient to climate change. It is thus vital to learn from these indigenous adaptation and mitigation practices to tackle climate change (Singh et al. 2011). Therefore, it is also important to understand farmers' perception of change as their adaptation practices are basically based on their perceptions (and experiences) of change.

1.1. Climate change and Nepal

The main feature of climate change has been the rise in temperature and changes in precipitation patterns. A study of climate data from 1975 to 2006 reveals that average temperatures increased all over the Hindu-Kush Himalaya, as indicated by lower and higher percentiles of the daily maximum, minimum, and average temperatures (Singh et al. 2011, 8). The increases in average temperature ranged from 0.6 to 1.3 degree Celsius; the differences in the maximum temperatures across the stations ranged from 1.1 to 2.0 degree Celsius and the minimum from 0.2 to 0.5 degree Celsius. Decadal trends indicate a rapid increase in the number of warm days and warm nights, while the number of cold nights has decreased. The same study also shows that the precipitation is more varied and the trends less definite. A distinct shift in precipitation from snow to rain is apparent. The longest number of consecutive dry days during winter increased and the longest period of consecutive wet days decreased (*ibid*, 9). In the case of Nepal, the climatic data collected from mid-1970s to late 1990s reveal the following findings (Shrestha et al. 1999; Shrestha and Aryal 2011):

- The average temperature between 1977 and 1994 increased at a rate of 0.06 degree Celsius per year.
- The rise in temperature was greater at the higher altitudes, for example, the adjacent plains and foothill areas experienced only negligible warming.
- For all of Nepal, the increase in temperature was more pronounced during the cooler months (0.06–0.08 degree Celsius per year from October–February) than for the warmer months (0.02–0.05 degree Celsius per year for March–September).
- In the high-altitude areas, the temperature rise is leading to glacier retreat. For example, there was a 1.4 degree Celsius rise in temperature from 1989–1991 at the terminus of a glacier in Shorong Himal (Kadota et al. 1996 as cited in Singh et al. 2011, 10).
- In general, temperatures are predicted to increase with altitude and are expected to be greater during winter months. Thus, the increase in temperature is projected to be greater in the northern parts of the country.
- Precipitation is expected to increase in summer and decrease in winter but the overall annual average is not expected to show any significant changes. Precipitation changes will be greater in the eastern and southern parts of Nepal than in the northern parts (APN 2003).

- A study showed a 16 percent decrease in snow-cover area in the Himalayas from 1990 to 2001 (Menon et al. 2010). There is a prediction that the snow cover of the Himalayan regions will decrease by 43–81 percent by 2100 if the annual mean temperatures at higher elevations increases by 1 to 6 degree C as predicted by the IPCC (Bohner and Lehmkühl 2005).

The changes in glaciers associated with climate change will have greater consequences as glaciers store fresh water and feed this water into the river system that provides water to a wide population of South Asia. Himalayan region has over 50,000 glaciers within it and comprises a total glacial area greater than 61,000 sq. km. Overall, a retreat of 15 m per year or less was recorded for about 70 percent of the glaciers studied. Studies indicate a substantial decrease in the total area of glaciers accompanied by an accelerated fragmentation of glaciers in Bhutan and Nepal. Glacial depletion in Nepal was measured for 21 glaciers (measured in 2008) (Bajracharya et al. 2011; Bajracharya and Shrestha 2011; Bajracharya et al. 2010a and 2010b; Bajracharya et al. 2007).

Increased flood risks and other extreme events associated with water could affect farmland, physical infrastructure, and water quality. Shrestha et al. (2003) suggest that the number of flood days and consecutive days of flood events have been increasing in Nepal. Increases in glacial melting and likely increases in runoff will also heighten the risk of glacial lake outburst floods (GLOF). Already disaster-prone and the 30th most at-risk country to flooding, Nepal has experienced a steady rise in the occurrence of floods, droughts, and landslides in recent years. Additionally, climate change may also accelerate the damage to wetlands and freshwater ecosystems such as lakes, marshes and rivers, and increased temperature will have unpredictable consequences for many aquatic species and freshwater biodiversity. Moreover, climate change is likely to increase the occurrence of pests and diseases affecting humans, crops, animals and forests.

The impact of climate change on the health system has also been observed and will in turn affect the functioning of the farming system, requiring more healthy farmworkers and managers. The human health system will be adversely affected by heat waves, flash-floods including GLOF, riverine (plains) floods, water scarcity and quality, drought, diseases like malaria, Japanese encephalitis, Kala-azar, dengue, filariasis, and water-borne diseases that will increase in the context of climate change. In many cases these problems have already been observed in Nepal and their links to climate change has also been established, particularly in the subtropical and hot regions (Regmi et al. 2006; Oxfam 2009).

1.2. Impact of climate change on agriculture in Nepal

Agriculture, particularly rain-fed agriculture, is extremely sensitive to climate change (Ramay 2011). Climate change will impact the physical, chemical and biological properties of resources (like land, seeds, water, wetlands, forests, as well as people who work on these resources) used for producing

food and fibre. The main direct effects of climate change will be through changes in factors such as temperature, precipitation, length of growing season, and timing of critical events related to crop development. Several other factors, such as loss of biodiversity and common property resources, growing water stress for irrigation, recurrent crop damage due to natural hazards (such as floods and droughts), possible damage to infrastructure, and inadequate institutional support, such as credit, crop insurance, and storage and processing facilities, will contribute to possible decline in agricultural production and food security. Several studies in the past have shown that the production of rice, corn, and wheat has declined due to increasing water stress arising partly from increasing temperature, and partly from a reduction in the number of rainy days (Agarwal et al. 2000).

The changes in amount and seasonality of precipitation have affected soil moisture and groundwater reserves, projecting an increase in drought-affected areas. The beneficial impact of increased annual runoff in some areas is likely to be negated by the negative effects of increased variability in precipitation and seasonal shifts in runoff water supply, water quality, and flood risk. A study on farmers' perceptions was conducted in Gulmi district to understand how farmers' experience the effects of climate change on agriculture and the different adaptation measures adopted. The study showed that while big change has not been noticed in total monsoon precipitation, erratic rainfall is continuing and winter rain is decreasing (Ghimire 2013). The proper timing and amount of rainfall is very important in agriculture as it has great impact on yields. Erratic rainfall is also increasing incidences of drought and floods.

Heavy reliance on rain-fed farming, limited irrigation facilities, and a significant lack of water conservation and harvesting practices mean that extreme events can prove disastrous for agricultural output. Furthermore, rising temperatures will have a significant impact on the moisture and nutrient level of soil through rapid evapo-transpiration, soil erosion, and landslides.

As climate change will have major impact on water availability, rice production will have to bear significant brunt of this change. Rice is a prime food crop in Nepal whose production will stagger from changes in the reliability of stream flow, a more intense and potentially erratic monsoon rainfall and the impacts of flooding (NAPA 2010). Approximately 64 percent of the cultivated areas are heavily dependent on monsoon rainfall and changes in the time and duration of this monsoon rainfall could affect the overall agricultural production significantly, especially rice yields (Lohani 2007). In the higher altitude, population entirely relies on subsistence agriculture and such extreme climatic conditions will put these areas under economic stress by affecting agricultural production and food security (Malla 2008; Pokharel and Pandey 2011). The development and spread of crop diseases, pests and weeds will also have an adverse impact on agriculture, human health, and the environment (Malla 2008). Several pathogens, such as rust and foliar blight, have already adapted to the hills and mid-hills of Nepal. Mosquitoes that once only populated the Terai region are now able to survive in mid- and high-hills.

It is also difficult to separate the impacts of climate change on agriculture as this sector has simultaneously been affected by other global and local drivers like globalization and economic integration. For example, because of globalization and availability of cheap food products (due to subsidy in other countries), farmers often choose to convert croplands for other purposes, especially to substitute food crops for commercial cash crops like fruits, spices (like ginger), vegetables and other high-value cash crops (Tulachan 2001). Nepal has also started to see the abandonment of farmland because of low returns, encouraging people to migrate to non-farm (especially foreign labour migration) jobs further causing shortages of labour and high wages causing de-intensification and abandonment of lands (Adhikari and Hobley 2012). Everyday about 1500 to 1700 Nepali youths, mainly male, migrate to Gulf States, Malaysia and India for work. The 2011 census estimated that about 1.9 million Nepalese are working in foreign countries, but, other estimates show that number is much higher mainly due to undocumented migration. The estimates range from 2.6 million to 3 million. Note that it is still difficult to clearly state how much of this out migration is due to direct or indirect adverse impact of climate change and its effect on deteriorating their food security or livelihood opportunities or because of other attractions like higher remuneration in foreign developed places. Migration as a coping/adapting mechanism of climate change will be discussed later on.

Some of the ways climate change has affected agriculture in Nepal are listed below:

- While some will benefit from substantial increases in suitable areas and production potential, there will be a decline in potentially good agricultural land for others (Fischer et al. 2002). The positive effects of climate change such as longer growing seasons, lower natural winter mortality, and faster growth rates at higher altitudes may be offset by negative factors such as changes in established reproductive patterns, migration routes, and ecosystem relationships.
- Early greening of vegetation and early breeding of organism in response to warming.
- With the decrease in the number of rainy days, erratic and higher rainfall suggests that rainfall occurs in bursts. Consequently, river flow is increasing at 1.48 m³/s/year, which is about 1.5 times higher than increases in precipitation. High increases in summer river flow provides further evidence that high summer temperatures are leading to faster glacial melt (Dahal and Khanal 2010). Similar impacts are already being felt in the plain areas of Nepal; there was rain deficit in the eastern Terai during the year 2005/06 which reduced the national crop production by 12.5 percent (Malla 2008). Meanwhile, there was torrential rain in the mid-western Terai and reduced crop production by 30 percent in the year 2005/06 (Malla 2008 and Regmi 2007). Triggered by heavy rainfall within a short period of time, the Mahakali River flooded in the second week of June 2013 (early monsoon period) resulting in loss of lives and property (Adhikari 2013). The unpredictable rains and prolonged droughts have already disturbed traditional farming practices as a result of which food crisis has become a regular feature.

- There have been frequent droughts, soil erosion and land degradation through landslides, river cutting and floods, all resulting in a decline in production of crops. Mass movement and edge cutting are other impacts of heavy rainfall that carry away fertile soil and deposit sediments on agricultural land (Timsina 2011).
- There has been a decline in traditional water sources for drinking and irrigation. For example, in Dhadeldhura, 60 percent of the water sources have dried (OXFAM 2009).
- Decline in biodiversity and bio-cultural practices—one of the adverse impacts of modern agriculture and a likely outcome of climate change—have also caused many problems, especially the food crisis.
- Increased risk of hailstorm, flooding, pest and diseases will also adversely affect farming.
- Increase in malaria, kalazar, Japanese encephalitis, along with flooding and water contamination has resulted in increased health risks affecting the labour productivity of farm workers—both owners as well as wage workers. As farm wage workers are poor, they tend to be most adversely affected by climate change impacts deteriorating their labour productivity.

The above mentioned impact of climate change and its effect on Nepal's agriculture production has already been observed along with an increase in food insecurity in the region. Moreover, most food insecure regions in the country like Karnali zone, mid-west hills and mountains, far west hills and Himalayan region in general, are severely affected by the adverse impacts of climate change.

Unsustainable practices in agriculture production and eco-system management at the community and eco/bio-regional levels are also exacerbating the adverse impacts of climate change. These farming techniques have many disadvantages in terms of losing the capacity of bio-physical systems to cope with the changes brought on by climate change. Some of these are reduction of bio-diversity and interdependence among the species, pollution, soil erosion and degradation, high energy input from fossil fuel contributing towards greenhouse gases (GHGs), etc.

Climate change will affect people of different gender and class differently. Available studies suggest that women, children and elderly will have relatively more severe impacts than other groups of people. Dependence of women on subsistence farming is relatively higher in Nepal as it is mainly the men who dominate the outside world of external markets, employment and other socio-political activities. However, the out-migration of young men is creating highly feminized farming system, where the inputs of women is very high in terms of labour and the need to generate livelihoods including food security for the family. As a result, rising temperatures, unpredictable precipitation patterns, and an increase in extreme-weather events will have a disproportionate impact on women who depend on subsistence farming for their livelihoods.

1.3. Climate change and women: with especial reference to agriculture

As revealed by various empirical studies, climate change disproportionately impacts women thus increasing the need for women to bear a greater burden of the impacts of climate change. As women carry out a large proportion of farm work and are responsible for ensuring household food security due to their culturally defined role and domestic responsibility, they will have difficulty in dealing with the impacts of climate change and thus will suffer more burden and stress.

The system of division of labour in Nepali society poses different types of restrictions for women to access various social, political and economic opportunities. In a traditional Nepalese society—often patriarchal—women, especially rural women, strongly follow gender roles and are thus responsible for domestic work such as housekeeping, child rearing, cooking, and fetching water and firewood. Furthermore, women generally do not have access to education, and, in turn, to economic independence. The structure of property ownership pattern also limits women's rights to property like land, houses and animals, except in a few cases. In fact, the agricultural census of 2001 reveals that only 10 percent of the land holdings in Nepal are owned by women. This essentially means that women are economically dependence since the lack of property ownership ties them to the household chores. A study conducted on labour migration of women reveals that many of the women who wanted to move out for non-farm jobs, especially migration for domestic help in foreign countries (due to lack of education), were not able to do so as they could not get a loan to finance the trip and were unable to sell or put property up as collateral (NIDS and UNIFEM 2006).

In many cases, women also receive lower wages than men even in the same type of farm work, especially in rural areas. Such gender discrimination restricts women to household chores or domestic non-cash economy where production has also been insufficient to ensure food security. For example, about 60 percent farm households in Nepal cannot produce sufficient food for more than six months. This, along with traditional roles puts greater stress on women to sustain their family. Moreover, under the prevailing cultural practices, women and girls are generally the last ones in the family to eat and thus their food intake depends on what is left over. Accordingly, if food production declines further due to climate change (which is expected), women's stress and vulnerability will also increase. This is due to women's limited range of coping mechanism if some problem in food supply occurs.

As men and women have access to different range of opportunities—more so for the men—women and men show different coping strategies to deal with stress caused by changing climatic patterns on agriculture and food systems. One of the main adaptation practices for young men has been out-migration to urban areas or foreign countries for employment opportunities. In the far west and mid-west Nepal, men and boys migrate to India after they plant or sow the crops, leaving all the farming

responsibilities to the women. In other parts of Nepal, men move out for longer periods, 2-3 years or longer, leaving all the farm and household works in the hands of the women (OXFAM 2009). In such cases, women have started to undertake farming and other activities which were traditionally within the domain of men, for example, ploughing the fields, cutting trees and chopping firewood, masonry work, roofing, etc. (Adhikari and Hobley 2012). In the Terai, men are able to remain closer to home if they move to India, as there is an abundance of agricultural work in India and other parts of Nepal. But the practice of travelling farther distances for work by men of Terai has increased tremendously in the recent years; currently more people from Terai travel to foreign country for work than from other regions. The out-migration of men, partly as a result of climate change, is increasing the workload on women. Moreover, this in turn, has increased the social and psychological stress on women. Today, women not only undertake the traditionally domestic work reserved for them, but also work that traditionally belonged to men. Women are responsible, in many cases, of securing additional income by engaging in economic activities outside the household.

The consequences of climate change, decrease in water for drinking and irrigation and deforestation in particular, results in women walking further for resources like drinking water, fuel wood and fodder. For example, in a study carried out in Baitadi, Surkhet and Dailekh districts, women reported the increased distances they must travel to collect water, fuel and fodder for household uses, in addition to the need to collect water for cattle because rivers and streams are drying (OXFAM 2009). This means that women's workload has increased and is likely to adversely affect their health and welfare of the family, especially those of children and elderly. The study shows that women did not have time to take children to school, or had to withdraw children from school in order to look after their younger siblings and livestock whilst their mothers were out working. A study states that in villages, there is a shortage of men due to the impacts of political conflicts in the past that resulted in men being killed. Climate change further adds to the decrease in male population by the out-migration of men due to unproductive agricultural practices and in search for better employment. This is especially true for Dalit women who are unable to find a suitable male for marriage. Therefore, the disproportionate impact of climate change on lower caste women is concerning. Without the ability to remarry or migrate, it is likely that these women will become increasingly vulnerable to climate change (*ibid*, 17-19).

2. A review of farmers' adaptation practices in Nepal

As discussed above farmers have also developed their own practices to adapt to climate change based on their traditional knowledge and experience. There are also some practices which came through their observation and awareness of new modern practices coming from formal agents of change like research stations, and government and non-government staffs. In the following section, the evidence

based on various studies has been collected, especially to demonstrate what practices were developed in responses to different perception of change.

Studies done across Nepal reveal that farmer have perceived climate change and its impact in agriculture. However, currently there are very few programs, government and non-government alike, that provide support for the farmers to tackle the impacts of climate change (Chaudhary and Bawa 2011; Chaudhary et al. 2011; Charmakar 2010; Manandhar et al. 2011; OXFAM 2009; IPCC 2007; Jodha et al. 2011). The main problems encountered by farmers are related to the impacts of climate change, mainly floods and droughts. Farmers have also experienced lack of government support for infrastructure development. The studies also states that, for the most part, government policies are either absent, or not well communicated to these communities, and that governments do not routinely collect or use information from them to record the status of water availability in their villages. In such situations, farmers have used their own knowledge and initiated adaptive actions/practices, some of which are mentioned below:

- Adapting through technological innovations.
- Changing cropping pattern as per the climatic adjustments.
- Prioritizing the use of organic manure rather than chemical fertilizers.
- Taking advantage of warming and rising of temperature in the higher altitude by mainly growing green vegetables.
- Using indigenous knowledge of environmental clues to help forecast flash floods.
- Using traditional methods to store and preserve food and avoid loss through floods.
- Using time-honoured adaptation strategies such as depending on horticultural crops when cereal crops fail due to floods and droughts.
- Relying on community organizations as user groups and building water-harvesting and distribution structures (also seen in Panchkhal as discussed in the case study of this report).
- Migration as a survival strategy.

The above adaptive strategy also includes farmers' ability to take advantage of warming conditions, especially in the high altitude areas. But, such cases could be very less and may confine to temperate conditions like Himalayan region.

A study in Gulmi, West Nepal revealed that there are increased problems of soil fertility and irrigation management due to climate change impacts (Ghimire 2013). In the study, only 5-10 percent households were financially well-off farmers with irrigation facility to raise nursery, prepare the field and transplant paddy while others rely on the monsoon rains. Climate change impacts in the village led to loss of some local rice varieties which were unable to adjust to the changing environment. Similarly, erratic rainfall and increasing temperatures have promoted the incidence of insects, pests and diseases. A combination of all these factors led to reduced agriculture production in

the area. In few cases, extreme stress was also reported when all options were exhausted. For instance, in order to adjust to the climatic extremity of drought and late rainfall, most of farmers changed cropping calendar, pattern and planting method. Most of the farmers have slowly shifted to hybrid, less water-requiring and early-maturing varieties. Some farmers are even making adjustments in agricultural practices such as varietal changes, changes in cropping calendar, pattern, planting method, application of pesticide and chemical fertilizers and resource conservation technologies such as zero tillage and surface seeding in both low and upland areas.

Allen (2011) conducted a study on perception of climate change and adaptive strategies farmers have followed by interviewing representative farmers in low-, mid- and high-hill districts of central, west, and far-western Nepal. Farmers stated that:

- Weather patterns have changed over the past 5 to 10 years, becoming more extreme and erratic.
- Summer rains are now delayed and last for a shorter period but are more intense than in previous times.
- Prolonged periods of drought, less snowfall at the higher altitudes, and a perceived warming in ambient temperatures were also recorded.
- There was a decrease in the productivity of traditional crops (such as wheat, maize, and rice).
- Crops failing due to drought during the growing stage and intense heavy rainfall later in the season resulting in flattening and flooding of crops that are close to maturity.
- A loss in agricultural production; crop losses of up to 50 percent were attributed to problems of erratic rainfall and increased drought.
- A trend in changing flowering times for fruit trees and other tree species⁴ causing poor quality in fruits.
- Local drinking water sources drying up by 50 percent (decrease in water).

Under these changing conditions, farmers followed various adaptive strategies. These strategies include: adjusting sowing times; introducing mixed cropping to salvage at least some of their production; introducing new crop varieties; and learning as much as they can when partnering with non-governmental organisations (NGOs) who specialize in helping to introduce improved farming methods (Allen 2011).

Macchi and Choudhury (2011) did an assessment of ninety villages across fifteen districts in Bhutan, India, and Nepal to document community perceptions on climate change and its impact on farming. Their study revealed that farmers were experiencing reduced snowfall and warmer winters, delayed

⁴ Such as rhododendron, kaphal (*Myrica nagi*), gophi, and cotton tree (*Bombax ceiba*), apple, peach, mango, plum, orange, and wild pear flowered two months earlier than in previous years.

and erratic rainfall during the rainy season followed by prolonged dry periods, and out of season flowering (in some cases twice a year) of fruit trees. As a means of adaptation, the farmers adopted crops that had a market demand to diversify their cash generation options. As a result, cereal crops were being replaced rapidly by crops that offered potential opportunities for cash returns. Therefore, seasonal vegetables and spices, such as ginger and turmeric, were rapidly becoming important crops. There was also a shift to horticultural crops, particularly fruit crops, as an important cash generation option.

Unfortunately the greater impacts of climate change are felt in areas that already suffer from food security problems. For example, far-west and mid-west regions in Nepal are known for less food production and lack adequate food security, mainly due to their dry condition, i.e., they receive less rain. In such areas, the impact of climate change is higher. Studies done in far west reveal such problems arising from climate change and some of the problems faced by farmers in the area are stated below (Synnott 2012; OXFAM 2009):

- Change in rainfall patterns and rain distribution - it either does not rain at all or it rains very heavily. Correspondingly, monsoon does not arrive when it is expected and is more irregular.
- Due to delayed monsoon rice plantation is delayed and production decreased.
- Drought frequency is increasing while springs are drying up.
- Over the last 10 years, water level in the local aquifer has decreased from about 20 feet to about 50 feet.
- Fruits are now maturing more quickly. Rice, wheat, and other crops are maturing 15-20 days earlier.
- More landslides and riverbank erosion are occurring, rivers are becoming wider.
- Small farmers are not able to fortify their land and house.
- New types of insects and diseases are damaging crops.
- Deforestation has increased over the last 10-20 years.
- Production is too low to feed the household for the entire year.

Despite the many problems farmers have observed, they have adopted new practices to cope with them and derive livelihoods. Some of these adaptive strategies that the above-mentioned studies found were:

- changes in the timing of planting in order to cope with the climate variability;
- increasingly turning to irrigation for planting crops by taking turns;
- growing desire for storing rain water through rainwater harvesting system and using ponds for collecting water;
- increase in seasonal migration, although it was occurring since generations;
- families selling assets such as gold when they need extra cash to purchase food; and

- exploring the potential growing practices of more sources of food—both cultivated and uncultivated.

A comprehensive survey by OXFAM (OXFAM 2009, 9-15) on the impact of climate change and coping mechanisms followed by farmers in the mid-west and far-west areas of the Nepal showed several consequences of climate change that farmers have observed. These were:

- warmer, drier winter and lack of winter rain and snow;
- unpredictable monsoon, seasons changing and rainfall more intense;
- destruction of crops from intense 'cold waves' in the Terai resulting in a decline in crops and food security;
- rivers becoming drier leading to difficulty in washing, irrigation, and livestock feeding;
- flood and inundation becoming more common in Terai;
- changing crops - from grain crops to vegetables – for selling and home consumption;
- opting for crops that can be quickly harvested and require less water, e.g. choosing vegetables over rice and wheat; and
- improving water management (e.g. catchment management, re-use of water and rainwater harvesting).

Considering the impact of climate change, simple practices are increasingly becoming popular, including among others:

- building small ponds or installing rainwater tanks to collect rainwater for consumption and to irrigate kitchen gardens;
- construction of check dams and reforestation catchment areas for recharge of water system;
- income diversification by shifting to non-agriculture income through small business enterprises and animal rearing;
- using caste-specific old skills like tailoring, pot-making, basket-weaving and other cottage industries;
- regeneration of savings and credit schemes to regenerate livelihood assets such as rearing of goats;
- preference for small animals like goats because of shortage of feed and fodder; and
- following harsh coping strategy (by most vulnerable) like skipping meals, consuming less, consuming seed stock, sale of assets (such as livestock) and migration in search for work.

The above study clearly shows that farmers in Nepal have adopted different measures to cope with the impacts of climate change. Most studies concur that farmers have changed cropping patterns, and used various measures like income diversification, using organic manure, preferring small livestock like goat compared to larger animals, and managing water stress through efficient use of irrigation.

But again, the adaptation pattern is much contextualized and thus, differs from location to location because of the diverse nature of resources and different magnitudes of climate change impact.

Table 1: Climate change impacts and examples of interventions in South Asia.

Change	Sector	Impact	Intervention example
Increase in temperature	Agriculture	Altered cropping seasons Increase evapotranspiration Increase in irrigation water requirements Heat stress on crops and livestock	Introduction of short cropping varieties Diversification of crops Introduction of heat/moisture tolerant seed varieties Increase soil organic content/low tillage agriculture Water saving crop management practices Tree planting to provide shade and fodder for livestock
Increase in temperature	Water resources	Increase in glacial melt, snow melt impacting river flows Increase in water requirements and/or reduced water availability Formation of glacial lakes leading to outbursts in longer run Reduction in availability of fish stocks	Introduction of water storage methods Water conservation Monitoring and early warning systems for GLOFs Conservations of coastal mangroves and other vegetation
Changes in rainfall patterns and/or seasonality	Agriculture	Increased run off/soil erosion Farmers uncertain when to cultivate, sow and harvest Crops damaged by unseasonable heavy downpours Reduction in agricultural seasons	Appropriate, accessible, and reliable seasonal and weather forecasts Crop diversification and crop mixing Livelihood diversification Crop insurance Floating gardens during times of inundation
Changes in rainfall patterns and/or seasonality	Water Resources	Shift in monsoon season Erratic/intensive rains Reduced water recharge Increased frequency/severity of floods Increased frequency/severity of droughts	Rainwater harvesting at household level Checks on dams, plantations Improved drainage Protected/raised food, water and sanitation Community water management committees

Source: Review of Climate Change Adaptation Practices in South Asia, Oxfam Research Report, November 2011. Page 27.

3. Case studies:

Three case studies have been presented here briefly to illustrate how farmers have perceived climate change and adapted to them.

Case Study 1: Adapting to and using climate change for cash crops production—A case of Mustang

Due to its location in the Himalayan belt, Mustang district is one of the highly impacted districts in terms of climate change impacts. For example, average rainfall in Mustang almost doubled in 2051-62 (450ml) as compared to 2040-50 (250ml). A sudden rise in temperature was also observed where in 2040-50 the maximum temperature was 21-22 degree Celsius but currently it is 25-26 degree Celsius.

Discussions with elderly people of Mustang clearly revealed that they have seen less snowfall in recent times. In Tetang, Mustang for example, all the consulted communities responded that they used to have heavy snowfall 5-6 times during the winter but currently the occurrence of such snowfall has decreased to only once or twice a year. This has significantly reduced the unbearable winter chills and minimized the trouble of clearing the snow from rooftops and trails. But on the other hand, reduced snowfall—the main source of water supply—has contributed to water shortages which in turn have adversely affected agriculture production. In addition, severe water scarcity could force the communities to abandon their settlement.

In lower Mustang, especially in areas below Kobang, temperature increase has been significant and there has also been more rainfall. Although these changes have been perceived positively by the people, they have also realized its negative impacts, mainly on apple farming; the increase in rainfall and moisture in the air has been causing diseases in apples. Similarly, apples have not been getting the type of texture and colour in the skin that was seen in the past. The result has been the decline in apple production, and farmers have started destroying their apple orchards.

Adaptive practices:

- As an adaptive practice to the changing climate, there has been a shift in apple farming from lower to higher altitudes. Although climate change has affected apple farming in the lower region of Mustang, the overall apple production in the region has not declined due to the increase in production by farmers of the upper region, especially up to Muktinath. The changing weather pattern has made the lower region less suitable for apple farming and the higher altitudes that used to produce very little apple due to the cold weather are not considered suitable. However, the incidences of diseases have increased. Fortunately, farmers have been able to counter the

problem of diseases through the application of organic pesticides they prepare from a concoction of various herbs grown locally.

- Farmers in the higher altitude, which used to depend more on livestock and trade, are now developing apple orchards and nursery farms.
- Farmers in lower Mustang are now increasingly turning towards production of green vegetables like cabbages, cauliflower, cucumber, chilli and tomatoes in open gardens. This form of farming is slowly replacing apple farming. Vegetable farming has been done in open garden as well as through the practice of a greenhouse (plastic green house) (see picture). Green vegetable farming is also seen in Muktinath, whereas in the past, it was impossible to grow vegetables in open gardens due to the cold temperature.
- To cope with the shortage of water, a practice of constructing small ponds for water storage is growing.
- The local institution of *Subba* is more strict and functioning well in Mustang villages, especially in lower Mustang. This institution is taking more interest in water management, water rationing and developing ponds for water storage.

Case Study 2: Jhiku Khola Watershed—A case of adaptation to water crisis

Jhiku Khola watershed, termed as the vegetable bowl for Kathmandu, is also affected by the growing water scarcity possibly due to climate change. This water crisis has several consequences in farming, raising livestock and maintaining household livelihood activities by the farmers, resulting in the whole local livelihood system being disturbed. A common sight when you travel to Jhiku Khola, mainly the Panchkhal valley, is of villagers carrying empty water pots or long lines of empty water pots awaiting their turns for a rationed quantity (measured by water-pot) of water. Another strange sight is of people carrying kerosene jerry cans to run water pump to irrigate their fields, even in the middle of monsoon.

Previously there were a large number of natural springs and old wells for drinking water and for irrigation in the area. Some of these natural springs (*muls*) were permanent, while others supplied water for both longer and shorter period of time. Currently, even those natural sources that supplied water year round have dried. In monsoon, streams like Jhiku Khola used to over flow, but today it looks dry not only in the winter or dry season but also in the monsoons.

Adaptive practices:

Farmers in the area have adopted different water management practices to deal with the growing water crisis in Jhiku Khola watershed. Some of them are listed below:

- New informal institutions have evolved to ration and regulate well water for drinking. For example, people now completely control access to well water which was previously freely accessible to the public. Five years ago, there were two windows in the wall structure constructed to preserve the well and people could dip their water-pot through the windows. But with the increasing water shortages, one of the windows was blocked. The only remaining window is now accessible just for 2 hours in the morning and evening, and the key to the window is rotated within different households in the community. This is an example of new informal institution that has been created to adapt to severe water crisis.
- People have dug private wells; though this has implications for long-term sustainability of water supply, the wells has partly helped in relieving the current problem. Water has become a scarce commodity and people do not waste it. They always lock their wells and use it only when needed.
- There is a shift towards the use of more organic manure (compost) in the field as farmers know that it helps to retaining moisture. This area was known for heavy use of chemical fertilizer, and this made the land/soil unhealthy and dry. Realizing this, farmers started using more compost and making compost at home.
- Farmers have started developing rainwater collection system at their homes, and bio-gas has also been developed through support from the government.
- People have started developing ponds in the river bed (which has become dry) where water that has seeped is collected. This water is pumped to the field to irrigate paddy as well as vegetables.
- Water crisis was considered a main problem by women more than men, thus their strategies for coping also differed. While men preferred to migrate as a response to decline in income opportunities within the village, women were favouring rationing and judicious use of water, and increasing the sources of water through wells, government piped water distribution, and irrigation system.

Case Study 3: Living with floods in West Rapti River in Banke

Villages located near the banks of the West Rapti River are very prone to flooding. Almost every year they are inundated. It is difficult to say exactly how much of this is caused by climate change or other factors, but it can be argued that climate change is also a contributing factor. The most affected villages are Betahani, Holiya, Binauna and Phatepur. The impact of flooding goes up to Nepaljung city. The increased frequency of flooding in recent years together with poor institutional setup to deal with the problem has severely affected people in the region. As in other disasters, marginalized groups like landless, women, children and elderly are mostly affected by such events (see pictures).

Adaptive practices:

- Farmers have built small mud thatch houses to store things like food in a raised platform. They also hang their belongings like clothes on the roof in their house (see pictures). So, even in cases of flooding they do not have to move their food stock and personal belongings and it remains dry.
- Building small house with bamboo structures.
- Emphasizing vegetable farming and having irrigation facilities like hand-pump or leg-pump (see picture).
- Emphasizing animal husbandry (mainly raising buffaloes) for milk production. During flooding, buffaloes could be more easily saved than other animals, they could protect themselves also (see picture).

4. Sharing of climate change adaptation practices across South Asia:

There are two ways for sharing adaptation practices in South Asia. The first one is through informal mechanisms which have been taking place since a long time ago, and this comes from personal contacts and communication, along with travel and migration of people between the countries. However, the extent of how this form of sharing has helped farmers' share their adaptation practices across the countries has not been properly documented or explored. The presence of similar traditional practices across the region could well be attributed to this informal transfer of technology.

The second way of cooperation is more formal and directed by different state agencies (for example government research and extension organizations) or other semi-government agencies like NGOs and INGOs, civil societies and private sector. Although these agencies often stress the need for such cooperation in their policies to address the impacts of climate change, the extent of cooperation, has not been properly documented.

It is also difficult to differentiate which adaptation practices have resulted from informal cooperation and/or planned co-operation. For example, some of the adaptation practices (table 2) followed in South Asia must have been shared because adaptation practices followed by Nepali farmers are similar to those in other countries. Although most of these shared practices described in the table come from planned intervention, some are also developed by Nepali farmers autonomously.

4.1. Informal mechanisms of cooperation

As there is no proper documentation or research on the sharing of adaptive agricultural practices within South Asian countries, much of the information presented comes from anecdotal sources and personal experiences.

The long history of human settlement in South Asia⁵ and mobility of people across the region has led to similar farming systems in different geo-physical conditions. On the other hand the wide diversity in natural resources for agriculture and the presence of diverse cultural practices has also led to different farming systems within the region. The observed similarities in farming practices in the region can be attributed to mobility of people, their frequent interaction and exchange of seeds and experiences. For example, studies have shown that agricultural practices commonly observed in many traditional farming systems in Nepal and India are instrumental in avoiding various risks and in achieving stability in the farming system in the aspects of yield stability, maintaining soil fertility, and attaining a constant supply of human and animal food (Jodha, 1981; Subedi et al. 2004; Sthapit, Rana, Eyzaguirre & Jarvis 2008; Sunwar 2003).

Another study from Nepal has shown that farmers with limited disposable income grow a wide range of perennial and annual plants (up to 123-131 plant species) in their home gardens, which provides wide range of food and nutrients for the family. This biodiversity within the home garden also means that it is an important reserve of on-farm plant genetic resources. It is assumed that exchange of practices among the farmers of Nepal and India must have occurred for the development of such diverse, integrated and mixed farming system, which seems suitable for adapting to climate change impacts. However, the slow introduction of mono-cultural practices in these regions have compromised the ability of farming systems to cope with existing weather fluctuations and other perturbations in the system, leaving the countries vulnerable to climate change.

Even currently the interaction and mobility of people in the region is high, especially across Nepal and India due to open borders. This interaction between farmers has also taken a more formal structure through the involvement of government and other agencies facilitating these interactions. However, as stated earlier, it is difficult to objectively analyse these interactions because of lack of research or documentation of these practices.

4.2. Formal cooperation for sharing of agricultural practices (for adaptation to climate change)

Cooperation seems to have taken place at different levels and in various forms between Nepal and other South Asian countries:

- 1) civil society (community) cooperation;
- 2) NGO cooperation (directly or through INGOs);

⁵ South Asia here refers to what is generally known as eight countries, including Afghanistan, included in SAARC.

- 3) private sector agencies (trading partners, etc.); and
- 4) cooperation between state or semi-state agencies.

Cooperation between civil societies has taken place, more so now than in the past; farmer visits organized by farmers' associations can be taken as an example of such cooperation. For example, Indian and Bangladeshi farmers involved in conservation of local seeds through community seed banks have visited Nepal to understand how these seed banks works, and vice versa. However, due to lack of resources and proper documentations, only anecdotal information is present for illustration.

NGOs have played an important role in promoting cooperation in this area by having a great deal of interactions among organizations working in climate change and adaptation practices. Table 2 illustrates some of the common adaptation practices in South Asia promoted mostly by intervention from NGOs and INGOs. The role of INGOs is bigger in this context as they launch and implement similar projects in different countries keeping in mind the local context. These INGOs have also helped in bringing together experts and farmers to share their experiences. For example, a new initiative to share information on climate change adaptation practices in South Asia is expected to encourage farmers, scientists and policy makers to share effective ways of dealing with the impacts of global warming. Consultative Group on International Agriculture Research (CGIAR)'s program on Climate Change, Agriculture and Food Security (CCAFS) in South Asia⁶, consists of a global network of research bodies, with the aim of sharing all available data and scientific analysis on projected changes in climate, observed and expected impacts on agriculture, and best practices for adaptation. CCAFS has in fact launched a "learning platform" to improve communication and share knowledge, which it hopes will bolster the region's agricultural resilience, improve food security and help reduce the carbon footprint of the agriculture sector. The aim of the program is to develop climate-smart villages by providing them access to the internet. This project has been initially implemented in India and Bangladesh to help farmers share best practices being implemented. The project is also expected to promote dialogue by organizing meetings, seminars and panel discussions, bringing policy makers, scientists and farmers together.

Private (business) sector is also responsible for bringing various practices and technology (know-how) or technology-products that helps in CCTT (climate change technology transfer). In Nepal they are mainly responsible for introducing seeds, and know-how machineries. Most of these seeds and technologies come from India due to the country's involvement in greater innovations of modern technology as compared to other countries in South Asia. Improved seeds of wheat and rice were developed long ago in India and were supplied through private agencies to Nepali farmers. Similarly, agricultural tools including tractors come mainly to Nepal from India through private channels. A large quantity of hybrid seeds along with various agro-chemicals and machinery also comes to Nepal

⁶ <http://www.scidev.net/global/policy/news/south-asia-gets-climate-smart-learning-platform.html>

from India. In recent times, organic fertilizers and pesticides have also come from Indian companies through private sector. However, hybrid seeds that come to market through private sector have adverse impact to local biodiversity and have made farmers vulnerable to climate change.

At the government level, policies on cooperation have often been formulated. For example, SAARC has recognized that climate change is a threat and included it in its agenda since a long time ago. SAARC was concerned on environmental issues since 1987 and formed a commission to study the protection and preservation of the environment and developed the Kathmandu Declaration. In its later summits, climate change has appeared as a serious issue. Similarly, cooperation among the countries has been emphasized as an important step to tackle environmental issues since the Male Declaration in 1990.

The issue of co-operation, at least on rhetorical level, was also seen in the seed sector. For example, in the Fifth SAARC Summit held in Male in November 1990, a decision was taken to extend cooperation for the exchange of expertise in genetic conservation and maintenance of germplasm required for the conservation of biodiversity as well as further development in seed quality, and this was important in the context of climate change. The Sixteenth SAARC Summit (2010) agreed to promote cooperation for a regional seed bank in South Asia, and in the Seventh SAARC Summit (2011) countries signed the SAARC Seed Bank Agreement and the Framework for Material Transfer Agreement.

The major objective of the Seed Bank was to provide regional support to national seed security efforts, address regional seed shortages through collective actions, foster inter-country partnerships and act as a regional seed security reserve for the member states of SAARC. Meanwhile, the Framework for Material Transfer was to facilitate supply/exchange of seeds for common varieties among the member countries to ensure food security in the region. This transfer has to be done in accordance to the existing laws, regulations and guidelines of SAARC member states, and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The issue of co-operation on seeds is important in the context of climate change adaptation. Farmers have understood the issue and followed practices for seed conservation through community seed banks as well as through planned interventions (Adhikari 2012a; Adhikari 2012b).

In case of climate change, Dhaka Declaration on Climate Change and SAARC Action Plan on Climate Change (2008), and Thimphu Statement on Climate Change (2010) [which discussed ways to jointly fight climate change and establishing an inter-governmental expert group on climate change] are noteworthy steps for regional co-operation. SAARC mechanism would provide capital for projects that promote low-carbon technology and renewable energy, and establish a Low Carbon Research and Development Institute in South Asian University. It is difficult to analyse how far these cooperation statements have been formulated into programs at the national and regional level, and

verify their implementation status, mainly due to lack of information. In fact, there has been no concrete program to bring these statements on cooperation into practice. Although the Thimphu Statement makes no specific reference to the agriculture sector, implementing other statements for promoting relevant technologies in agriculture still has long ways to go.

5. Technology (modern or traditional) sharing or transfer

In the past, Nepal brought and used many seeds from other countries, especially from India. Research institutions in the country mainly followed 'trial selection' methods to find suitable varieties of improved seeds/breeds. This was in essence, a testing of technologies borrowed from neighbouring countries, and was much evident from the year 1965 to 1980 (Yadav 1987). The seeds developed for green revolution, especially wheat, were borrowed, improved through selection/testing, and released in Nepal. Therefore, the practice of seed exchange in Nepal has existed in the past. Between 1981 and 1995 the country reformed its agricultural research institutions and began focusing on the innovation of location-specific technology. Consequently, climate sensitivity traits (e.g. drought resistance) began to emerge as an important issue. Since the mid-1990s, Nepal brought a radical change in the development/innovation of technology through the participation of farmers, and other stakeholders like NGOs, community based organisations (CBOs) and private sector. This effort helped in developing seeds with greater sensitivity to location-specific climatic conditions. This also led to the decentralization of development of technology by including farmers, civil society (NGOs and CBOs) and private enterprises in seed development. This institutional innovative was shared in other countries in South Asia through international agencies like CGIAR (Chettri et al. 2011).

There are a few other technological innovations that Nepal has also brought in from other South Asian countries in recent times, including 'zero-tillage' rice-wheat cultivation technique for the improving productivity using conservation tillage farming in low-rainfall areas. This practice was formally introduced in the Gangetic Plains and was successful (Erenstein 2009). In this no-tillage practice, seeds are sown in unploughed fields in order to conserve soil fertility, economize water scarcity, reduce land degradation, and lower production costs. The zero tillage technique was also practiced in Pakistan for wheat using drill planting, which saved 15-20 percent water as it reduced evaporation and runoff and increased yield (Hobbs et al. 2000). These innovations evolved spontaneously in response to climate change, and many similar climate change adaptation experiences can and should be exchanged across the region to benefit South Asia. However, seed exchange today has become difficult due to greater restrictions placed by government of different countries on the exchange of germ plasma.

Micro-hydropower, an allied sector of agriculture, is another area where technology transfer occurs in South Asia. It is mainly exported to Afghanistan. Nepal developed its micro-hydro technology through collaboration with developed countries, and currently this technology is very useful in the

mountain environment. The water-mills, which can generate energy as well as help in grain milling, are also popular within the country and are also exported. Since micro-hydro and water-mills help farmers in their farming practices they can be identified as an integral part of the agricultural sector.

Another example of transfer of innovative technologies is through community forestry which contributes significantly to the agriculture sector. The institution/practice of community forestry, which helps in the conservation of forest and other tree resources, biodiversity, and, at the same time, improves the livelihoods of people, is well recognized in Nepal. Knowledge and experiences generated in Nepal in this area has also been utilized in other South Asian countries, especially through the aid of international agencies.

Many other practices are shared across South Asian countries to help fight poverty and the impact of climate change. For example, NREGA (National Rural Employment Guarantee Act; later named as Mahatma Gandhi National Rural Employment Guarantee), India's most important anti-poverty scheme, is regarded as the country's main initiative to fight the adverse impacts of climate change. This initiative provides income security and improves greenery; since 70 percent of its jobs are in green sector, 14 percent of work undertaken relates to afforestation and 17 percent of total work undertaken relate to rural connectivity. Recently, the Indian government has started a pilot project to quantify climate benefits from NREGA (Singh 2012). In Nepal, the National Planning Commission is also developing such regulation to provide guarantee employment to rural people or cash transfer if employment cannot be provided to certain targeted group in disadvantaged regions. This program aims to save people from the risks of disasters arising from climate change by providing guaranteed income to fight the uncertainties faced in the farming system. In addition, Nepal has also adopted the concept of *Grameen* Banks from Bangladesh; these Banks provide support to the rural poor to help them adapt to climate change and to cope with the risks.

Although many of the institutional innovations mentioned above are generally not considered as technological innovations or technology transfer, they can nonetheless contribute to better production and better resiliency to climate change.

6. Identification of impediments for sharing of adaptive practices

In order to identify the impediments of sharing or transferring climate change adaptation technology, it is also important to look into how such transfer takes place (see the framework in table 2). Generally, this takes place in two ways—formal agreements, which may sometimes be legal binding (group 1 mechanism) and informal mechanism which generally has no formal agreements or legal bindings (group 2 mechanism). Looking into the situation across South Asian countries, there are more impediments under group 1 mechanism compared to those under group 2. In the case of Nepal

and India, group 2 mechanism is more flexible as compared to other countries in the region. This is mostly due to open border, free migration, long-established migration pattern and cooperation in education.

Table 2: Technology Transfer Mechanisms (Rogers et al. 2001)

	Mechanisms	Characteristics
Group 1	Foreign Direct Investment	Vehicles for transmitting technology, technical know-how or technology-intensive products through joint-ventures, wholly owned subsidiaries or spin-off companies
	Licensing Agreements	Legal contractual rights for commercial and non-commercial uses of developed intellectual property rights (patents, copy-rights, trademarks, utility models etc.) and other technological assets
	Grants and Co-operative Agreements	Contracts allowing different entities (industry, non-governmental organization, academia, public institutions, etc.) to collaborate with one another for the purpose of joint R&D activities.
Group 2	Publications	Open literature (book, articles, academic journals, magazines etc.) and trade literature to transmit and share knowledge
	Cross-border movement of personnel	Site visits, personnel exchanges, labour mobility programs, migration, etc.
	Public meetings	Conferences, seminars, workshops, symposiums and other public forums

Foreign direct investment (FDI) is very low in South Asia as compared to other countries, especially those in Southeast Asia; the main reason for this is the political instability in the region. Adhikari (2013, 1) mentions that FDI in South Asia started to pick up after 2009 and reached US\$39 billion in 2011, but four-fifth of this goes to India and Nepal receives the least amount in South Asia. This can be observed in the formulation of ADS (Agricultural Development Strategy) in Nepal in 2011-2013. In terms of FDI's contribution to GFCF (Gross Fix Capital Formation), it is 2.5 percent in Nepal, which is the highest ever recorded, although this is the lowest in South Asia⁷. The agricultural sector in Nepal is almost devoid of FDI. Nepal's geographical location and lack of accessibility are also responsible for the low FDI. However, there are a few niche products in Nepal (like medicinal herbs) which could attract FDI in future if political stability is achieved and a FDI friendly environment is created. This will prove beneficial for both investors and farmers.

⁷ India 6.4 percent, Pakistan 5.3 percent and Bangladesh 4 percent, Sri Lanka 2.1 percent, Bhutan 2.1 percent, and Afghanistan 2 percent (Adhikari 2013, 3)

There are also contradictory voices in bringing in FDI in the agricultural sector. FDI usually brings new modern technologies to increase productivity. As enterprises established from FDI have to compete in the global market or even in local market, they tend to bring new innovations in the management or in technology. In some cases, there are requirements that FDI-based enterprises need to meet in the transfer of technology. This is mainly done through training of local human resources, and the introduction of new genetic materials or knowledge to facilitate the use of modern farming technologies. Due to these reasons, technology transfer for climate change adaptation has been difficult in the case of Nepal.

The role of grants and aid from foreign partners in terms of technology transfers, especially adaptive technology transfer for climate change, has not been fully understood. In the past, much of the technology transfer through foreign projects coming as grants or loans have not been helpful in terms of climate change adaptation. For example, monoculture, improved seeds/breeds, technology requiring fertilizers and pesticides have, in fact, increased the vulnerability to climate change. There are few exceptions to this such as the development of seeds that could resist drought, diseases and pest, and sustainable agricultural technology like Stopping Agricultural Land Technology (SALT). Technologies like integrated pest management (IPM) which are brought from international research institutes like IRRI Philippines promote sustainable agriculture aimed at increasing the resiliency to climate change impacts. However, the complete understanding of these technologies and how they aid in climate change adaptation is still lacking.

The investment in research and development (R&D) is also critical in the development and sharing of technology. Investment in agriculture is declining in Nepal, and the budget for agricultural research is almost negligible. Within South Asia, India is slightly better in terms of research capacity to develop formal technology that can help farmers to adapt to climate change. Because of the budgetary constraints, there is less collaboration in research among the institutions in South Asian countries. New issues like fee amounts and visa regulations have added constraints to the academic exchange across South Asia (except for the case of Nepal and India). Private sector's investment in R&D is almost negligible in Nepal and other South Asian countries, and very nominal in India.

Regulatory mechanisms (e.g. licensing agreements and cooperative agreements/contracts) have also brought impediments in the transfer or sharing of technology. This is not only so for North-South collaboration, but also collaboration or technology transfer within South Asia. Despite south-south being the preferred mechanism for technology transfer among South Asian countries, mainly due to low cost of transfer and high adaptability, the existing socio-cultural conditions and SAARC's inactive role serve as major barrier to the transfer. The above mentioned statements on cooperation have also not been practically materialized.

IPR (Intellectual Property Rights) and TRIPS (Trade-Related Aspects of Intellectual Property Rights) of World Trade Organization (WTO) has also been posing some constraints in the transfer of technology. SAARC has accepted the fact that the material transfer (i.e., genetic resources) should be within these international norms. There are different concepts regarding farmers' rights or breeders' rights in the case of IPR. Countries like Bangladesh are members of UPOV (International Union for the Protection of New Varieties of Plants) but others like Nepal are not. Hence, IPR/TRIPS have and will continue to influence the transfer of technology in the future.

On the theoretical question of the effect of IPR on technology transfer, there are divergent views. The common assumption that IPR alone leads to innovation of technology is a wrong concept. Strong IPRs *per se* do not result in better or more transfer of technology (Srinivas 2012, 3). While some technologies (mainly seeds) are IP-protected, some other practices or technologies are not. There is still more to do in the innovation and diffusion of technology across the South Asian countries for technologies that are not protected by IPR (Srinivas 2012). Other regulatory mechanisms like quarantine regulations have also hindered the free movements of technological products in agriculture.

There are also impediments in CCTT (Climate Change Technology Transfer) because of some restrictions that impede the complete use of the group 2 mechanisms as listed in table 2. The regulation of visa and difficulty to get across borders in South Asia is also causing problems for the transfer/sharing of knowledge and ideas. Access to literature has also been restricted because of the lack of resources to develop electronic documentations and to develop mechanisms for quick transfer of these resources. Open borders between India and Nepal make site visits, personal exchange and labour migration between these countries easier but the same is not true for other countries.

There are two other constraints in CCTT. Firstly, the linear model of CCTT is based on the thinking that technology transfer is from a modern/developed place to traditional/undeveloped place, and thus considers that there is no innovation in traditional places, and it is only the scientists who develop technology. Secondly, the lack of resources or economic barriers is another impediment to CCTT. Owing to resource constraints in South Asian countries, there is only limited innovation, especially high-tech innovation.

The magnitude and influence of the barriers to CCTT differ by country and by type of technologies involved since the local capacity to adopt a particular technology is different in different countries of South Asia. There is a perception that technology currently means hard technology like seed, chemical, infrastructure, etc. This has implications in the transfer of technology casting a shadow on the innovations made in areas of transfer of soft technologies like organization, policies, and institutions.

7. Recommendations

The deliberations at the South Asia region clearly indicate that there is consensus and seriousness to deal with the adverse impact of climate change. Despite this, there is limited understanding of how the affected people, particularly farmers, have been adapting to climate change using their traditional knowledge and practices. The development/innovation in the formal sector has been slow and even those present at the farmers' level or at the formal level, are not transferred well across the South Asian countries because of various barriers.

The realization of seriousness of the adverse impact of climate among the policy makers and political leaders is evident from the fact that South Asian countries have developed their own national plan for adaptation—National Adaptation Programmes of Action (NAPA) in Nepal, Climate Change Strategy and Action Plan (BCCSAP) in Bangladesh, National Climate Change Adaptation 2011-2016 in Sri Lanka, National Action Plan on Climate Change in India, and the draft National Climate Change Policy in Pakistan. Unfortunately, these plans are yet to be fully operational and there is still lack of resources for their implementation. Similarly, various other developmental stakeholders in these countries have also been developing their own program of action sometimes as 'stand-alone' projects and sometimes in line with the national adaptation plans.

Despite such progress, the information and analysis presented in the report clearly reveals that a lot needs to be done within South Asia for better innovation and transfer of technology to counter the adverse impacts of climate change. Based on these gaps, the following recommendations are made.

1. Recognition of multiple locations of innovations and flexibility in policies to let people and institutions interact in these locations

This study reveals that innovative practices to adapt to climate change have been undertaken at multiple locations, whether formal or informal. But policies related to the transfer of technology have given more attention to technologies developed at formal institutions and in developed countries. Moreover, technology is defined by hardware type of technology, narrowing the scale of CCTT. As the study shows, farmers are also innovators and possess the know-hows and traditional knowledge about the ecosystem including weather patterns. This has enabled them to develop practices to deal with climate change. Therefore, government and policy makers should recognize the fact that innovations have taken place at the local level and there is a need to document these innovations. Similarly, policies need to be developed in a flexible way so that people and institutions can interact develop, improve and share this knowledge and expertise. This calls for investment in the documentation of both informal and formal innovation practices, and their widespread dissemination across the region. Special attention and investment must be directed towards documenting the practices that farmers have developed based on their

observation and knowledge of the ecosystem, mainly because the adoption of many locally developed innovations can be less costly and easy to implement.

2. Need for greater investment in R&D

More investment on agriculture research in the public sector is required in all countries in South Asia. Private sector's involvement in R&D in agriculture has thus far been very low. However, though investment of the private sector in R&D is important, the development of technology suitable for climate change is not possible without the involvement of the public sector. But despite the urgent need to develop technology that helps farmers to deal with climate change—drought resistant seeds, seeds which can mature in long duration as well as short duration, disease and pest resistant seeds, high yielding seeds that can survive in inundation—unless appropriate, required technology is developed, the mechanism to transfer them will have no relevance. Therefore, more investment in R&D is required.

3. Focus on the regional transfer of IP-irrelevant technologies

There are certainly many impediments for the transfer of technology to South Asian countries. Existing impediments arise not only from IPR related or TRIP related matters but also from the policies related to trade, quarantine and open border issues. Hence, there needs to be openness in regional agricultural trading regime, which will help in sharing the risks associated with climate change, and thereby increasing the resiliency. There are many new options in open innovation and open source models which are least affected by IPR, and hence technology needs to be developed and transferred through such mechanism. A multi-stakeholder method of innovation in which end users like farmers participate in developing varieties and breeds that are suitable for them can cater to the need of farmers to fight the impacts of climate change. For example, seed varieties that are flood resistant and drought tolerant, and that could fix nitrogen, are important. Thus, research should be done at different locations that lead to the production of such seeds; Nepal has been able to develop suitable varieties through this method. In such a model, farmers have the right to regenerate seeds and they can also build the technology on the already existing traditional varieties and practices. This can, thus, help preserve local/indigenous varieties. The other practices that go with agronomic practices like cropping season, and water and soil management are not IP-protected. Therefore, adoption of such seeds becomes easy for farmers. Moreover, a code needs to be developed within South Asia to harmonize seed testing and certification and facilitation of seed trade. With the recognition that farmers of different locations have developed their traditional seed varieties, the free exchange of seed for improvement under participatory plant breeding research could benefit all. It implies that genetic resources within traditional societies in South Asia become 'common pool' resources.

4. Push for greater regional cooperation

Regional cooperation among governments in South Asia needs to be improved to ensure effective implementation of national adaptation strategies. The agreements made so far like the Thimphu Statement on Climate Change needs to be implemented and operationalized. Because of the low cost in transferring technology within South Asia, the potential of co-operation within the region needs to be explored as far as possible. In this context, SAARC can act as a catalyst for South-South technology transfer in the region.

5. Facilitate free movement of people across South Asia

There is a need for a regulatory framework to increase the mobility of people across the region. This will lead to an increase in farmer-to-farmer contact. There is need for an increased participation in seminar and conferences of those in academics.

6. Create a regional knowledge exchange platform

Increase in the regional exchange of students in universities, especially for research, is needed. An exchange of scientists in research institutions through fellowships or scholarships will aid in the exchange of information. SAARC should act as a platform for such exchange and allocate the required funds for it.

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Photos

Mustang Case Study

1. Growing vegetable production in Mustang and use of plastic tunnels. In Mustang, farmers have resorted to vegetable farming, which is done in open as well as under plastic tunnel. Increase in temperature has facilitated this.



2. River training efforts in Mustang to cope with seasonal floods. The flat mud roofs are not working effectively due to more rain. In the past, these traditional types of roof were made as there used to be mainly snow.



3. Apple farming has shifted to higher altitudes in Mustang. Lower altitude apples are of less quality and are also affected by diseases mainly because of more rain now.



A case of Rapti river flood

4. Granaries built to cope with floods in Banke. These earthen granaries are built at some height from the ground so that flood water may not affect them. In the small thatch houses – we see clothes and other valuables hanging on the roof so that they are protected from flood water of the Rapti river. Because of plain area and a dam built a few kilometres south, Rapti river gets flooded most of time in monsoon season.



5. Migration is becoming more and more a coping mechanisms of decline in food production and impacts from disasters like floods and landslides. Climate change is also responsible for this. These young persons have returned from working in India in mod-west Nepal. They bring cash as well as goods like rice, wheat flour, utensils, radios, batteries and the like (which they have carried) when they return.



6. Water Crisis in Jhiku Khola Watershed, Panchkhal

Wells have dried and there is less and less water nowadays in the natural wells which used to have plenty of water. These wells could be free accessed in the past as there used to be plenty of water. But, now people have to ration the distribution of water, and there is always queue for the collection of water. Khiku Khola (river) has dried in the winter season, whereas in the past, there used to have water flowing all the time. Now, people make pits to collect water that seeps

through the river bed and pump it to the fields for irrigation. People have also started to dig the wells, which are always locked in order to avoid the theft of water. Water balance has also been declining in these wells, which means that deeper and deeper wells have to be constructed now to get water.

