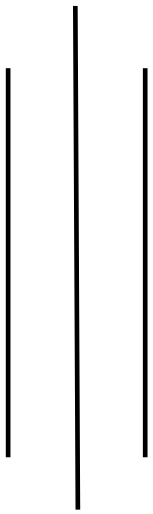
Stocktaking: Climate Vulnerability on Agricultural Sector for National Adaptation Plan Process



Final Report

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Jalsrot Vikas Sanstha(JVS)/GWP Nepal

1. Introduction

Contributing about 35 percent of the national gross domestic product (GDP), representing 13% of total foreign trade and with two-third of the country's economically active population engaged on it, agriculture is still accounted as the major economic sector of Nepal. It is an important component of industrial activity with the processing of agricultural products (CBS, 2012). Over 50% of farmers are small holders cultivating land usually less than 0.5 ha. Agriculture in Nepal is mostly rain-fed and climate sensitive. In comparison to other economic sectors this sector is highly vulnerable to climate change. A rise in temperature could have some location-specific positive effects, for instance increased agriculture yield. However most of the benefits will only be short-term soon to be overweighed by the vast negative consequences of rising temperature and drought on the ecosystem and food security.

Crop and livestock farming, in different combination, are major way of life in the communities. Cereal crops including rice, wheat, maize, millet, barely and buckwheat is the mainstay of Nepal's agriculture. However, Nepal is much vulnerable to climate change due to weather variability including rising temperature and changing pattern of precipitation, comprising drought. Rice is the prime food crop of the country which could face risk due to changes in the reliability of stream flows, a more intense and potentially erratic monsoon rainfall and flooding. Approximately 64% of the cultivated areas are heavily dependent on monsoon rainfall and changes in the time and duration of this monsoon rainfall could affect the agricultural production significantly, especially rice yields. The level of vulnerability will differ across the regional setting. The impact of climate change is expected to be severe in the mountain and Himalayas as compared to plain areas. In the higher altitude, population entirely relies on agriculture for their subsistence and the extreme climatic conditions that affect the agricultural production and food security will put these areas in economic stress.

Nepal is the fourth vulnerable country from the perspective of climate change (Maplecroft, 2012) despite our very negligible contribution to global greenhouse gas (GHG) emission. Weather variability associated with rising temperature and changing pattern of precipitation and drought is expected to have utmost adverse impacts on various components of agricultural systems. The impacts, though expected to become higher in the mountains compared to low lying Terai region, are detrimental to both the regions and ultimately to agricultural production, food security and the people's economic existence . Moreover, both the agriculture sector performance that depended mainly on conduciveness of weather conditions, and the agrarian community that showed higher intensity of poverty in the country irrespective of the regions are foremost sufferers of any adverse situation brought about by the change (MOE, 2010).

2. GHGs Emission from the Agricultural Sector

In Nepal, the agriculture is existent due to nature. Use of machineries and fossil fuels in agriculture is very limited resulting into the negligible amount of CO_2 emission. However, agriculture is one of the major sources of CH_4 and N_2O emission. The GHG inventory for

agriculture developed has used the following scoping framework: CH_4 emission is attributed to enteric fermentation, manure management, rice cultivation, and soil management whereas N_2O and NOx emissions are credited to manure management, and soil management. Other sources of GHGs such as savanna burning are not relevant for Nepal. In agricultural burning, the CO_2 released is not considered to be the net emission and the long term net emission of CO_2 from the burning of crop residues are considered to be zero (IPCC 1997). Though other GHG emission from residue burning comes under the net emission, data required for analysis are not available in Nepal (MoSTE2014).

The quantification of the emission was done by multiplying the eligible activity data for agriculture obtained from published government sources by the respective emission factors obtained from the source category for a specified gas as the Emission Factor Database (EFDB) default value of the revised 1996 IPCC guidelines (IPCC, 2006). The time series emission data was obtained by estimating the annual emission from the year 1996 to 2009 in addition to the base year 2000.

The standard methodologies recommended by the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1997) were used. The future projections of GHG emission show that methane emission in Nepal will reach to 614 Gg by 2015, 730 Gg by 2025 and 796 Gg by 2030. Similarly, the N_2O emission is feared to reach to 40 Gg by 2030. As a result, Nepal's total emission is most likely to reach 835 Gg in 2030. The study suffered both from the non-availability of emission factors at the national level and activity data set as defined by the emission factor data base (EFDB) of the IPCC 2006. While selecting the emission factors reported by IPCC, preference was given to those reported for the Indian sub-continent to the extent that such figures are available.

2.1 GHG Emission for Base Year 2000

(a) **Emission from enteric fermentation and manure management**: Cattle farming are a major source of methane emission from enteric fermentation. This is mainly fodder based rather than feed based and expected to have a lower level of methane emission per head. Methane emission from manure management is reported to be usually smaller than that from enteric fermentation emission, and is principally associated with confined animal management facilities where manure is handled as a liquid (IPCC, 1997). However, manure is handled as a dry lot in Nepal.
As a cattle farming in Nepal is generally semi-range-based, the emission from manure management per capita is expected to be lower than the coefficient reported by the IPCC database. Methane is produced when the organic dung is decomposed in an anaerobic environment, but the smallholder farmers manage the dung in small heaps which exposes most parts of it, thus reducing the chance of anaerobic action. As the manure in the country is stored in small heaps or pits and not generally stored as a liquid in ponds or lagoons, methane emission is expected to be low.

Methane emission from domestic livestock from enteric fermentation and manure management was 468.52 Gg in the year 2000. Similarly, nitrous oxide emission from animal waste management systems (AWMS) was 7.65 Gg.

(b) **Emission from flooded rice field**: Rice cultivation in Nepal is practiced under flooded conditions. As flooding limits the supply of oxygen at the deeper layers, and anaerobic decomposition of organic material in flooded rice field produces methane. Though rice production in some part of the country, particularly under low lying conditions is flooded, rice farming in most of the hill slopes is practiced under small terraces with limited water supply. Continuous flooding is neither possible due to limited water nor feasible under the hilly terrains. Some portion of the rice is even grown under upland conditions without any irrigation. Therefore, methane emission from such rice fields in Nepal is expected to be much lower than that from rice cultivation under continuous flooding. The emission coefficients were selected to fit the country situation of rice farming. Using emission factors defined in the IPCC database, methane emission from the rice field is estimated at 1.57 Gg per year.

(c) **Emission from savanna burning:** Savanna burning is not recorded in Nepal.

(d) **Emission from field burning of agricultural residues**: A few case studies report that agricultural residues are burnt in the field however such data have not been available at the national level. Emission factors such as carbon fraction and nitrogen fraction from burning agricultural residues are also not available in Nepal. Moreover, there are limited practices of field burning of agricultural residues; so, emission from this activity is negligible. Moreover, as the biomass burned is generally replaced by re-growth over the subsequent year, the CO_2 released is not considered to be the net emission. An equivalent amount of carbon is removed from the atmosphere during this re-growth to offset the total carbon released from combustion. Therefore, the long term net emission of CO_2 is considered to be zero (IPCC 1997). Hence, emission from this activity is not included in the estimation.

(e) **Emission from agricultural soils**: Use of synthetic fertilizer, nitrogen from animal wastes, nitrogen from increased biological N-fixation, and nitrogen derived from cultivation of mineral and organic soils through enhanced organic matter mineralization are sources of nitrous oxide emission from the soil (IPCC 1997). As the application of synthetic fertilizers is very low (25 kg of nutrients/ha), the emission is also low. The farming technologies and soil management practices followed in Nepal do not perfectly match with those reported by the EFDB of the IPCC. The nearest possible technologies and practices were identified to match them with the emission factors reported by the IPCC. As no emission factor is found reported in Nepal for such activities, the IPCC EF is used for inventorying GHG from the agriculture sector as a whole.

In the base year, the direct nitrous oxide emission from agricultural fields, excluding cultivation of histosols was found to be 13.26 Gg per year. Nitrous oxide soil emission from grazing animals from pasture range and paddock was estimated to be 3.37 Gg per year. Similarly, indirect nitrous oxide emission from atmospheric deposition of NH_3 and NO_X are found to be 0.78 Gg per year. Likewise, indirect nitrous oxide emission from leaching was 2.08 Gg per year. In aggregate, methane emission from Nepalese agriculture during the year 2000 was found to be 470 Gg. Similarly, nitrous oxide emission was 27 Gg for the same year.

2.2 Trend in GHG emission

The methane emission, which was 450.8 Gg in the year 1996, reached 564.3 Gg in the year 2009. Similarly, the nitrous oxide emission which was 25 Gg in the year 1996, reached 30 Gg in the year 2009. Though the emission of these gases is increasing over the years, the growth is very slow, corresponding to the slow growth in the agricultural economy.

2.3 Projection of GHG emission

The emission of GHGs in the agricultural sector is projected from the year 2000 to 2030 and presented in Table 1. This shows that the emission of CH_4, N_2O and CO_2 will increase from 470.08, 27.14 and 18285.08 Gg to 795.84, 39.84 and 29063.04 Gg respectively.

Table 1. Projected emission of GHGs in the agriculture sector

Year	CH_4 (Gg)	N_2O (Gg)	CO_2 eq. (Gg)
2000	470.08	27.14	18285.08
2005	511.77	28.49	19579.07
2009	564.30	30.14	21193.7
2015	614.11	32.64	23014.71
2020	669.53	34.88	24872.93
2025	729.96	37.28	26885.96
2030	795.84	39.84	29063.04

3. Impacts of Climate Change on Agriculture

Agriculture is sensitive to both short-term change in weather and to diurnal, seasonal, annual and long term variation in climate. Increases of greenhouse gases or greenhouse effects or global warming or air temperature rise in the atmosphere directly affect the food supply and access through their direct and indirect effect on crops, soils, livestock, fisheries, diseases and insect pests. The increase in atmospheric CO2 concentration promotes the growth and productivity of crops, while other considerable factors like land use change, availability of water for irrigation, frequency and intensity of soil organic transformation, soil erosion and decline of arable areas is likely to pose threats to the production. The increased level of GHGs has created a greenhouse effect which subsequently altered precipitation patterns and global temperature around the world.

Nepal’s vulnerable farming economy will face additional risk due to changes in the reliability of stream flow, a more intense and potentially erratic monsoon rainfall, and the impacts of flooding. Decline in rainfall from November to April has adversely affected the winter and spring crops.

Impacts of climate change on agriculture are in major multidimensional and intricately vicious as 'agriculture' is function of several biotic and abiotic factors. Climate change can be visualized as affecting various components in a location-specific system of agriculture through its impacts not only in biophysical but also in socio-economic factors. Impacts of changing climate through its various parameters on biophysical and socio-economic factors affecting a range of components

in an agricultural system have ultimate negative effects on farm productivity. Some agricultural intellectuals presume some kind of positive impacts of climate change on crop and animal production (Gautam and Pokhrel, 2010). However, harnessing such hidden opportunities by farming communities is not possible and productive due to lack of relevant knowledge and technologies. The consequences of climate change in agriculture are very complex compared to other sectors. Even then, it should not be ignored in any development effort due to its association with livelihoods of grassroots, social stability and well tracked development of other sectors. Moreover, a well planned agriculture development in any location contributes to better adaptation to climate change and reduction of GHGs emissions, while that on haphazard planning worsens the situation (Pant, 2009). While the country's overall agriculture development is considering changes in its coping strategy, the rural smallholder farmers are facing increasing challenges in their daily livelihoods and they are looking for effective adaptation options and technologies to accompany their urgent and immediate responses to climate change. Not all climate change impacts are negative. In some areas, rising temperature has provided an opportunity for growing economically lucrative crop varieties that were unsuitable in the past, however, further adaptive and participatory research is needed to better define these opportunities.

3.1 Impact on production and productivity

A study on Economic Assessment of Climate Change in Key Sectors has estimated direct cost of current climate variability and extreme events equivalent to 1.5 to 2 percent of current GDP/year (approximately USD 270-360 million/year in 2013 prices) and much higher in extreme years (MoSTE, 2014). The declining forage production in natural pasture due to poor emergence of grasses, pastoral degradation and invasive species, increasing prevalence of animal parasites and vector-borne and parasitic diseases, heat stresses especially in pig, eroding breeds of sheep and pig, transhumance system loss, changes in animal reproductive behavior especially in terms of heat-period and fertility, shortage of feed ingredient and increased production/emission of GHGs due to animal health reasons have been major impacts and concerns of climate change in animal husbandry. It has also been foreseen the outbreak of feed toxicity, nutritional diseases and poor health in farm animals resulting in higher mortality rate, increasing production costs and low productivity as consequences of the impacts thereby affecting animal herders' livelihood. Likewise, major impacts speculated in crop husbandry are declining availability of water for agricultural uses, hindrance in operation of conventional irrigation systems and decreasing water use efficiency, increasingly degrading agricultural land, increasing depletion of land from agricultural uses, diseases and pests epidemics and increasing crop management risks. Those associated with poor availability of quality planting materials and technologies, catering changing context needs, are foreseen to affect crop production and economic sustenance of farmers adversely. Agro-ecological extension of some crops due to temperature rise and increased number of warmer days, prevalence of livestock diseases and parasites and declines in fodder and forage productions are reported in high mountains. The impacts reported in middle mountains and Terai are decreasing crop available soil moisture, crop failures and reduced crop productivity, and those typical to Terai are climate-induced disasters rendering agricultural land uncultivable (MOE, 2010).

Effects of climate change on water resources could yield manifold implications either due to too much and/or too little water. Climate-induced water stress directly affects agricultural productivity, human health and sanitation and ultimately accelerates malnutrition. On the other hand, too much water adversely affects human settlements, infrastructure and agriculture land. Increased temperature and rainfall variability have resulted into shifts in agro-ecological zones, prolonged dry spells, and higher incidences of pests and diseases.

Agriculture-dependent livelihoods are frequently exposed to a variety of climate extremes such as floods, droughts, hailstorms, thunderstorms, cold waves and heat waves. Floods and landslides are particularly regular phenomena in Nepal because of the country's undulating topography. Pest and disease outbreaks in plants and animals are another major concern. About 90 percent of crop loss in Nepal is caused by weather or meteorological events. Of all hydro-meteorological hazards, drought has the most severe impact on crops. Between 1971 and 2007, nearly 850 000 ha of crops was lost to weather- and climate-related events: droughts accounted for 38.9 percent of lost agricultural crops, and floods for 23.2 percent (UNDP, 2009). Disaster impact to the agriculture sector is on the increase. However, since the 1990s the impact has risen dramatically. Visible reasons are the increase in the occurrence and intensities of damaging meteorological hazards (FAO, 2014).

The losses have occurred in agricultural sector of Nepal due to climatic events (Tables 2 and 3) in the past four decades. Climate change threats are bound to further increase the number of hazardous events and their social, economic and environmental impacts. It is likely that a variety of climate-induced threats will extend the impacts of hazards in new areas. Rapid population growth, shrinking farm size in the Tarai Region and continued unplanned agriculture in hazard-prone areas are expected to add to the damage and losses if no countermeasures are put in place timely. The cropping intensity in vulnerable areas is increasing because of demand for food.

Table 2. Loss of agricultural land and crops as a result of climate-related extreme events in Nepal (1971-2007)

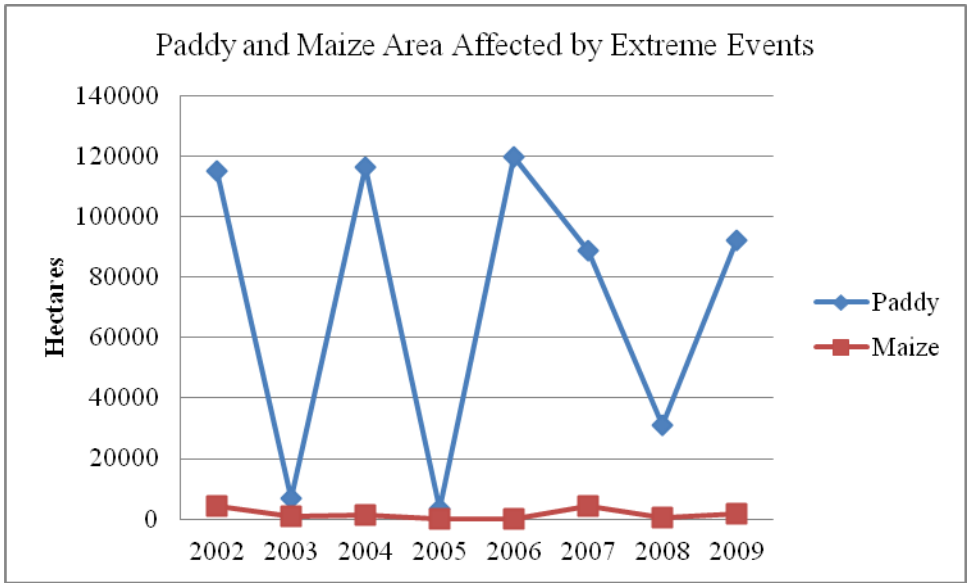
Events	**Loss (in hectares)**
Drought	329332
Flood	196977
Hailstorm	117518
Rains	54895
Strong wind	23239
Cold waves	21794
Others (forest epidemic, snow storm, fire, storm etc,)	83336
Total	**847648**

Source: IFAD (2013)

Table 3: Area (in hectares) of crops affected by climate-related extreme events in Nepal

Description	***Year***							
	2002	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***
Paddy	115000	6967	116506	3585	120000	88800	30873	92000
Maize	4 435	954	1293	20	47	4271	549	1700
Millet	-	-	500	419	-	1451	3	-
Others	2067	611	-	-	-	-	324	-
Total	121502	8532	118299	4024	120047	94522	31749	93700

Source: IFAD, 2013



3.2 Impacts on food security

The climate change affects the food security adversely at all four levels—global, national, household and individual. It is realized that among the climate parameters, the rise in minimum temperature reduces yield of rainy season crops affecting national self-sufficiency of food grains. The climate change affects the entire food system from production, processing, distribution, consumption and utilization. Food security in Nepal is particularly vulnerable to climate change due to low level of human control over the water and temperature and fragile ecosystems that get easily affected from the climate change and related extreme weather events (Pant, 2012).
Rainfall distribution is uneven across the cropping seasons. Summer crops are often over fed, if not flooded. Most winter crops and those planted during spring season are affected by prolonged dry spells. Increased climatic variability and change effects have diverse repercussions for agricultural productivity and thereby food security across all agro-ecological zones.

In the mid-hill and high mountain regions increasing temperatures has led to the expansion of agro-ecological belts into higher altitudes and increased length of growing period for some crop

species. Conversely, high hill animal herders have reported declines in fodder and forage production that has aggravated the prevalence of livestock parasites and meet the food demand of livestock. In the mid hills, decreasing soil moisture availability (due to changes in rainfall and temperature) result in early maturation of crops, crop failures and reduced agricultural productivity. In addition, decreasing run-off water to feed natural streams (used for irrigation) and re-charging natural ponds, reservoirs and lakes has been reported. In the Tarai region similar issues were noted, particularly reduced recharge rate of groundwater that has resulted in a reduction of discharge of water in shallow and even deep tube-wells to be used for agriculture.
To a certain extent, the negative impacts of increasing temperatures and increasingly seasonal and erratic rains on agricultural products can be mitigated through improved access to irrigation. However, not all cultivable lands in Nepal are irrigable. Of the total cultivable land (18 percent of the territory), only two thirds can and/or could have access to irrigation. This means that over one-third of the total cultivable land is rain-fed. The feasibility of accessing irrigation varies according to agro-ecological zones. The largest area that can be irrigated is in the Tarai (98 percent). A significantly lower proportion of the hill and still less in mountain regions are irrigable.

Pokhrel and Pandey (2011) stated that, for Nepal, “decreasing availability of food is presumed in the country due to climate-induced reduction in crop productivity, decreasing availability of agricultural water or inefficiency of conventional irrigation systems, poor availability of quality inputs/breed, under-utilization of available technologies, cereals based food habit, agricultural land depletion and degradation and, on account of those, possible occupational shifts, peoples' migration and land fallowing. Likewise, reduced access to food is anticipated because of decreasing livelihood options, imperfectness of market operation, constrained input/output distribution and increasing food import that discouraged local production. Less flexible food habit, limited food diversification, increasing cost of food quality control, increasing dependence on imported food and deteriorating traditional food market are recognized as food utilization related problems, and poor market operation and infrastructure, diseases/pests, increasing climate induced disasters and economic vulnerability as factors degrading food stability.”

Current initiatives to address climate change impacts include the introduction of better suited crop varieties, adoption of organic farming thus reducing the application of fertilizer, integrated plant nutrient management; community based integrated pest management, on-farm water management, and the establishment of farmers’ cooperatives to facilitate local adaptation. The adaptation priorities in agriculture have looked into the broader perspectives of sustainable agriculture land use system, agro-biodiversity management and favorable and conducive governance mechanism to facilitate local level adaptation responses. Hence, the proposed urgent and immediate adaptation options are specifically targeted to develop resilience of farming communities through better access to seed, technology and market, increase agro-ecosystem resilience and crop productivity and improve the conventional cropping patterns.

4. Climate Variability and Change

Observed changes in temperature trends indicate an increase in temperature. A study based on an analysis of temperature trends in Nepal from 1977 to 1994 (collected from 49 stations); indicate

a consistent and continuous warming in the period at an annual rate of 0.06^0C. Similarly, a study conducted by Practical action (2009), looking at data from 45 weather stations for the period 1996-2005, indicated a consistent and continuous warming in maximum temperatures at an annual rate of 0.04^0C. The studies also indicate that the observed warming trend in the country is spatially variable.

Nepal is experiencing intense rainfall and/or drought with increased frequencies of landslides, floods, droughts, and forest fires and with accelerated damage to life and property but no clear and significant trend has been noticed in rainfall pattern. There is an increase at an average annual precipitation of 3.6 mm based on the analysis of 166 stations all over Nepal from 1976 to 2005. However, observed precipitation has reached over 40 mm/year in some small pocket areas (Kaski district) while decreased annual rainfall has been observed in most parts of mid-western development region.

Climate model projections for Nepal indicate a rise in annual mean temperature by an average of 1.2°C by 2030, 1.7° C by 2050 and 3° C by 2100 compared to a pre-2000 baseline. As a result, agro-ecological zones will shift upwards altitudinally, as is already being experienced by mountain farmers in Nepal. Currently, rainfall patterns have become erratic and a decreasing annual trend has been noted primarily in the mid-Western region during the critical agricultural period of June, July and August. Conversely, increasing intensity of summer monsoon rain events are causing flash floods, erosion and landslides. The rapid retreat of glaciers is leading to the formation of new glacial lakes with potential for catastrophic outbursts. Shifts in precipitation patterns, longer droughts, more severe floods and deficit in the recharge of groundwater are major factors affecting hill and mountain farming. The projections show higher temperature increments during winter as compared to the monsoon seasons. Higher increments in temperature are projected over western and central Nepal as compared to eastern Nepal for the years 2030, 2060, and 2090, with projections for western Nepal being greatest. Similar trends are projected for the frequency of hot days and nights for 2060 and 2090.

Precipitation projections show no change in western and up to 5-10% increase in eastern Nepal for winter. During the summer months precipitations are projected to increase for the whole country in the range of 15 to 20%. A regional circulation model study projects both rise and decline in the mean annual precipitation with no clear trends. In terms of spatial distribution, an increase in monsoon rainfall in eastern and central Nepal as compared to western Nepal. Further, the projections indicate an increase in monsoon and post-monsoon rainfall as well as an increase in the intensity of rainfall, and a decrease.

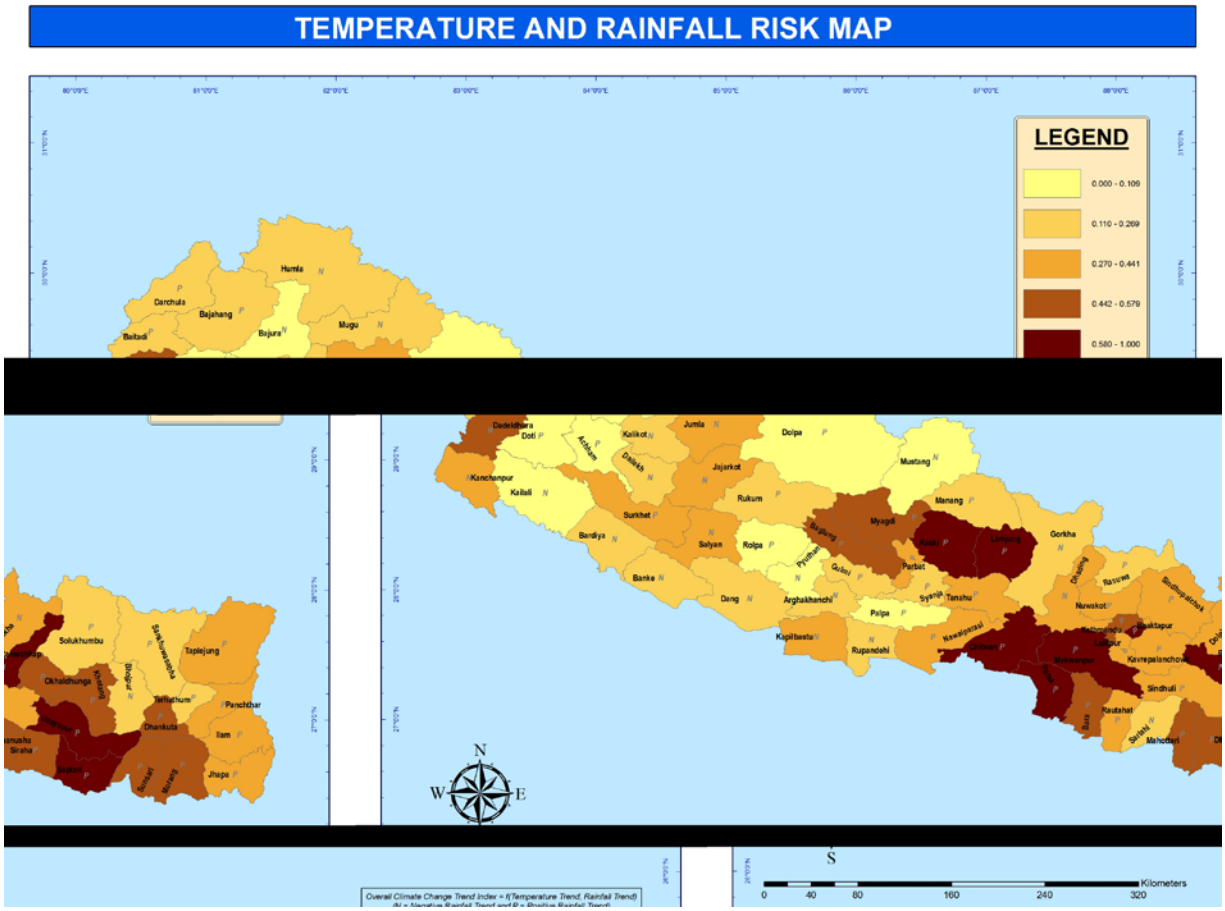
Nepal receives more than 80% of precipitation in the monsoon during June to September. In most parts of the country, peasants rely on this form of precipitation for farming. This implies that small peasants in Nepal are likely to suffer more since the poor farmers practice rain fed agriculture. The following is a summary of anticipated changes in temperature, precipitation and runoff based on a review of current literatures (FAO, 2014):

- Overall, temperatures will increase throughout Nepal, especially at high altitudes and during the winter season
- The numbers of days and nights considered hot by current climate standards will increase

- There will be a wide range of mean annual precipitation changes across the eco-regions of Nepal, with the tendency varying according to different scenarios and models.
- Downstream river flows would be higher in the short term, but lower in the long term because of a shift from snow to rain in the winter months.
- Extreme weather events will increase, especially floods during the monsoon season and the duration of droughts during the winter months.

5. Climate Vulnerability

Based on the severity of the impacts, vulnerability index of climate change for Nepal is categorized at different levels. It is estimated that about 1.9 million people are highly vulnerable to climate change. In general, the temperature over Nepal show increasing trend with few pockets of decreasing trends, which have been discarded as outliers for the purpose of analysis. In case of rainfall there are areas of positive and negative trends.



Source: MoE, 2010

5.1 Vulnerability at the district level

The ranking of the district from temperature and rainfall risks consideration is presented in Table 4. Districts of Hill and Terai Ecological Zone of Eastern and Central Nepal and Mountain

Ecological Zone districts of Western Nepal show higher exposure potential in terms of temperature and rainfall trends (MoE, 2010).

Table 4. District Ranks – Temperature and rainfall risk sub-indices

Overall Climate Change Trend	**Districts**
Very High (0.580-1.000)	Lamjung (P), Ramechhap (N), Saptari (P), Makwanpur (P), Chitwan (P), Parsa (P), Kaski (P), Udayapur (P), Bhaktapur (P)
High (0.442-0.579)	Morang (P), Bara (P), Kathmandu (P), Mahottari (P), Dhanusha (P), Dhankuta (P), Okhaldhunga (P), Myagdi (P), Dadeldhura (N) Khotang (P), Siraha (P), Baglung (P), Sunsari (P)
Moderate (0.270-0.441)	Parbat (P), Kapilbastu (N), Taplejung (P), Lalitpur (P), Jhapa (P), Panchthar (P), Jajarkot (N), Kanchanpur (N), Tanahu (P), Ilam (P), Jumla (N), Sindhupalchok (P), Kavrepalanchowk (P), Nuwakot (P), Dhading (N), Surkhet (P), Dolakha (N), Nawalparasi (P), Rautahat (P), Sindhuli (P), Salyan (N)
Low (0.110-0.269)	Mugu (N), Manang (P), Terhathum (P), Kalikot (N), Dailekh (N), Baitadi (P), Darchula (P), Rupandehi (N), Sarlahi (N), Solukhumbu (P), Bhojpur (N), Gorkha (N), Sankhuwasabha (P), Gulmi (P), Syangja (P), Banke (N), Rasuwa (P), Bardiya (N), Humla (N), Arghakhanchi (N), Dang (N), Rukum (P), Bajahang (P)
Very Low (0.000-0.109)	Kailali (N), Doti (P), Achham (P), Dolpa (P), Mustang (N), Rolpa (P), Bajura (N), Palpa (P), Pyuthan (N)

Note: P = positive rainfall trend, N= negative rainfall trend

5.2 Vulnerability at the community level

Smallholders, landless laborers, Dalits, Janajatis and low-income groups are the most vulnerable to climate variability and change. Even well-off and medium category farmers are vulnerable if their land is along a riverbank or in the foothills. According to FAO (2014), several factors contribute to the vulnerability of these livelihood groups, including the following:

Frequent occurrence of floods and landslides: Houses and cultivated land in flood- and landslide-prone areas (mainly along riverbanks and in the foothills) are the most vulnerable to climate impacts. The destruction of livelihood assets (homes, sheds, canals, roads, weirs and dams) and the sedimentation of cultivated land affect livelihood activities.

Dependence on rainwater for irrigation: Irrigation is one of the most important inputs for improved crop productivity. Farmers who rely on rainwater for irrigation are more vulnerable than those who have irrigation facilities.

Small landholdings: Smallholders are often vulnerable because they have insufficient land suitable for enterprise diversification.

Increasing number of landless people: The sukumbasis (landless people) are compelled to live near forests. Although the forest land is productive, these livelihood groups face competition from wildlife, and disputes arise between forest user groups and landless people.
Flood and inundation areas: People living in areas subject to frequent flooding and inundation are particularly vulnerable. Flooding and inundation often damage or destroy productive land and important assets such as houses, livestock and grain stocks.

Lack of resources to invest in farming: Because of their inability to invest more in improved farming, poor farmers are vulnerable to repeated crop failure.

Emergence of new diseases and pests: Epidemics of diseases – such as rust and loose smut in wheat, and late blight in potato – are often the result of abnormal climatic variations. The trend for high temperatures and high-intensity rainfall followed by longer droughts induces outbreaks of many insect pests. Sheath rot and northern blight in maize, aphids in winter vegetables, and ticks, scabies, lice and leaches in animals are considered major problems.

Poor knowledge and skills: Farmers are unable to treat the diseases and pests of livestock, crops and vegetables because of their inadequate knowledge and skills.

Lack of on-farm employment within the village: The search for alternative employment opportunities forces many men to leave the village, mainly for nearby cities in Nepal and India, leaving women, children and elderly people at home.

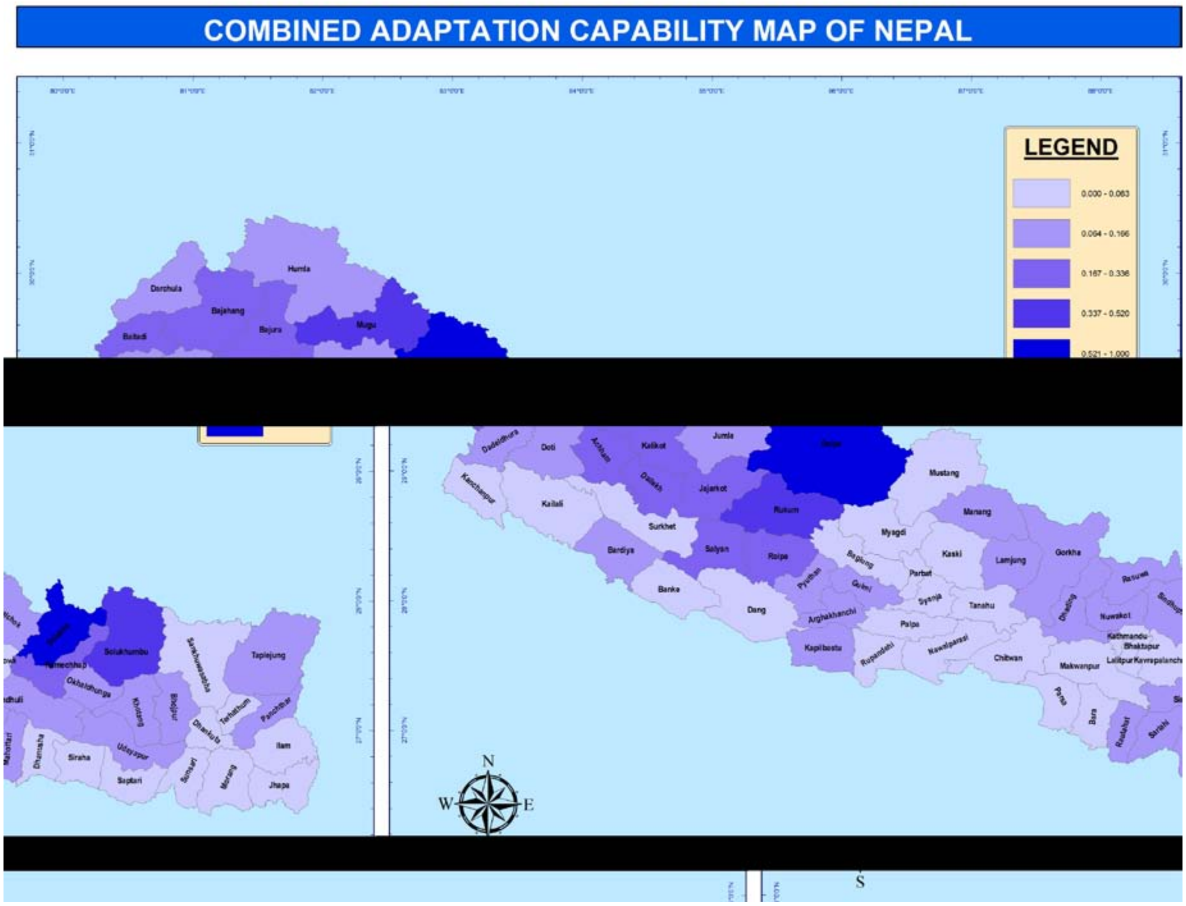
5.3 Adaptive capacity

Adaptive capacity or adaptation capability is defined as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2001). Adaptation capability here is defined as the function of socio-economic, technology and infrastructure factors and is represented as under:
The combined/multiple adaptation capability map was prepared by adding the weighted values of socio-economic, technology and infrastructure sub-indices. Weight to the different indices was assigned based on expert judgment considering the significance of the indicators for enhancing adaptation capacity (MoE, 2010).

Table 5. District ranks – combined/multiple adaptation capability index

Combined Adaptation Capability	**Districts**
Very High (0.000-0.063)	Kathmandu, Kaski, Lalitpur
High (0.064-0.166)	Bhaktapur, Rupandehi, Morang, Chitwan, Jhapa
Moderate (0.167-0.336)	Kavrepalanchowk, Sunsari, Dhankuta, Ilam, Banke, Syangja, Parbat, Terhathum, Kanchanpur, Tanahu, Nawalparasi, Makwanpur, Palpa, Baglung, Lamjung, Udayapur, Surkhet, Kailali, Saptari, Parsa, Dhanusha, Dang, Sankhuwasabha,

	Arghakhanchi, Myagdi, Nuwakot, Mustang, Bara, Panchthar, Okhaldhunga, Bardiya, Gulmi, Taplejung
Low (0.337-0.520)	Kapilbastu, Gorkha, Siraha, Bhojpur, Dadeldhura, Sindhuli, Khotang, Manang, Sarlahi, Sindhupalchok, Dhading, Pyuthan, Rautahat, Darchula, Mahottari, Rasuwa, Ramechhap, Solukhumbu, Baitadi, Salyan, Doti, Dailekh
Very Low (0.521-1.000)	Jumla, Dolakha, Rolpa, Bajahang, Achham, Jajarkot, Kalikot, Rukum, Bajura, Humla, Dolpa, Mugu



6. Review of Policies and Strategies and Institutions

There are over two dozen policies and strategies implemented (some yet to be implemented) related to agricultural development in the country and institutions at different levels and types are involved in agricultural development and climate change. Although the policies and strategies developed in early 2000s might not reflect climate change concerns, key elements of agriculture-related policies and strategies are reviewed here for better understanding on future needs to adapt to, and build resilience to, climate change impacts on agricultural sector.

6.1 Policies and strategies

(i) National Agriculture Policy, 2061 (2004)

The objective of this policy is to create an enabling environment for agriculture-led rural development. It emphasizes competitiveness of agriculture sector encouraging farmers to go for commercial production. The policy aims at increasing productivity and promoting natural resources to utilize them in the interest of farmers. The long-term vision of the agriculture sector is to bring improvement in the living standards through sustainable agricultural development by transforming subsistence agricultural system into a commercial and competitive agricultural system. The policy emphasizes on

- increased agricultural production and productivity,
- making agriculture competitive in regional and world markets with commercial agriculture system,
- conserving, promoting and utilizing natural resources, environment and bio-diversity

(ii) Agriculture Bio-diversity Policy, 2063 (2007)

This policy has been formulated in accordance with the objectives of National Agriculture Policy to protect, promote and utilize bio-diversity. The policy emphasizes sustainable development and maintenance of ecological balance by protecting agricultural bio-diversity. It intends to benefit from protection and utilization of genetic resources for food security and poverty reduction. Other objectives followed are:

(i) To protect, promote and utilize genetic resources for sustainable agriculture development coupled with food and nutrition security;
(ii) To protect and promote farmers' indigenous knowledge, skills and practices;
(iii) To maintain equitable and fair distribution of benefits accruing from access and utilization of agricultural genetic sources and materials; and
(iv) To promote ecological balance by protecting and promoting agricultural bio-diversities.

iii) National Seed Policy, 2056 (2000)

The main aim of formulating this Policy is to effectively manage production, processing and testing of high quality seeds and their timely availability to the farmers. The Seed Act of 2045 and Seed Regulation, 2054 signifies contribution of the quality seeds in agricultural production. Its objectives are to ensure:

- Availability of quality seeds of different crops in a required quantity
- Production of quality seeds and promotion of export
- Making seed business effective in view of the international market
- Conservation of genetic characteristics of the indigenous seeds and maintain patent right

The main features of the policy are

- Emphasis on replacement of low yielding traditional seeds with modern variety seeds.
- Stressed on conservation of agro-biodiversity and establishment of breeders rights over new variety of seeds. it proposed for conducting 'research' (which may also be construed as risk assessment) on GMO seeds.
- Proposed for seed quality control not only through seed certification and truthful labeling, but also following quality declared seed system.
- Private sector participation in seed testing, seed analysis, seed sampling, crop inspection etc. for maintaining seed quality in the country.

iv) National Fertilizer Policy, 2058 (2002)

This policy was formulated to support agricultural production by ensuring supply (production, import and distribution) of good quality fertilizer. This Fertilizer Policy is sub-component of the Government's broad National Agriculture Policy as set out in the Agriculture Perspective Plan (1995-2015).

The aim of this policy is to enhance agricultural productivity through improvement in soil fertility and thereby contribute to the national goal of poverty alleviation. Specifically, this policy emphasizes the following:

(a) Provision of conditions (policy and infrastructure management) for enhancing fertilizer consumption; and

(b) Promotion of integrated plant nutrients management system for efficient and balanced use of fertilizer.

The policy adopts following strategies to achieve its objectives:

- Ensure fertilizer availability;
- Making fertilizer distribution system transparent, competitive and effective
- Maintain the use of quality fertilizer; and
- Manage Integrated Plant Nutrients System

v) Irrigation Policy, 2070 (2014)

There are many climate related risks associated with the irrigation infrastructure and their utilization. The water resources management and variability of water supply is the major issue related to the irrigation sector. Drought conditions reduce the effectiveness of irrigation systems and can cause long term damage to infrastructure and losses in crop production. Similarly, flooding causes direct destruction of infrastructure and sedimentation within irrigation systems.

The vision of this policy is to avail the sustainable and reliable year round irrigation facilities to all the agricultural lands so as to contribute to agricultural productivity.

Extension of irrigation services is important in the context of meeting the objectives of increasing agricultural production and reduction of poverty.

This demands promotion of conjunctive use of ground and surface water based irrigation systems along with new/non-conventional irrigation systems such as rain water harvest, pond irrigation; sprinkler irrigation, drip irrigation and treadle pump irrigation. In the country, the irrigation systems developed so far are limited to run-off the river system. To

make the system good for round the irrigation, it is necessary to develop storage so that the problem of low flow of rivers during the winter season can be mitigated to some extent. The policy emphasizes implementing reservoir-based and inter-basin water transfer types of water sector strategy development and integrated water resources management. The policy aims to develop irrigation facility for the achievement of following objectives:

- To avail round the year irrigation facility through effective management of existing water resources;
- To develop institutional capacity of water users for sustainable management of existing systems; and
- To enhance knowledge, skills and institutional working capability of technical human resources, water users and NGOs relating to development of irrigation sector.

vi) Rangeland Policy, 2068(2012)

In high hill and mid-hills region, livestock farming is the main source of livelihood of people and rangeland is the major basis for livestock production. Rangeland management is expected to contribute to livelihood improvement and food security of the people, reduce internal migration and minimize the effects of climate change. For providing clear direction for managing uncontrolled extraction or harvesting of rangeland resources like herbs and NTFPs, preventing the declining rangeland productivity and biodiversity due to uncontrolled grazing, minimizing the effects of climate change and environmental degradation, evaluating their roles in carbon sequestration, and promoting indigenous knowledge, skills, technologies, a Rangeland Policy' was formulated and implemented.

The Policy, *inter alia*:

- Recognizes the Department of Livestock Services as the lead agency for rangeland management.
- Highlights the importance of rangelands and analyses the holistic management of rangelands from the viewpoint of different stakeholders.
- Considers rangelands as under constant and serious threats, which require urgent attention.
- Envisages sustainable use and development of natural rangeland with a view to support livelihood of the local people and also about the development of livestock sector through sustained feed supply and grazing management.

The main policies are

- Upgrade the status of the rangelands and thereby increasing its productivity
- Develop and expand the rangeland based enterprises, and
- Conserve, promote and utilize rangeland biodiversities in a sustainable and scientific manner thereby contributing in balancing the rangeland ecosystem, and

vii) National Land use Policy, 2069 (2013)

This policy was formulated considering the growing concerns about increasing fragmentation of fertile land and unplanned urbanization. The policy emphasizes to:

- Ensure optimum use of land and control land fragmentation;

- Help establish a link between agricultural with industrial sectors, and encourage optimal use of land for agriculture;
- Categorize for the first time in the country, land into seven categories — agricultural, forest, residential, commercial, public, industrial, and others;
- Make sure that fertile land is used for farming only, and bar dealings in land allocated for agriculture;
- Adopt land pooling concept to acquire land for development projects; and
- Establish the Land Use Management Department, which will have experts from agriculture, irrigation, environment, urban development and management sector.

viii) Agricultural Mechanization Promotion Policy, 2014

Labor shortage has become a challenging issue in recent years for agriculture development due to migration of young farmers from the rural areas of Nepal. Thousands of youths have out-migrated for finding employment (in the urban centers and abroad). To address this challenging issue and modernize agriculture, agricultural mechanization policy has been formulated. Agricultural mechanization involves use of different types of power: human, animal, mechanical and electrical. It helps achieve timeliness in field operations, increased productivity and reduced cost of production, and minimized farm drudgery. It also imparts dignity to farm work and makes farming attractive to educated rural youth.

The policy's salient features are as follows:

- Focus on smallholder farmers
- Increasing competitiveness, modernizing and commercializing Nepalese agriculture through appropriate mechanization
- Development of supply chain based on public-private partnership approach
- Focus on environment, women and youth farmer-friendly agricultural mechanization
- Institutional development for promotion of small agricultural machineries.
- Emphasis on the establishment of machinery testing and evaluation centre and promotion of safe and good quality machinery in agriculture

ix) Biotechnology Policy, 2063 (2006)

In order to face the existing challenges of a developing country like ours, the Biotechnology Policy, 2006 is formulated to obtain the potentials opened up by biotechnology. The implementation of this policy may assist in increasing the production of food grains through biotechnology, developing a new technology of medical treatment, 2 controlling environmental pollution and promoting various industrial sectors.

The vision of this policy is to increase production and productivity by means of research and development of biotechnology as well as transfer of technology, and improve the living standard of Nepali people by achieving a significant progress in the field of public health and environment.

The overall objective of this policy is to make contribution to the reduction of poverty by developing and expanding biotechnology with its use in the sectors of comparative benefit and its application as a basis of key substitute for the development of the country as well as environment protection and public welfare.

The salient features are:

- Fulfill a minimal need of food grains and nutritious food for growing population, thereby assisting in the reduction of poverty.
- Use biotechnology in the areas comparatively providing benefit to Nepal.
- Encourage research and development of biotechnology contributing for developing the forests, agriculture and food sectors in an internationally competitive and environmentally sustainable manner.
- Promote a managerial skill in the field of biotechnology, attract the competent researchers and experts, promote an entrepreneurship and maintain a balance.

x) Climate Change Policy, 2067 (2011)

Nepal formulated a broad-based, well-deliberated, and targets-based Climate Change Policy in 2011 to address climate change impacts, and help develop people's coping capacities.

The main goal of this policy is to improve the livelihood by mitigating the adverse impacts of climate change, adapting to it, adopting low carbon emission socio-economic development path and promoting the support and cooperation as per the commitments at the national and international mechanism related to climate change. Main features are to:

- Consider the importance of the sectors that are vulnerable to climate change;
- Enhance the climate adaptation and resilience capacity of local communities for optimum utilization of natural resources and their efficient management;
- Adopt the low carbon development path by making socio-economic development climate change friendly and resilient;
- Allocate at least 80 percent of the total budget directly at program implementation level/areas;
- Establish a semi-autonomous climate change center to coordinate the programs and projects;
- Develop the capacity for identifying the present and future impacts of climate change, quantifying the impacts, adopting adaptation measures to be safe from the risks and adverse impacts of climate change;
- Improve the living standard of people by maximum utilization of the opportunities created from the climate change related conventions, protocols and negotiations; and
- Establish a separate Climate Change Fund for implementing programs related to climate adaptation and resilience, and low-carbon development, identifying risks, carrying out studies and research and developing and utilizing technologies.

xi) Science and Technology Policy, 2061(2004)

The vision of this policy is to build developed, dynamic and prosperous State by raising the living standards through the appropriate development and use of science and technology.

The main objectives include enhance national capacity through the appropriate development and use of knowledge , skill and efficiency in the field of science and technology, assist in the poverty reduction activities by utilizing natural means and resources through the use of science and technology, and elevate the country to a competitive position through the optimum development of science and technology. The policy focuses to:

- Use science and technology as a powerful means to increase production and productivity of the country;
- Create an environment for the maximum utilization of knowledge and skill of science and technology available in regional and international arena by promoting mutual cooperation with the bilateral, multilateral, regional and international organizations;
- Promote participation of private sector in the development of science and technology;
- Develop and mobilize skilled human resources;
- Extend the development of technology to the rural levels; and
- Create a conducive environment to maintain high morale of the scientist and technologists and minimize the brain drain.

xii) Forest Policy, 2071 (2015)

The vision of this policy is to contribute to local and national prosperity through the sustainable management of forests, biodiversity, and watersheds.

The main goal is to create employment opportunities and increase income of poor and vulnerable communities through the sustainable management and utilization of forests, biodiversity, watersheds, protected areas and bio-resources; and make a balance between ecosystem and livelihood improvement.

The main features are to:

- Increasing forest productivity and supply of forest products through sustainable forest management;
- Conserving biodiversity and related resources and equitable distribution of benefits accruing from environmental services;
- Promoting integrated management of watershed areas for increasing land productivity;
- Enhancing management capacity of the local communities in all types of forests;
- Increasing the involvement of private sector for creating green jobs from forest enterprise development;
- Addressing adaptation and mitigation of the adverse impacts of climate change; and
- Improving forest governance, and promote inclusiveness in forest management.

xiii) National Seed Vision (2013 – 2025), 2013

It is a seed sector development strategy with a vision of "Quality seed for the well-being of farming families" aims to promote use of quality seeds by diversifying farmers' choice to raise crop yields and income. For high quality seeds, it considers genetic purity, trueness to type with high degree of physical purity, uniformity, high germination potential, optimum moisture and vigor, freedom from diseases and pests and noxious weeds. The vision is to substitute seed imports, make the country seed self-sufficient, and promote seed export.

xiv) National Biodiversity Strategy and Action Plan, 2014

The vision of NBSAP is conservation of biodiversity for sound and resilient ecosystems and national prosperity. The overall goal of the NBSAP is to significantly enhance the integrity of Nepal's ecological systems by 2020, thereby contributing to human well-being

and sustainable development of the country. The objective of developing the NBSAP is to provide a strategic planning framework for conservation and sustainable use of biodiversity and biological resources of Nepal for enhancing local livelihoods and eco-friendly national development, and equitable sharing of the benefits accrued from utilization of biological resources among all sections of the society.

The sector-specific strategies, and priority actions are designed to address the key biodiversity threats, gaps, and issues discussed in the preceding chapters; the 20 Aichi Biodiversity Targets of the Strategic Plan for Biodiversity 2011–2020 (CBD, 2010); and the Millennium Development Goals of ensuring environmental sustainability.

The major themes are as follows:

- Management of protected area
- Management of forest biodiversity outside protected area
- Management of rangeland biodiversity
- Management of wetland biodiversity
- Management of agro-biodiversity
- Management of mountain biodiversity
- Cross-cutting areas

xv) Agriculture Development Strategy (Draft 2014)

The Ministry of Agricultural Development has already forwarded it to the approval of the Government (cabinet level). It is the successor to the APP, which aims at providing long-term strategies for Nepal's agricultural development. It has a 20-year vision and a 10-year planning horizon.

The scope of the ADS is very wide and covers the following:

- Food security, productivity enhancement, connectivity and resilience;
- Sustainable production and resource management through climate change mitigation;
- Adaptation and improved land and water management and water allocation; increased private sector development (including cooperative sector), delivering fair reward to all stakeholders in the value chain; and
- Policies, institutions, and investments.

The ADS has proposed a program on improved resilience of farmers to climate change and disasters. The activities to be implemented are:

- Conduct research on stress tolerant varieties and breeds
- Establish an early warning system
- Establish a climate info and weather indexation system
- Promote agricultural insurance
- Improve capacity of extension and farmers on climate smart agriculture practices
- Establish a fund for preparedness and response to droughts, floods, epidemics
- Sustainable farming, Good Agricultural Practices and Good Veterinary Practices
- Integrated Soil Fertility Management, Integrated Plant Nutrient management, Integrated Pest Management, organic farming, uses of renewable energy technologies etc.

xvi) National Low Carbon Economic Development Strategy, 2014 (Draft)

The vision of this strategy is the promotion of low carbon green economy. The goal is to attain self-sufficiency in clean energy by 2022 and accelerated economic growth through green economy by 2030.

The main features are:

- Agriculture, hydropower and forestry as a base of economic development
- Hydro-energy as the main source of energy and emphasizes to adopt climate-friendly, economical and simple technologies in its production, transmission and distribution.
- Development and use of solar and wind energy.
- High priority to the development of environment-friendly transportation that uses clean energy.
- Traditional technologies with low energy capacity replaced by energy efficient technologies.
- Protection and development of local technologies that consume low energy
- Surge of energy capacity in the structures such as industry, factory and physical infrastructure, and use of the pollution-free technologies
- Considerations to the opportunities that support climate change adaptation in identification and use of low carbon (GHGs) emission technologies and practices.
- Climate smart agriculture technologies researched, developed and disseminated.

xvii) Forestry Sector Strategy (Draft), 2014

The vision of this strategy is to fully optimize the potentials of forest ecosystems, biodiversity and watersheds for peoples' prosperity. The goal is “the forest ecosystems and watersheds sustainably managed and climate-resilient through an inclusive, decentralized, competitive and well-governed forestry sector providing equitable incomes, employment and development opportunities”.

The vision for Nepal’s forestry sector is underpinned by the following eight strategic pillars that provide the foundation for the strategy. Past experience has shown that these pillars must be integral to all the key thematic areas making up the Forestry Sector Strategy. Sustainably managed resources and ecosystem services

- Conducive policy process and operational environment
- Responsive and transparent organizations and partnerships
- Improved governance and effective service delivery
- Security of resource use of the community
- Private sector engagement and economic development
- Gender equality, social inclusion and poverty reduction
- Climate change mitigation and resilience

6.2 Agricultural institutions

The MoAD, MoSTE, MoFSC, MoFALD, and MoIr are key ministries implementing climate change adaptation and REDD+ activities. The MoSTE functions as the climate change focal point for Nepal for UNFCCC and are responsible for the formulation and implementation of policy, plan and program, including on climate change. There are several NGOs, civil society organizations (CSOs), and community-based organizations (CBOs) engaged in implementing support-based awareness raising, and capacity building on climate change impact mitigation and adaptation.

The international NGOs such as WWF-Nepal, IUCN, CARE Nepal, Oxfam etc are engaged in implementing or supporting selected climate change activities. Most of the Nepali NGOs are engaged in information generation and repackaging, communication and advocacy to raise awareness and build capacity of their own and climate vulnerable communities. Local NGOs are not much engaged in program implementation. The functions of the key ministries/institutions engaged in promoting agriculture development and climate change are briefly summarized below:

Ministry of Agricultural Development (MoAD)

The MoAD has the overall responsibility and mandate of formulating policies, plans and programs on agriculture sector and implement them. The Ministry is also entrusted to develop and disseminate agricultural technologies, promote agricultural marketing and agri-business and provide necessary support to the farmers for the production of agriculture and livestock. The vision is to improve the standard of living of the people through sustainable agricultural growth by transforming the subsistence farming system to a competitive and commercialized one.

The main objectives of the MoAD are

- To reduce poverty through increased agricultural production and productivity;
- To make Nepalese agricultural products competitive in the regional and world markets by developing the foundation of commercial and competitive agricultural systems; and
- To conserve the natural resources, environment and ecological diversity and utilize them for sustainable agricultural development.

The Ministry has 3 Departments namely Department of Agriculture (DoA), Department of Livestock Services (DoLS) and Department of Food Technology and Quality Control (DoFTQC). The DoA and DoLS each have 75 district offices, 5 regional directorates and training centers in addition to Central Training Directorate. The DoA has 378 Service centers whereas DoLS has 359 service centers and 640 sub-service centers. The DFTQC has 5 regional offices and 4 quarantine laboratories. In addition, MoAD has Nepal Agricultural Research Council (NARC) established under NARC Act 2049 BS. It also has 2 Boards and 3 corporations/companies.

NAPA components 1 and 2 focus on climate change adaptation and insurance activities. The MoAD is involved in implementing PPCR component 2; NARC is developing drought-and flood-resilient varieties to adapt to, and build resilience to climate impacts.

Ministry of Forests and Soil Conservation (MoFSC)

The MoFSC has the overall mandate of formulating policies, plans and programs and implement them related to forests management, wildlife protection, biodiversity conservation, forests research, non-timber forest products (NTFPs) and medicinal and aromatic plants (MAPs) conservation and management, watershed conservation, promotion of forest-based enterprises and enforce acts and regulations. The goal of forestry sector is to contribute to sustainable development of the nation and maintaining environmental balance through the conservation and sustainable utilization of forests, plant resources, wildlife, watershed, protected areas and biodiversity and improve the living standard of people and increase their income through improving forest governance and commercialization of forests and related resources.

The main strategies of the forestry sector are to:

- Maintain 40% of the forest area in the country;
- Adopt participatory and landscape approach in conservation and management;
- Adopt the wider approach watershed management;
- Improve the governance and strengthen the institutional capacity;
- Contribute to national prosperity through green enterprises promotion and job creation; and
- Contribute to adapt and mitigate to the adverse impacts of climate change.

The Ministry has 5 Departments namely Department of Forests (DoF), Department Soil Conservation and Watershed Management (DSCWM), Department of National Parks and Wildlife Conservation (DNPWC), Department of Forests Research and Survey (DFRS) and Department of Plant Resources (DPR). The DoF has offices in 74 districts (except Mustang), the DSCWM has offices in 56 districts, the DNPWC has a network of protected areas that include 10 national parks, 3 wildlife reserves, 6 conservation areas, 1 hunting reserve, and 12 buffer zone areas. These protected areas cover 34,185.62 sq. km (23.23%) of the total geographical area of the country. The DPR has 6 offices in different parts of the country. In addition, there is a Central Forest Training and Extension Centre and 5 regional training centers, REDD Implementation Centre, 5 Regional Forests Directorates in the country. In addition, there are 3 Boards/companies under the MoFSC. The National Trust for Nature Conservation (NTNC), a statutory non-governmental organization, is affiliated with MoFSC was established with separate Act and approaches to the government through MoFSC.

Ministry of Science, Technology and Environment (MoSTE)

The MoSTE function as the climate changes focal point for Nepal for UNFCCC and is responsible for the formulation and implementation of policy, plan and program, including on climate change. The MoSTE is implementing NCCSP, PPCR component 3, Second National Communication and Technology Needs Assessment including adaptation

technology project. The Department of Hydrology and Meteorology is implementing climate change adaptation actions to help people to adapt to, and build resilience, to climate change.

Ministry of Federal Affairs and Local development (MoFALD)

The MoFALD has a widespread network up to grass-root level (VDCs and Municipalities). As per the Local Self-Governance Act (1999), this ministry has been placed at the apex of three tier structural framework and accredited with the role of coordination, cooperation, facilitation and monitoring and evaluation of activities undertaken by local bodies. Being the focal organization for local development, it has to coordinate, cooperate, facilitate and synergize the initiatives taken by different development partners.
The MoFALD has its organizations/political bodies at the district and VDC/Municipality levels. The MoFALD is now engaged in implementing LAPAs through DDCs and VDCs/municipalities in 14 most climate vulnerable districts of mid-west and far west to address climate change impacts. It has played significant role in integrating adaptation into local planning process.

Ministry of Irrigation (MoIr)

The responsibility of utilization and management of water resource for irrigation lies with the Ministry of Irrigation. Preparation of policies and plans and their implementation regarding development of irrigation for the efforts to achieve agricultural development targets are the objectives of this ministry. It will promote adaptation to climate change impacts in irrigation sector, developing climate resilient infrastructures and provide irrigation water to increase farm productivity. It has 2 Departments and Division Offices to implement the programs. The Ministry is entrusted to undertake the following tasks:

- Development and implementation of policies, plans and programs for the conservation, regulation and utilization of water for irrigation purposes;
- Development of irrigation infrastructures, activities related to flood and river training.
- Promotion of private sector in irrigation development; and
- Development and implementation of policies and plans for the conservation, regulation and utilization of water-induced disaster prevention.

The NAST is generating and managing knowledge on climate change impacts. The ICIMOD is conducting research and generating knowledge on impacts of climate change in the Hindu-Kush Himalayan region, including Nepal.

7. Issues and Challenges

Almost two-thirds of people in the labour force are engaged in agricultural activities, and majority are unskilled and lacks knowledge on sustainable cultivation techniques and practices. The sector largely depends on the monsoon, while access to modern inputs and extension service is limited and poor in quality. Underemployment is a serious problem with many young people leaving farming for foreign employment. Nepal, as a result, has become a net food importer.

Sustainable agricultural development, livelihood improvement of the poor and food security in Nepal are faced with a number of issues and challenges. Climate change has posed additional challenges in agriculture sector. These major issues and challenges are briefly described below:

i) The low agricultural productivity amidst a growing population resulting in chronic food security problems: The majority of the farms in Nepal are small in area and many are operated as subsistence farms. The use of quality inputs is minimal due to supply constraint and high cost which is reflected in the limited adoption of modern technology. Compared to the farmers in India, the Nepalese farmers have to bear higher production costs per unit of output as the technology and production inputs are heavily subsidized in India. Moreover, most of the farms do not have access to year-round irrigation facilities. Marketing and credit facilities are also lacking in the sector contributing to under-investment in productive farm assets. This has led to very low productivity in agriculture which contributes to the problem of low farm incomes and increased food insecurity.

ii) Weak support of the agricultural extension service delivery system: The agricultural extension service delivery system is not as effective as it could and should be and is not capable to deliver services (including climate adaptation and resilience building) as per the demand and the need of the farmers. The present level of coverage by the extension system is about 15% of agricultural households nationwide. The poor and marginal groups living in the remote areas are not getting even the limited services provided by the public sector, hence they are excluded from this opportunity. The linkages among agricultural research, education and extension services are also weak in Nepal.

iii) Irrigation infrastructure and management: Agriculture production and productivity can be sharply increased by year-round irrigation services through the construction/maintenance of infrastructure and better irrigation management. However, year-round irrigation services are now limited and moreover, the existing irrigation systems are becoming less reliable because of poor management and maintenance. Nepal implemented the Water Resources Strategy and the National Water Plan that encouraged farmer participation in the maintenance of public irrigation systems but the desired result has not been achieved with little impact on the envisaged increase in agricultural productivity and production.

iv) Unsustainable natural resource management practices: The Nepalese mountains and hill regions are prone to soil erosion and landslides while the Terai plains suffer from sedimentation and alluvial deposits which erode easily. Monsoon torrential rains often wash away top soils in the poorly managed crop production systems where sustainable farming practices are not promoted. Excessive pesticides are often used by commercial farms and Integrated Pest Management (IPM) coverage of crops is still limited. The occurrence of forest fire is frequent especially during summer with a heavy damage and loss of biodiversity. The conservation and sustainable utilization of the biodiversity has not been noticed in a planned way.

v) Institutional credit and insurance services: There are few commercial financial institutions in the rural areas willing to give credit to farmers. Commercial credit sources

charge exorbitantly high interest rates thus limiting the number of farmers who use farm credit. The challenge is to make agricultural credit available for production, processing and marketing as a part of the future programs envisaged to increase agriculture production and productivity. The risk reducing measures in agriculture and livestock through the provision of agricultural insurance is practiced in a limited areas.

vi) Adaptation to climate change: Nepal has recently been experiencing irregular rainfalls, frequent floods and droughts, cold waves, increased landslides, and increased prevalence of pests and diseases which already have had a direct affect on food production, productivity and food security. The institutional and technical capacity of responsible institutions at the national and district levels is not enough to address climate risk management and disaster prevention / preparedness related issues from an agricultural perspective. Some adaptation programs to climate change have been initiated with support from development partners, however, more has to be done by the GoN in the areas of agriculture such as adapting crop varieties, seeking suitable cropping patterns, fruit tree or hedge row intercropping, identifying suitable seed systems, reducing risk through water management at the farmers' field, and in the area of livestock management practices.

vii) Rural out-migration and the shortage of agriculture labor: Migration from rural to the urban areas within Nepal and abroad has adversely affected agricultural productivity and food security. Poverty and limited employment opportunities have become a push factor for out migration while even menial employment in urban areas has pulled people in from the rural areas. Furthermore, those who out-migrate for work purposes are usually the male members of farm families leaving the women to do all the farm labor as well as the farm management. About 52 percent of the women between the age of 15-44 years are employed in agriculture showing the feminization of agriculture. Besides feminization of agriculture and poverty, out-migration also has resulted in a rise in real wages affecting overall competitiveness of agriculture.

8. Gaps and Needs

i) Data and information

In an endeavor to the formulation of Low Carbon Economic Development Strategy, baseline picture of the emissions has helped to develop the reference scenario such that appropriate mitigation options can be adopted. However few data gaps still exist (AEPC, 2013) which are as follows:

- Country-specific emission factors are yet to be developed,
- Data on distribution of organic soils (histosols),
- Data on soil-types and their classification by ecological-regions,
- Distribution of Urea fertilizer by ecological-regions,
- Distribution of Urea fertilizer imported by private sectors other than Agriculture Inputs Company Limited ,
- Annual change in cropping patterns in different ecological regions,
- The burning of crop by-products and crop residues,
- Distribution of pasture land areas over years in different ecological regions, and

Data on herd composition of livestock sector by ecological regions in Nepal.

(ii) Integration/harmonization with existing policies/ strategies/programs

There has been less focus on climate adaptation and resilience building in program preparation and implementation on agricultural and related sector. Such climate adaptation related actions are not prioritized by the local institutions, inadequate technical capacity of local bodies in integrating climate change in planning and budgeting process, the current allocation is not consistent with the NAPA's and Climate Change Policy's commitment.

iii) Availability of technologies

As agricultural sector is impacted from the adverse impact of climate change, the technology needed for adaptation and promoting resilience are inadequate. As the research system is underfunded at present, it is not capable enough to generate adaptation related technologies required for diverse crops/commodities and enterprises, ecological settings, different categories of farmers. Most current agricultural practices and technologies have been developed under conditions of unevenly distributed (spatially and temporally) rainfall. Likely climate change scenarios and increased climatic variability create new challenges. There is a lack of technological innovations to ensure sustainability of initiated interventions and unclear demarcation between adaptation and development actions.

iv) Technical and institutional capacity

The technical capacity of existing public institutions at different levels, NGOs, CBOs and is not adequate to promote "science and technology-based approach" to tackle the climate change challenges in agricultural sector. The skills and knowledge for research, extension and implementation of the programs and awareness at the local level is not enough. Local farmers do not have scientific knowledge about climate change and its impact on their crops. Moreover, actions on climate change adaptation and mitigation are challenged by country's low financial capacity and inadequate coordination among the governmental sectors working on climate change. Present knowledge on climate change is 'perception-based' rather than on 'fact-based'.

v) Incentives and taxes

There are some regulatory measures that help to control the GHGs emission and contribute to create adverse impacts to the environment in agricultural sector. However, there are no incentives to farmers for using improved and climate resilient technologies (although developed in a limited scale). Hence, policies in the agricultural sector should include market-based mechanisms such as offset programs and conservation easements, as well as regulatory measures in the form of incentives and taxes. Proper guidelines and incentives for farmers are also necessary that include improved and sustainable farming practices, choices of crops and enterprise, and proper management of production factors (irrigation, fertilizer, pesticides etc.)

vi) Institutions and networks

Institutions play a key role in introducing new agricultural technologies to farmers. Their presence at different levels and networks of different institutions are required for promoting agricultural adaptation by introducing location-specific technologies. Farmers and their support institutions are the key players in technological innovations and have been an integral part of agricultural development. The capacity to respond to changing climate depends on knowledge flow through a broad range of institutions, including farmer-to-farmer interactions. The number of responsive institutions and their active networks are limited to really serve the needs of climate vulnerable farmers. In this context, there is a strong need for participation of institutions to enable improvement of agricultural support services to farmers. These institutions each have their areas of focus, and together they provide farmers with access to services that facilitate improved agricultural practices.

Innovative technologies at the local level are crucial for enhancing the adaptive capacity of farmers. Adaptation practices should be introduced with the full participation of farmers and the community-based organizations, as interactions among local institutions and farmers facilitate knowledge exchange and awareness raising. The development of multi-level institutional partnerships, including collaboration with farmers and NGOs at critical stages of technological development and transfer, is crucial to advancing climate risk management, adaptation and resilience building. The technical capacity of the institutions and farmers' groups and cooperatives, and CBOs and NGOs working with the farmers need to be enhanced.

9. Conclusion

Nepal is highly susceptible to climate change risks and is ranked 4th most vulnerable in the world while our contribution to the greenhouse gas emission is extremely low. Climate change is expected to intensify Nepal's already pronounced climate variability and frequency of climate extremes such as droughts and floods, steep terrain and heavy rainfall patterns. In extreme events, entire villages have been destroyed or washed away, and worse, these events are localized.

Poor and marginalized people are especially vulnerable to climate variability and change. They generally are the least able to cope with disaster, live in the most at-risk areas and have limited information, knowledge and resources to help reduce their level of risk. The predicted impacts of CC will intensify existing vulnerabilities, inequalities and exposure to hazards. In the agricultural sector, smallholder farmers face the greatest risk. They tend to own few livelihood assets such as land and livestock, receive a low income, and have a low level of education and limited access to community and government services. They are also likely to be dependent on rain-fed agriculture and occupy land that is prone to floods, drought and landslides. Many of Nepal's poor farmers occupy small parcels of land that barely produce enough food for the family.

GHG emissions in Nepal are primarily driven by the agricultural sector, which accounted for nearly 69% of GHG emissions. Enteric fermentation and emission from agricultural soils are

identified as major sources of GHG emissions. Therefore, when developing GHGs reducing policies, the policy makers should consider these aspects. .

The climate-related events have put fragile agricultural ecosystems at risk. The impacts of climate change and related extreme events on agriculture often generate food insecurity, which primarily affects poor and marginalized people, including women and children. Ultimately this has repercussions on the nation's economic growth. Climate change has become a serious concern for the Government of Nepal. The Ministry of Agricultural Development has to do more to counterbalance the impacts (especially through developing adaptation technologies and enhancing capacity of the stakeholders and integrating climate change aspects in program planning and implementation). MoAD has the greatest opportunity to ensure that investments in agriculture and rural development which are climate-smart and support the building of adaptive capacity.

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