Climate Change

Trends and Impacts on Livelihood of People

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SUMMARY

Precipitation network in Nepal was initiated in 1947 in the Kosi basin. Nationwide network establishment began in 1956. Nationwide long-term data are hence available from 1956 onwards. Although the assessment of long-term precipitation was carried out from 1956, temperature analyses were inappropriate before 1975 due to few data points. A summary of temperature and precipitation trends is presented in the following tables.

Temperature Trends ^{o}C: 1975-2006

		Elevation Range			
	Overall	72-200 m	200-1000 m	1000-2000 m	>2000 m
		Average Temperature			
Average Trend	**0.027**	0.014	0.031	0.031	0.034
Maximum Value	0.062	0.028	0.028	0.057	0.062
Minimum Value	-0.029	-0.008	-0.008	-0.029	0.015
No. of Stations	56	14	15	23	7
No. of Stations with Significant Trend	19				
		Average Minimum Temperature			
Average Trend	0.018	0.022	0.034	0.014	0.028
Maximum Value	0.107	0.050	0.090	0.090	0.107
Minimum Value	-0.101	-0.031	-0.006	-0.101	-0.031
No. of Stations	60	14	15	38	7
No. of Stations with Significant Trend	17				
		Extreme Minimum Temperature			
Average Trend	0.017	0.009	0.019	0.006	0.064
Maximum Value	0.222	0.057	0.076	0.052	0.222
Minimum Value	-0.102	-0.079	-0.083	-0.102	-0.057
No. of Stations	61	15	16	24	7
No. of Stations with Significant Trend	3				
		Average Maximum Temperature			
Average Trend	0.041	0.005	0.032	0.065	0.047
Maximum Value	0.152	0.024	0.066	0.152	0.101
Minimum Value	-0.049	-0.012	-0.008	-0.049	-0.030
No. of Stations	61	14	15	24	8
No. of Stations with Significant Trend	27				
		Extreme Maximum Temperature			
Average Trend	0.019	-0.006	0.002	0.041	0.031
Maximum Value	0.171	0.040	0.065	0.171	0.092
Minimum Value	-0.160	-0.036	-0.160	-0.083	-0.036
No. of Stations	62	15	16	24	8
No. of Stations with Significant Trend	3				

Precipitation Trends

	Annual		June-September		November-March	
	Trend	No of Years	Trend	No of Years	Trend	No of Years
	1956-2006					
Mean	**1.80**		0.50		0.25	
Maximum	32.2	50	24.0	50	2.4	50
Minimum	-37.3	36	-31.6	40	-2.2	40
Significant Numbers						
Increase	3		1		0	
Decrease	1		1		0	
	1956-1976					
Mean	10.9		8.52		-1	
Maximum	143	20	64.3	20	4.55	20
Minimum	-97.3	15	-75.9	16	-11.3	15
Significant Numbers						
Increase	2		1		0	
Decrease	1		0		0	
	1977-2006					
Mean	0.99		0.90		-0.57	
Maximum	62.6	30	56.4	30	2.91	30
Minimum	-54	16	-54.4	21	-11.6	18
Significant Numbers						
Increase	1		0		0	
Decrease	4		3		0	

Almost eighty percent of the population in Nepal derives its livelihood directly from agriculture. Although the contribution of agriculture to the national GDP has been decreasing during the recent decades, from more than 50 percent in 1995 to about 32 percent in 2008, it is still one of the highest among Southasian countries. The agrarian society, living primarily in the rural areas, has the strongest bond with the ecosystems, which are sensitive to climatic changes. Besides agriculture, the livelihood of rural population has close links with forest, another climate sensitive sector. More than 86 percent of energy needs of the population are met by fuel wood, agriculture residue and animal wastes. Majority of the population (30 percent are below national poverty line) are living in marginal conditions. Hence, any adverse impact as a result of climatic changes can turn into a disaster for the population living below the poverty line in particular and to the national economy in general. Besides agriculture, the anticipated losses resulting from increased intensities of weather related hazards, epidemics, and diseases are likely to add to the sufferings of the population with overall damage to the national infrastructure.

Melting Himalayas has been the most highlighted issue of climatic changes in Nepal. Its impacts on water resources are a concern not only in Nepal but also in Southasia and Southeast Asia. Major rivers of the region, such as the Ganga, Brhmaputra, Indus, Irrawadi, Salween and Yangtze originate in the Himalayas. People in Nepal are already facing the impacts of dwindling water sources, recurrent floods and prolonged droughts. Because of high dependence on agriculture, high population growth rate and marginalized economy, the existing hardship is likely to lead towards disastrous consequences in the scenarios of projected climatic changes in the region. Reducing vulnerabilities, developing coping mechanisms, and implementing adaptive measures are the only solutions to the problem of climatic changes as climate change mitigation is not an option for several years to come.

The report presents several findings regarding the pattern of climatic changes in Nepal based on available data at the Department of Hydrology and Meteorology. Similarly, Agriculture and other relevant data were derived from the publications of the Ministry of Agriculture and Cooperatives and different other sources. The report also includes the outcomes of interviews and discussions held with stakeholders at the central level and field levels.

Although at different levels of awareness and understanding, most of the people interacted are familiar with the issue of global warming and climate change even in remote rural areas. They have been dealing with the erratic behavior of weather on the basis of their traditional knowledge. There are several success stories of the application of indigenous knowledge in rural areas. In addition, some community based nongovernmental organizations were found to provide supports which helped the farmers to develop appropriate strategies to deal with adverse climatic conditions. Farming with crops resilient to the changing pattern of precipitation, crop diversification, development of micro-irrigation schemes, appropriate technologies for soling land etc were found to be highly successful for the sustainable living of the farmers. Wider application of such strategies can contribute to ameliorate the adverse impacts of climate change.

Because of fragile environment and high level of poverty, Nepal urgently needs capability to assess climate related vulnerabilities and develop appropriate strategies for adaptive measures. Besides strengthening of national economy, climate monitoring system, research, and experiment capabilities must be enhanced giving high priority in the national agenda. Although most of the government agencies have important role to play for impacts assessment and for developing adaptive measures, the Ministry of Irrigation, the Ministry of Energy, and the Ministry of Agriculture have special role as they are directly related to the livelihood of population.

There is an urgent need to implement water plan approved by the government of Nepal with additional consideration of new findings and policies regarding climate change. The role of the Water and Energy Commission becomes important in this respect. Besides providing information on past climate, Department of Hydrology and Meteorology (DHM) is the only agency capable to monitor climate in future and assess future scenarios. Government should give special consideration for strengthening DHM with support for establishing bench mark stations for reliable climate assessment and for developing climatic and hydrological modeling facilities.

Evaluation of agriculture research centres in Nepal, such as Nepal Agriculture Research Centre (NARC) has to be conducted for necessary facilitation to address the issues of climatic changes in relation to agriculture. Existing farms with research components, such as the farms located in Lumle, Parwanipur, Lalbandi, Tarahara, Hardinath, and Pakhribas, have important role as they represent different climatic and geographic regions of Nepal.

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List of Abbreviation

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
AEPC	Alternate Energy Promotion Centre
CDIAC	Carbon Dioxide Information Analysis Centre
CDM	Carbon Development Mechanism
CEGIS	Centre for Environment and Geographical Information Services
CFC	Chlorofluorocarbon
CO_2	Carbon dioxide
DFID	Department of International Development
DHM	Department of Hydrology and Meteorology
DNA	Designated National Authority
EVAN	Electric Vehicle Association of Nepal
FAO	Food and Agriculture Organization
FAR	Fourth Assessment Report
GCISC	Global Change Impact Studies Centre
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environmental Fund
GHG	Greenhouse Gas
HCCRC	Himalayan Climate Change Research Centre
HDI	Human Development Index
HPI	Human Poverty Index
HIV/AIDS	Acquired Immunity Deficiency Syndrome
ICIMOD	International Centre for Integrated Mountain Development
IMD	India meteorological Department
IPCC	Intergovernmental Panel on Climate change
ITMC	Indian Tropical Meteorological Centre
IWM	Institute of Water Modeling
JVS	Jalsrot Vikas Sanstha
LDC	Least Developed Country
MDG	Millennium Development Goal
MoAC	Ministry of Agriculture and Cooperatives
MoEST	Ministry of Environment Science and Technology (Reorganized as Ministry of Environment from June 2009)
MoU	Memorandum of Understanding
MTEF	Medium Term Expenditure Framework
NAPA	National Adaptation Program of Action
NARC	Nepal Agriculture Research Centre

NWP	Nepal Water Partnership
OECD	Organization of Economic Co-operation and Development
ppb	Parts per billion
ppt	Parts per trillion
REDD	Reduce Emissions from Deforestation and Degradation
ROAP	Regional Office for Asia Pacific
SAARC	South Asian Association of Regional Cooperation
SDMC	SAARC Disaster Management Centre
SMRC	SAARC Meteorological Research Centre
UNCED	United Nations Convention on Environment and Development
UNDP	United Nations Development Program
UNEP	United Nations Environmental program
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
WFP	World Food Program
WMO	World Meteorological Organization
WWF	World Wildlife Fund

Nepal: Facts and Figures

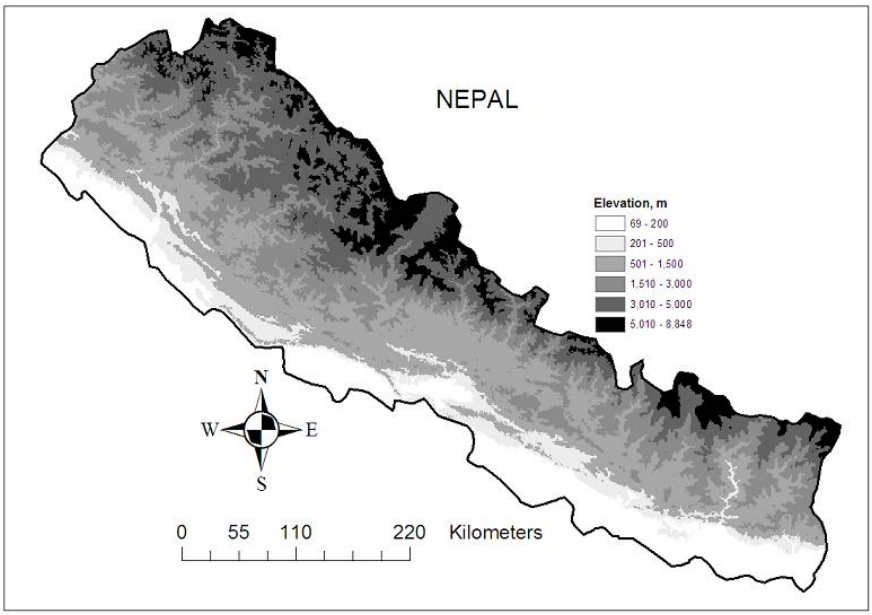

Figure i: Topographical Variations in Nepal

		Year			Year
Location			Education		
Latitude	26°22'N - 30°27'N		Literacy rate	54.1	2001
Longitude	80°04'E - 88°12'E		Male literacy	65.5	2001
Land Area:	147,181 km^2		Female literacy	42.8	2001
Elevation range:	70-8848 m		Agriculture		
Population	26,966,581	2008	Number of holding	3,364,139	2001
Annual growth rate	2.25%	2001	Area of holding	2,654,037 ha	2001
Urban population	13.90%	2001	Irrigated area	1,059,865 ha	2001
Access to water supply	76.80%	2008	Non-irrigated area	1,047,812 ha	2001
Access to basic sanitation	45.80%	2008	No. of livestock	19 million	2001
Access to electricity	48.50%	2008	Energy		
Crude birth rate	27.7/1000 population	2008	Installed capacity	710 MW	2008
Crude death rate	8.3/1000 population	2008	Hydro generation	1747 GWh	2008
Total fertility rate	3.1/woman	2006	Thermal generation	13 GWh	2008
Infant mortality rate	48/1000 live birth	2006	Petrol	101912 Kl	2008
Child mortality rate	61/1000 live birth	2006	Diesel	306687 Kl	2008
Average life expectancy	64.1 Years	2008	Kerosene	197849 Kl	2008
Economy			Electricity consumption	108 TOE	2001
Per capita GDP at current prices:	Rs 30,361 ($470)	2008	Coal consumption	246 TOE	2001
Annual growth rate of GDP	2.59%	2008	Gasoline consumption	734 TOE	2001
Export/Import	0.37	2008	Fuel wood consumption	6068 TOE	2001
Population below poverty line	30.80%	2008	Agro-residue-Animal waste	756 TOE	2001
Inequality between poor and rich	41.4	2008	Climate Change		
Telephone density	65 lines/1000	2008	Carbon footprint	0.03/capita	2005
Internet customers	> 50,000	2008	CO_2 emission	3.04 t	2004
Number of vehicles registered	701,109	2008			
(Including two and three wheelers)	7.7%	2008			
Inflation rate					

INTRODUCTION

Existence of life and vegetation on earth is the result of favourable climate and the availability of freshwater. Climate on the earth is influenced by several processes and interactions not only within the earth but also on the sun causing climate viabilities. . Rapid warming on the earth in relation to industrial activities particulrly since the 1950s has become a major concern with political dimension as the accelerating human interventions in nature have reached at the stage beyond the coping capacity of nature (Houghton, 2001). Climate change is no longer a subject of theoretical meteorology, but is a real issue affecting almost all the lives and activities on the earth.

The climatic variability at different time scales has been one of the subjects of research for meteorologists and paleoclimatologists. Long-term variability has been assessed with secular as well as proxy data derived for the period since the beginning of the Cambrian Era, 600 million years ago (Trewartha & Horn, 1989; Critchfield, 1983).

Regular observation of climatic elements in an organized manner did not exist before nineteenth century. The first organized network of meteorological observation was realized in Europe by 1965. Temperature trends based on an observation network for the northern Hemisphere have been well documented from 1880s. Recorded observations show increasing trends from 1880 to 1940 followed by a decreasing trend till 1960-1970 (Critchfield, 1983). Despite the observation of decreasing trends in the 1960s and 1970s, scientists were able to predict increasing trends in the following decades on the basis of recorded changes in greenhouse gases (Critchfield, 1983).

INTERNATIONAL CIRCUMSTANCES

A statement of Ban Ki-moon, General Secretary, UN, “The danger posed by war to all of humanity - and to our planet – is at least matched by the climate crisis and global warming” demonstrates the level of global concern regarding the issue of global warming. Despite observations of wide variability and uncertainties in the changes of climatic variables, demographic and anthropogenic changes can not be disputed. The global population estimated at two and half billion in 1955 has already crossed six and half billion by 2009 with projections exceeding nine billion by 2050. The impact of population rise and the use of resources have shown the changes in atmospheric constituents. The level of carbon dioxide has increased by more than 65 percent since the pre-industrial era (1750). Similarly, CDIAC reports that there has been almost threefold increase in methane (Blasing, 2008). The reports also indicate the existence of CFC-11 at 4750 ppt and CFC at 10900 ppt.

Global warming was not an issue prior to 1976. WMO issued the first authoritative statement on the accumulation of CO_2 and the potential impacts on the earth's climate in 1976. Climatic concerns led to the first World Climate Conference in 1979. Intergovernmental Panel on Climate Change (IPCC), which was formally established in 1988, was one of the major outcomes of the climate conference. The second World Climate Conference was held in 1990 and the third one has been recently organized in Geneva from 31 August to 4 September 2009.

IPCC produced the First Assessment Report in 1990. The report was instrumental in the establishment of the United Nations Framework Convention on Climate Change (UNFCCC). The convention, signed by over 160 countries came into force on 21 March 1994. The convention has set the agenda for action as follows.

- Develop and publish periodic national inventories of anthropogenic emissions;
- Publish, formulate and update national programs to mitigate climate change by addressing emissions by sources and sinks;
- Promote and cooperate in development of technologies, practices and processes that control or reduce emissions;
- Promote sustainable management and promote and cooperate in the conservation and enhancement as appropriate of sinks and reservoirs, etc.

IPCC completed its Fourth Assessment Report (FAR) in 2007. The report, which is the most comprehensive, has confirmed continuing process of global warming with certainty as, "unequivocal" (IPCC, 2007). Some of the IPCC findings of significant relevance are:

- CO_2 has increased 36% since the industrial revolution
- Global average temperature has increased by $0.74^{o}C$ since the start of 20th century
- Global average sea level rose by ~1.8 mm/yr during 1961-2003, ~3.1 mm/yr since 1993
- Twelve of the 13 (1995-2007) warmest year since 1850
- Arctic ocean has lost 17% of ice over the last 25 years

Similarly, some of the projections that draw particular attention include:

- Arctic sea ice will have disappeared in 30 to 40 years
- Temperature rise $1.1^{o}C$ to $6.4^{o}C$ by the end of 21st century
- Sea level rise 0.18 m to 0.59 m by the end of 21st century
- Increasing frequency and intensity of heat extremes, heat waves, tropical cyclones, droughts, and floods

The United Nations general Assembly held from 16 Sep – 24 Dec 2008, expressing deep concern over the risk from the negative effects of climate change, recognizes, "climate change, natural disaster and water related issues are becoming important topics in the agenda of all UN principle bodies."

The USA and China top the list of GHG emitting countries and hence hold the key to arrest global warming (Changhua, 2009). Both of these countries are considered strength in terms of technologies and their management capacity as well as weakness in their inadequate commitments. Situation has been changing with the change in climate related policies in Obama administration. Similarly, China in its 11th five-year plan has committed to increase renewable energy by ten percent.

One of the major events on the environment day 2009 was the telecast in 17 languages of a documentary 'home' which highlighted several issues related to global changes. The Himalayan region of Nepal was one of the highlighted hotspot regarding the impacts of climate change. Some information with serious concerns included:

- Average temperature of the last 15 years is the highest ever recorded
- North pole lost 30 percent of snow area during the last 30 years
- Greenland ice has the potential to increase the sea level by seven meters if all the ice is melted
- Two billion people may be effected by the glacier retreats in the Himalayas
- Eighty percent glacier disappeared in the Mount Kilemanzaro
- Seal-level rise is one of the greatest concerns as 70 percent of the global population lives in coastal region
- Half of the farmers in Australia are already effected by droughts
- Two hundred million people are likely to be climate refugees by 2050
- One-fourth of the species are will be threatened of extinction by 2050
- Absence of permafrost in Siberia can become a source of a additional 20 percent GHG, the consequence is not easy to predict
- Twenty percent of the global population consume 80 percent of the global resources making the poor more vulnerable to climate change
- Economic giants like Dubai have endless sun but no solar-powered electricity.

NATIONAL CIRCUMSTANCES

Nepal lies in a geographical region of extremities. Extreme topographical variations (Figure i) and the strong seasonality of the monsoon are typical features of Nepal. Because of high sensitivity of the mountain environment, even a small change in climate can have huge impact

on the environment affecting the livelihood of population and development activities (Republica, 2009a 6 5). The impacts will not be limited in the territory of Nepal, but will extend to the Gangetic plains of India and Bangladesh (Republica, 2009b 6 5). Monitoring of climatic changes, impacts of such changes, future projections, and the assessment of potential damage are not only urgently required but are also challenging tasks.

Besides being a Least Developed Country, Nepal is also a food importing country. Out of 26,400 km^2 of cultivable land in Nepal, only about 10,000 km^2 has some level of irrigation facilities (WECS, 2005). Similarly, despite the economically feasible power potential of about 42,000 MW, only about 600 MW (<1.5%) is developed. More deterioration is forecast in the projected scenarios of climatic changes (IPCC, 2007). Proper management of water resources with more power generation, enhanced irrigation facilities, and disaster mitigation measures are the keys to improve the livelihood of Nepali population

Each and every aspect of physical and biological behaviors in Nepal is dominated by topographical variations. Demography and livelihood are supported by highly favourable environment in the Terai, foothills, and river valleys in low elevation areas and limited by the extreme unfavourable conditions of the high Himalayan region. One quarter of the country in the North is unsuitable for settlements and economic activities; whereas another quarter of the country in the South accommodates almost three-fourth of the population. The statistical survey of 2001-2002 shows that the density of population is as high as 2739 per square kilometer in urban district such as Kathmandu and less than 3 persons per square kilometre in the Himalayan district Dolpa. Population growth rate reported during the survey ranges from 0.20 percent per year in Bhojpur to 4.71 percent per year in Kathmandu.

Almost half of the poor of the world live in Southasia with high dependence on agriculture for livelihood. Because of high population and monsoonal climate, Southasia is considered as one of the most vulnerable area regarding the impacts of climate change (Figure 1). Media in the first week of September 2009 highlighted an initial report of ADB that mentions the vulnerability of Afghanistan, Bangladesh, India and Nepal because of disappearing snow and glacier areas. The report predicts the reduction of maize yield by 17 percent, wheat by 12 percent, and rice by 10 percent resulting food scarcities and significant price rises by 2050. Another highlight during the last week of August 2009 was the release of a report by Oxfam on, “Even the Himalayas have Stopped Smiling: Climate Change, Poverty and Adaptation in Nepal.” The Oxfam findings show that 3.4 million people in Nepal are estimated to require food assistance and that steeply increasing food prices have reduced poor’s ability to purchase food.

The frail economic environment is also similar to the fragile physiographic environment of Nepal. Overall insecurity in the country, low-salary, limited employment opportunities outside the farm sector and liberal policies of the government has contributed towards the development of economy with remittance base. The official figure of remittance at Rs 550 million in 1990/91 has exponentially increased to the level of Rs 98 billion by 2005/06 (Shrestha, 2008).

Figure 1. A display during eighth COP held in Delhi in 1996

The global gas inventory of 1998 shows that every year the world and Nepal (Figure 2) are producing 24,215 million tonnes and 3.04 million tonnes of carbon dioxide respectively (WRI, 2003). It shows that, although Nepal shares only 0.03 percent of global land surface area, it's share is only 0.0126%. Studies show that an average Briton produces 126 times more carbon dioxide than someone living in Nepal; and that Carbon dioxide emission from using an electric kettle for one year in the UK are equivalent to average person's total annual carbon dioxide emission in Nepal (Vidal, 2006). Relative rankings of Nepal for different socio-economic and climate change issues are presented in Table 1 and Table 2. Comparisons are made with major global economy and neighbouring nations. The tables illustrate the poor adaptive capabilities of Nepal. Since poor communities would bear the burnt of the effects of increasing greenhouse gas emissions through the use of fossil fuels in rich countries and fast developing nations such as China and India, the issue is likely to be raised up to the level of human rights (Kongrut, 2007).

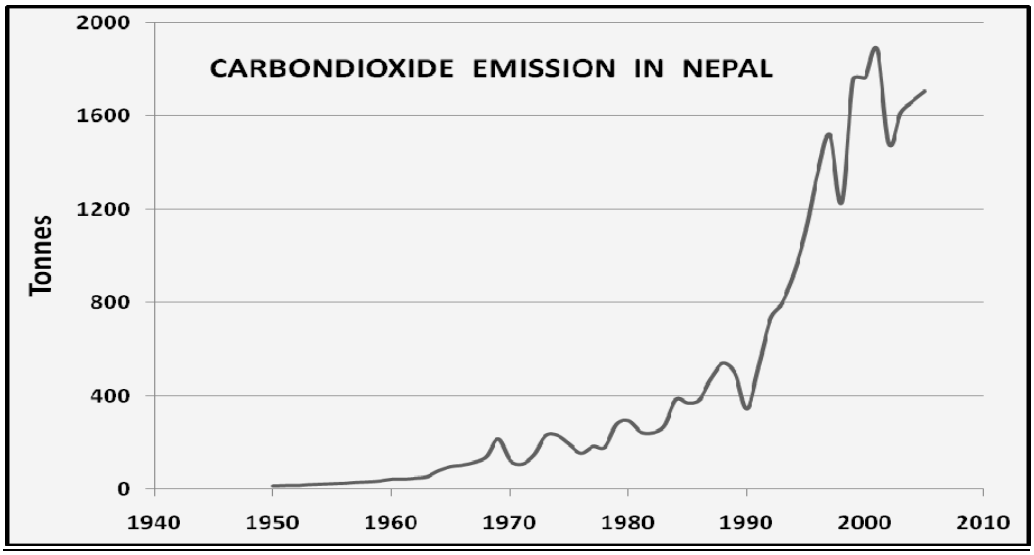

Figure 2. Time series of CO_2 emission in Nepal. Source (CDIAC, 2009)

Table 1. Relative strength (rank) of land, water, people, and development

Element	Unit	Rank 1	USA	China	India	Bangladesh	Nepal
Land area	Km^2	Russia 16,995,800	(3/240) 9,161,923	(2/240) 9,326,410	(7/240) 2,973,190	(94/240) 133,910	(92/240) 147,181
HDI	-	Iceland 0.968	(12/159) 0.951	(81/159) 0.777	(128/159)	(140/159) 0.547	(142/159) 0.534
Arable land	%	Bangladesh 55.39	60/207 18.01	77/207 14.86	7/207 48.83	1/207 55.39	73/207 16.07
Population below poverty line	%	Zambia 86	(78/95) 12	(83/95) 10	(56/95) 25	(23/95) 45	(43/95) 31
Water resources	Km3/yr	Brazil 8230	(3/140) 3070	(5/140) 2900	(9/140) 1900	12(140) 1210	39(210) 210
Water footprint	Km3/yr	India 987	(3/140) 696	(2/140) 883	(1/140) 987	(116/140) 116	(58/140) 19.3

Figures in parenthesis indicate rank/total cases considered. Source: (Coutsoukis, 2008)

Table 2. Relative ranking of climate change-related factors

Element	Unit	Rank 1	USA	China	India	Bangladesh	Nepal
C- footprint per capita (2005)	tCO_2-equiv	Gibralter 42.48	(12/214) 5.49	(92/214) 1.11	(148/214) 0.29	(184/214) 0.08	(198/214) 0.03
C-intensity of economy(2005)	t/$1000 of GDP	Ukraine 7.62	(145/203) 0.54	(23/203) 2.84	(41/203) 1.78	117/203 0.68	(158/203) 0.49
CO_2 Emission (2004)	tCO_2	USA 6,040	(1/81) 6,040	(2/81) 5,010	(4/81) 1,340	(80/81) 15.4	(>81/81) 3.04
Share of CO_2	%	USA 20.9	(1/81) 20.9	(2/81) 17.3	(4/81) 4.6	(80/81) 0.1	(>81/81)
Environmental Performance	%	Switzerland 95.5	(39/149) 81.0	(104/149) 65.1	(120/149) 160.3	(125/149) 58.0	(82/149) 72.1

Figures in parenthesis indicate (rank/total cases considered). Source: (Coutsoukis, 2008)

Nepal is prone to almost all climates, water and weather related disasters. Rapid development of road network has led to other development activities, which are likely to suffer any changes in climatic variability. The Development Assistance Committee of OECD estimates that over one-half of all aid will suffer negative impacts in Nepal as a result of climatic changes (UNDP, 2007).

Concerns on climate chnge in Nepal were extraordinarily high in Nepal in 2009 compared to the earlier years. One of the reasons was the prolonged drought with adverse impacts on agriculture and worsening of hydropower production. The UNFCCC summit-level coonference

in Copenhagen held on 7-18 December 2009 also made Nepal pro-active towards the climate issues. A regional conference on Climate Change was organized in Kathmandu feom 31 August to 1 September with the theme 'Kathmandu to Copenhagen'. The conference was followed by a the Sothasian Youth Summit on Climate Change held in Dhulikhel from 3-6 September 2009 for developing agenda to be presented in Copehagen conference.

The other events related to climate change orgized in 2009 includes: 6-7 August 2009 workshop on, "Challenges of Water Stress and Climate Change in the Himalayan River Basins Collaborative Dialogue Process" and 1-3 September 2009 workshop on, "Trade Union Debates around Climate Change." Jalsrot Vikas Sanstha (JVS)/Nepal Water Partnership (NWP) organized a Consultation Meeting on Climatic Changes & Impacts in Nepal on 17th December 2009. A discussion followed a presentation on, 'Climatic Changes in Nepal, Impacts on Water Resources and the Implication of Copenhagen Conference' during the meeting. In addition, climate change was the major focus during the week-long celebration of water day, celebration of WMO day and the celebration of Environment day. Celebration of ozone day on 14 September 2009 was also special in 2009 with an extensive gathering of experts dealing with climate change issue.

The sensitivity of the mountainous environment was highlighted during the 19th ascent of Sagarmatha (Mount Everest) by Apa Sherpa who urged the world to act against climate change. He unfurled a banner, 'Stop Climate Change-Let the Himalayas Live' at the top of the Sagarmatha on 18 May 2009. The expedition was organized by WWF as a part of the Campaign 'Climate for Life."

CONVENTIONS AND THE ROLE OF NEPAL

Several activities of UNFCCC are not mandatory for a least developed country like Nepal. For instance, developed and developing countries must report a detailed description of adopted policies and measures, which is not mandatory for least developed countries. Nepal was, however, able to prepare Initial National Communication in 2004 with the assistance of UNEP/GEF. Under the assistance of UNEP/ROAP and ADB, Nepal was also able to organize a national workshop on the UNFCCC and the institutional design of the cooperative implementation mechanism of the Kyoto Protocol in 2000.

Nepal accessed the Kyoto Protocol on 16 September 2005 and put into force from 14 December 2005. The Ministry of Forestry has already established the Climate Change Unit to deal with the program, 'Reduce Emissions from Deforestation and Degradation (REDD).' Twenty-nine percent of Nepal, i.e. 42,688 km^2 is covered by forest with potential to gain from Carbon. The Forest Ministry has received $200,000 to develop capabilities for active participation in CDM (मियाँ, २०६६ ३ १). Similarly, Government of Nepal has established the Designated National

Authority (DNA) on 22 December 2005. The Ministry of Environment has been nominated and mandated to function as a DNA.

Several government and non-governmental organizations are working for awareness programs from the Terai to the Himalayas. A week-long water day program participated by several relevant organizations organized programs with a theme 'water, climate and our life: Merging Interests, Creating Synergies' highlighting the issue of climatic changes. Similarly, the Ministry of Environment, Science and Technology sponsored several programs on the Environment Day 2009 with the UNEP theme, 'your planet needs YOU! United to combat climate change.

PLANS AND POLICIES

After the completion of Tenth Five-Year Plan (2002-2007), Nepal, for the first time, changed its five-year plan approach to a three year interim plan to accommodate the difficulties associated with political transition. The annual policy and program of the Government of Nepal announced for the 2009-2010 on 9 July 2009 highlights the priority given to the formulation of adaptation measures for mitigating adverse impacts of climate change on different sectors including agriculture. Accordingly, the Government of Nepal has already formed the Work-Plan Preparation Committee under the chairmanship of the Prime Minister. Furthermore, the priority of the government includes the development of renewable energy with emphasis on rural energy improvement for sustainable clean development activities.

The Government of Nepal has promoted the development of greenhouse gas-free hydropower energy. Similarly, the successful implementation of community forest is contributing to the greenhouse gas sinks. The recent major development in Nepal is the progress in National Adaptation Program of Action (NAPA). NAPA was signed between the Government of Nepal and UNDP on 14 November 2008.

LIVELIHOOD

Development and prosperity of a nation is directly related to the human power. Development trends can not be maintained unless the population is effective and able to deliver in a sustainable and inclusive manner. The starving population is considered as unproductive population. A nation cannot claim to have sustainable democracy and human rights if it cannot guarantee at least twice a day meal to its citizens.

Figure 3 shows that HDI varies widely with geographical locations. HDI is the highest in the middle mountain regions in and around the capital. It is the lowest in the western high mountain region. Similarly, HDI is the highest for the urban areas estimated at 0.630. The average HDI value is estimated at 0.482 for the rural areas. UNDP (2009) estimates the overall HDI for Nepal at 0.509.

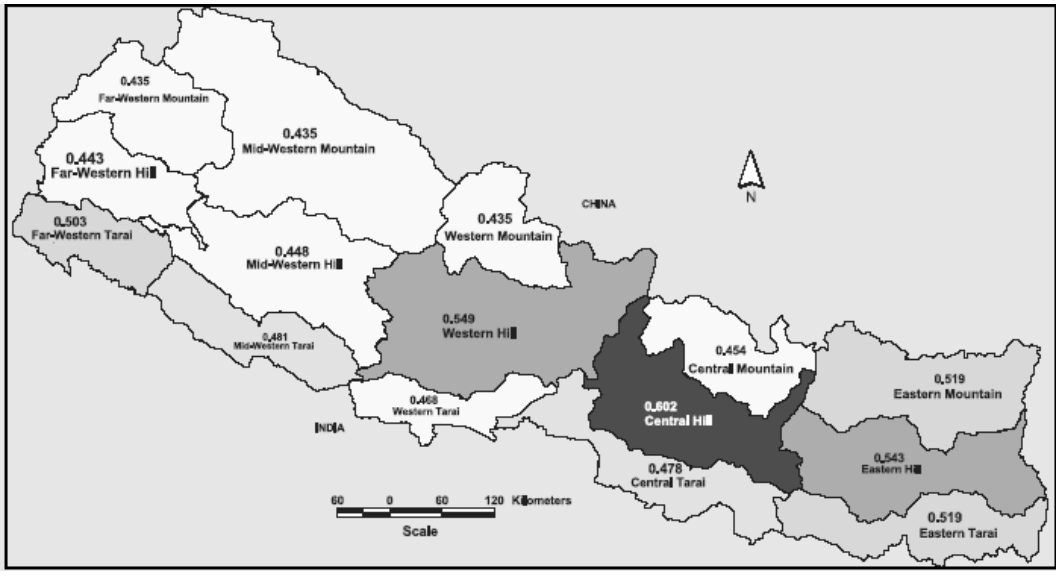

Figure 3. Geographical distribution of Human Development Index in Nepal. Source: (UNDP, 2009).

Some extreme HDI and poverty related indexes of Nepal as reported in UNDP (2009) are presented in Table 3. The table shows that the extremities are the highest in the Terai. HDI is the lowest in the case of Madhesi Dalits sharing negligible lands prone to recurrent droughts, floods, and innnundation. The same group has the lowest level of literacy making them more vulnerable to any climate induced hazards.

Table 3. Extreme development and poverty indices of Nepal

Index	**Maximum**	**Minimum**
HDI by caste	0.625: Madhesi Brhman/Chhetri	0.383: Madhesi dalits
HPI by region	48.1: Western and Far-western Mountainous region	28.2: Central hills
HPI by urbanization	38.2: rural	20.7: Urban
HPI by topographic region	43.3: Mountain	32.7: Hills
HPI by geographic region	39.0: Far western region	33.2: Western region
Average per capita income by ethnicity 2003-2004	Rs 23,900: Madhesi Brahman/Chhetri	Rs 8,830: Madhesi Dalit
Average per capita income by ethnicity 2003-2004: Urban	Rs 36,600: Newar	Rs 11,563: Muslims
Average per capita income by ethnicity 2003-2004: Rural	Rs 21,465: Madhesi Brahman/Chhetri	Rs 8,018: Hill dalits
Literacy rate by ethnicity and gender (15 to 49 years) 2006	96.9%: Hill Brahmin Male	17.2%: Madhesi dalits Female
Secondary School (15 to 49 years) 2006	90.1: Madhesi Brahmin/chetri Male	5.2%: Madhesi dalits Female

Source: UNDP (2009)

Rural population, women and children, spend significant time in collecting firewood. The households spend 10 pecent to 15 percent of their earning in fuelwood despite the opportunity cost related to the time spent by them (UNDP, 2007).

PEOPLE'S PERCEPTION

People's perception regarding climatic changes has been frequently reported in different studies and media during the past few years. Figure 4 illustrates some of the media reporting in 2009. Most of the findings and observations are similar. Some of the observations made by the author are included in this section in addition to the observations made by the others.

Sher Bahadur Tamang of Chitwan reports (Vidal, 2006), "The floods are coming more severely, more frequently. Not only is the rainfall far heavier these days than anyone has ever experienced, it is also coming at different times of the year."

Poudel (2009), based on his interactions with local communities and students in the mountainous village of Khudi in western Nepal, reports that the people in and around the Khudi watershed are experiencing:

- Different rainfall pattern, flooding and landslides
- Overall decrease in annual rainfall in arid and semi-arid regions of the Annapurna range
- Decreasing water levels
- Bare Himal where there used to be huge amount of snow
- Increasing tendency of extreme showers and storms in summer leading to severer floods and soil erosion
- Increasing disasters, such as heat waves, droughts, dust storms, and thunderstorms
- Improvement in crop growths
- Increase in mosquitoes and insects

Some reporting on the increased mosquitoes and mosquito-bites in Kathmandu in 2009 needs to be investigated in relation to global climatic changes. Doctors at the Sahid Sukraraj Tropical Hospital reported more than 200 snkebite cases in the month of Baisakh 2066 (April-May, 2009) alone, which is much higher than the cases reported in previous years. The available data in Kathmandu shows that the dry and warm condition of 2009 was responsible in signifinly incresed rates of snakebites. The projection indicates the appearance of Terai-based diseases, such as malaria, dengue, encepalitis, and filariasis in Kathmandu (मिस्र, २०६६ ३ ८).

Figure 4. Some of the headlines of media reporting in 2009.

Loss of water sources is one of the greatest concerns among rural populations. Not only laymen but also experts working in the field of climate change opine that several thousand springs and canals have already dried up in Nepal forcing people to migrate (खडका, २०६६ ३ २७). खडका (२०६६ ३ २७), based on interviews with the locals, further reports that:

- A cloudburst observed by the residents of Bhaktapur ending the prolonged dry spell of 2009 was something never experienced before. While it was havoc in a particular area of Bhaktapur, it was dry and dusty in Kathmandu 10 kilometres away. The following days were, however, hot and sunny in Bhaktapur striking the hopes of farmers.

- Gurans, a usual springtime flower in the mountains of Nepal, have been flowering in the jungles of Achham at the start of rainy season in 2009.
- People are surprised to get ripen Kafal in February instead of its usual time in spring.
- Some mountainous parts of Nepal are reporting the appearance of mosquitoes.

Practical Action (2009), an INGO, in a study of the Jugedi watershed in the Chitawan district of Nepal found that the locals were experiencing hotter and wetter summer but colder and drier winter with prolonged droughts and dclining water sources. An additional aspect highlighted by the Practical Action is, "an increase in alcohol production to offset the failure of agriculture" with negative impacts on livelihood of the population. The study also reveals the changing pattern of agriculture: conversion of paddy field into maize and millet cultivation.

The issue of climate change has also been discussed in severeal programs on TV channels telecast from Nepal. One of the recent exzamples is the BBC program "Sajhga Sawal" telecast on Kantipur TV on 30 August 2009. The interaction program included participants from Dhulikhel and adjoining villages in the Kavre ditrict.

The local participants on the "Sajha Sawal" program described indications of climatic changes with adverse impacts on agriculture and water supply. Some of the major climate related problems described by the farmers (Ms Geeta Banjara from Panauti, Mr Jeet B. KC from Dhulikhel, Mrs Bhubaneswori Shrestha from Dapcha, Mrs Yasoda Bhurtel frm Bhakunde, Mr Krishna C. Acharya, Activist, etc) in the Kavre district included:

- Potato yield is decreasing every year due to shortening of the ripening period. The usual period of 90 days for potato has come down to almost 70 days.
- Agriculture production is often negatively influenced by frequent diseases and drying out of plants.
- Weather has become more erratic. Farmers, who could anticipate the nature of weather for scheduling farming activities, are not able to do so these days.
- Low yield of spring and summer crops (maize and vegetables) because of lack of rain in non-monsoon period.
- Subsequent dry winters during the last four years.
- Fetching water for domestic purposes has become more and more difficult every year.
- Observations of less snow cover in the Himalayas.

The major request of the farmers included support from the government in adaptation measures, such as technologies for extracting additional groundwater and appropriate agriculture practices.

A student (Figure 5), who recently completed his Master Level thesis under the author's supervision conducted surveys in a rural village of Khudi watershed in western Nepal. Some of the major findings of Sharma (2009) are as follows:

Figure 5. A Villager being interviewed by a research student about a drying-up spring in Khudi.

- Hundred percent respondent of the lower belts has experienced increasing temperature in recent years.
- Ninety-three percent respondent of the upper belt experienced increasing temperature in recent years.
- Seventy percent respondent felt the changing pattern of rainfall.
- Ninety-one percent respondents experienced the unusual rainfall pattern
- Eighty-three percent felt an increase in heavy precipitation.
- Seventy-five percent respondents believed in the decreasing pattern of rainfall
- Fifty percent were of the opinion that total rainfall is lowering.
- Changing pattern of rainfall was the major concern for the communities

BIZARRE RITUALS

Bizarre rituals are common among the farmers of Nepal as different beliefs exist among them. Two typical examples of 2009 from the western and eastern Nepal are illustrated as follows.

Our team had a discussion with a Tharu community on the bank of the Babai near Gularia regarding the on going drought conditions (Figure 6). They explained the bizarre rituals they perform during prolonged drought conditions. During the rituals, which are also mentioned by Bhandari (2009 7 12), Tharu women plough their house yard in a reverse manner at night singing song to appease rain god when dry spells persist too long effecting agriculture. Husbands are blindfolded, and if any of them are peeping, they are punished and fined foodstuff, which is again offered to the rain god. The punishment may also include the dressing up of the males in female attire. Tharu communities also worship frogs as a part of the rituals.

The month of Srawan (July-August) is not the right month for marriage in Nepal; however, अधिकारी (२०६६, ४५) reports the marriage ceremony of frogs at Sijuwa in the Morang district as the farmers in the region were worried due to the total absence of rain. Invitation card was distributed to about 1500 persons for the marriage ceremony of Meghnath from Kohabara to Sulochana from Sijuwa. The ceremony was complete in all respect conducted by a priest. that was held on the fourth of Srawan. The male frog was named Meghnath meaning 'lord of cloud'. Sulochana is the wife of Meghnath in Purana, a hindu epic. The report, however, does not provide information whether the rituals was a success or not to appease the rain god.

Figure 6. Discussing climate, droughts, and floods with farmers in the Bardia district.

MONITORING CLIMATE AND WATER RESOURCES

Hydrological and meteorological data are important for monitoring climate and water resources. These data are also essential for assessing risks and for managing adaptation and mitigation measures. Hydrological and meteorological data are the basic tools for investigating and modeling climatic changes including the associated impacts.

Department of Hydrology and Meteorology (DHM) under the Ministry of Environment, Government of Nepal is the sole organization in Nepal with a responsibility to establish hydrological and meteorological stations, and measurement of hydro-climatic elements. DHM is also responsible for processing, publishing and disseminating data. The hydro-meteorological network maintained by the department is the basic source of information available for any climate related assessment.

Southasia got its first observatory at Cacutta established in 1875. Regular publication of meteorological data recorded by a sparse network started in India in 1880 (Sharma, 1982; शर्मा, २००९). Precipitation recording in Kathmandu was started on a regular basis in 1921 in the premises of the Indian Embassy at Lainchaur (DHM, 1977). The station was gradually upgraded into a climate monitoring station through the years. The lone station of Lainchaur got a network character in the Kathmandu valley with two additional precipitation stations in Sundarijal established in 1940 (DHM, 1968). The network was extended to cover the Kosi basin

in Nepal in 1947 with the installation of 40 stations within one year. A program to cover the whole nation with precipitation was initiated in 1955. By 1958, the number of stations in the network crossed a century (Figure 7).

Figure 7 shows that more than 500 precipitation stations were established in Nepal since the beginning of meteorology in Nepal. After closing several stations at different locations, precipitation network of DHM, at this stage, consists of 445 stations as shown in Figure 8.

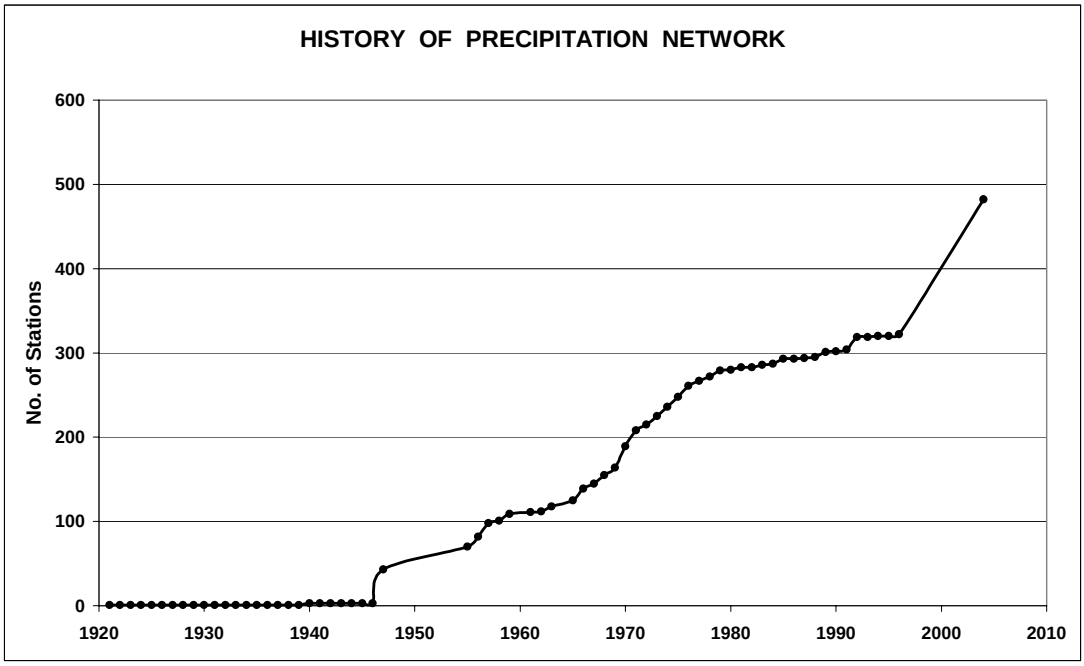

Figure 7. Historical strengthening of precipitation network in Nepal.

Besides monsoon meteorology, spatial and temporal distribution of precipitation depends on several aspects, out of which extreme topographic variations in Nepal is a dominating factor. Although 42 percent of the country lies above 2000 m the network in this area is poor. Considering the existing precipitation gauging network of 445 stations (106 stations in plain region and 339 in mountain region), the network density distribution is 331 km^2 per gauge on an average. The distribution of precipitation networks with respect to physiographic regions of the country is shown in Table 4. Table 4 compares the network densities of existing stations and WMO norms. The comparison shows that network density in low-land areas can be considered adequate, whereas it is inadequate in most part of the country.

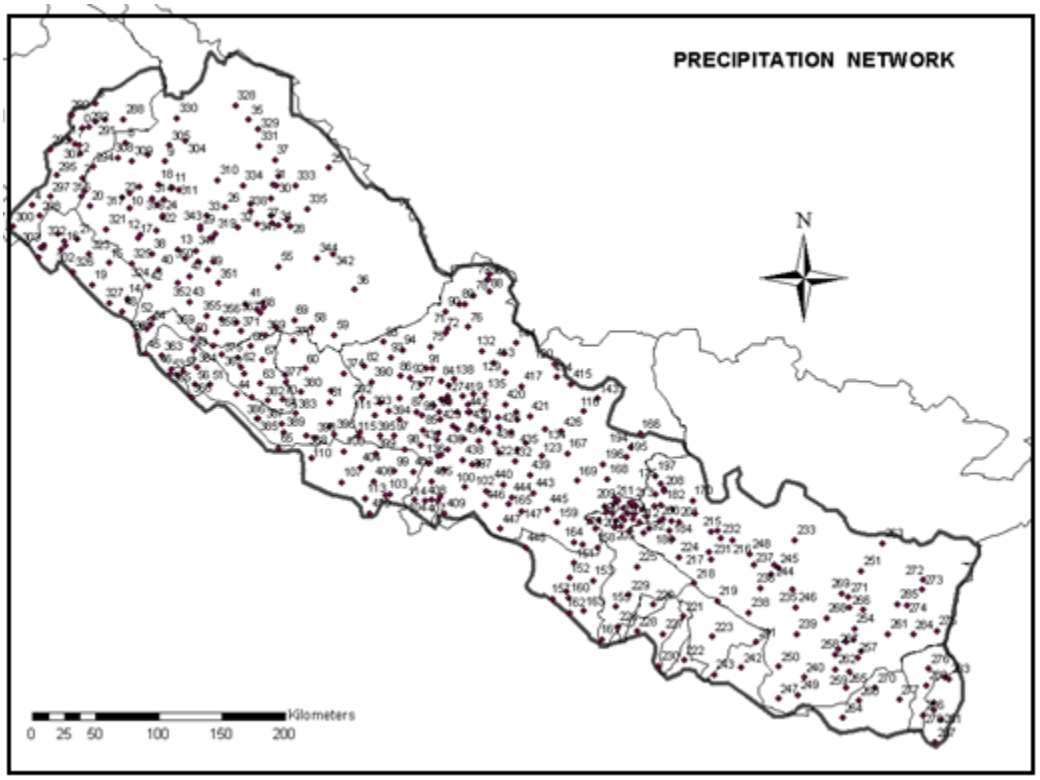

Figure 8. Existing precipitation gauging stations.

Table 4. Physiographic distribution of network in Nepal.

			WMO Recommended Range	
	Area (km^2)	Existing N0. of Stns.	Max. No. of Stns.	Min. No. of Stns.
Flat Land	26,700	106	45	30
Mountain (300 m-3000 m)	77,000	322	770	308
Difficult Condition (>3000 m)	43,500	17	29	4
Total	147,200	445	844	343

The length of rainfall records is particularly important for the assessment of climatic changes. The length of records of existing precipitation network is shown in Figure 9. The figure shows that 129 stations are having relatively good records for climatic assessment with more than 30 years record length. As per the WMO guideline, the basic networks are those which are generally functioning during at least 10 years (WMO, 1983). Accordingly, rain gauge networks of 284 stations can be considered as basic rain gauge networks in the country.

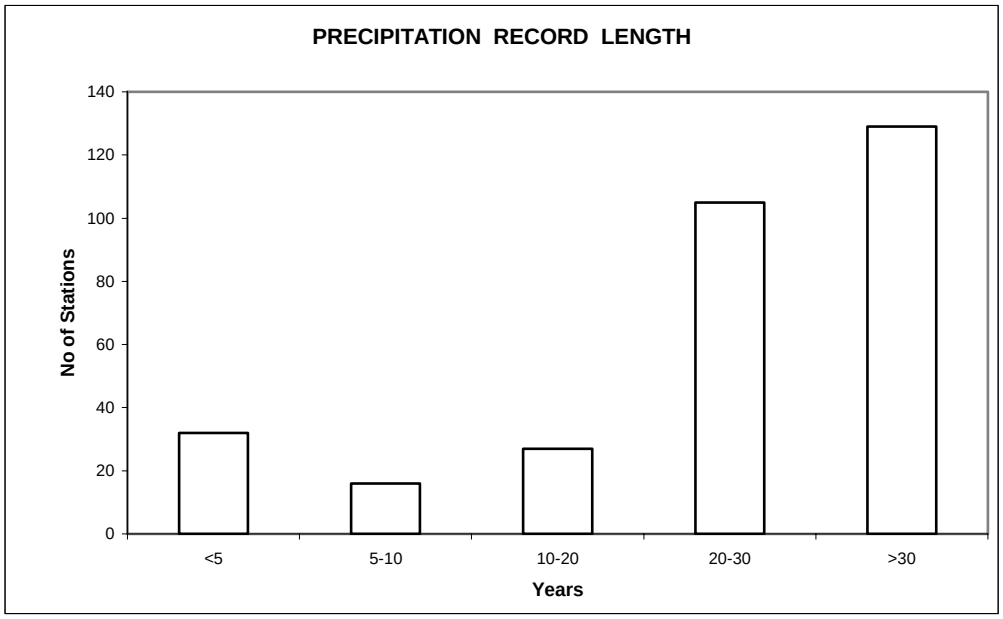

Figure 9. Length of records at precipitation stations.

Although reasonable number of stations is being maintained by DHM, there is a concern about inadequate information in high mountain areas. Ten stations were established in Nepal during 1947 to 1975 in the high mountain areas out of which only one station at Lomathang is in operation. There is, hence, not enough information to validate the warming pattern with higher confidence in the high mountain range of Nepal. The remaining stations located above 3000 m were closed by 1980s. Table 5 presents the altitudinal pattern of closed stations.

Table 5. Altitudinal pattern of closed stations.

	Precipitation Station			**Temperature Station**		
Elevation Range (m)	No. of Stations Established	No. of Stations Closed	Percentage of Stations Closed	No. of Stations Established	No. of Stations Closed	Percentage of Stations Closed
< 150	37	10	27	20	5	25
150-1000	111	15	14	41	4	10
1000-2000	146	37	23	45	9	20
2000-3000	33	6	18	18	2	11
3000-4000	24	13	46	10	8	80
>4000	3	3	100	1	1	100
Total	354	84		135	29	

CLIMATIC TRENDS

As described in earlier section, precipitation data are available from 1947 in the Kosi basin. Since nationwide network establishment began in 1956, nationwide long-term data are available only from 1956 onwards. Annex 1 and Annex 2 presents the data available for the meteorological network in Nepal from the start of record to 2006. Data available for the following years are not used in this study as they are at different stages of processing. The annexes show that the data are intermittent for several stations and that several stations have been discontinued. For the assessment of long-term climatic trends, we used the data with record length extending 20 years or more.

Although the assessment of long-term precipitation was carried out from 1956, temperature analyses were inappropriate before 1975 due to few data points. Temperature trend analyses included the average temperature, minimum temperature, maximum temperature and extremes. The analyses of trends are presented in Annex 3 and Annex 4. Annex 5 and Annex 6 present the figures indicating actual observations and trends. Figure 10 and Figure 11 illustrates the spatial variation of average temperature and precipitation trends respectively.

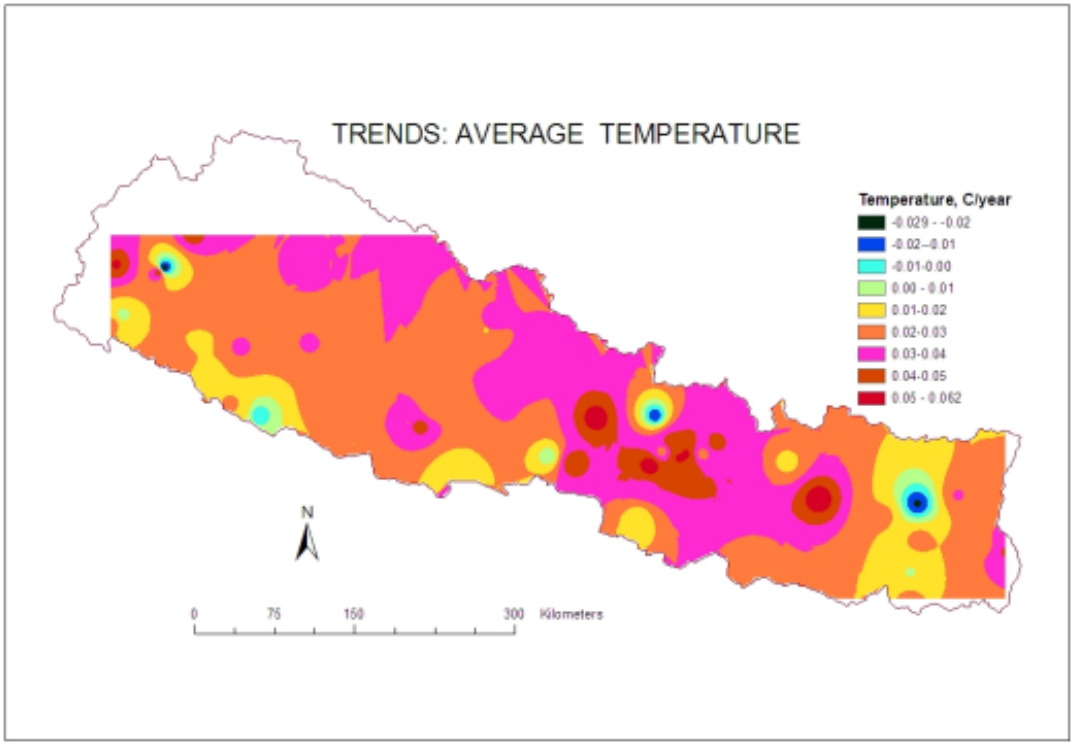

Figure 10. Average temperature trends in Nepal (1975-2006). Gaps are the areas of inadequate data.

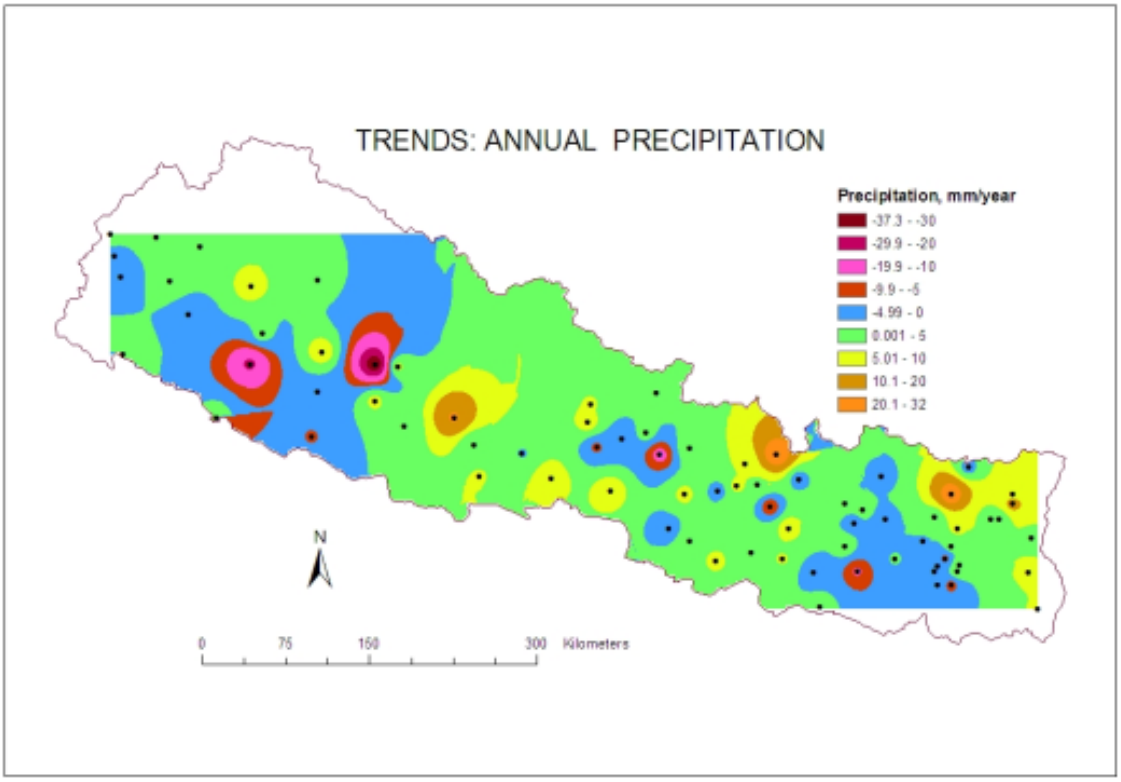

Figure 11. Average precipitation trends in Nepal (1956-2006). Gaps are the areas of inadequate data.

A summary of temperature trends in Nepal is presented in Table 6. Table 7 presents the summary of precipitation trends.

As presented in Table 6, the average temperature trend in Nepal from 1975 to 2006 is 0.027^{o}C per decade. The global average trend for the similar period is 0.017^{o}C (IPCC, 2007). The findings indicate that the average temperature in Nepal is increasing by more than 50 percent compared to the global average. The increases in maximum temperature are higher than minimum temperature.

Table 7 indicates that the overall precipitation trends in Nepal are almost insignificant. The long-term trends of annual precipitation ranged between -37.3 mm/year to 32.2 mm/year with average at 1.8 mm per year. Trend during the last thirty years showed only 0.99 mm/year. Although insignificant, the negative trend of winter precipitation during the past thirty years can become an issue if it amplifies in the years to come. Winter precipitation has special significance for the livelihood in Nepal as it supplement the water requirements for wheat

maize and barley, which are the major sources of food grains. A case of such experience in Nepal is described in the following section considering the recent case of extreme weather.

Table 6. Summary of temperature trends (°C/yr) during 1975-2006 in Nepal

		Elevation Range			
	Overall	72-200 m	200-1000 m	1000-2000 m	>2000 m
		Average Temperature			
Average Trend	**0.027**	0.014	0.031	0.031	0.034
Maximum Value	0.062	0.028	0.028	0.057	0.062
Minimum Value	-0.029	-0.008	-0.008	-0.029	0.015
No. of Stations	56	14	15	23	7
No. of Stations with Significant Trend	19				
		Average Minimum Temperature			
Average Trend	0.018	0.022	0.034	0.014	0.028
Maximum Value	0.107	0.050	0.090	0.090	0.107
Minimum Value	-0.101	-0.031	-0.006	-0.101	-0.031
No. of Stations	60	14	15	38	7
No. of Stations with Significant Trend	17				
		Extreme Minimum Temperature			
Average Trend	0.017	0.009	0.019	0.006	0.064
Maximum Value	0.222	0.057	0.076	0.052	0.222
Minimum Value	-0.102	-0.079	-0.083	-0.102	-0.057
No. of Stations	61	15	16	24	7
No. of Stations with Significant Trend	3				
		Average Maximum Temperature			
Average Trend	0.041	0.005	0.032	0.065	0.047
Maximum Value	0.152	0.024	0.066	0.152	0.101
Minimum Value	-0.049	-0.012	-0.008	-0.049	-0.030
No. of Stations	61	14	15	24	8
No. of Stations with Significant Trend	27				
		Extreme Maximum Temperature			
Average Trend	0.019	-0.006	0.002	0.041	0.031
Maximum Value	0.171	0.040	0.065	0.171	0.092
Minimum Value	-0.160	-0.036	-0.160	-0.083	-0.036
No. of Stations	62	15	16	24	8
No. of Stations with Significant Trend	3				

Table 7. Summary of precipitation trends (mm/yr) in Nepal

	Annual		June-September		November-March	
	Trend	No of Years	Trend	No of Years	Trend	No of Years
	1956-2006					
Mean	**1.80**		0.50		0.25	
Maximum	32.2	50	24.0	50	2.4	50
Minimum	-37.3	36	-31.6	40	-2.2	40
Significant Numbers						
Increase	3		1		0	
Decrease	1		1		0	
	1956-1976					
Mean	10.9		8.52		-1	
Maximum	143	20	64.3	20	4.55	20
Minimum	-97.3	15	-75.9	16	-11.3	15
Significant Numbers						
Increase	2		1		0	
Decrease	1		0		0	
	1977-2006					
Mean	0.99		0.90		-0.57	
Maximum	62.6	30	56.4	30	2.91	30
Minimum	-54	16	-54.4	21	-11.6	18
Significant Numbers						
Increase	1		0		0	
Decrease	4		3		0	

2008-2009: ONE OF THE DRIEST YEARS

The years 2006 and 2009 are reported to be the driest years in terms of rainfall during winter (December to February) which is essential for good Kharif (DHM, 2009). Based on the readily available data from 35 meteorological stations in Nepal, DHM (2009) reports that eleven stations could not receive a single drop of water during this period. The reported rainfall is less than 20 percent of normal in more than half of the country, highest recorded being less than 70 percent of normal at Okhaldhunga (Figure 12).

Besides dry winter, the year 2009 was also extreme in terms of temperature records and the delayed monsoon. The recorded temperature is higher than normal at almost all the 35 stations. Some locations report the maximum temperature exceeding six degree Celsius from the normal (DHM, 2009).

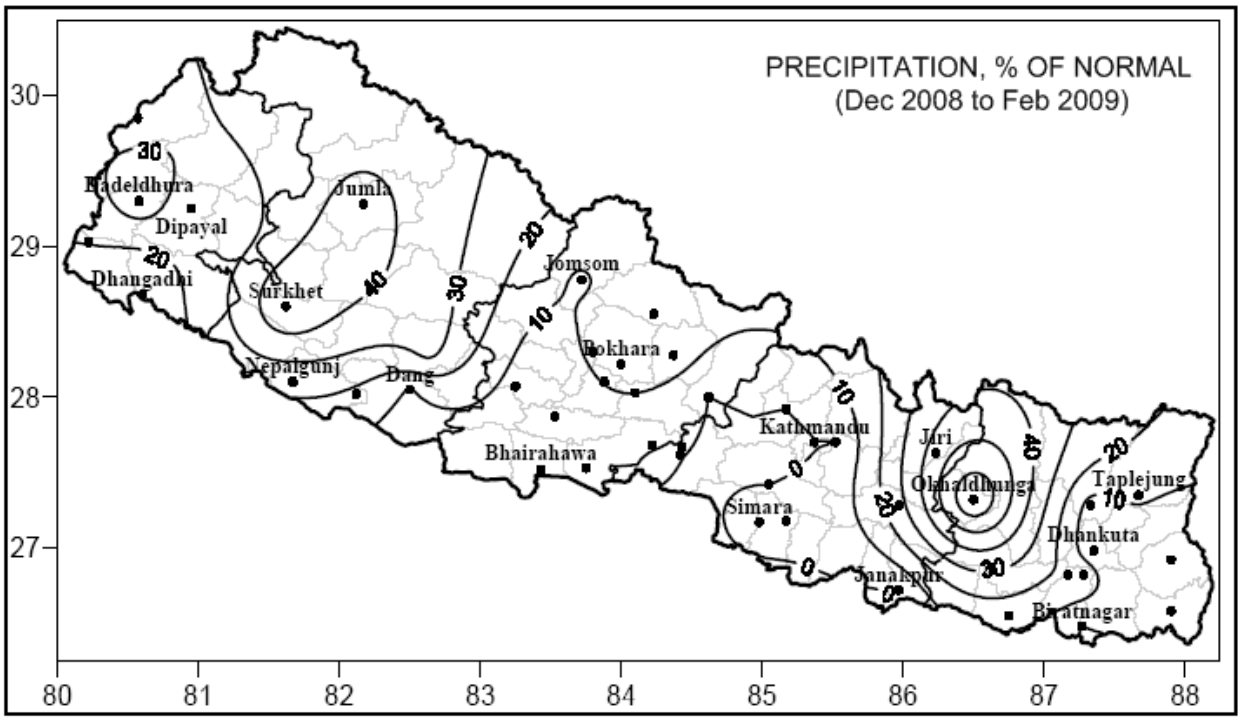

Figure 12. Percent of normal precipitation recorded in Nepal during the winter of 2008-2009. (DHM, 2009).

Normally monsoon sets in Nepal between 10 and 12 June; however, the monsoon entered Nepal from the eastern side on 23 June in 2009. The precipitation recorded in Kathmandu during 2008-2009 is compared with the normal precipitation in Figure 13. The onset of the monsoon was relatively weak in most part of the country. The weak onset of the monsoon was not able to ameliorate the farmers' woes particularly in west Nepal.

Although the overall impacts of drought conditions in Nepal is yet to be assessed, 2009 can be considered as a special case for assessing climatic impacts for developing adaptation measures. An assessment made by the Ministry of Agriculture and Cooperatives, WFP, and FAO shows that the production of wheat and barley went down by 14 percent 17 percent respectively (WFP, 2009). The report, presented by WFP also indicates that the situation was worse in western Nepal where food production dropped by almost fifty percent. General observations of the impacts of such adverse climate have been widely covered by media in relation to the global climatic changes. Some observations on the basis of media reporting indicate alarming situation of food security in different parts of the country.

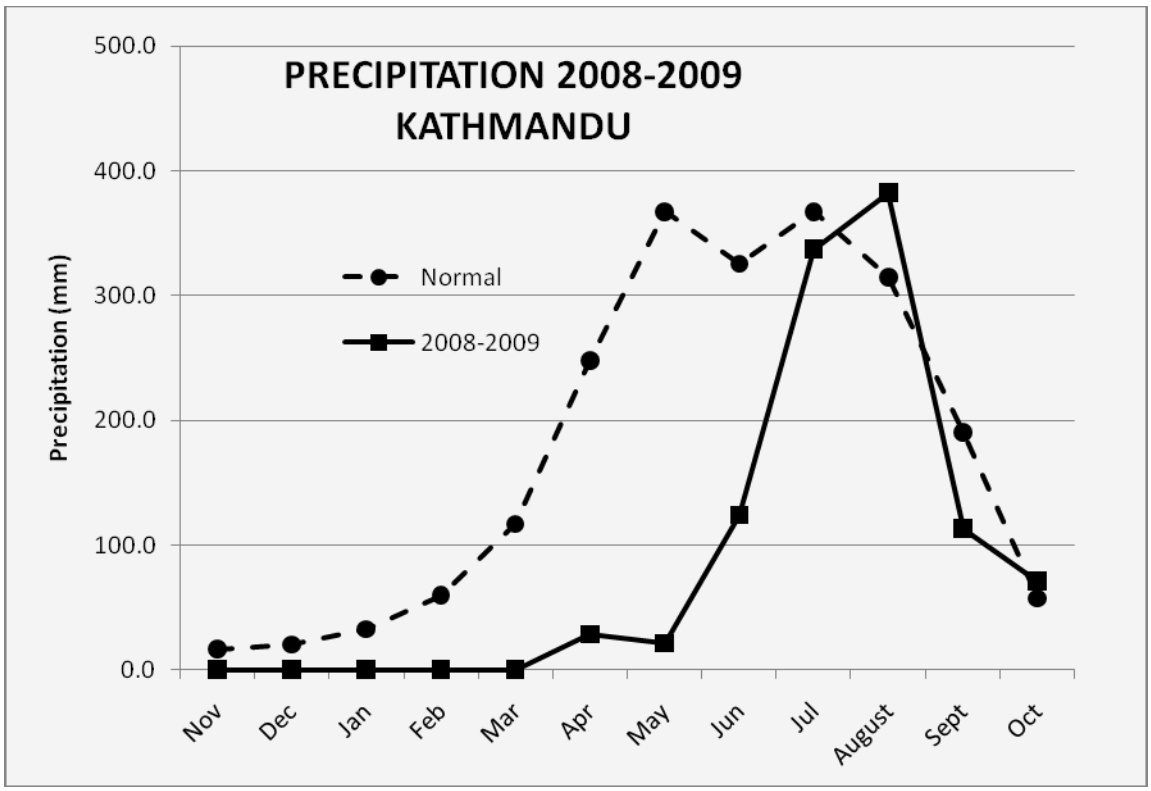

Figure 13. Precipitation recorded in Kathmandu during 2008-2009 is compared with the normal precipitation.

Temperature exceeding forty degree Celsius is common in some parts of the western Terai in Nepal. In 2009, however, some locations in the mountainous areas of western Nepal reported temperature exceeding 40^{o}C, which is the highest, recorded so far at Mangalsen and Sanfebagar (कान्तिपुर, २०६६). The western region of Nepal received the first wet spell of 2009 only in the last week of June. The drought-like situation caused the failure of spring-season paddy and the poor seedling of monsoon season paddy (Baral, 2009). Farmers are usually prepared to plant paddy starting from the first week of June. The delayed monsoon, hence, caused the losses of seeds as well.

Newspapers have extensively highlighted the agriculture damages caused by the prolonged drought conditions in Nepal. The reported losses in different parts of Nepal range from of 20 percent to 90 percent and exceed 50 percent in most of the mountainous region (कान्तिपुर, २०६६ ३ ८; तिमिल्सिना, २०६६ ३ १४). The percentage of successful paddy plantation varies from nine percent in the Sarlahi district to 90 percent in the Jumla district by the third week of July (धिताल, २०६६ ४ ४). More than 80 percent of the arable lands in the Ramechhap district

are reported barren. Locals claim that the 2009 drought is the worst drought observed so far in the last 32 years from B.S 2034 (कान्तिपुर, ४ ४ २०६६) . The prolonged droughts are also blamed for plant diseases in some cases (कान्तिपुर, २०६६ ३ ८).

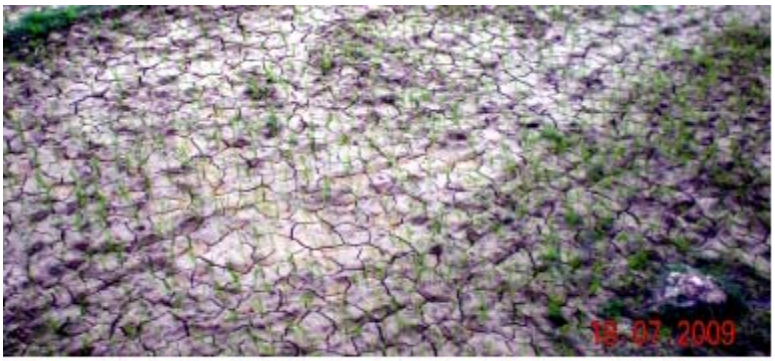

Figure 14. Paddy field in the Bardiya district on 18 July 2009

Although July is the active monsoon period, the whole country remained almost dry. Farmers were not able to plant rice in more than 35 percent of the cultivable paddy fields in the hilly and mountainous districts. The plantation was possible in only about 25 percent of the paddy fields in Terai. Figure 14 illustrates the condition of a paddy field in the Bardia district of western Terai where some plantation was carried out.

The farmers in the Terai were waiting for a wet spells as there was some scope of rice planting till mid-August (Ghimire, 2009). Some precipitation received from the third week of June was too little to ameliorate the situation in western Nepal until mid-July (THT, 11 7 2009). The reporting described acute suffering of farmers in some districts in west Nepal where only about five percent of the required food supplies could be met. food supplies does not exceed five percent. Farmers were also found to spend lot of their time and energy ferrying water from rivers to farmland as the canals have gone dry. The looming food crisis was also a reason behind the soaring food process in 2009. The inflation during 2008-2009 exceeded 13 percent, a level not experienced before.

AGRICULTURE

Besides soil fertility, agriculture depends on weather, climate, and water. An effective monitoring and forecasting system of weather aid decision making for maximization of crop production. Agriculture is one of the major sectors concerned about the global warming as it has direct implications on the livelihood and the economy of a country is dependant on agricultural products.

The contribution of agriculture to the GDP of Nepal exceeded 50 percent 25 years ago. It is decreasing over the years; however it still exceeds 30 percent (Figure 15). Contribution of rice alone has been estimated at 16 percent.

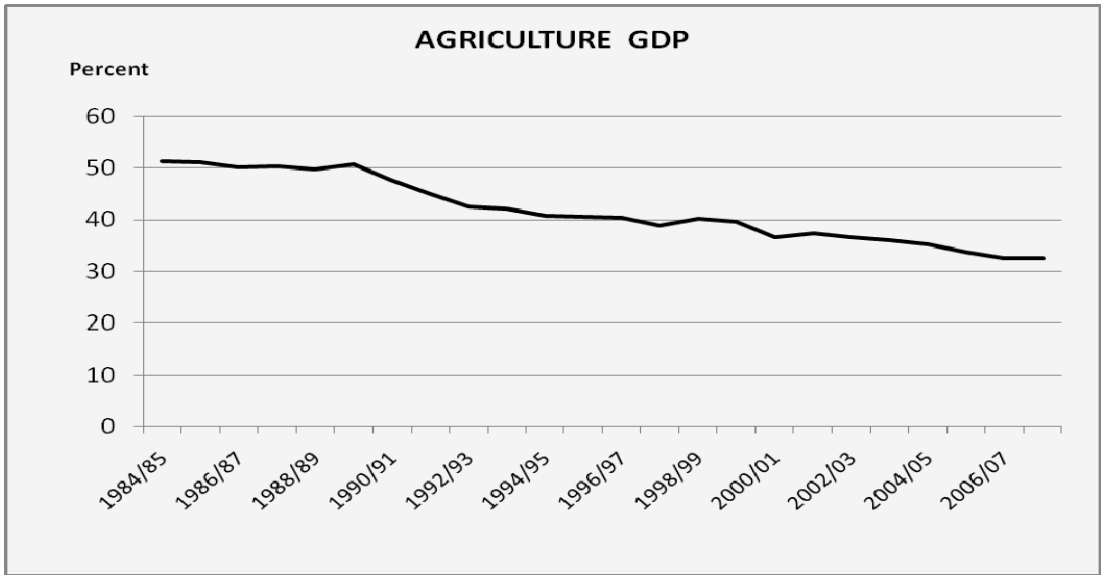

Figure 15. Contribution of agriculture to the GDP of Nepal (Source: MoAC 2007/2008 Economic Survey).

Based on the survey of 2000/2001 (CBS, 2002), the area under paddy is estimated at 15,600 km^2. Out of the total paddy field, 11,300 km^2 (72 percent) lies in the Terai, and the rest in the sloping hills and valleys of the mountainous region. The areas under cultivation of maize, wheat, millet, and barley are 8,240 km^2, 6,410 km^2, 2,600 km^2, and 281 km^2 respectively. Out of the total area, 24 percent of maize 55 percent of wheat, 4 percent of millet, and 5 percent of barley fields are located in the Terai.

The estimates of agriculture status and the consumption pattern during 2001-2002 are presented in Table 8 and Figure 16 respectively. The computations are based on the agriculture statistics available for Nepal (CBS, 2002)

Table 8. Agriculture consumption patterns of Nepal in 2000-2001

Item	Rice	Maize	Wheat	Millet	Barley	Total	Required	Balance
Production (Million tonnes)	2.36	1	0.91	0.23	0.008	4.51	4.43	0.08

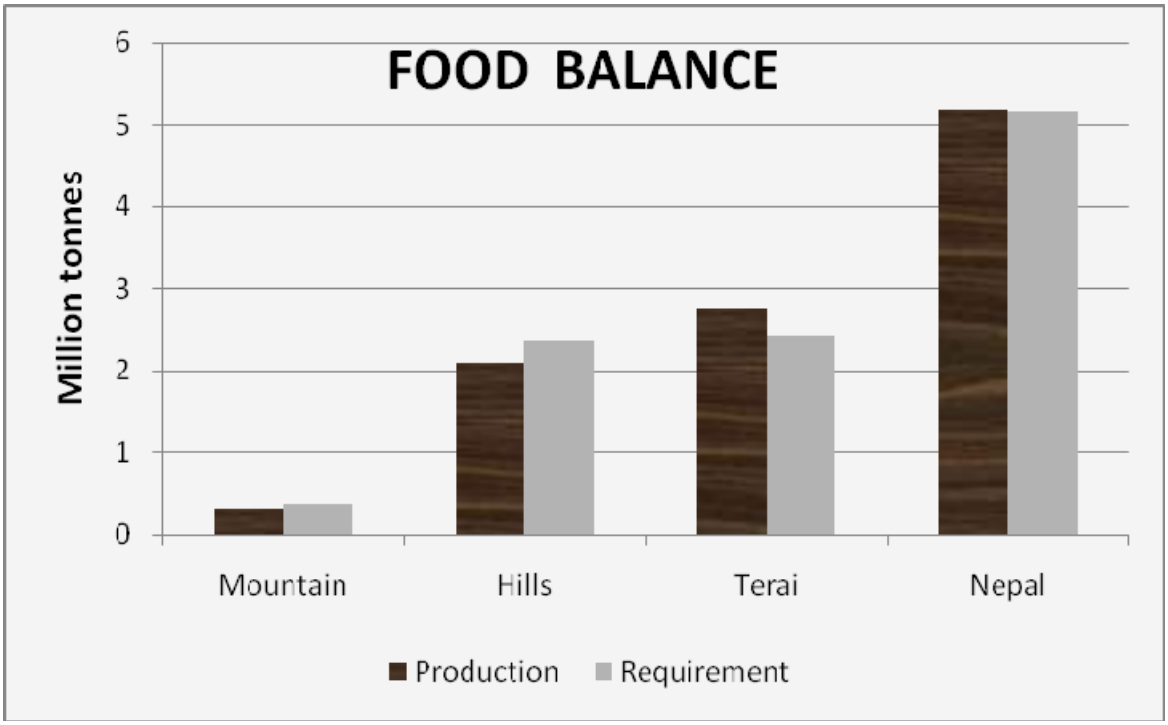

Figure 16. Comparison of food balance status in 2000-2001 in different physiographic region.

Table 8 shows that the production of staple foods in 2000-2001, which was relatively good year in terms of monsoon normality, could meet the requirement of the population. In the case of failed monsoon, such as the monsoon of 2009 significant population face food scarcity.

Based on the per capita annual consumption pattern in Nepal estimated by Department of Commerce (THT, 2009 9 6), requirement of food as computed for 2009 is presented in Table 9. Figure 17 shows the pattern of food surplus and food deficit during the 1995-19996 to 2007-2008.

Climatic changes that causes prolonged drought conditions is the worst disaster for agriculture. Recent assessments of erratic climatic behavior highlight the impacts on livelihood of people. Northern districts of the Karnali zone are particularly vulnerable regarding the availability of food supplies. More than ten thousand quintal food items are supplied to the Humla district alone via the airport located at Simikot. The transportation cost from Nepalging to Simikot was found to be as high as s Rs 168/kg.

Table 9. Consumption pattern of 2008 products in 2009

	Per capita consumption	Consumption in 2009	Production in 2008
Rice	122	3.3	2.4
Maize	44	1.2	1.0
Wheat	17	0.46	0.92
Potato	50	1.4	2.1
Lentil	9	0.24	0.27
Milk	48	1.3	1.4
Fish & Meat	8	0.22	0.23
Oil	4	0.11	0.13

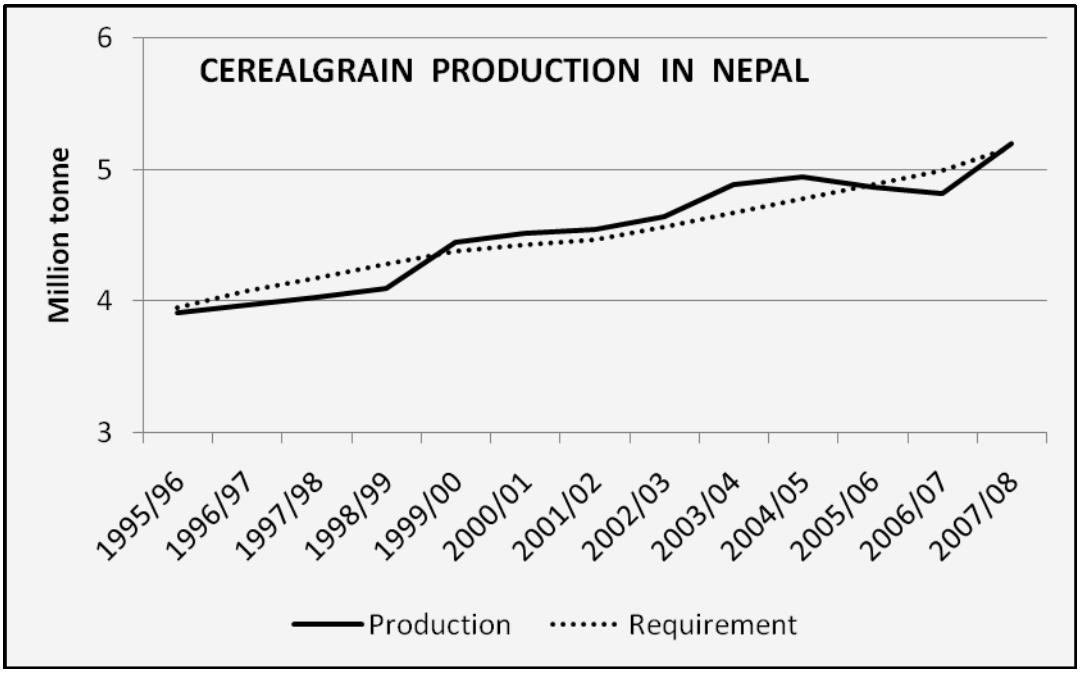

Figure 17. Time series of production and requirements of cereal grain in Nepal

Increasing population and improved economic conditions have resulted in the rapid increase in livestock production (Figure 18). The statistics and trends on livestock show that the production doubles in a period of 20 to 25 years in Nepal. Such increases doubles the need of water, grazing lands and fodder.

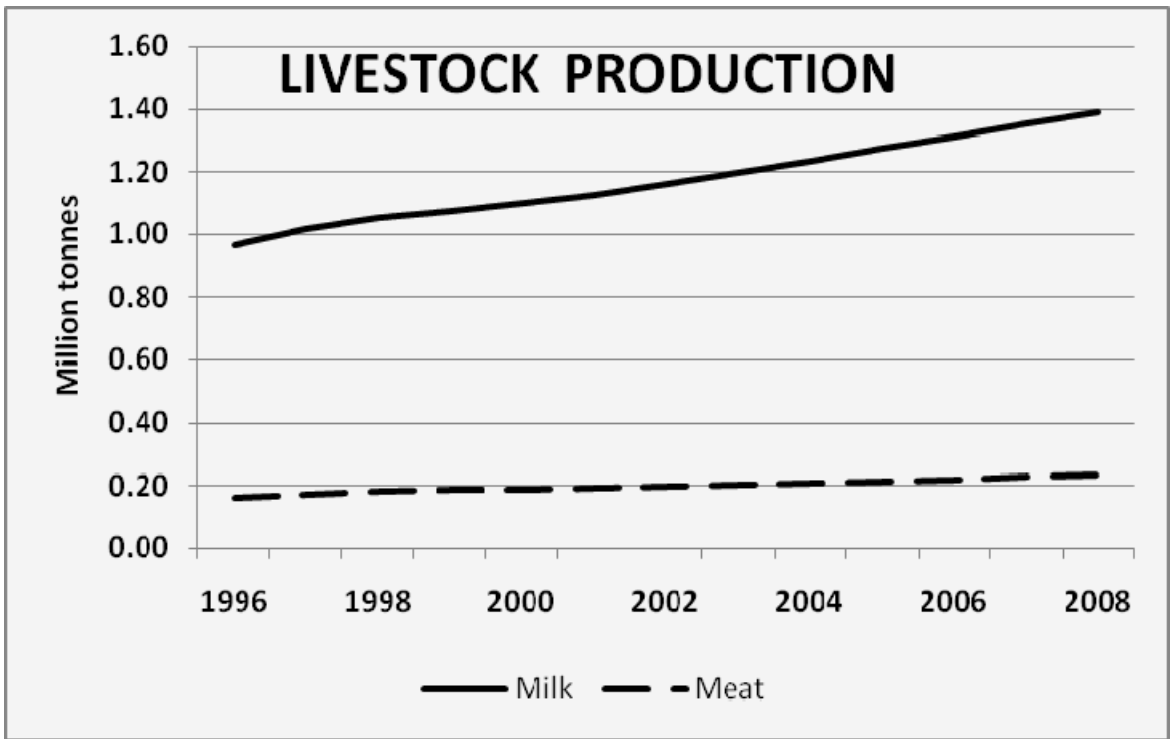

Figure 18. Time series of the milk and meat production in Nepal.

HYDROLOGY WATER RESOURCES AND VULNERABILITY

Almost everything on earth including living beings, agriculture and forest is under the direct and indirect influence of water. Future projection of enhanced monsoon that may intensify floods, droughts, soil erosion, sedimentation, are some of the major water related concerns in Nepal.

Nepal is considered one of the most vulnerable countries in the world regarding the impacts of climatic changes. Three major reasons are the fragile mountain ecosystem, extreme variability of climatic pattern and the poverty. Combined effects are the overexploitation of natural resources, land degradation, ecological imbalance, loss of natural habitats, thinning of already thin layer of mountain soil, increase in reservoir sedimentation, drying up of wetlands etc.

The per capita GDP of Nepal at $470 is the lowest in South Asia. Poor people are considered vulnerable as they live in places susceptible to natural disasters; they have limited coping capability and they lack awareness and education. In addition, Nepal is vulnerable to climate change as the economy of the country is dependant on agriculture, which is a climate sensitive sector as described in earlier chapters. Enhanced hydrological cycle inducing hydrological hazards and adverse impacts on the water availability contributes towards the vulnerabilities as illustrated by the following examples.

- Almost half of the irrigable lands do not have irrigation facilities.

- One million hectare of irrigable lands are sensitive to the water stress that is likely to deteriorate as a result of climate change.
- About 10 percent of the area of Nepal lies above snowline (5000 m) which is sensitive to rise in temperature
- Drought and flood can occur in the same area within a month (Figure 19),
- Particularly in the monsoon region, climate is predicted to become more variable with frequent extreme events (Houghton, 2001),

Govt appeal for $120m flood, drought assistance

POST REPORT
KATHMANDU, SEPT 4

According to initial esti- Sharan Mahat apprised th
mates, some 150,000 hectare of donors about the assistance

Figure 19. Media coverage of simultaneous flood and drought.

- Most of the people living in mountain ridge and higher elevation of a mountain have access to meager sources of water,
- Three thousand two hundred and fifty two glaciers cover 5,324 km^2 in the Himalayan region of Nepal (Mool, Bajracharya, & Joshi, 2001).
- Out of identified 2,323 glacial lakes, 20 lakes are considered potentially dangerous, which need urgent monitoring and mitigating measures (Mool, Bajracharya, & Joshi, 2001).
- The contribution of snowmelt to the snow-fed rivers of Nepal is about 10 percent (Sharma, 1993). Upward migration of snowline is likely to change the snow cover area reducing flows during snowmelt season.
- Inadequate research, poor understanding of the climate impacts on different sectors, inadequate scientists and scientific knowledge are hindrances to adopt appropriate adaptive measures.
- Poor awareness: only 52 percent of the population are literate
- Poorly managed natural resources degraded status of watershed adds additional challenges.
- Poor infrastructure, weak technological capabilities, and inadequate institutional arrangements limit the capabilities to face challenges.
- Several political reasons, such as growing conflict among political parties, tribal, and marginalized communities pushes down the climate issue towards low priority.

Unlike direct influence of climate change on surface water hydrology, groundwater is influenced in an indirect manner. Dwindling surface water, over exploitation of groundwater, and prolonged droughts contribute to the lowering of groundwater level.

DRYING STREAM SOURCES

Drying up of springs every year has been frequently reported in media (कान्तिपुर, २०६६ ३ १०; कान्तिपुर, २०६६ १० ३; THT, 2009 7 11). The 2009 media widely covered the problems faced by general public dependents on nearby streams due to the impacts of prolonged drought. Two streams around the Daksinkali Temple in Pharping dried up during the pre-monsoon season of 2009 (कान्तिपुर, २०६६ २ ३०). Inhabitants of the Ramechhap, Sukajor, Rampur, Okhreni, Bhaluwajor, Salu, Sunarpani, Manthali, Kathjor and Deurali village development committees are suffering of acute water shortage as the water sources are drying up (कान्तिपुर, २०६६ ३ २). Locals of Tamghas are facing acute water shortage with drying springs as a result of prolonged drought spells (THT, 2009 6 22). Since potable water is the basic need, drying-up of springs can have direct influence on the population. It not only adds hardship, but can also result in the migration. Three hundred persons were forced to migrate from the Belghari village of Sindhuli in February 2009 as the local spring was too dry to meet the requirements of the locals (खडका, २०६६).

GENDER AND CHILDREN ISSUES

Social structure of Nepal is primarily dominated by males. Despite the contribution of females in rural society for running the day-to-day business of a house, their contribution in national economy is hardly accounted for. Typical gender-based characteristics in Nepalese society can be listed as:

Although women take interest in environmental and other issues, their participation in high-level talk programs and seminars is very limited. Their participation in local-level programs, however, are usually high (Figure 20).

Figure 20. A gathering in a village in Syangja to discuss climate change and disaster issues.

Some gender issues of Nepal that may influence the adaptive measures in climate change are:

- High percentage of seasonal migration of males to India
- High percentage of migration of males to several Arabian and South-East Asian countries.
- High percentage of women is involved in fetching water and collecting fuel and fodders.
- Children must spent significant time in fetching water, collecting fodder and looking after cattle (Figure 21).


Figure 21. Chilldren (5-12 years) collecting fodder

Children are always eager to learn, fascinated by new technologies, and are responsive to environmental conservation. Whatever they learn, they are always eager to share with their family members. The materials, children need, however, should be easy to understand, illustrative, and interesting. The experience of the Practical Action, a NGO involved in a disaster mitigation activities in western Nepal, have shown the high effectiveness of developing participatory video for community education and engagement. Studies, based on field visits, also indicate that most of the local people did not know much about the climate change issue, whereas most of the students are aware of it (Poudel, 2009).

Absenteeism of children is high when safe access to schools is disrupted by floods, flash floods, and landslides. Disaster-induced cases include missing exams, drowning, health hazards etc.

High temperature condition, particularly in the Terai, is usually a harsh condition for school children. Most of the schools have steel roof which become intolerable during noon-time in summer (नेपाल, २०६६ ३ २६, नेपाल, २०६६ ३ ३०). Similarly, the conditions are noisy during rain. Warm winter may be favourable during winter, but hotter summer and intense rainfall events are likely to be more unfavourable condition particularly for students in the Terai.

Women need to travel for half an hour to more than an hour in most of the cases to fetch water. The problem has amplified with drying springs. For an example, in addition to the labour contribution by villagers, the Tamakosi Sewa Samiti of Ramechhap had to manage a one and half million rupees project for water supply as the existing supply failed due to drying up of the streams (भट्ट, २०६६ २ २१). In the same issue the newspaper reports that children are more worried by domestic water supply than by

the examination. Women and children need to get up early in the morning to fetch water as the collected water in mountain wells during night time is more productive (बास्तोला, २०६६ २ २१).

Regular attendance of students at schools is essential for children to receive education in an effective manner. Climate change can develop unfavourable conditions for education. For instance, schools were closed for several days in many parts of the country due to the scorching heat during pre-monsoon period of 2009. Most of the schools in the Gorkha district and the Nawalparasi district were closed 10 days before the summer vacation in 2009 (THT, 2009 6 21). Similarly floods, which are likely to intensify in monsoon region due to climatic changes, cause severe hardship for students to attend schools (Adhikari, 2009 7 12). More suspension bridges are required in areas where students have to cross rivers to attend schools.

ADAPTATION

Mitigation of climatic changes is beyond the ability of human beings even with all the mights of available technologies and efforts. We can not stop the extra heat and associated extremes, which are likely to be worse at least over the next 50 years. Adaptation is, hence, the only strategy to become climate change resilient. Efficient use of water and energy; and promoting local resources and indigenous knowledge can be the bases for developing adaptation strategies to climatic changes.

People in Nepal are living happily in almost all the climatic range possible on earth. The people living in the southern plains experience temperature exceeding 48^{o}C in summer. Similarly, people living in the North experience temperature below -10^{o}C in winter. People are adapted to all types of climatic hazards. Notwithstanding, examples in different parts of the world indicate otherwise. For instance, the heat wave in Europe during the first half of August 2003 is blamed for the death of 52,000 lives. The deadliest climate related disaster in western history caused about 15,000 deaths in France alone (Poumadere, Mays, Mer, & Blong, 2005). The event led French Government to spend $6.8 billion over five years.

Following paragraphs lists some of the potential adaptive measure for improving livelihood by minimizing the adverse impacts of climatic changes.

Eco-Home: Eco-homes are the houses constructed in an environment friendly manner for waste disposal, water management and energy management. THT (2009, 6 19) explains a house constructed in Kathmandu in a land of about 127 m^2. The house has capacity to store eight cubic metres of rainwater and a 100 watt solar power system. Promotion of such eco-homes can directly provide an efficient adaption means with additional benefit of pollution control. Eco-homes can be scaled up to develop eco-cities with proper planning and management for which strong support from the government is essential.

Indigenous Technologies and Agriculture: Traditional agriculture in Nepal is primarily based on organic farming. Nepal started importing fertilizers only about 30 years ago. The import and consumption of fertilizers in Nepal has reached almost 50,000 t/year (CBS, 2002) exerting pressure on hard currency at the tune of $50 million. High dependence but poor access to the improved fertilizers has already become an acute problem for the farmers. Furthermore, chemical-based technologies have often been blamed for deteriorating water quality with direct impacts on health. Environment friendly 'Green Technology', which is based on organic farming, is again being promoted by different agencies including UN (Pyakurel, 2009). Several farmers are already involved in Nepal in Green Technology including commercial establishments. The Herbo Industrial Pvt. Ltd. has already started producing and marketing tea adopting such technology (Pyakurel, 2009).

Agricultural practices based on crop rotation and compost manure, without use of chemicals and pesticides, are the tradition of agrarian society in Nepal. Despite the popularity of fertilizers and pesticides during the past three decades, most remote villages in Nepal depend on traditional organic farming. Some areas with easy availability of fertilisers and pesticides have also turned back to organic farming, which has been popularised by hotels and different environment concerned groups. A few examples are the commercial organic farming at Thali, Kavresthali, and experimental Ullen's organic farm at Champi. Maize experimental centre at Rampur has demonstrated (Kantipur TV News on 22 July, 2009) that the farming of Dhaincha for manure could save Rs 2,400 per hectare to Rs 5,100 per hectare required for the fertiliser. The most likely advantages of organic farming is the sustainability, affordability, and the sustained health of people and livestock (Adhikari, 2009 7 7).

Improved Agriculture and Agro-forestry: A simplified calculation carried out by Nepali economists indicate that one percent increase in agriculture yield results in the reduction of the population below poverty line by 17 percent (Pyakuryal, 2009).

Since carbon sequestration, CDM, cash crop, bio-fuel, forest-wood, fodder, pasture etc are highly interlinked with day-to-day human activities, agro-forestry should be considered as a strategy for developing adaptation measures. A community-based agro-forestry in Chitawan supplemented with herbal plants was able to generate impressive economic benefits to the farmers besides increase in forest density (त्रिपाठी, २०६६ ३ १). Similarly, reported cases of earnings related to agro-forestry are as high as Rs 150,000 per hectare in the mountainous district of Dolakha (मानन्धर, २०६६ २ २९). Contour planting of bamboos is found to be an effective means not only for improving ground cover but also for producing briquettes.

Diversification in Agriculture Practices: Ms Devi Thapa of Tikabhairab had the potential of earning about Rs 500 in a year growing maize in the field she had. With the support from NARC, she started cultivating hybrid tomato, which has upgraded her economic status. She has the record of earning Rs 8,000 within a

month by selling the product (खड्का, २०६६ ३ २७). Mr Upendra MuKhiya of Hanumannagar saptari leased a fishpond for two years at the rate of Rs 14,000/year. With some technical support from a NGO, he could earn as much as Rs 100,000/yr (ईको-नेपाल, २०६६). We can find several success stories in media these days which are good exmples that could be adopted as adaptive measures for dealing with the adverse impacts of climatic changes. Government should work together with NGOs to organize demonstration tours and training to the communitiues. Such activities will not only improve the economic conditions of the poor, but can also support the national economy by reducing imports and increasing exports.

Since droughts are the major hazards for agriculture, adaptive measure can be based on the cultivation of drought-tolerant crop. When most of the farmers were reeling under crop failure due to prolonged dry season of 2009, farmers of Gunjnagar in Chitawan were enjoing bumper production with the introduction of drought tolerant crop farming. The farmers were able to double the corn yield from 3t/ha to 7 t/ha; in some cases up to 9 t/ha (बडुवाल, २०६६). Farmers can expect further enhancement of yield in a more favourable rainfall conditions.

High yielding Imported and hybrid seeds, however, are not always problem free. Well managed implementation with appropriate use of fertiliser is an essential aspect of such agriculture practices. In addition, loss of traditional farming practices, indigenous agricultural knowledge and loss of local seeds are the drawbacks of changes in agricultural practices. For instance, NARC scientists report the extinction of 75 percent rice and maize seeds in the Terai, 90 percent wheat seeds in the mountains, and 20 percent maize and rice seeds in the mountains (THT, 2009 7 11).

Preparedness for disasters: One of the successful schemes in Nepal is the Community-Based Disaster Preparedness (CBDP). Several CBDP units are formed in Nepal with some support from the Nepal Red Cross Society and government agencies. Some non-governmental organizations are also contributing in strengthening such organizations in terms of community-based early warning system and flood fighting technologies. After a successful implementation of a flood warning system in western Nepal, Practical Action, a UK-based NGO and the Mercy Corp, a USA-based NGO are enhancing their early warning system in collaboration with DHM. A MoU was signed by these organizations with DHM in the early 2009 to implement pilot projects in the Banke and Bardia districts of Nepal.

Fuel-efficiency: efficiency in use of fuel is the key to most of the adaptive measures. It is equally important in rural areas as well as urban areas. Available studies in Nepal indicate that the change in energy system in rural areas from traditional fuel wood to briquette can have 37 percent more energy efficiency at one-fourth of cost (TGT, 2009 6 17). Besides energy efficiency, energy efficient stoves have significant health benefit particularly to women and children.

Nepal is a geographical region which is one of the most potential regions for wind and solar radiation. In a map of global insolation, Nepal lies close to the high insolation area receiving

about 180 Kcal/cm^2/year (Trewartha & Horn, 1989). The estimates made by Alternate Energy Promotion Center show 4.5 kWh/m^2/day (SEMAN, CADEC, 2003). Similarly, a preliminary estimate, made by Alternate Energy Center in Nepal, indicate the potential of 3,000 MW wind energy in Nepal (Prasain, 2009 1 1). Kathmandu alone has the capacity of 70 MW.

Forest wood is the major source of energy in rural Nepal that meets the requirement of about 86 percent of the population. Replacement of forest wood by renewable energy is the best option for adaptation as well as for mitigation of global warming. AEPC under the ministry of Environment has been working in this direction since the last 15 years. Electrification of villages with alternate energy not only halts denudation of forest but also improves the living standard and saves time for women, and provides conducive environment for wildlife (Niraula, 2009 7 2). It is estimated that the forest of Nepal store about 70,000 tCO_2/Yr (Pokhrel, 2009 9 3).

Water is the major source of energy in Nepal. It is also one of the most sensitive key sector for most of the climate change related issues. Hydropower is the source of clean energy with immense potential to mitigate greenhouse gases (Houghton, 2001). The available hydropower is, however, inadequate to meet demand. Figure 22 shows that we need to double hydropower production capacity to meet the current demand.

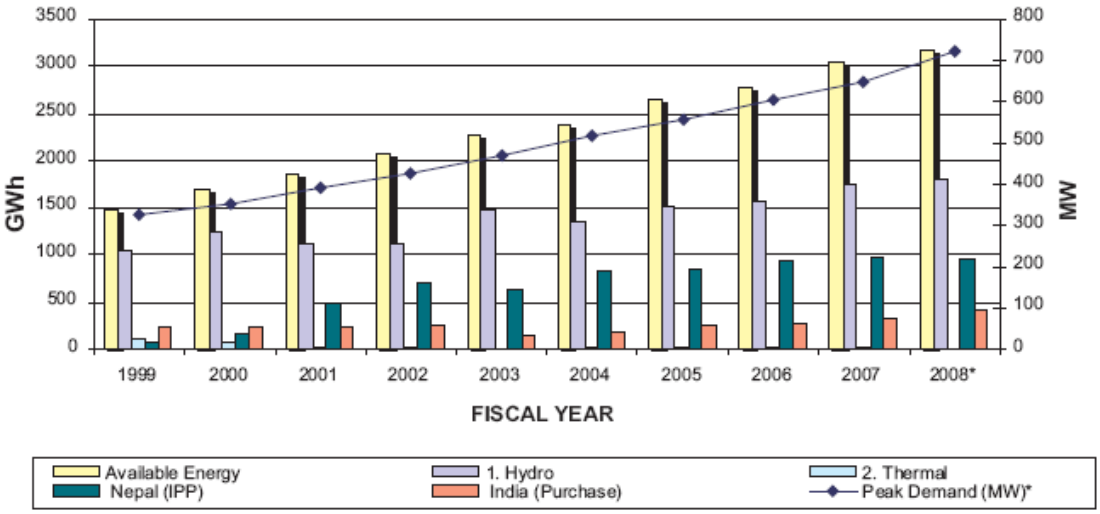

Figure 22. Time series of power status in Nepal. Source: (NEA, 2008)

Electric Vehicles: Gasoline-based vehicle is one of the worst pollutants regarding GHG emission. Nepal observed almost tenfold increase in the number of vehicles from 68,891 in 1990 to 701, 109 in 2008. The consumption of petroleum products is as high as $300 million in a year. Automobiles, being a major source of pollution, have also been considered as an agent of GHGs. Realising the importance of

electric vehicles, particularly for the control of urban pollution in Kathmandu, electric three wheelers were introduced in the late 1990s for public transport. The experiment has been a great success with more than 80 electric vehicles plying on the road of Kathmandu providing reliable service. Some international organizations, such as ICIMOD, GTZ, WFP and foreign embassies such as the American Embassy and the Norwegian Embassy have started using a few eclectic cars for their daily business.

Huge initial investment required for electric car has limited the scope of its use at individual level. The tax imposed for the import of cars for personal use in Nepal is as high as 200%. Government of Nepal can play an important role by reducing the taxes on electric vehicles bringing the price down to the reaches of people. The proactive role of the Electric Vehicle Association of Nepal (EVAN) can be an important step in this direction. Organization of a rally that included 20 Reva cars (electric cars), two electric scooters, and four electric three wheelers on 13 June 2009 in Kathmandu was a notable demonstration of the scope of such vehicles in Nepal. The rally, with participation of EVAN, ICIMOD, GTZ, media, and embassies was a successful event to raise awareness.

Change in Design Criteria: Existing design criteria approved by the government of Nepal can be taken as an example to illustrate the needs to change in the context of climatic changes. The approved design criteria of the Government of Nepal need that the roofs of school buildings are made of steel sheets. As described earlier, such buildings are likely to be unfriendly for children. Government should, hence, change the design criteria to allow concrete roof to improve the intensified unfavourable situation. Such changes in policy may not add additional cost making it economically feasible. Revisits are also required for assessing design criteria used for project developments, such as dam construction, hydropower installations, irrigation schemes, road construction etc to consider the climate change components.

Water Conservation and Rainwater Harvesting: Water needs for public consumption and agriculture can be optimised if managed in an efficient manner. Use of efficient equipment and technologies, recharging groundwater during monsoon, and use of appropriate household techniques for rainwater harvesting are some of the techniques of water management. Based on a simple calculation, it has been reported that 350 million litres of water per day can be collected if only about 10 percent of the households in Kathmandu opt for water harvesting (THT, 2009 6 27).

GAPS

Information gaps and knowledge gaps are some of the major gaps, regarding the assessment of climatic changes and the impacts of such changes. In addition, knowledge regarding mitigative and adaptive measures is limited to implement appropriate technologies. One of the major challenges in this regards is the inability of available climate models to represent the conditions of Nepal. A typical atmospheric model, with a horizontal resolution of $2.5^{o}X3.75^{o}$, is too coarse considering the size of the country. Besides, none of the available model represents the vertical dimension of topography, which is the main characteristic of Nepal. Nepal should collaborate with regional and international centres to fill this gap. DHM has been able to establish contacts with some regional modeling centres including: Hadley Centre, Indian Institute of Meteorology

– Pune, Medium Range Weather Prediction Centre – Delhi, SAARC Meteorological Research Centre (SMRC)– Dhaka, and Asian Disaster Prevention Centre (ADPC)– Bangkok.

Government Nepal has significant gaps in terms of policies regarding climatic changes. Despite the initiation of NAPA and other policy level activities in the late 2008 and 2009, the activities are inadequate to address climate change concerns. Major gaps in development activities are the absence of integrating national development plans addressing climate change realities.

Uncertainties in climate sciences and the complexities of impacts demand high level of research and studies. Operation of a representative data collection system and regular updating of studies can provide guidance in formulating policies and plan to address climate change issues.

POLICY

Climate change was never an issue for the Government of Nepal till the implementation of the Tenth National Development Plan (2002-2007). Three year Interim Plan (2007-2010) of Nepal has first time emphasized on policy formulation and institutional strengthening linking disaster management with climate change. The interim plan talks about the use of technology for robust weather and climatic forecasts and effective implementation of disaster control measures.

Government agencies related to the field of science and technology are found to have concerns regarding climate change all the way from 1980s. The bureaucratic circles, however, have realized the need to address this issue only in the recent past partly because of international hullabaloo.

Need of capacity building was discussed among experts during the preparation of water resources strategy during the late 1990s. Accordingly, the expert group proposed the establishment of the Himalayan Climate Change Study Centre in Nepal, which can be considered as a significant step in this direction to begin with the institutional arrangement. The centre, proposed as part of Water Resources Strategy (WECS, 2002) and proposed to be established by 2007 under Water Plan (WECS, 2005), could not garner enough support from the government. Although the government of Nepal promised to establish the centre during the budget (2008-2009) speech, not even the modalities are approved. The proposed centre, besides coordinating climate change-related action at national and international levels, should develop facilities for climatic and hydrospheric modeling. It should also provide support to DHM for developing drought, floods, flashfloods monitoring with early warning and forecasting capabilities.

Nepal is rich in hydropower and renewable energy. It has the potential of reducing greenhouse gases at regional scale. Development and use of such potential has global significance. Development of hydro-power so far has not been adequate even to meet the national requirements. At least one major reservoir-based hydropower system should be considered so that enough storage is available to address enhanced climatic extremes. Besides addressing the issue of climate change, such measures contribute to disaster mitigation downstream of the project areas.

Based on the experience of electric three- wheelers, it is necessary to promote manufacturing of electric small vehicles suitable for urban commuting. The government may consider replacing old outdated vehicles at government offices by electric vehicles.

Some additional policy matter for further discussion is listed as:

- Government should provide support through financial contributions, tax credits, and market creation of clean technology development, such as electric vehicles and fuel-efficient commodities.
- Government support is required to reestablish Kathmandu-Bhaktapur trolley bus system through private-public-partnership.
- Sustainability should get strong emphasis while selecting development options as sustainable developments have more scope in reducing emissions and vulnerability to climate change.
- Construction of Kathmandu-Terai fast track for lower consumption of fuel and efficient travel and transportation should be the major national agenda.
- Government should set the target of forest area in Nepal and build on the successful stories of community forest.

Nepal is one of the 189 countries committed to the Millennium Development goals (MDG). One of the major goals is the eradication of extreme poverty and hunger by 2015. The challenges, Nepal is facing, are the failure of monsoon resulting in crop failure and poor economic growth. The MDG Needs Assessment report for Nepal 2006 shows that the government must make a public investment of $12.6 billion over the next decade if the goals are to be reached. An assessment made by UNDP indicates that about 50 percent of the UNDP investment in Nepal is at risk (Kjorven, 2008). Government of Nepal expects to achieve MDG except primary education and HIV/AIDS. Although the government is implementing the programs in line with the Medium Term Expenditure Framework (MTEF), climate change concerns are yet to be addressed.

Education, awareness, and civic sense are the keys to most of the problems related to environment. Creating better understanding and raising awareness on climate change should be done at schools and colleges. Environmental education, including climate issues, should be introduced as a mandatory subject at schools. Before implementing such programs, the prerequisites are the development of courses and course materials suitable for each level of education. In addition, trainings of teachers and trainers should be initiated as an early activity.

The year starting 2007 appeared in Nepal with acute shortage of electricity and prolonged load shedding extending to 16 hours a day in winter. It was an opportunity for the power users to change life style to adjust with minimum power consuming system. Although government introduced several programs in this regard, it has been partially successful. For instance, the proposed change of electric bulbs and mercury lamps to CFL technology has not been fully implemented even at government offices. The announced incentives for changing to CFL technology was made available after a delay of about eight months in September 2009. The government should implement this program with political will as it has long-term adverse impact on mitigating climate change impacts.

The existing committees headed by the prime minister and the existing climate networks are likely to be effective only for sensitizing the issues. They are likely to be incapable to bring Nepal into international forefront capable to negotiate due to its extreme complexities. It would be advisable to form a steering committee to implement the proposed Water Plan regarding the monitoring of climate and establishing a centre. The committee should be formed at the earliest with members from the most relevant government and academic institutions. The committee, under the chairmanship of the Secretary, Ministry of Environment may include the members from the climate-related departmental heads, Ministry of Water Resources, National Agriculture Research Centre (NARC), Department of Water Induced Disaster Prevention, Department of Wildlife and National Park, Tribhuvan University, Kathmandu University etc. The Director General, Department of Hydrology and Meteorology may act as the member-secretary of the committee. It should include a member from NGO, for which, Global Water Partnership can be one of the potential choices.

STRATEGIES

Nepal has been participating in almost all the international forums of climate change. The level and strength of participation are important factors for assessing and exploiting available opportunities. Inclusion of well-trained active members in negotiation and participation teams is essential to reap the benefits of international supports. In-house preparation, studies, research activities and discussions among major stakeholders are the keys for effective participations.

Capacity Building: Because of the complexities of climate system and its impacts, research and investigation should be given the highest priority. For the development of the science policy, it is the most important prerequisite. Although Nepal is currently involved in developing policies and strategies related to climate change, they are likely to be politics driven rather than science driven. The major opportunity missed by the Government of Nepal is the implementation of Water Resources Strategy (WECS, 2002) and Water Plan (WECS, 2005) which proposed the establishment of the Himalayan Climate change Research Centre (HCCRC). Such a centre is essential for developing regional modeling capabilities, understanding climatic trends based on secular as well as proxy data, developing skills, developing training materials, increasing awareness among stakeholders etc. Although the centre was proposed to gat established by 2007, it is still not too late.

Data Management and Information Flow: Right information at right time to the right people is the most powerful strategy to adaptive measures. If such information includes reliable forecasts, it provides opportunity to the people to prepare themselves. DHM can play an important role in managing data related to climate and water resources. There is an urgent need to strengthening the department with better instrumentation, efficient organization and effective management. Since a climatic event can not be repeated, responsible organization should not miss the recording of any observation which provides important information for assessing climate or its impacts.

All the countries concerned with climatic changes are considering renewable energy sources to limit greenhouse gas emission. Collection of data on wind, radiation, and streamflows has become more important than before for assessing the potentials and for utilizing renewable energy.

Long-term high quality data is important for monitoring climate change. Since almost a quarter of stations were closed during the observation period in Nepal, significant amount of achievable information are not available. DHM should, hence, needs to put an extra effort to maintain stations with long-term data. Notwithstanding, the increasing trend of the number of stations operated by DHM is encouraging. Out of the huge amount of data collected by DHM, only some data are published and disseminated. Some data are not published because of poor quality, whereas some data with automatic recordings are only partially processed. Since the historical data has become important, DHM should consider data rescue projects. The project can also be incorporated through the proposed HCCRC.

Although studies available from different parts of the world are useful to gain knowledge, the results are not directly applicable in the Nepalese environment. Development of regional models based on global and regional data is essential particularly for developing future

scenarios. Development of such scenarios can help to develop policies and strategies for mitigating the impacts of climate change.

Establishment of a system to obtain remotely sensed data can be useful in delineating snow-cover area on regular basis, which is useful in assessing changes in snowline, glacier area, and glacial lakes. Since soil moisture information is important in agriculture, satellite images can be used for obtaining such information.

Effective Weather and Climate Information: Observation networks at national, regional and global levels, satellite-based information, upper air observations, broadcasts on media, and availability of real-time data transmission systems have not been satisfactorily utilized in Nepal. Inadequate capacity of the government authorities to deliver reliable weather forecast and climatic projections is a major stumbling block in this regard. In addition, inadequate awareness of farmers and lack of credibility of weather forecasting system in Nepal have contributed towards the lack of effectiveness of such important tools. Government should give high priority to upgrade the effectiveness of weather and climate information system.

Integrated Management: Strategy development considering river basin as a unit can be effective for addressing climate change-related impacts in Nepal. Such a strategy based on river basin can be useful not only to assess the related processes in an integrated approach but also in developing a basin for optimal use of water resources with optimum agricultural production. A basin provides an opportunity to study water in its complete hydrological cycle, which is also useful in integrated hazard management. The Karnali basin, The Rapti basin, the Narayani basin, the Bagmati basin and the Kosi basin are the five major basins that can be considered as major units for integrated land, water and disaster management purpose alongside the assessment of climatic changes.

Community-Based Program: Nepal Red Cross Society has been able to develop several community-based organizations in Nepal for dealing with natural disasters. The organizations, known as Community Based Disaster Prevention (CBDP) units, are successful in managing water-induced disasters. Since, climate change is directly linked with the increasing disasters; the members of the units can further be trained and involved in climate-related awareness and mitigation programs. Since the units are parts of the district-level disaster preparedness network, and since it provides membership to each household, it has the strength to deal with climate change aspects as well with some additional support.

Insurance schemes: Insurance of properties against disasters and crop insurance can be a viable option to face with climate-induced disaster-like situation.

Regional Cooperation: Based on the Maldova Conference 2008, the MeteoWorld, a WMO news bulletin reports that the total investment required for strengthening the National Meteorological and Hydrological Services of seven countries in south-eastern Europe could be reduced by one third through regional cooperation. Nepal, as a member state, can take advantage of the regional centres, such as SMRC and SDMC where some modeling and research facilities are already in place. Nepal may further explore joint collaboration with other specialized centres, such as India meteorological Department (IMD), India; Indian Tropical Meteorological Centre (ITMC), India; Institute of Water Modeling (IWM), Bangladesh; Centre for Environment and Geographical Information Services (CEGIS), Bangladesh; Global Change Impact Studies Centre (GCISC), Pakistan; Asian Disaster Prevention Centre (ADPC), Thailand; International Centre for Hazard and Risk Management (ICHARM), Japan etc. Nepal has already gained experience working with some of these institutes for joint programs and projects.

Effective Implementation of Convention and Relevant Strategies: A team should be developed and trained to prepare necessary reports and implement international commitments in time. As most of the climate related problems are linked with disaster management, effective implementation of the Disaster Management Strategy can be instrumental in solving several climate related problems.

Promotion of Scientific Research and Investigations: Brain drain, particularly in scientific fields, has been a burning issue in Nepal. The prevalent political and bureaucratic interferences in terms of favouritism and nepotism provide poor environment for productive human resources in Nepal. On the other hand, developed countries with effective organizations provide scope and opportunities for talents. For example, more than 60 percent of the available hydrologists at DHM, some of whom were trained in climate change issues, migrated during the past five years. None of the vacancies, created by them are filled yet. Similarly, about 60 agro-scientists working for NARC migrated for better opportunities abroad and 24 agro-scientists tendered their resignation (Basnet, 2009 7 8).

CONCLUSIONS

As any part in the world, climatic data were collected in Nepal primarily for assessing climatology of a location or a region. People hardly realized its scientific importance for assessing several ecological and resource management aspects. Fortunately, Nepal was able to setup a climate and water resources monitoring system, which is able to provide valuable information at least in a part of the time domain that covers the period of strong global warming signals.

Almost all the climate change related mitigation and adaptation measures have extra benefits, such as disaster mitigation, pollution control, improvement in health sectors, implementation of sound technologies, and enhancement in research activities.

Since climate is a global-scale phenomenon, international cooperation is essential. In this regard, participation of Nepal in scientific and negotiation forums is an inseparable part of the global efforts. Nepal has taken part in most of the international and regional activities. Although the participation has helped Nepal to upgrade its capabilities, it is severely lacking in institutional aspects. Upgrading existing institutions for surveys, investigations, and research is essential for enhancement of the capability of Nepal to deal not only with the adverse impacts of climate change but also to increase the effectiveness in international negotiations. Research on agriculture is particularly important to address the problems related to livelihood. Recognition of the role of women and small farmers is important as they can play important role in improving the situation in rural areas of Nepal

Community forestry program is one of the most successful stories in Nepal. It has special role in the mitigation aspects of climatic change as well. The principle of community-based participatory approach for dealing with forest can be extended to manage flood and drought hazard in the context of changing climate. Some community-based Disaster Preparedness (CBDP) units are already in place with support from government and non-government organizations.

Uncertainties and complexities of meteorological processes are the major challenges to reach to any conclusion regarding the changes in climate and its impacts. Global warming and climate change is frequently blamed for any unusual atmospheric and earth system processes, which in several cases may not be true. Identification and quantification of the role of climate needs high level of expertise and credible information.

Since elevated temperature and the dwindling water sources are the major issues, enhancement of technical capabilities is urgently needed to develop appropriate farming practices and efficient management of water resources. New varieties of seeds must be explored not only for the observed changes but also for the potential changes in climatic pattern. More diversity in agriculture practices may be required to avoid disasters which may result with the failure of a single variety. Because of increasing pressure on water resources, more research and planning are required for the integrated management of water resources. For significant achievement, Nepal should set priorities and accept the challenges. The priorities may include:

- Strengthening DHM for monitoring climate with high quality data.
- Establishing a network of well equipped bench-mark stations should be considered as an urgent task.

- Establish an institute to deal with climate change issues and to coordinate with national and international stakeholders.
- Develop up-to-date inventory of GHG emission
- Update information on climate and climate-related trends
- Develop regional climate modeling facilities
- Disseminate information on climate change through internet, digital media, and hardcopy
- Develop and maintain documentation and library of relevant publications
- Organize nationwide training and discussion programs
- Organize workshop and seminars on regional issues with regional and international participation
- Develop and implement pilot projects including stakeholders
- Provide secretarial service to the proposed Committee on Climate Change

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