DRAFT: for consultation only

Government of Nepal

Ministry of Environment

National Adaptation Programme of Action (NAPA)

Thematic Working Group Summary Report

Kathmandu, Nepal

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Introduction and overview

ACRONYMS

ADB	:	Asian Development Bank
DFID	:	Department for Foreign and International Development
DNIDA	:	Danish International Development Agency
DWIDP	:	Department of Water Induced Disaster Prevention
DPNet	:	Disaster Preparedness Network, Nepal
DDC	:	District Development Committee
EDC	:	Equality Development Center
GEF	:	Global Environment Facilities
GCM	:	General Circulation Model (GCM)
ICIMOD:		International Center for Integrated Mountain Development
IPCC	:	Intergovernmental Panel for Climate Change
IIED	:	International Institute for Environment and Development
ISET	:	Institute for Social and Environmental Transition
MOAC	:	Ministry of Agriculture and Cooperatives
MOHA	:	Ministry of Home Affairs
MOE	:	Ministry of Environment
NAPA	:	National Adaptation Programme of Action
LEG	:	Least Developed Countries Expert Group (LEG
LDC	:	Least Developed Countries (LDCs)
PEB	:	Project Executive Board (PEB);
PAC	:	Practical Action Consulting (PAC)
RCM	:	Regional Circulation Model
TWG	:	Thematic Working Group
UNFCCC:		United Nations Framework Convention for Climate Change
UNCCD	:	United Nations Convention to Combat Desertification
UNCBD	:	United Nations Convention on Biodiversity
VDC		Village Development Committee

Introduction and overview

Nepal, being a Least Developed Country, is highly vulnerable to the adverse impacts of climate change. Rises in temperature and the associated changes to rainfall patterns (such as less frequent but more intense rainfall events) are likely to result in increasing frequency and intensity of floods, intermittent and/or longer dry spells and drought events, increasing storms, and a growing threat from Glacial Lake Outburst Floods (GLOF). These climate-induced events are not only causing damage and loss of human lives and property; they also increase uncertainty and undermine the development process in Nepal.

Nepal is therefore undertaking the development of its National Adaptation Programme of Action (NAPA), which is a requirement under the United Nations Convention on Climate Change for all Least Developed Countries (LDCs) party to the Convention. NAPAs provide a process for the LDCs to identify, communicate and respond to their most "urgent and immediate" adaptation needs, and prioritize those needs. The priority activities identified through the NAPA process will be made available to the entity that will operate the LDC fund, and also other sources of funding, for the provision of financial resources to implement these activities (LEG, 2002). All NAPAs are developed in accordance with guidelines produced by the Least Developed Countries Expert Group (LEG) under the UNFCCC, however these guidelines are deliberately flexible to ensure a country-driven approach to NAPA development is taken.

To date, 43 LDCs have already submitted NAPAs. This puts Nepal in an advantageous position of being able to learn from the experiences of others. As such, the approach to NAPA in Nepal draws significantly from the best practices and cautionary lessons of other LDCs, including[i]:

- The need to ensure a country driven approach
- The need for NAPA to be strategically aligned with other national climate change and development processes to ensure effective mainstreaming and rapid follow-up to implementation of adaptation projects
- The need to ensure the effective participation of vulnerable groups with the most urgent and immediate adaptation needs
- The need for a comprehensive assessment of vulnerability and adaptation measures that integrates technical data on the impacts of climate variability and climate change; with local and indigenous information related to vulnerability and coping with existing climatic stresses.

In response to these lessons, the Government of Nepal has mobilized significant co-financing to undertake an "Expanded NAPA" process, using the NAPA as the basis of a sustainable framework for national climate change action, which can result in swift and well-coordinated follow-up to the NAPA priorities identified. The overall structure of the NAPA has three components:

Component 1: Preparation and dissemination of a NAPA document
Component 2: Development and maintenance of a Climate Change Knowledge Management and Learning Platform for Nepal; and
Component 3: Development of a multi-stakeholder Framework of Action for Climate Change in Nepal.

Further, the NAPA in Nepal has adopted an innovative approach to multi-stakeholder engagement and vulnerability analysis, moving beyond the regional and national consultation meeting approach adopted under other NAPAs, towards a framework that generates and incorporates meaningful inputs from a wide range of stakeholders including vulnerable communities themselves. First, NAPA is being

developed through six semi-autonomous Governments led multi-stakeholder Thematic Working Groups. Second, these multi-stakeholder groups are leading a two-phase participatory vulnerability assessment.

These approaches are detailed in this TWG summary Report, which is intended as a stocktaking and summary document to communicate on the NAPA preparation process in Nepal to interested national and international stakeholders. The report describes the country context and climate change implications for Nepal; the approach to NAPA development; the progress and achievements during the first phase of work during 2009; and the forward plan towards finalization and follow-up of NAPA in 2010. This document has been prepared by the NAPA project team together with the six NAPA Thematic Working Groups. The team would also like to acknowledge the support of a DFID funded consortium of consultants[1] who provided feedback and inputs. This report is a "living" document designed as an interim report to inform and update interested stakeholders, and prepare the NAPA project for the next phase of work. This report is not a formal NAPA document. Further information on the details of the NAPA process in Nepal can be found at www.napanepal.gov.np or contact info@napanepal.gov.np.

[1] This consortium is comprised of consultants drawn from the International Institute for Environment and Development (IIED); the Institute for Social and Environmental Transition (ISET); and Practical Action Consulting (PAC).

1. Context and background for the National Adaptation Programme of Action in Nepal

1.1 Country background

Physiographic characteristics

Nepal is a land-locked, predominantly mountainous country situated in the central part of the Himalayas located in between $26^0$22' and $30^0$27' N latitudes and $80^0$40' and $88^0$12' E longitudes. The total area of the country is 147,181 km^2 and is divided into 5 Physiographic Regions (LRMP, 1986): High Himal, High Mountain, Middle Mountain, Siwalik (the Churia Range), and the Terai (see figure 1).

Nepal has more than 6,000 rivers, with all river systems draining north to south towards the Ganges. The four Major River systems from west to east are the Mahakali, Karnali, Narayani (Gandaki), and Saptakosi. Each of the Physiographic Regions has a distinct altitude and climatic characteristics which discern the regions from each other, which vary from Tropical/Sub-tropical at the elevation of 67 meters above sea level, to Alpine conditions at 8,848m at the world's highest peak of Mt. Everest, all within a span of less than 200km. Table 1 shows the characteristics in different ecological belts of Nepal.

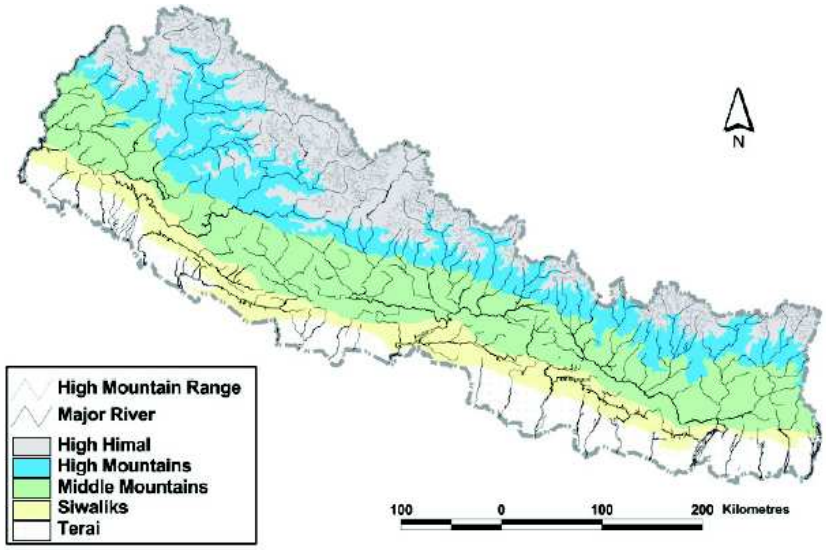


Figure 1: Physiographic characteristics of Nepal. Source: LRMP,1986

Table 1: Climate characteristics in different ecological belts of Nepal

Physiographic zone	**Ecological belt**	**Climate**	**Average Annual Precipitation**	**Mean Annual Precipitation**
High Himal	*Mountain*	Arctic/Alpine	Snow/150mm-200mm	<3°C - 10°C
High Mountain				
Middle Mountain	*Hill*	Cool/warm	275mm-2300mm	10°C - 20°C
Siwalik	*Terai*	Tropical/Sub-tropical	1100mm – 3000mm	20°C - 25°C
Terai				

Source: WECS, 2005

Climate characteristics

Nepal's climate is affected by two major features: the Himalaya mountain range, and the South Asian monsoon (NCVST, 2009). Based on the temporal variation in the weather system (monsoon and westerly disturbance) the country's weather falls into four distinct seasons per year: pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November) and winter (December-February). The average rainfall of Nepal is 1857.6 mm per year (Practical Action, 2009), but with sharp spatial and temporal variations both north-south and east-west. The monsoon rain is most abundant in the east and declines westwards; while winter rains are higher in the northwest and decline south-eastwards (Practical Action, 2009). Rainfall maximums are located in the areas around Pokhara and northeast and east of the Kathmandu valley (Practical Action, 2009). The temperature in Nepal varies with altitude and season: in general, the temperature decreases from north to south with decreasing altitude. The winter season is coldest, with the highest temperatures during pre-monsoon.

Socio-economic characteristics

The population of Nepal in 2008 was estimated at 27.03 million (CBS, 2008). Population density is lowest in the High Himal and the Siwalik Physiographic Region. About 85% of the population of Nepal resides in rural areas. Nepal is one of the poorest countries in the world, ranked 142 among a total of 147 poorest countries in the World by the recent Human Development Report (HDR 2007/08). Nepal's GDP is US$5.5 billion; an annual average growth rate of 4.9% and per capita income is US$250, which is among the lowest in the world (Regmi and Adhikari, 2007.) The agriculture sector employs 82% of the labour force (World Bank, 2002), however agriculture is primarily a subsistence activity and contributes only 38 percent to GDP, compared to industry at 23 percent, and services at 39 percent (NAPA Case Study, 2003). Tourism also contributes significantly to Nepal's income, with receipts in 2000 amounting to 15 percent of exports. Some have suggested that a heavy reliance on ecosystem-based tourism and agriculture makes Nepal's economy very sensitive to climate variability (Regmi and Adhikari, 2007).

1.2 Climate change scenarios in Nepal

The NAPA guidelines suggest that preparation of NAPA should include an assessment of vulnerability to current climate variability and extreme events; and also assess where climate change may cause increased risk. In many other LDCs, climate change information has not been available at the time of NAPA preparation so has not been incorporated into NAPA assessments. In Nepal, however, new climate change scenarios were generated in September 2009, in time for the results to be incorporated into NAPA development. The scenarios are based on available General Circulation Model (GCM) and Regional Circulation Model (RCM) data (NCVST, 2009). The data is summarized in tables presented in Annex 1 and key findings are described below:

The projected impacts of climate change on Nepal from the GCMs include:

Temperature:

- Mean annual temperature across Nepal is projected to increase by:
  - 0.5 – 2.0°C, with a multi-model mean of 1.4°C, by the 2030s
  - 1.7 - 4.1°C, with a multi-model mean of 2.8°C, by the 2060s

    - 3.0 - 6.3°C, with a multi-model mean of 4.7°C, by the 2090s.
- Increases in temperature are lower in the monsoon and post-monsoon season than in winter and pre-monsoon, by up to 1.6°C by the 2090s, partly due to projected increases in monsoon rainfall and cloudiness which will reduce incoming solar radiation and enhance cooling through evaporation.
- Projected temperature increases are lower in Eastern Nepal than Western and Central Nepal. This difference is projected to be 0.7°C by the 2090s.
- The frequency of "hot days"[ii] in the pre-monsoon period are projected to increase by 15-55% by the 2060s; and 26-69% by the 2090s.
- The frequency of "hot nights"[iii] are projected to increase most in the monsoon period 6-77% by the 2060s; and 29-93% by the 2090s.

Precipitation

- Mean annual precipitation is projected to both increase and decrease, with no clear trend:
    - -34 - +22% with a multi-model mean of +0% by the 2030s
    - -36 - +67% with a multi-model mean of +4% by the 2060s
    - -43 - +80% with a multi-model mean of +8% by the 2090s
- Monsoon rainfall projections vary widely but more models suggest an increase than a decrease by the end of the century:
    - -40 - +143% with a multi-model mean of +2% by the 2030s
    - -40 - +143% with a multi-model mean of +7% by the 2060s
    - -52 - +135% with a multi-model mean of +16%by the 2090s
- Monsoon rainfall in Eastern and Central Nepal is projected to increase more than Western Nepal. In Western Nepal the model mean increase by the 2090s is only +6%
- Winter precipitation projects show a tendency for a decrease but with several models projecting an increase. The multimodal mean projection is -14%
- Heavy rainfall is expected to increase slightly in the monsoon and post monsoon seasons; and decrease slightly in the winter and pre-monsoon seasons.

Overall, these climate change scenarios support existing information on climate change in Nepal which suggests that the key impacts are likely to include[iv]:

- Significant warming, particularly at higher elevations, leading to reductions in snow and ice coverage;
- Increased climatic variability and frequency of extreme events, including floods and droughts;
- An overall increase in regional precipitation during the wet season but a decrease in precipitation in the mid hills.

The low development status of Nepal renders its population very vulnerable to these current and future impacts of climate change. Developing a national strategy to adapt to these impacts is therefore an urgent priority.

2. The NAPA preparation process in Nepal

2.1 Project implementation modality

The LEG Guidelines for NAPA preparation require that a NAPA Team is set up to guide the NAPA development process. An organizational chart of the structure of the NAPA implementation modality is shown in figure 2. The NAPA Project organizational structure consists of: (i) Advisory Board (AB); (ii) Project Executive Board (PEB); (iii) Technical Advisory Committee (TAC); and (iv) Project Team. In order to provide guidance and ensure coordination, the constitution of the Advisory Board has representation from the concerned government organizations, donor community, academia, civil society/NGO, private sector, local bodies and IPCC focal point under the chairmanship of the Secretary of MOE (see annex xx). The Project team consists of Project Executive, Project Manager, consultants, Programme Officer, and Technical Officer, supported by administrative and finance staff.

The NAPA guidelines suggest that a multi-disciplinary team is established under the guidance of the NAPA Team, to undertake many of the tasks required in the development of the NAPA. The guidelines also suggest that NAPA preparation is a country-driven participatory process undertaken with consultation with a wide range of stakeholders. During the NAPA Induction Workshop in May 2009, it was decided that these requirements could be fulfilled by developing the NAPA through Government-led multi-stakeholder Thematic Working Groups (TWGs) to ensure the engagement and ownership of a wide range of stakeholders and key government line ministries from the very beginning. Six TWGs have since been established, each led by a different line ministry (see figure 2):

1. Agriculture and Food Security (Chair: Ministry of Agriculture)
2. Forests and Biodiversity (Chair: Ministry of Forests and Soil Conservation)
3. Water and Energy (Chair: Ministry of Energy)
4. Climate Induced Disasters (Chair: Ministry of Home Affairs)
5. Public Health (Chair: Ministry of Public Health)
6. Human Settlements and infrastructure (Chair: Department of Urban Development and Building Construction)

The TWGs are open-ended in nature and are expected to continue work during the implementation of the adaptation projects and activities after the preparation of the NAPA document. The immediate responsibility of the TWGs is to undertake information gathering (through the review of secondary sources as well as fieldwork and consultation exercises), synthesis, analysis and prioritization of adaptation options, related to specific themes; and the development of thematic reports. Thematic reports will both inform NAPA and also form baseline information documents for other adaptation planning processes under that theme. Over the long-term TWGs are expected to form part of the institutional framework for mainstreaming climate adaptation into development initiatives in Nepal.

Each TWG consists of 10-15 members from relevant Government agencies; NGOs and INGOs; special interest groups; research and academia; and private sector. The TWGs are supported by a wider "reference groups" of interested persons and organizations who can register their interest in specific working groups, be kept up to date on TWG progress, and engage in thematic consultations on TWG outputs. Each TWG has a facilitator who is responsible for assisting the theme coordinator for managing the team and achieving timely team deliverables. The composition of NAPA TWGs can be found in Annex

2. TWGs will be complemented by the work of cross-cutting theme leaders on gender & social inclusion, local governance, and the private sector.

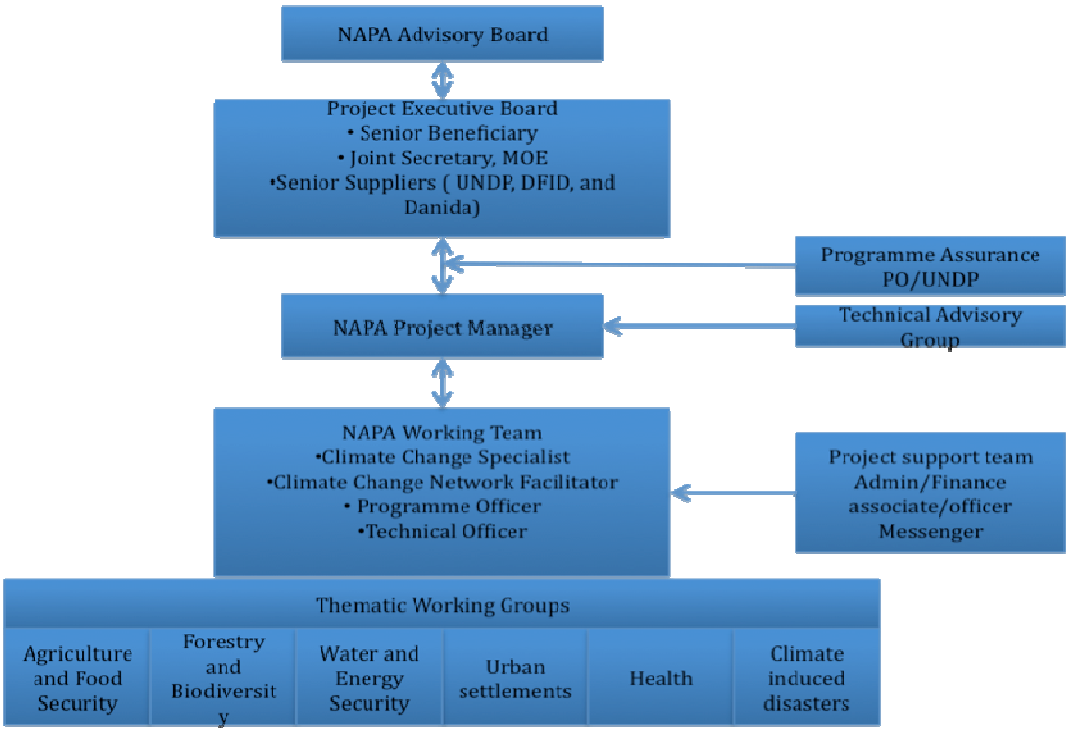


Figure 2: The organizational structure of the NAPA

2.2 The approach of NAPA in Nepal: An "Expanded NAPA"

Lessons from other NAPAs that have begun to emerge have demonstrated the need to consider how the NAPA process can be used more strategically, rather than being developed in isolation of wider climate change processes and investments. At the same time, the Government of Nepal is facing the challenge of managing a number of concurrent initiatives on climate change.[v] The Government of Nepal is therefore undertaking to implement an 'expanded NAPA' process in Nepal, to ensure the NAPA forms the basis of a sustainable framework for national climate change action. This wider programme of work is supported by co-financing from DFID and Danida. The overall structure of the NAPA has three components:

Component 1: Preparation and dissemination of a NAPA document
Component 2: Development and maintenance of a Climate Change Knowledge Management and Learning Platform for Nepal; and
Component 3: Development of a multi-stakeholder Framework of Action for Climate Change in Nepal.

Component 1, the development of the NAPA document, will provide the basis for the development of a multi-stakeholder framework for NAPA implementation that is backed-up by dedicated knowledge management and learning support. In turn, the mobilization of multi-stakeholder support through components 2 and 3 will help ensure swift and well-coordinated implementation of the adaptation priorities identified in component 1. This provision puts the Government of Nepal in a strong position to not only submit a NAPA document at the end of the project duration but also have the institutional capacities in place to implement the priority adaptation actions in the NAPA and to address the adaptation needs of Nepal.

The total fund for NAPA project is 1.325 million US$. It is funded from the GEF operated LDC Fund (US$ 200,000) and UNDP (US$ 50,000) to implement, in particular its Component 1 (NAPA preparation). Implementation of Components 2 and 3 are funded by DFID (US$ 875,000) and the Embassy of Denmark, Kathmandu (US$ 200,000).

2.2.1 Component 1: Preparing NAPA

Component 1, the development of the NAPA document, will follow the NAPA preparation guidelines developed by the LDC Expert Group, whilst also building on the lessons and best practices from other NAPAs. The NAPA guidelines include the followings steps (LEG, 2002):

i. Synthesize available information on the adverse effects of climate change and coping strategies
ii. Conduct a participatory vulnerability assessment of vulnerability to current variability and extreme events and of areas where risks would increase because of climate change
iii. Identify key adaptation measures
iv. Identify and prioritize country-driven criteria for selecting priority activities
v. Select a prioritized short list of activities and projects to address urgent and immediate adaptation needs

The approach taken in Nepal to these steps will be described in turn.

Information synthesis

In Nepal, the information synthesis stage of NAPA preparation is taking place through a stocktaking exercise undertaken by each Thematic Working Group. This includes the collation, synthesis and analysis of information under each theme, on country situation; the adverse affects of climate change and variability; existing strategies at the community and policy level that have the potential to address climate induced vulnerability; and the institutional frameworks within which these strategies operate and with which NAPA should engage. While the NAPA guidelines do not specificy institutional analysis as a necessary step, this is being considered in Nepal's NAPA to ensure that the adaptation options prioritized are realistic, appropriate, and can be swiftly implemented in the NAPA follow-up programme of work under components 2 and 3.

A more general stocktaking is also being prepared which includes information collected under the other framework conventions such as UNCCD, and UNCBD, with a focus on identified programmes and their potential in addressing climate induced vulnerability; information in the PRSP, with a focus on

disaggregated poverty assessment; information on trade commitments, with a focus on economic diversification potential; and so on.

Drawing on best practices from other countries, the existing information already collated through the National Capacity Self Assessment studies, National Communications, and other international communication documents are being reviewed and updated to avoid duplication of efforts. Grey literature and literature documenting "indigenous knowledge" have also been incorporated into the review process, recognizing that information from the grass roots is an important contribution to the NAPA document. At the same time, the recently generated climate change scenarios have been incorporated as an important part of the available data on likely future climate change impacts.

Learning from the lessons in other countries which have shown that much of the data collected for NAPA preparation is subsequently lost (COWI and IIED, 2009), the stocktaking exercises undertaken by each TWG will form part of their TWG reports that will be published as background documents to the NAPA.

Impact and vulnerability analysis

The NAPA preparation guidelines on vulnerability analysis give prominence to participatory approaches and community-level inputs as an important source of information to inform national and international adaptation policy. At the same time, the guidelines also state that information is required regarding observed and projected climate change and the associated actual and potential adverse effects of climate change.

In Nepal, a "shared learning dialogue" (SLD) [vi] approach has been adopted to meet these requirements, and to achieve the challenging task of integrating of people's perceptions related to changing climate with the scientific evidence. The SLD process in this NAPA is characterized by two components: 1) Climate change information and 2) Ground truthing. The literature reviews, international and national consultations and TWG meetings, and assessments of the climate change scenarios undertaken under the information synthesis phase of NAPA are the basic components of the climate change information. The ground-truthing comprises of vulnerability assessments undertaken through several stages:

First, broad issues for vulnerability and adaptation in Nepal have been identified through multi-stakeholder consultation workshops. These include the NAPA Inception Workshop in May 2009, attended by over 200 participants across Government, civil society, academia and the private sector; and the Thematic Working Group Induction Workshop, conducted in October 2009, attended by over 80 different organizations who are actively involved in TWGs, during which some key climate change impacts and coping strategies were discussed under each theme. Several consultations have also been held with special interest groups inside the Kathmandu valley. These include youth groups; foresters groups; indigenous women's groups; and disaster risk networks. Over 250 people have been engaged in these consultations. The outcomes of these consultations have informed the design of NAPA as well as raised key issues around impacts and vulnerability that have been taken into consideration as NAPA outputs are generated. Regional level consultations are also being undertaken to ensure inputs from vulnerable regions beyond Kathmandu Valley. One regional consultation has been undertaken to date, in Lahan, for which there were over 100 participants from 7 districts representing the Churia and Terai

region of Mid-region and eastern region. The outputs from all consultations are continuing to inform the NAPA preparation process.

The vulnerability assessments under many other NAPA preparation processes have been limited to the types of national and regional consultations conducted above. However, the limitations of these methods for engaging local stakeholders, and the need for adaptation options identified under NAPA to respond to context-specific vulnerabilities at the grass-roots level and build on local coping strategies, has been recognized by the NAPA project in Nepal. The NAPA in Nepal has therefore decided to undertake additional activities under the vulnerability assessment phase of the NAPA:

i. Macro-level Assessment through Transect Appraisal Exercises

In November 2009, NAPA TWGs undertook Transect Appraisal Exercises in the Western, Central and Eastern regions of Nepal.[vii] The purpose of these exercises was to obtain an *overview of perceptions* from the grassroots related to climatic changes; impacts; and existing coping strategies for climate-related hazards; and to consider how the NAPA could support realistic adaptation options on the ground. Adopting an ecosystem-based approach, TWGs travelled from north to south across the major river basin regions of Nepal, covering the High Mountains, Mid-Hills, and Terai, in the Far Western, Central, and Eastern regions of Nepal. Within each ecosystem, an attempt was made to look at the impacts of climate-related hazards such as floods and landslides; and changes in climatic trends trends including changes in temperature and precipitation. Marco-level impacts on different sectors and livelihoods were looked at, and an attempt was made to assess coping capacity within different livelihood groups and review coping and adaptation options. Using a SLD framework, the methods adopted across the transects varied, but included observations; focus group discussions; structured and unstructured interviews with individuals and local institutions; and district level workshops.

Teams were mixed to encourage cross-theme learning, and to highlight the cross-sectoral nature of climate change vulnerability experienced on the ground. Over 60 Government and non-government TWG members participated in the transect exercises, and have since undertaken analysis on the outputs of the transects according to both agro-ecological zone and also thematic area. The outputs of this analysis will be incorporated into TWG reports, and is summarized in section 3 of this summary Report below. Reports on each of the transect appraisal exercises are available at www.napanepal.gov.np

ii. Vulnerability assessments

In January 2009, detailed vulnerability assessments will be undertaken in selected localities, again using an SLD approach. This phase will involve: a disaggregated *vulnerability assessment* to identify vulnerable livelihoods and groups; a *root cause analysis*, to understand the role of climate change impacts on the identified vulnerabilities; and *coping capacity assessment* looking in detail at coping strategies, and how these could be supported, and who would benefit from this support. In addition, a local-level institutional assessment will be carried out for existing coping strategies. While this last stage is beyond the requirements of NAPA, this will help to inform more strategic decision making around the delivery of adaptation options identified by NAPA, which will speed up NAPA follow-up and implementation under the "expanded NAPA" process. The outputs of the vulnerability assessment not required for NAPA will be incorporated into the TWG reports.

Identify and prioritize key adaptation measures; develop a short-list of activities

The vulnerability assessments will give rise to a "long-list" of adaptation options. This list will be evaluated and particular options will be incorporated into the relevant TWG reports, to inform future adaptation planning and implementation under each theme. TWG reports will be circulated, reviewed and revised according to inputs from all TWG members and wider reference groups in March 2009.

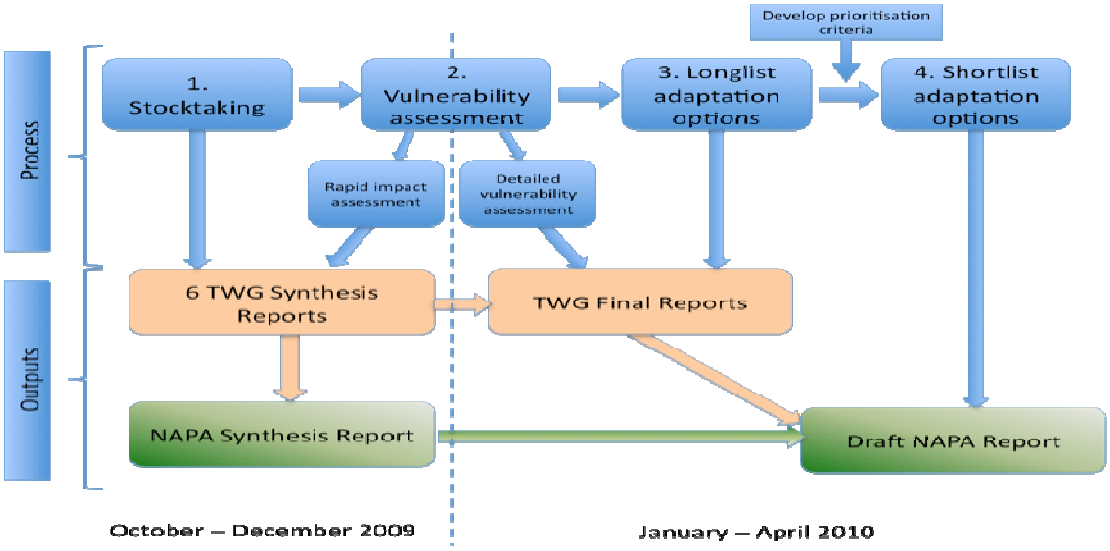
Prioritization of adaptation options for inclusion into the final NAPA document will take place following a multi-stakeholder workshop of all TWGs. Reviews of other NAPAs[viii] have shown that this stage is often rushed, and multi-criteria analysis is used because of a lack of resources and capacity on other criteria. In Nepal, the workshop will therefore include training for TWGs on a range of prioritization criteria options including multi-criteria analysis and cost-benefit analysis. The TWGs will then have the responsibility of selecting and applying the prioritization criteria available to them, to ensure a country-driven approach. Short-listed adaptation options will be incorporated into the NAPA document to be drafted April 2010.

To ensure a truly consultative process, the draft NAPA will undergo several rounds of consultation, though national workshops for different stakeholder groups; regional workshops; and feedback forums facilitated by component 2 of the NAPA process, the Climate Change Knowledge Management Platform. Feedback for the consultation process will be taken into account and the final NAPA document will be submitted in August 2010. During this phase, "NAPA follow-up" will begin, which will involve the development of project proposals under NAPA for a range of funding sources, facilitated though Component 3 of the NAPA, the Multi-stakeholder Framework for Action on Climate Change in Nepal.

The key milestones in the preparation of the NAPA document are therefore:

1. Synthesis of available information: Working draft stocktaking reports under each TWG November 2009 (completed); general synthesis (ongoing).
2. Vulnerability assessment
    a. Phase 1: Marco-level impact assessment: November 2009 (completed)
    b. Phase 2: Detailed vulnerability assessment: Planned January-February 2010
3. Interim reporting on progress and outputs to date (NAPA synthesis report; TWG synthesis reports): December 2009 (completed drafts)
4. Identifying "long-list" adaptation options: February 2010
5. Completion of TWG final reports: March 2010
6. Prioritization of "shortlist" adaptation options: April 2010
7. Completion of draft NAPA document for consultation and review: April/May 2010
8. Final NAPA document following dissemination and consultations on draft: August 2010
9. NAPA follow-up: August-December 2010.

A schematic of the NAPA Preparation process in Nepal up to the development of the draft NAPA is shown in figure 3.



2.4 Component 2: The Climate Change Knowledge Management Platform

Recognizing the need to maximize the value of the NAPA *process* as well as NAPA outcome, the knowledge management platform aims to ensure that the information gathered and lessons learned during the NAPA process are captured, codified, and made available for related processes and future planning exercises. It will also support the implementation of actions identified under the NAPA by facilitating stakeholder access to climate-related data and information.

The platform will have the following components:

1) *A web-based portal on climate and development* that will serve as a repository of carefully selected information on climate science, impacts, mitigation, and adaptation. The portal aims to enhance evidence-based policy making and adaptation planning and guide the design of climate change actions, programmes and projects by connecting: (i) policy and NGO communities with the latest developments in the research communities and (ii) various research communities.

2) *A moderated mailing list on climate and development topics* will provide a channel through which information on NAPA developments, climate change-related activities, and climate resources will be exchanged and disseminated.

3) Publicly-accessible c*limate change information centers* will be also set up. The centers will house books, publications, journals, and other materials on climate change. These centers will be networked and as necessary, the lists of their collections will be made accessible and searchable online through the Climate and Development Portal.

4) *Regular updates on NAPA developments* are being released by NAPA project team to keep the stakeholders sufficiently informed about the process.

A 'soft launch' of the Platform is planned for April 2010 to coincide with the first draft NAPA document, to showcase the operational sections of the platform and discuss those under development.

2.5 Component 3: A Multi-stakeholder Framework for Action on Climate Change

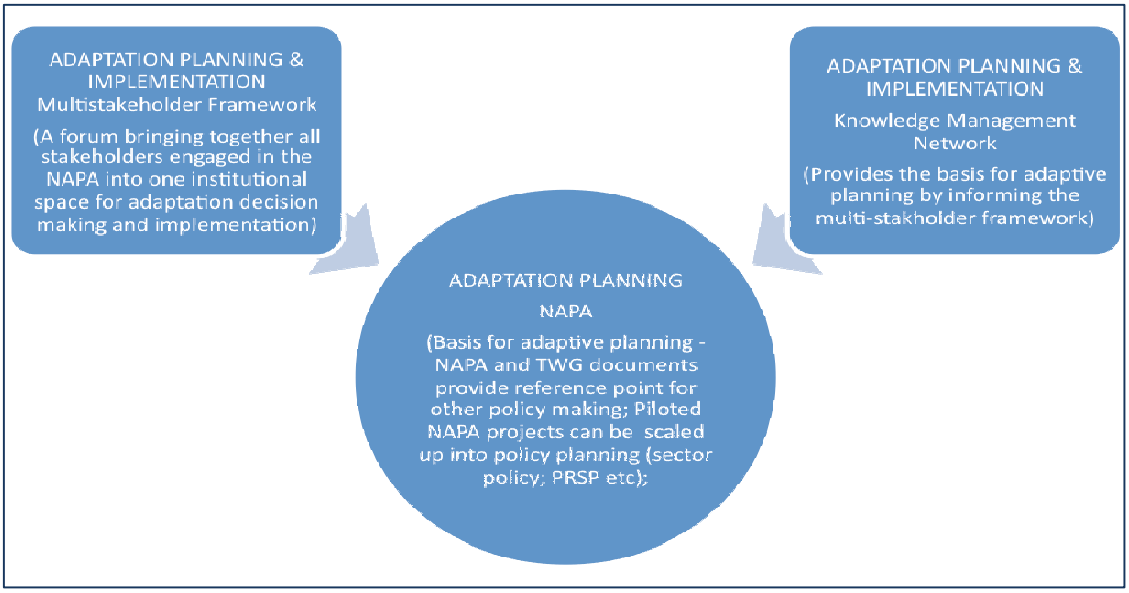
A multi-stakeholder framework of action will be constituted to ensure that the programmes identified in the NAPA are implemented through coordinated multi-stakeholder action and strategic donor financing. The framework will build on the institutional processes and momentum already built through the NAPA process, consolidating the strengths of the six government-led thematic working groups under the NAPA; facilitating the engagement of the local-level institutions identified during vulnerability analysis exercises; and building on the Donor Compact on Climate Change which was signed by the Government of Nepal and 14 development partners on 2 September 2009.[ix]

It is envisioned that the institutional structure for NAPA implementation will include following mandates:

- Climate change-related policy advisory and coordination
- Provide oversight in the implementation of NAPA
- Coordinate adaptation financing
- Provide a forum for the participation of local-level institutions in the adaptation planning process
- Facilitate mainstreaming of NAPA into national and local development plans

A technical task force will be constituted to carry out an institutional and policy analysis and based on the findings of the analysis, propose a framework to policymakers for endorsement. Every effort will be made to ensure that the process of establishing an institutional mechanism for NAPA implementation is aligned with current processes and initiatives, particularly efforts related to enacting a Climate Change Policy in Nepal and the implementation of the Pilot Program for Climate Resilience (PPCR). Training activities will be also carried out to ensure that the professionals supporting NAPA implementation and coordination have the technical capacity to carry out their functions.

Components 2 and 3 will provide a platform for more strategic long term adaptive planning. Baseline data collected during the NAPA assessment phase can help decision makers assess the effectiveness of planned adaptation interventions and review investments as per needs. These components will also create a forum for more inclusive adaptive management, by providing a space for stakeholders at different levels (government; donors; and local-level government and community-based organizations) to interact, ensuring participatory decision-making; bottom-up and top-down accountability and transparency; and a flexible mechanism to review actions and investments (see figure 4):



The following sections of this report will summarize the initial outputs to date under each Thematic Working group.

3. Findings generated by the Thematic Working Groups

This section will review the early findings under each thematic area. First, an overview of the perceptions of climate related hazards and climatic changes revealed by the Transect Appraisal Exercises are provided (Table 2). Next, the impacts of these changes, and existing coping strategies, are presented against each thematic area. For each thematic area, a thematic overview is provided, summarized from the information provided by each TWG under the stocktaking exercises. Next, an initial assessment of the transect appraisal exercise findings is presented in matrix form, followed by a short discussion. The discussion is based on additional outputs from the transect appraisal exercises that are not included in the matrix, as well as further insights from TWG members. More detailed analysis undertaken by TWGs will be made available in TWG reports. It should be noted that this section presents early analysis only and should be taken as a work in progress, and will continue to be revised and updated as the NAPA process progresses.

Table 2: Perceptions of climatic hazards and climatic changes identified by the Transect Appraisal Exercises

West	Central	East
Mountain Ecological Zone		
• Increase in temperature: days are getting warmer and night are less cold • Dramatic changes in precipitation pattern: becoming erratic, delayed	• Increase in temperature: days are becoming hotter; maximum temperature last year was 24°C to 25°C now it is 27°C • Change in rainfall in terms of	• Increase in surface temperature; days becoming hotter • Rainfall variability: Rain is irregular and unpredictable • Rainfall duration: Short but

onset; reduced rainfall in the dry months; intense rainfall episodes in the monsoon; changes in frost/hail patterns • Snow: snowfall decreased substantially; snowline has changed • Untimely and unusual snowfall • Increase in extreme weather conditions • Increased incidence of avalanche • Increased trends of snowmelt • Untimely tuwalo	variability: delay in occurrence, high intensity episodes while total amount remain the same; in recent years, more rainfall is experienced during the later stage of the monsoon • Change in snowfall: decreased amount; shift in the timing of occurrence (e.g. in Mustang, snowfall occurs in late April); duration increased up to Baishakh; changing to rainfall/hail stone • Changes in wind pattern and direction – North wind used to blow only on specific periods; now it occurs throughout the year (from seasonal to annual changes) • Increasing hailstorm events	intense rain spells; shorter winter rainy season • Rainfall timing: Delay in the occurrence of monsoon rain (it used to start from Baishak or Jestha (May-June), now it starts from Sharaban (July to August); shorter west-to-east rainfall season • Cloudy day decreased • Stronger wind and erratic storm; western wind blows more than eastern wind • Snowfall period shortened • Intensity of frost and dew shortened • Lightning frequency increased
Hill Ecological Zone		
• Increase in temperature: Days are getting warmer; nights are less colder; rural areas are getting warmer (Dadeldhura) • Change in rainfall pattern: rainfall becoming erratic (it used to rain in Ashad (June/July) but now it rains during Ashoj/Kartik (September/October) and untimely rainfall is becoming uncommon (Dadeldhura); delayed onset, reduced rainfall in the dry months; intense rainfall episodes in the late monsoon • Decrease in amount and duration of snowfall for the past 5 years • Dry season water flow in west Seti river has decreased last year from minimum record flow of 35 cubic m/sec to 31 cubic m/sec (Gopghat stream gauging station) • Increase in extreme weather conditions	• Changes in temperature: increase in temperature (not much difference between Palpa and Butwal); cold wave in the winter has increased • Change in rainfall – increasingly erratic and high intensity rainfall episodes increased • Change in wind pattern – intensity increased and timing changed • Fog & tuanlo – duration of fog decreased (previously, fog is until 12 PM but now visibility starts by 10 AM); tuanlo pattern changed • Hailstorm: changes in the period of hailstorm (previously hailstorms occur in March-April, now it has been delayed); changes in size and shape of hailstorms (previously their shapes are rounded, now their shapes are pointed)	• Increase in surface temperature • Number of hot days increasing • Changing rainfall pattern: short intense spells of rainfall; delay in the onset of rainfall by as much as 2-3 months; rainfall season duration decreased • Incidences of prolonged droughts • Cloudy day decreased • Stronger wind becoming more prevalent, very erratic • Intensity and duration of frost and dew decreased • Increased incidence of windstorm and hailstorm; hailstorm season has shifted • Thunderstorm episodes associated with lightning increased
Terai Ecological Zone		
• Temperature: increase in temperature; extreme	• Temperature increase: days becoming increasingly hotter,	• Temperature increase • Changes in rainfall pattern:

temperature events with extreme cold days and extreme hot days; increase in cold waves (Sitlahar) during winter; village is becoming warm (Sukhad) • Shifts in rainy season: delayed onset - rainfall of Chaitra to Ashad (April/June) has now shifted to Bhadra/Ashoj (August/September) • Rainfall amount: decreasing but comes in short intense rain spells (leading to occasional floods); • Rainfall variability: unpredictable; reports of both increased and decreased duration • Altered wind patterns – duration of western winds is longer • No timely rain, sun, and fog (Fattepur) • Decrease in underground water table from 18 to 35 feet (Fattepur)	while mornings are cooler • Sitlahar (cold waves) duration has become longer - starts earlier and lasts for a longer time compared to the last 5-10 years in winter • Rainfall pattern has become more erratic; high intensity but short duration • Insufficient rainfall but high intensity rainfall episodes observed • Change in wind pattern: Early occurrence of westerly winds. It used to blow only after January 15th, now it blows as early as October/November	High intensity of rainfall in shorter period of time; decreased number of rainy days, however an increase in intense rainfall (year round rainfall remaining the same) • Normal Foggy mornings disappeared, however Sitlahar (cold wave) days increased in winter • Hot wind has been blowing in dry summer

3.1 Water and Energy Security

3.1.1 Overview of water and energy situation in Nepal

Water

The major water sources of Nepal are rainfall, rivers, glaciers, groundwater and reservoirs, lakes, ponds and marshes.

The southeasterly monsoon and the western disturbances are the primary drivers of rainfall in Nepal. The yearly rainfall is a key for the maintenance of the water reserves in the glaciers, and groundwater and seasonal discharges in the river systems in Nepal. The rainfall contributes nearly 267 billion cubic meters of water annually within the Nepalese territory (Shrestha et.al 1996 and Yagacharya, 1998). Of the total, 26.7 billion cubic meter precipitate in the form of snow and 240.30 billion cubic meters occurs in the form of rain.

Nepal is drained by more than 6000 rivers and streams, contained within four major river basins: Sapta Kosi in the east, Sapta Gandaki in the centre and Karnali and Mahakali in the west. The annual runoff of the rivers at the exit point of the Nepalese territory to India totals around 224.5 billion cubic meters

(WECS, 2005). Of the total annual runoff about 53.96 billion cubic meter enters Nepal from Tibetan Autonomous Region of China (Yogacharya, 1996). Nearly 75% of the annual volume of water available in Nepal is drained as runoff out of its boarder in the monsoon months (June to September). Only one quarter of the remaining annual volume is drained as runoff in the remaining eight months. Generally, the summer months (March to April) has the lowest possible discharge in the rivers of Nepal. Any change in the average temporal rainfall pattern has a direct influence on the water discharges of the Nepalese rivers even if the annual rainfall remains constant. High intensity and abundant rainfall in monsoon is seen to enhance high runoff resulting into landslides and erosion in the Mountain and Hill ecological zones and flash floods and sedimentation in the Terai ecological zone. Low rainfall in winter is observed to reduce the water storage in the form of snow and ice in Mountain ecological zone with corresponding decrease in the dry season base flow of the rivers, particularly, the rain and spring fed rivers with implications on the small irrigation systems, water supply schemes, mini and micro-hydro installations.

About 5.31% of the land area equaling to 7863 km^2 is under the cover of snow (Forest Research and Survey -Nov.1990-Jan, 1991). Approximately 3% of the land area above 5000m is covered by snow and ice throughout the year forming the glaciers (Bajracharya et.al. 2001). There are 3,252 glaciers in Nepal, observed from 3000 to 8000m altitude (Adhikari, 1993), covering an area of 5,323 km^2 with an estimated ice reserve of 481 km^3, about 15% the of the total snow cover area and ice reserve of the Himalayan Mountain Range (Bajracharya et.al. 2001). The storage of precipitation in the form of snow in these areas is regulating the annual distribution of water not only in Nepal but also to the northern part of India. It is estimated that the rivers flowing from Nepal contribute about 71% of the dry season flow and 41% of the total annual average flow of the Ganges in India. Since 1970 the glaciers are observed to be rapidly retreating and melting (Kadota and Ageta,1992; Seko et al., 1998; Kadota et al. 2000; Naito et al. ,2000; Yamada et al., 1992; Ageta et al. 1984; Nakawo et al., 1976; Fujita et al. 2001; Asahi et al., 2000) with a net loss in the water storage while additional snow accumulation is constrained by low winter precipitation. The result is the low water regulating capacity in the downstream basins of these fresh water storage areas in the long term. There are about 2,323 lakes above 3500 masl, with the highest in the Saptakosi basin followed by Karnali, Narayani and Mahakali. Some of these lakes are at risk of bursting, a phenomenon known as Glacial Lake Outburst Flood (GLOF). In the past GLOF incidents have frequently occurred in Nepal (Ives, 1986; Yamada, 1998). There are 20 GLOF potential lakes in the Saptakosi and Narayani basins (Bajracharya et.al. 2001) posing risks to the road and hydropower infrastructures apart from the riverine agricultural lands and settlements in the downstream of these basins.

The Terai ecological zone is rich in groundwater reserves. Rechargeable groundwater in the Terai is estimated to be anywhere between 5.8 BCM and 11.5 BCM (WECS, 2005). With the declining forest cover in the foothill areas (Bhabhar), the primary area for groundwater recharge in the region, the recharge potential of the Terai groundwater is also declining due to high surface runoff and reduced infiltration capacity. Similar observations are made by the communities in the Inner Terai plains and Kathmandu valley (Hill ecological zone) where the groundwater is mined in excess of the groundwater recharge potential.

Total area occupied by the Reservoirs, lakes, ponds and Marshland in Nepal is estimated to be around 335.33km^2 (DOAD, 1992). Lakes hold nearly 3% of the available water of Nepal. Excessive siltation due to upland erosion and associated nutrient enrichment and plant successions many of the lakes in the Terai

and Hill ecological zones have been gradually converted into marshes. The Kulekhani, the only man made reservoir developed to regulate the monsoon runoff for peak hydropower energy generation had a total reservoir storage capacity (dead and live) of 85.31 million cubic meter. Due to high sedimentation related to cloud burst of 1993 the reservoir capacity is reduced to only 62 million cubic meter (Winrock International Nepal, 2004).

Of the total available runoff annual water budget, only 15 billion cubic meters or 6.7% is used for various end uses (WECS, 2005). The use of water in the domestic, industrial and agricultural sector is 3.43, 0.27 and 96.3% respectively (Yogacharya, 1996). Though the annual water used is a small fraction of the total annual water budget, the source and geographical position of the source of water used is of significance. Nepal has utilized mainly medium and small rain and spring feed rivers of the Hill and Mountain ecological zone for different uses such as drinking water, irrigation and hydropower. Similarly groundwater resources are also being used for irrigation, domestic and industrial uses in the Terai and some parts of Hill ecological zone such as Inner Terai (Chure/Siwalik Physiographic Region) and Kathmandu valley (Middle Mountain Physiographic Region). The lakes and ponds in the Terai Physiographic Region have been used to limited extent for irrigation and fishery. The lakes and ponds in the High Himal, High Mountain, Middle Mountain and Chure/Siwaliks Physiographic Regions are largely unused for any consumptive beneficial purpose except for limited non-consumptive tourism, recreation, and religious purpose.

Though per capita water availability is estimated to be 8164m^3 in Nepal, there is extreme water hardship on larger parts of Nepal particularly in the Mountain and Hill ecological zone. This is a result of topography and location of the settlements and agricultural areas high above the riverine gorges with abundant water discharges. The steep character of the mountain slopes, shallow soil depths and decreasing forest cover etc. are increasingly reducing the water holding capacity of the ground to maintain a sustained spring discharges round the years. As a result, in the Mountain and Hill ecological zones, the water absorbed by the ground in the monsoon is quickly lost to evaporation and evapo-transpiration in the post-monsoon and winter period and soil become moisture deficient. The direct implication is on winter and summer agriculture productivity and reduced groundwater discharges of spring causing water scarcity for domestic and livestock consumption. The above situation of too little water in the winter and summer and too much water in the monsoon reflects the diabolically opposite water stress vulnerability in the Hill and Mountain ecological zones.

The water quality of the snow-fed and rain-fed/spring-fed rivers is good to fair for all type of consumptive uses with limited treatment intervention. However, most of the rivers remain turbid with high suspended sediment load during monsoon or immediately after rainfall. Microbial contamination is invariably reported in all most all surface water bodies of Nepal. Such contaminations are high during the monsoon compared to winter. Lack of adequate sanitation facilities in the river catchments, and practices of open defecation in all the rural settlements cause higher degree of contaminations as rainfall runoff bring these deleterious wastes to the river systems. The rivers passing through the cities and townships (Kathmandu, Biratnagar, Birgunj etc.) in all the ecological zones are also highly contaminated due to direct discharge of sewers and industrial effluents without treatment into the rivers. The implication is on the freshwater aquatic ecology and diversity and to the health and hygiene of the downstream water user communities.

Energy

Nepal's total energy consumption for the base year 2005 was 367.26 million GJ (Table 3) with a per capita energy consumption of 0.34 TOE (14.64 Gj or 13.88 million BTU). Nepal per capita energy consumption for the base year 2005 was about one fifth of world average per capita energy consumption. On an average energy consumption in Nepal is increasing by about 2.28% annually. The main supply sources of energy in Nepal is divided into three categories namely traditional (comprising of fuelwood, agricultural residue, and animal dung), commercial (comprising of LPG, motor spirit, air turbine fuel, kerosene, high speed diesel, light diesel oil, fuel oil, coal, electricity and others), and renewable (comprising of biogas, micro-hydro, solar and others). The share of traditional, commercial and renewable energy sources in the total energy supply for the year 2005 was 87.71, 11.76 and 0.53% respectively (WECS, 2005). The share of sectoral energy consumption (Table 4) is highest in the residential followed by transport and industrial sector.

Table 3: Energy Consumption by Fuel Type

Fuel Type	**1995**	**2005**	**Share % 1995**	**Share % 2005**
Traditional	**258212**	**322105**	**91.14**	**87.71**
Fuel wood	230651	286960	81.41	78.14
Agricultural Residue	10354	13946	3.65	3.80
Animal Dung	17207	21181	6.07	5.77
Commercial	**24784**	**43195**	**8.75**	**11.76**
Petroleum	***19119***	***30063***	***6.75***	***8.19***
LPG	643	3821	0.23	1.04
Motor spirit	1172	2534	0.41	0.69
Air turbine fuel	1357	2417	0.48	0.66
Kerosene	6559	8659	2.32	2.36
High speed diesel	8597	11911	3.03	3.24
Light diesel oil	149	3	0.05	0.00
Fuel oil	406	-28	0.14	-0.01
others	236	747	0.08	0.20
Coal	***2839***	***6459***	***1.00***	***1.76***
Electricity	***2826***	***6673***	***1.00***	***1.82***
Renewable	**319**	**1955**	**0.11**	**0.53**
Biogas	298	1930	0.11	0.52
Micro-hydro	21	50	0.01	0.01
Solar	0	2	0.00	0.00
Others	0	0	0.00	0.00
Grand Total	**283315**	**367255**	**100**	**100**

(*Source: WECS, 2006)*

Table 4: Energy Consumption Percentiles by Sector and by Sources

Sector	Traditional %	Commercial %	Renewable %	Total Energy
Residential	95.85	3.56	0.59	90.28
Industrial	17.59	82.41	0	3.74
Commercial	35.77	57.36	6.88	1.45
Transport	0	99.85	0.15	3.78
Agriculture	0	94.49	5.51	0.84
Others				0.17
Total of	87.71	11.76	0.53	100

Source: from WECS 2006 for the year 2005

In the recent years, though the share of traditional energy source on the total energy supply is declining, the amount of energy supplied by the traditional sources is increasing at a pace of 1.91% annually. The traditional source of energy constituting nearly 88% of the total energy use is derived primarily from the fuel wood (78.14%) followed by animal dung (5.77%) and agricultural residue (3.80%).

Traditional energy source is the dominant source of energy in the residential sector (98.66% of traditional energy consumed), while its share in the industrial, commercial, transport and agricultural sector is very small. The key traditional energy consumption in the residential sector is household cooking and livestock feeding because of its availability as a low or no cost commodity.

In the context of declining forest areas and forest stock, the demand of fuel wood as the primary energy source in the residential sector falls significantly short of supply. In the existing scenario, the government managed forests are the prime axe targets of the communities in all ecological zones. With the declining access, over time, in the available forested areas, there is a likely shift to the agricultural residue for energy supplement as an easy and low cost alternative. The former over harvesting of forest lands for fuel wood needs will leave an unrecoverable damage to the existing forest ecology and biodiversity. The latter will further impact the agricultural productivity, animal husbandry and above all the public health enormously. A combined effect will be degradation in the water holding capacity of the soil, enhanced runoff and erosion leading to desertification and people suffering in the long term.

The commercial energy constitutes about 11.76% of the total energy use. Over the years, the share of commercial energy in the total energy consumed has increased compared to others, but is unlikely to make noticeable shift in the energy consumption pattern for a foreseeable future. Major consumer of commercial energy is transport followed by residential, industrial, commercial and agricultural sector. Leaving aside the electricity, a renewable energy supply source based on in country hydropower, the other sources are imported from third countries

Though the country has a proven hydropower potential of above 42000MW, only 1.51% has been harnessed so far. Major consumers of generated electricity are industrial and residential sectors. The shortfall of electrical energy by 200MW in rainy season and 600MW in the winter season (Ten Years Hydropower Development Task Force Report, 2008) has forced the nation for up to 18 hours load shedding in the winter of 2009.

In total only 40% of the Nepalese population has access to electricity, but the access to electricity in the rural areas is limited to only 27% of the population. Of the total electrified households, about 42.53% have access to the grid electricity, while 3.31% of access to off grid facilities (UNDP, 2007).

Financial constraints to harness large scale hydropower projects and develop countrywide transmission and distribution networks, has given impetus for the development of various alternative renewable energy such as solar, biogas, micro-hydro, and wind in the remote rural areas with the help of bilateral, and multilateral donors. Though the contribution to the total energy use is very insignificant, it has given access to the modern form of energy to the rural population (Table 5).

Table 5: Alternative Energy Technologies in Nepal

SN	Alternative Energy Technologies	Unit	Status	Access to Energy to HHs
1	Biogas Plants	No	214,000	214,000
2	Micro hydropower and IWM	kW	21,200	262,000
3	Solar PV Home System	No.	240,000	240,000
4	Solar Cooker/Dryer	No	2,500	2,500
5	Improved Cook Stoves	No.	278,342	278,342
6	Wind Power Technologies	No.	4	50
7	Institutional Solar	No	141	
8	Solar Water Heaters*	No	61000	61000
	Total			996,892

Source: Alternative Energy Promotion Center, 2009. WECS, 2005*

To date, the energy from alternative renewable technologies have been used basically for household lighting, cooking, drying and water heating in a limited way. But there are immense potential of the alternative renewable technologies particularly micro-hydro in the Mountain and Hill ecological zone, Solar and improved cooking stoves in all the ecological zones, and biogas in the Terai and low lying valley areas of Hill ecological zone.

National Greenhouse Gas Inventory for base year 1994/95 projected a total greenhouse gas emission of 39265 Gg Co_2 equivalents for Nepal. Of the total 8.22 % of GHG is contributed by the energy sector. The share of Co_2, CH_4 and NO_2 in the GHG emission form energy sector is 44.52, 45.93 and 9.55% respectively. Share of CO_2, CH_4 and NO_2 from the energy sector in the total national GHG emissions is estimated at 14.83, 7.49, 3.23% respectively.

In the context of Nepal, the concern with regard to the GHG emission is not directly related to the quantum of GHG emissions, but is related with the degradation of forest, the primary source of energy use in Nepal. National Greenhouse Gas Inventory for base year 1994/95 estimated GHG emission by land use change (usually from forest to others) as 22895 Gg CO_2 equivalent and corresponding removal of GHG from forest areas as 14778 Gg CO_2 equivalent. With the degradation of forested areas for energy supplement in the scenario of increasing population at an annual rate of 2.25%, expected land use

change related GHG emissions is expected to increase, while the removal potential of GHG from the forested areas will decrease considerably.

Recognizing the importance of water and energy sector in the overall national economic development a number of policy and legislative instruments have been brought forward time and again to mainstream the sector development and management. Though these policies and legislative instruments do not examine the sector from climate change perspectives include environmental sustainability component in the sector development and management. The key policies endorsed by the government of Nepal in the water and energy sector are Hydropower Development Policy (2001), Rural Energy Policy (2006), Petroleum, Coal and Natural Gas Sub-sector Policy, Nepal Transport Policy (2001), Forest Sector Policy (2000), Water Resource Strategy (2002), Nepal Water Plan (2005), Irrigation Policy (2003), National Water Supply Policy (1997), National Sanitation Policy (1998), Rural Water Supply and Sanitation Policy (2003), Rural Water Supply and Sanitation Strategy (2003), Urban Water Supply and Sanitation Policy (2005), Water Induced Disaster Management Policy (2003) etc. Key feature of the Water Resource Strategy (2002) and Nepal Water Plan (2005) is Integrated Water Resource Management at basin level based on the guiding principle of social development, economic development, and environmental sustainability. A number of legislative Acts are promulgated to facilitate the sector development such as Water Resource Act (1992), Electricity Act (1992), Nepal Petroleum Act (1983) etc, however, lack incorporation of the later policies/strategies and plans to facilitate developmental activities in the sector.

3.1.2 Outputs from the Transect Appraisal Exercises: An initial assessment of impacts of climate change on water and energy

Perceptions	**West**	**Central**	**East**
Mountain Ecological Zone			
Impacts	Water • Landslides becoming common due to intense and short spell of rainfall. • Water availability for drinking is getting scarce. • Water availability for Irrigation is getting scarce including deteriorating performance of micro-irrigation facilities. • Concerns about future of micro-hydro projects	WATER • Increasing frequency of rainfall compared to snow reducing the water infiltration of capacity of the soil with implication on range land productivity and pastoral communities (*Dhoppa communities)* • Increasing frequency of rainfall has intensified erosion and land degradation with implication on the agricultural productivity	WATER ▪ Reduction in water sources with implication on the traditional profession of utensil making from local wood variety ▪ Decrease in the river/streamlet discharges have made the traditional water mill redundant ▪ Decline in water

	and water mills because of sharp variation in stream flows causing reduced electricity generation during longer dryer spells. • Too little water to sustain traditional agricultural productivity vis a vis food security due to delayed rainfall and long dry spell between consecutive rainfall • Irrigation water shortage due to drying of streams and erratic rainfall behaviors • Shortage of domestic water supply due to drying out or reduction in spring discharges • Extreme water shortages due to less rain/snow with high implication both to agricultural productivity and household water use • Retreat of valley glacier and high discharge in the form of flash floods in the snow feed rivers in the bright sunny days of summer and monsoon • Increase in the formation of glacier lakes in the glaciated areas and increase in the GLOF risk in the downstream areas ENERGY	• Increasing frequency of rainfall compared to snow has made the traditional flat mud roof redundant • Decrease in snowfall has implications on water availability for traditional agriculture production resulting to migration of village communities (Chosher village Ward No. 9, Mustang) • Increase in the unusual rainfall associated to hailstorm damaging apple production, and other agriculture productions such as maize, potatoes, naked barley and wheat. • decline in water • quality due to impact on natural filtration systems by change in precipitation type • Time spent by for water collection increased ENERGY • Efficiency of alternative energy systems (solar & hydro-power) decreasing • Increased cloud cover impacts solar PV systems and changes in water flow impact hydro. • Changing consumption pattern: Reduced use of energy for space heating. • Energy uses: Increasing use of dung cakes for heating energy to counteract reduced availability of wood fuel; LPG and various sources	quality and increase in health vulnerability ▪ Decline in rainfall volume and rainy days ▪ High intense rainfall and increase in the landslide and erosion and associated loss of human life and property ▪ Delay in monsoon affecting agricultural calendar and agriculture productivity ▪ Increase in land dryness (decrease in soil moisture) and decrease in agriculture productivity and increase in forest fires ▪ Increase in Thunderstorms frequency related loss of human life and property ▪ Conflict on the water rights for water supply system increasing ENERGY ▪ Decrease in the river/streamlet discharges have reduced the power output of micro-hydro and peltric sets

	• Performance of micro-hydro facilities has deteriorated due to reduction in river discharge • Loss of efficiency in solar systems due to increased cloud cover in cold seasons • GLOF risk to micro-hydro facilities • Decline in forest annual regeneration due to change in water cycle causing higher deforestation as most of the communities depend on the fuel wood for their household energy • Decline in the availability of the fuel wood as a result of increasing forest fires due to low precipitation in post monsoon and increase in temperature	of electricity (solar, micro hydro and grid) for mainly lighting; traditional and improved water mills are used for agro processing • Decline in forest production – forest productivity declined due to changes in water system (other drivers like deforestation and population growth were also identified); change in plantation cycle due to reduced/slow growth	▪ Decrease in the river/streamlet discharges have made the water mills redundant in summer
Coping /Adaptation	WATER • Plantation to provide slope protection (limited success) • Small-scale irrigation canals linked to adjoining rivers • Domestic water use management • Filtration systems for household water • Migration to water sources • Bioengineering for slope protection • Seasonal migration of able bodied male outside for labor and other jobs (mostly to	WATER ▪ Controlled grazing of livestocks ▪ Taping of snow for irrigation purpose ▪ Promotion of Small scale irrigation ▪ Household water conservation ▪ Use of water filtration unit at household level ▪ Rainwater harvesting at household (roof water harvesting) and community level (run off collection ponds) ▪ Government subsidies on kerosene and LPG ▪ Land development for agriculture (conversion of	• Afforestation /plantation of non-timber forest crop species • Conservation of water sources by means of vegetation planting ENERGY • Use of other alternative lighting energy such as photo voltaic and solar tuki • Use of improved cooking stoves

	India) ENERGY • Electricity (from grid) coverage gradually increasing • Financial support for biogas, subsidies offered by the government • Solar lanterns for lighting (NGO supported)	waste land to agriculture) ▪ Use of improved cooking stoves ▪ Implementation of community pasture development activities ▪ Afforestation of barren lands for erosion control and water conservation ▪ Replacement of mud roof with corrugated sheet roof ▪ Seasonal migration for trade mainly in winter (mostly in India) ENERGY • Rural electrification programme scaled-up • Enhancing supply of LPG/kerosene at subsidized rates • Promotion of solar, micro-hydro and improved water mills • Increased community capacity building for new technologies • Promotion of improved cooking stoves • Warning system against GLOF in localized areas such as Tama Kosi • Glacial lake draining in localized areas such as Cho Rolpa • Awareness raising against GLOF Hazard such as Tama Kosi	
Hill Ecological Zone			
Impact Assessment	WATER • Drought situation in the dry season • Landslides • Drying up of small water reservoirs due to late	WATER • Reduction of water at source, leading to decrease in drinking water availability • Drought like situation in	WATER ▪ Late monsoon arrival affecting agricultural calendar and agricultural productivity

	onset of monsoon • Insufficient water supply for domestic purposes from locally available small streams • Loss of agricultural productivity (both rain fed and irrigated) • Flooding causing erosion and sedimentation, implications for agriculture infrastructure, and human wellbeing. • Degradation in water quality (health and sanitation implications) • Conflict over water rights due to drying out of springs and rivulets ENERGY • Decline in fuel wood due to increasing forest fires • Water mills redundant in dry season	the dry season (low soil moisture affecting winter and summer crops) • Insufficient or non-functional water supply systems in the uphill mountain slopes due to decrease in discharge or drying out of springs owing to little or no rain in the summer and winter • Insufficient water in the irrigation canals affecting agriculture due to decrease in the discharge of the source streams and rivers • Loss of rain fed agriculture productivity because of the late monsoon • Increasing incidents of landslide and debris flows due to frequent extreme rainfall events with implications on agricultural land, settlements, infrastructures (such as roads, irrigation canal, water supply system, etc.) • Degradation in water quality (multiple use of water and related pollution in the water stress period and contamination by runoff in the high water period with implication on public health particularly related to water borne diseases) ENERGY	▪ Decrease in the monsoon rainfall duration from 5 months to 2 months affecting the agricultural productivity ▪ Rainfall has declined in all season with implications on the spring and hill side rivulet discharge which often dry out in the late winter and summer months which has made the small irrigation system and water sourcing point redundant ▪ Flies and mosquitoes have increased with health consequences • Water quality has declined because of multiple water use with health implications ENERGY • Water mills and micro-hydro projects are affected due to variations in stream flows. • Decreasing access to energy sources: forest land

		• Decline in the availability of the fuel wood as a result of increasing forest fires due to low precipitation in post monsoon and increase in temperature	productivity and access to energy sources and water sources
Coping & Adaptation Assessment	WATER • Plantation to provide slope protection • Water collection from far off sources • Crop diversification to drought resistant/less water intensive crops • Water management (regulate timing of water supply; water rationing; drip irrigation) • Greenhouses for vegetable crops • Household water conservation strategies such as storage of kitchen waste water for livestock • Rainwater harvesting (household level for domestic use; community level for livestock use) • Bio-engineering for slope protection • Rainwater harvesting (limited coverage, concentrated in Doti) • Water reservoirs for storage • Switch to traditional house grinding implements such as "Zato" • Seasonal migration of able bodied male	WATER • Installation of hand pumps, • Collection of rainwater in ponds for irrigation • Plastic lining to prevent seepage (storage improvement) • Rainwater harvesting system for livestock feeding and household usage (in ponds and tanks) • Plantation of faledo trees for enhancement of water sources • Digging ponds in damp places for drinking water ENERGY • Use of canals from micro-hydro projects as irrigation canals • Installation of biogas for cooking energy • Installation of micro-hydro for lighting energy • Social environmental management for source protection and promotion of bio-engineering	WATER • Promotion of toilet at household level to improve sanitation and water quality • Use of boiled water for drinking • Fetch water from far of distance for domestic use • Source protection of water supply systems • Rain water and fog water harvesting for household consumption • Protection of community forest for water conservation • Plantation of water conserving trees such as Alnus nepalensis ENERGY • Electrification using micro hydro, grid electricity and

	outside for labor and other jobs (mostly to India) ENERGY • Financial support for biogas and micro-hydro (subsidies offered by the government) • Solar lanterns for lighting (NGO supported, limited coverage) • Improved cooking stoves (Government subsidy support) • Community efforts to avoid/manage forest fires		solar photo voltaic and community electricity generators. • Biomass for cooking. • Storage battery based lights.
Terai Ecological Zone			
Impact Assessment	WATER • Drought is occurring earlier • Floods in peak monsoon, increase in flash-floods • Delayed monsoon • Landslides, debris flow, sedimentation • Reduced performance of water storage ponds • Shrinking ponds and groundwater for water storage • Degradation of water quality with health and sanitation impacts • Micro-irrigation not performing well • Lowering of groundwater table ENERGY • Decline in fuel-wood from increased forest fires	WATER • Reduced availability of water due to insufficient rainfall. Supply systems are becoming useless • Cost implications of boring at higher depths for water • Water conflicts • High intensity rainfall episodes causing inundation of households and agricultural lands • Change in river courses, improper drainage systems, and sedimentation of the bed aggravating inundation	WATER • Change in the timing of enhanced and reduced spring flows • Lowering of groundwater table • Decline in water quality • High sedimentation of silt in the agricultural land and decline in the agricultural productivity • Increased risk of flood due to intense rainfall in monsoon • Untimely rainfall and decline in agricultural

			productivity of rain fed lands • Low or no rainfall in the winter season affecting agricultural productivity • Dew in the winter months declined sharply affecting the Mustard and Masoor (a kind of pulse) agricultural productivity • Scattered rainfall, some areas too much water associated with floodings and some area dry • The land is getting increasingly dry ENERGY • Increased requirement for irrigation energy
Coping & Adaptation Assessment	WATER • Irrigation from ponds and other sources • Micro-irrigation systems • Installations of hand pumps and shallow tube wells • Conservation ponds for water storage • Plantation for bank protection • Flood warning systems • Seasonal migration of	WATER • Irrigation to avoid moisture stress • Join old irrigation canals with the river • Build overhead tanks to ensure supply of drinking water ENERGY • Use of energy saving cooking stoves and biogas	WATER • Installation of hand pumps, shallow tube wells and deep tube wells for domestic, and irrigation purpose • Change in winter agricultural crops

	able bodied male outside for labor and other jobs (mostly to India) ENERGY • Community lanterns for lighting • Biogas plants including govt. subsidy Community forestry and managed harvesting, as necessary (systematic)		ENERGY • Use of alternative energy for cooking and lighting (biogas, solar photo voltaic, Solar lanterns) • Use of improved cooking stoves

Discussion

Water is a critical input to production systems. Any change in the water regime (precipitation, river flow, groundwater, or snow and ice) brings a profound change in the production systems (human based or natural) and life forms depending upon these production systems. Stocktaking of water and energy sector reveals the sector to be already in a state of stress both because of climatic and non-climatic factors. Contribution of climatic factors in the present scenario is very difficult to access due to poor or inadequate database and research relating water and energy sector to climate change. Though the impacts of precipitation variability to the existing socio-ecological and natural environment could be derived based on the assessment elsewhere (such as IPCC TAR and AR4), the specific vulnerability assessment in the geographical, ecological and social cross-section is difficult to develop at this stage. Theoretically, the poor and deprived community groups and women groups in particular are the vulnerable groups in the context of Nepal and they are or will have to face the consequences of the climate brought water and energy stress because of the extremely reduced adaptation capacity. The assessment presented in this discussion note is based on the perceptions of the communities of the three transects across Nepal and need to be evaluated from this perspective only.

The communities met across the three transects have a fair idea of the changing climate than before, though they were not scientifically aware of the global climate change as discussed in academia and scientific communities. They have their own yardstick of indicators to explain the change in temperature and memories of the past in the rainfall variability. It is therefore, the main impacts of changing climate noted by the communities on the water and energy sector were on agricultural systems, livelihoods and well being or quality of life of the people.

Changes in precipitation patterns and intensity were observed across all three transects to have cross-thematic implications: for example, the impacts of water stress (to little water) on domestic water supply was noted to affect health and sanitation apart from agricultural productivity and malnutrition across all ecological zones; other water stress related hazards (too much water) such as landslides and erosion/siltation were having an impact on settlements, agriculture land and communications/transport infrastructure apart from loss of biodiversity in the Hill and Mountain ecological zones; the flash floods

and associated erosion and sedimentation was observed to have a profound impact on the agriculture, human settlement and infrastructures in the Terai ecological zone.

The most direct impact of changing climate trends and hazards was noted on renewable energy sources (such as micro-hydro power projects) in Hill and Mountain ecological zones; and also solar power which were noted to be affected by changes in weather affecting cloud cover in the Mountain ecological zone. Climate hazards also affected energy security indirectly; for example, a noted decline in forest productivity and increase in forest fires that was attributed to declining timely rainfall in dry seasons reduced the availability of wood for fuel, putting greater pressure on alternative energy sources (with cross-thematic implications for forests and biodiversity). In the energy sector, the impact of decreasing river discharges highlighted by respondents is likely to affect the efficiency of hydroelectric projects (micro to mega) in the Hill and Mountain ecological zones.

Adaptation and coping mechanisms were being undertaken at the household level (rainwater harvesting; household level water management; water filtration systems; changing household energy consumption patterns from different energy sources); community level (community ponds for water harvesting; water rationing; micro-hydro projects); and district level, for example agricultural extension; irrigation systems. Many of the options identified were coping responses and may not be adequate against long-term climate changes where the impacts of climate change are likely to worsen over time, such as travelling greater and greater distances to collect water and seasonal migration for additional income for livelihood.

A short institutional analysis undertaken during the transects identified several levels of institutional support for coping and adaptive strategies. In the Western region, there was a high presence of both government service providers as well as INGOs/NGOs, especially in the energy sector as well as in the provision of slope protection against landslides. In the Central region, District Water Supply was undertaking monitoring of water systems, and VDC & Water User groups were identified as playing a role in facilitating community-based water management programmes. Many NGOs were also providing specific technological assistance into micro-hydro projects;' small-scale irrigations schemes; and the provision of biogas as an alternative source of energy. In the East, MOE (formerly MOWR) was identified as a key institution in managing the provision of water rights, which needed to take account of the optimal use of resources. Government, NGO and INGO interventions were generally limited to the measures which require high financial resources such as river bank protection, small irrigation system, flood warning systems, water supply systems, micro-hydro installation, improved cooking system, biogas, solar house system, solar cooker, solar Tuki, and flood rescue and rehabilitation. A number of government departments and their line district offices were involved, but their outreach in terms of area coverage and population served was below the required level.

Finally, the literature revealed a number of additional impacts and adaptation strategies worth highlighting. In the Mountain, the increased melting of the glaciers is understood to be increasing the risk of Glacial Lake Outburst Floods (GLOF). Several adaptation options to this increasing hazard have been identified, including early warning systems (for example in Tama Kosi); glacial lake drainage (for example in Cho-Rolpha); and awareness raising for downstream communities (in the Tama Kosi valley).

Considering the perceived risks, sensitivity of the exposed population and natural environment, and adaptation capacity of the people, the first hand crude vulnerability assessment reveals that hill and

mountain ecological zone of the far-western and mid western Nepal is very likely highly vulnerable geographic area of Nepal. The hill and mountain ecological zone of western Nepal, Mountain ecological zone of central Nepal, and Terai zone of central, western and mid-western Nepal is the second likely vulnerable geographical areas compared to rest of the other eco-geographical zones of Nepal. Further scientific analysis, however, is required to validate the above eco-geographical vulnerability assessment.

3.2 Forests and Biodiversity

3.2.1 Overview of Forests and Biodiversity sector in Nepal

Forests

In Nepal, according to Forest Act 1993, forest is defined as all the area which is fully or partially covered by trees. Under this definition, an inventory of forest cover undertaken by the Department of Forest Research and Survey using the satellite images from 1994 to 1998, shows that the forest area of Nepal is is 4.27 million hectares (29%)[2], and shrub land area is 1.56 million hectares (10.6%) (DFRS, 1999). These forested areas fall under different categories of forest as defined by Forest act 1993, which include:

- **Government Managed Forests**: Forests managed by government for the benefit of the country and people through production and protection of the resources.
- **Protection Forests**: Forests declared as "protected forests" and managed for the environmental, scientific and cultural importance.
- **Leasehold forests:** Forest handed over to the forest based industries for production of raw materials, or handed over to the people below the poverty line in order to harvest forests products like firewood, timber, forage, non-timber forest product etc.
- **Religious forest**: Forests handed over to the local religious institution for development, protection and utilization.
- **Collaborative forest[3]:** This is a recently developed concept of forest management in partnership with local people, local government, and the Department of Forests, where inputs and responsibility of forest management are shared among the partners.
- Community forest: Parts of national forests handed over directly to the communities living around the forests according to Forest Act 1993 and Forest Rule 1995. For handing over of community forests, District Forest Office has to consider accessibility or distance from village to forest, interest and capacity of users. The objective of community forestry is to produce collective benefit to the local communities and the nation from development, conservation and utilization of the forest.

(GoN, 1993)

[2] Percent (%) of total land area in Nepal

[3] This category is later on added by government from the directive in 2001

Today, there are more than 14,337community forest users group managing more than one million (12,19,272) hectares (DoF, 2009a). Similarly, there are 23,424 hectares of leasehold forests managed by 36,472 households (DoF, 2009 b) and there are also Collaborative Forests managed by local communities. Therefore, community based forests add to 1,242,696 ha managed by1,684,189 households or approximately 21 percent of country's forests managed by 40 percent of the total population.

The forest areas that are not designated as community based forests or religious forests, are considered as government managed forests. In practice there are still large areas of forest (5.83 M ha-1.24 M ha – some as protected area) which are, in theory, managed by government. These forests are mostly in Terai region and at high altitude. In the midhills, most of the forest areas are handed over to local people as community forests or leasehold forests. Collaborative forests are designated mostly in the Terai districts of central Nepal.

Forested areas are in decline in Nepal, largely due to deforestation. As compared to the forest area inventory conducted by Land Resources Mapping Project in 1978/79, in the Terai forest area has decreased at an annual rate of 1.3 %, where as in the hills the forest area has decreased at the rate 2.3 % per year (although at the same time shrub area has increased). Thus, the net decrease in forest (tree and shrub) in the hills is 0.2 percent (DFRS, 1999). In the whole country the forest area has decreased at the rate of 1.7 percent, but while considering shrub land the net decrease is only 0.5 % per year.

The main species found in forest of Nepal is *Shorea robusta* (28.2% in volume), followed by *Quercus spp* (9.3%), *Terminalia spp* (7.6%), *Pinus roxburghii* (6.3%), *Abies spectabilis* (4.4 %), *Rhododendron spp* (4.2%) and *Alnus nepalensis* (2.9%) (DFRS, 1999).

Biodiversity

Nepal's biodiversity reflects its unique geographical position and climatic variations. There are over 6500 species of flowering plants, over 1500 fungi species, and over 350 lichen species. Out of those about 370 species of flowering plants are considered endemic to Nepal. Faunal diversity in Nepal is also vast, and the country harbors 175 mammal species, 836 bird species, 147 reptile and amphibian species, 180 species of fish, 640 species of butterfly and above 6000 species of moth (Maskey, 1996). Of these 26 species of mammals, nine birds and three reptile species are either endangered or vulnerable or threatened. Those species include tiger, rhinoceros, elephant, musk deer, snow leopard, swamp deer, wild buffalo, Bengal florican, lesser florican, red panda, clouded leopard, Gangatic dolphin, gharial etc.

Table 4: Species diversity of main fauna and flora in Nepal

Faunal diversity		*Floral diversity*	
Group	*No of species*	*Group*	*No*
Mammals	181	Gymnosperm	28
Birds	844	Angiosperm	5160
Reptiles	100	Ferns and allies	380

Amphibians	43	Mosses	463
Fish	185	Lichens	465
Butterflies	635	Algae	687
Spiders	144		

Source (Maskey, 1996)

The biodiversity in Nepal is supported by the forest ecosystem, rangeland ecosystem, wetland ecosystem and mountain ecosystem. To protect these ecosystems, the government of Nepal has established four types of protected areas: national parks, wildlife reserves, conservation areas and buffer zones. The National Parks and Wildlife Conservation Act (NPWCA) 1973 is the principal legal instrument that governs the management of protected areas in Nepal. The Act provides complete protection to 27 species of mammals, nine species of birds, and three species of reptiles. The Government also brought forward Buffer zone Management Regulations in 1996, which gave local communities rights to manage the forests around protected areas to fulfill their needs and at the same time maintaining the buffer zone forests as a security belt to conserve core protected areas. There are two other Acts pertaining to conservation of biodiversity: the Aquatic Animals Protection Act (AAP Act) 1961, and National Trust for Nature Conservation (NTNC) Act 1982 (previously KMTNC Act). The Aquatic Animals Protection Act 1961 provides legislative protection for habitats of aquatic species.

3.2.2 Outputs from the Transect Appraisal Exercises: An initial assessment of impacts of climate change on forests and biodiversity

	East	**Central**	**Far West**
Mountain Ecological Zone			
Impact	• Habitat changed, invasive species has increased. • Increased forest fire • Upward shifting of Utis , less snow fall • Diseases and insects have increased. • Parasites have increased in Utis • Leopard, katus, ground grass, jackal, Himali Vulture, yakura have decreased • Deer, porcupine, Kalij and Luiche have increased • Early flowering is observed in Rhododendrons, Stem borer (beni kira) and larva increased	• Upward shifting of tree species. • Landslides and erosion are increasing. • Jackal is now common. • Migratory birds like cranes are not seen in the sky. • Domicile crane do not use this migratory route as before • Firewood scarcity means roots are now used as fuel, increasing the damage to forests, promoting erosion, and exacerbating desertification (Mustang).	

Coping/ Adaptation	• Afforestation programs • Bio-engineering techniques to stabilize slopes. • Various community user groups are formed • Fire lines are made • Community awareness to conserve and protected endangered species	• Restricted grazing and initiated plantation by community. • Initiation of forest management by using forest operational plan by community forest user groups	
Hill Ecological Zone			
Impact	• Utis, chestnut and chilauni are increasing, Insect attack in sal and utis • Upward shifting of Dhupi salla and Utis • Stem borer and Aijuru increasing • Increased regeneration of seedlings per hectares • Water source are decreasing • Risk of fire and fire incidences are increasing • Rate of natural regeneration has slowed. • Landslides are increasing • Birds and animals like Dhukur, Nyauli, Vulture, Kalij, Jackal, Pangolin, Dhukur, Bhakur and Haleso are decreasing • Increase in number of deer, monkey and rhododendron • Early flowering of plants like simal and rhododendron • Diseases and insects have increased • Eupatorium is replacing tite and allo. • Wide spread of eupatorium • Banmara rapidly spreading	• Diseases are seen in trees like sal and katus • Local wild vegetables and herbs like “Jaluka”, Sugandhakokila and wild mint are disappearing • Forest are getting drier and more susceptible to fire • Forest area is increasing but water is decreasing • Water table declining • More drought and floods • Erosion and landslides due to high intensity rainfall • Early sprouting in trees • Poisonous snake like cobra and caret are seen • Crane, vulture, bat, local dhukar, white money and vulture are disappearing • Terai dhukar, jackal, deer and red monkey are seen • Local rice (marshi), cucumber and bitter gourd are disappearing (Palpa). • Eupatorium is increasing in forest and common land.	• National forest is declining whereas community forest has increased. • Sandan, bamboo, nigalo, silajit, taxus, guchichau, bhase, satu, panch aule, silajit, amala, ritha, timur, bel, yarshagumba, Aiselu, Chutro mushroom and other medicinal plants are decreasing • Forests are getting dry and susceptible to fire • Dry season discharge has decreased, • Lakes, ponds, streams, water chanals in forest have less water or even dried up • Soils are getting drier • Landslides is increasing • More flash flood and river bank erosion • Fruit ripening period altered • Early flowering of Rhododendron • Local birds like eagle and vulture as well as migratory birds

			are decreasing • Wild animal and fishes are decreasing but harmful animals like wild bores are increasing • Pests have increased. Insect infestations are occurring for longer period. • Invasive species like Lantana and Eupatorium is increasing
Coping/ adaptation	• Bioengineering • Forest protection and management (Community forest promotion) • Use of alternate energy • Forest management, fire protection, fire line construction • Control of invasive species • Awareness on community for conservation and protection of endangered species and animals	• Utis are harvested • Vulture conservation • Conservation of ponds • Management of community forest • Fire protection programme • Collection of dry leaves from ground • Awareness programmes in media • Pesticides use has increased • People change their habits • Use of water pumps • Rainwater harvesting • Silviculture operation • Bio engineering	• Management of forests by community • Fire protection • Bio-engineering • Conservation pond in Churia. • Arhar been used to control Lantana. • National parks and wild reserves • Shifting to alternative energy such as biogas and solar
Terai Ecological Zone			
Impact	• Khair, sissoo and simal trees are decreasing in forests (Sunsari). • Forests are drier and there are more incidence of forest fire • Ponds are drying • Water table is declining • Wetland is shrinking • Biodiversity loss due to floods and siltation • River bank cutting has become common • Python, peacock and maina, Crab, Jhingefish, buhari, tengra, singhi, shipi, bet, kamal, purni pat, chakhewa,	• Neem and tulsi are decreasing • Water logging at the time of flooding has killed the trees • Sissoo trees are killed by diseases. • Blossoming season has started later • Forest are getting dry and chance of forest fires • Water sources polluted • Decline in soil moisture • Jackals, kilhat, malchari, Changal chehara bird, earthworm, barula, cobra and vultures are increasing. • Furmudhhi birds are getting extinct.	• Diseases are seen even in wild trees like sissoo • Satisal, harro, barro, sal, kurilo, pipla, dalchini, kaulo and bijasal trees • New insects are damaging fruits and trees • Wild fruits and vegetables such as mushrooms are reduced in forests. • Early ripening of forest fruits like Jamun, pyarifal and

	ghaghan, pani hans, Karra, diddha, pani kauwa, sparrow, peacock, leopard, monkey, rajhans and small bees are decreasing • Migratory birds have reduced • Wild buffalos are increasing • Diseases and insects increased. • Michenia macarantha and Lantana are increasing • Increased attack of termites	• Pests in agriculture land are increasing. • Forest fire increasing • Indigenous vegetation has declined • Invasive plants like lantana and michenia are encroaching forests and common lands.	damarahi • Early defoliation and early sprouting and flowering in trees • Reduced soil moisture • Forests are getting drier, forest fire increasing • Reduced water in canals and sources • Water table declining • Lakes, ponds, streams, water chanals in forest have less water or even dried. • Wetlands are shrinking • Siltation of river and flood destroying agriculture land • Forest and water related disaster like is increasing • More erosion in Churia • River cutting of forest edge and agriculture land and road • Less rain and more flood • Fishes, tigers, elephant, cheetals, malewa, suga, gauthali, eagle, hyena, deer, vultures, cranes and owl are decreasing. • Mating season of wild dog has changed • Wild bore, porcupines and monkeys are increasing • Invasive species like Lantana and Michenia are increasing

			• Harmful insect are increasing in forest, farm and village. • Snake, insects and frogs are increasing
Coping/ Adaptation	• Plantation in forest, communal land and long the rivers • Management of Churai forests River training and bio-engineering • Maintenance and protection of green belt • Awareness raising and capacity building of community forest use groups	• River training and construction of embankments • Bio-engineering • Protection and management of community forests. • Wetlands management • Trees, plantation • More irrigation facilities. • Cultivation of local species. • Awareness camps Installation water purification technology both in surface and ground water • Use boiled water for drinking • Change in rice type	• Community forest management • Plantation in blank patch of community forests and along the stream bank • Flood affected areas around the river are planted with sissoo tree • Forest fire protection • Institutions work in order to minimize park-people conflicts. • Urban population depends on non-fuel-wood energy sources

Discussion

The stocktaking review of literature relating to climate change, forestry and biodiversity in Nepal revealed a lack of concrete scientific data on the impacts of climate change for this thematic area. Further, there are no comprehensive databases of biological diversity in Nepal so there is no baseline against which to evaluate the impacts of climate change at a national scale (NCSA, 2008). However, the anecdotal evidence from the Transect Appraisal Exercise showed that communities are experiencing changes in temperature, rainfall, water availability in forests. Communities also stated that they are experiencing seasonal changes that are resulting in early sprouting, flowering and fruiting.

In some cases, these changes are bringing benefits to communities, increasing the ecological range of cultivation for certain crops. In other cases, climatic changes are having a negative impact, for example herbs like *Bhase*, *Satu*, *panch aule*, *silajit*, *amala*, *ritha*, *timur*, *bel* are declining and shifting to higher altitude ranges. There is a sharp decline in the green grass in the Himalaya region (Mustang). Animals like leopard, jackals and vultures have drastically reduced. Similarly migratory birds are seen less (Mustang). In the Far Western Mid-Himalaya region, the decreasing Nigalo and bamboos have affected the livelihoods of the communities dependent on making *doko*, *dalo*, *nanglo* and *mandro*. Further, increases in temperature are being associated with the appearance of new parasites, pests, and diseases into areas where the people do not know to tackle these new problems. Increasing temperatures and changing precipitation patterns are also being associated with an increase in forest fires. The transect visit did, however, also reveal a need for a greater level of root-causes analysis in identifying climate change impacts and developing adaptive strategies. For example, in the mid-hills it was reported that

wild herbs are disappearing; however some respondents suggested that this was a result of over-harvesting or illegal harvesting rather than changes in the climate.

Many of the vulnerability and adaptation issues discussed under forestry and biodiversity are also relevant for other TWGs. For example, one adaptive strategy identified by the Agriculture and Food Security TWG was agricultural diversification, which depends on biodiversity; while forest plantations have been identified as adaptive strategies under other TWGs given their role in regulating water flow and controlling erosion.

During the transect visits, a rapid institutional analysis was undertaken to identify which institutions were playing a role in coping and adaptation strategies. At the community level, community-forestry user groups, "buffer-zone" groups and lease-hold community forestry groups were mobilizing themselves to undertake afforestation programmes and were also forming fire management committees. CFUGs are also being targeted by many NGO and INGO programmes for awareness raising. Community forestry was identified as one of the best options for building adaptive capacity for communities dependent on forests and biodiversity.

At the district level, the key institutions identified by the transect were the District Soil Conservation Office; District Forest Office; District Agriculture Office; and District Livestock Office (similar institutions to those also identified by the Agriculture and Food Security Group). The VDC and DDC and municipality also played a role in supporting coping strategies. NGOs working with FUGs included FECOCUN, CDM Nepal and United Mission Nepal, as well as conservation NGOs.

The stocktaking report also reveals several national institutions and policies/plans that play a role in supporting coping and adaptation in Forestry and Biodiversity. These include the Ministry of Forests and Soil Conservation, which has recently brought forward the National Forest Fire Management Strategy , 2009 (B.S. 2066). The strategy calls for policy and legal reform, education and awareness, forest fire management, research and information dissemination, and the development of partnerships and networks to combat forest fires. The Ministry of Environment is another key line ministry that should be engaged in managing adaptation for forest and biodiversity. Under MOE, the National Climate Change Policy is currently being finalized, which calls for (among other strategies) the implementation of land use plans sustainable management of forests with livelihood opportunities, and plantation in communal and private lands. The policy also mentions forest fire management and using forests for carbon trading. The policy proposes integrated ecosystem management and plantation of multipurpose trees (National Climate Change Policy, Draft 2066).

3.3 Agriculture and Food Security

3.3.1 Overview of Agriculture and Food Security situation in Nepal

Agriculture remains Nepal's principal economic activity, employing 66 percent of the population (CBS, 2003). Its contribution to national economy is estimated at 33.1 percent (MOAC 2007). About 27 percent of the land is cultivable of which 38% has irrigation facility (MOAC 2008). Smallholders and subsistence farming predominates the agriculture scene, constituting 78% of all agricultural holdings with an average holding size of 0.8ha (Karkee 2008). The present annual production of cereal crops stands at about 8.1 million tons. The total annual production of potato, oilseeds, and pulses together stands at 2.35 million tons, and fruits and vegetables 5.9 million tons (MOAC, 2008).

The food security situations are very variable over ecological zones and development regions. Forty districts are food deficit (2008). All districts in the mountain region, six of the 39 hilly districts and five of the 14 Tarai districts are food deficit. Although the *Terai* generates agricultural surplus, supplying much of the food for the food-deficient hill and mountain regions; all *Terai* districts produce surplus food except districts of central and far western regions. The other food deficit regions include central and far western regions. The total food deficit for the mountain, mid hill and the *Terai* region is at 127, 483 and 125 thousand tons, respectively. To meet the national food demand Nepal imports over 485 thousand tons of foods every year (MOAC, 2007/8). Until recently, food situations are estimated based on the production and supply of main cereal crops though other agriculture sub-sectors livestock, horticulture, poultry, fishery, potatoes including other cash crops increasingly contributing to peoples' livelihoods.

Because of very rain fed nature of Nepalese agriculture, any extent of climatic deviation directly affects agriculture productivity, putting food security more uncertain. Under similar and even worse climatic situations, India would not be in a position to supply foods to Nepal. Hence, declining food production to create situation where people may not have access to food even if they have cash to purchase. Hence, Nepal can be food secured only when it becomes self-reliance on food production to feed the growing population.

Food crops cultivated under natural conditions are affected most from climatic variability, climate change and climate induced disasters. Food becomes unsecured when climate change directly affect production of nationally important food crop species particularly rice, maize, wheat, potatoes, millet, barley and buckwheat.

Impacts of climate change are often related to declining agriculture performance. Impacts of climate change varied over ecological zones. Inconsistent productivity of winter potatoes in the hills and summer season potatoes in mountain region are associated with increasing uncertainty in the form, timing and intensity of precipitation. In mid hills, climate change impacts are observed on maize and maize-based ecosystems. Likewise, in mountain and mid hill regions, climate change impacts are observed on fodder and forage production as a result, animal herders are gradually decreasing their herd size.

Unlike mountain and hilly regions where foods are sort supply, Tarai region as of 2008/9 produce sufficient food (MOAC, 2008/9). In the *Tarai* region rice is cultivated in 1.5m hectares; most of which remains fallow, but remaining goes under cultivation of winter crops especially wheat. In eastern and central Tarai regions, where total rainfall and available soil moisture are recorded high, more than 90% areas left fallow after rice. Most crop growing areas are rain fed and therefore the extent and distribution of rain fall as well as the availability of soil moisture content affect crop production. WATBAL model analysis revealed that soil moistures are favorable throughout Tarai regions during June to December but face deficit between February and March. Also the model revealed western Tarai faces severe moisture deficit stress especially when winter rains were not received (Pandey *et al*., 2000). Also cold or hot wave affects crop yield. In the Tarai region, area under winter legumes such as chickpea and Kheshari (*Lathyrus*) has decreased by 36-40% (Pandey *et al*., 2000). Over the last 15 years, the area under lentil has however, increased by 75% which compensated total legume areas by 27% and production by 60%. In another study where ten years yield data was analyzed (1987-1997), show a reduction of yields of potato (28%), Toria (37%), Sarson (11%), Rayo (30%), Lentil (38%) and Chickpea (38%) primarily due to climate related stresses especially cold waves (NARC 2007). Hence, climate induced impacts have already been experienced regardless of crop system and agriculture commodities under use.

The vegetable and fruit crop species are important commodities that contribute to food security which generate cash and supply nutrition. In Nepal, the estimated area and production of vegetable crops is

221,108 hectares and production is 2,724,904 tons. The central region produces the highest volume (1,105,208 tons) followed by eastern region (601,413 tons) and western region (374,211 tons). The summer fruit crop species especially mango, banana, guava, papaya, jackfruit, pineapple, lychee, coconut and areca nut are cultivated in 31,858 hectares and the total production is estimated at 304383 tons. The area and production of citrus species (mandarin, sweet oranges, lime and lemon) recorded are 19,915 and 226,404 hectares, respectively. Like wise the total area of winter fruit crops particularly apple, pear, walnut, peach, plum, apricot, persimmon, pomegranate, and almond are 1,362 hectares and the production is estimated at 9,564 tons. The production and distribution of citrus, winter and summer fruit species are variable across the ecological regions within each development regions (MOAC, 2007/8). Over the last decade horticulture sector has been established as potential entrepreneur in Nepal. UNDP funded MEDEP counts more than 30,000 micro-enterprises developed of which 29 percent are horticulture based. These micro-enterprises not only generate income, created jobs for above 35 000 people but have aspired people towards agro-based micro-enterprises (Pun, 2008). Any impact due to climatic variability on horticulture crop can directly affect such agro-based micro-enterprises. For example, a slight deviation on the form, timing and frequency of precipitation can decrease yield of temperate fruit. Increased temperature and decreased total number of chilling hours when combined with rainfall instead of snow improves size of the apple fruit but the number of fruits per plant may decrease.

Spice crops are other important sources of cash generations. The cultivation and promotion of cash crops generates both income and employment. The spice crops such as ginger, garlic, turmeric and chilly are cultivated mainly in the mid hill region. The crops grown in relatively large area include ginger (14007ha), cardamom (13784ha) and garlic (4958ha). The other region specific cash crops grown include cotton (75ha), tea (16,594ha), coffee (1,450ha) and jute (11,590ha) and their production has been recorded at 69; 16,127; 276; and 16,988 tons. Their export internationally has also significantly contributed to the national economy. Certain degree of climate change impacts are observed on the performance of annual spice crop but yet unclear about impacts on the performance of perennial fruit crop species.

Despite climatic stresses, local communities have been continually searching adaptation measures based on locally available resources using their own knowledge. Also people are increasingly seeking technical advices from service providers as well as raising voices for supports to combat growing climatic impacts. Despite growing scope of cash crop production and entrepreneur, agriculture has not been a preferred enterprise of the young and educated people. Together with cultural belief peoples' interests are declining towards agriculture. Some of the critical reasons are lacking insurance policies and resilient mechanism to climatic hazards and growing migration trend in search of work. Studies have also shown that migration has been increasing over years. 96% of surveyed informants reported that rural people migrate year round to look for work. 57% informants reported that migration takes place between November and April though some migrate during July and September. The majority migrants seek non-agriculture wage labor, some engage in agriculture wage labor and other income generation activities. 66% reported people aged between 20-29 years out-migrate in search of work The highest rate was reported from the hills followed by central and western regions (WFP, 2005). Growing trend of migration for alternative work and discontinue agriculture occupation concerted efforts are required that aspire to retain economically active population in agriculture.

Livestock products are important sub-sets of agriculture, which contributes to the national economy and peoples' livelihoods. The animal products developed locally include milk and milk derived products, meat and egg. Nepal produces more than 333,900 metric tons every year of meat from buffaloes, sheep, goat, pig, chicken and duck. Buff and goat meat constitute the largest proportion of the total production. The highest amount of meat is produced in the central region (71,075 tons per year) followed by eastern region (58,726 tons) and mid western region (45,244 tons). Similarly, the milk production record reveals that the highest volume of milk is produced in the central region (407,427

tons) followed by eastern region (341,973 metric tons) and western region (323,471 tons). The quantity of meat and milk production is related to the demand of the population of the region. An increased production of meat and milk in central and eastern regions are due to growing market demand created by growing population along with urbanization. Increasing income earned through remittance and agriculture and forest production peoples' purchasing power have also been increasing which can be seen on their improved dietary diversity. However, income disparity between rich and poor has widened over years. Along with the reduction of absolute poverty from 42% to 31% unequal income distribution was increased from 0.31 to 0.41 (HDI, 2008).

Food security situation

Until 1990, Nepal produced sufficient food grain to feed it's population (Koirala and Thapa, 1997). In later years, the food production did not meet food requirements for the growing population especially between 1990 and 1998. In 1999, agriculture production regained and Nepal become self-sufficient. However, 2005/06, production declined and estimated deficit of 179910 tons for the year 2006/07. Food security has deteriorated due to reduction in the access of means of production and resources, inequality within households, shortfall in emergency assistance, and consumption of easily available but less food. This also supports that Nepal food situation is primarily regulated by climatic conditions (MOAC, 2006-7).

Current food analysis situation reveals that more than 3% of the total food would be required to meet food demand for the growing population (MOAC, 2008/9). This deficit is accounted at 5 kg/capita/year. The situation varies by development and agro-ecological regions. The surplus food produced on the Tarai region does not meet food deficit likely to occur in the mountain and hill regions. The analysis reveals that all the mountain regions observe food insufficiency except the eastern mountain. Similarly, east and western hilly regions produce enough food to meet the requirements but acute food shortage likely to happen on far western and central hilly regions. Overall, Tarai region produce surplus edible cereals. The highest food production would to be attained on the western Tarai followed by central and eastern Tarai regions. As the analysis of climate change scenarios for Nepal and the recent transect appraisal exercises revealed that the western regions are affected most where acute food deficit has hit hard the people especially surviving below poverty.

Apart from edible cereal crop production and supply there are important commodities that significantly contribute to household food security. Though potatoes, livestock, fisheries and poultry are not directly considered in food security analysis their contribution to supply energy and generate income need to be highly valued. Agriculture sub-sectors across mountain, mid hill and on the Tarai regions are thus being affected from climatic hazards. Obviously, people cultivating marginal lands and ecosystems become more vulnerable to climatic vulnerability.

The transect appraisal exercise conducted in Karnali. Gandaki and Koshi river basin revealed that the nature of change, kind of impact as a result of climate change and peoples response to such changes and institutions involved are briefly summarized by individual ecological regions.

Mountain agro-ecological zone

The major climatic changes reported include increase in temperature; water scarcity; change in precipitation pattern; soil erosion and finally the climatic variability, which makes everything unpredictable. As a result, impacts have been observed on agricultural production (food crops; cash crops; and livestock). In response to these problems high hill farmers adopt a variety of adaptation measures and or coping strategies. Depending upon the situations people Intensify inputs (demand side options –change the way they use resources

- Prioritised uses of water; rainwater harvesting; tapping snow;
- Restricted grazing of animals/ reduced herd size
- Improved irrigation efficiency
- Alternative/diversified livelihoods – using alternative energy/ diversification of occupation
- Diversifying crops that are better adapted
- Moving away from the sector or shifting occupation
- Migration is taken as a last option

Some of the critical issues not addressed from the field but need further verification include who has access to these strategies? Do they actually build resilience? If they do then how can planned adaptation support them? Do local people envision different kind of adaptation measure? It is unclear if people do have capacity to protect apples from hailstorm or cold wave? Also we don't know if R&D can support more resilient apple production? Further studies are required. Further details are given in Table 1.

Table 1. Outputs from the Transect Appraisal Exercises: An initial assessment of impacts of climate change on Agriculture and Food Security

	East	**Central**	**West**
High hill ecological zone			
Major commodities	Potatoes, Maize, millet, Rice and Livestock	Potatoes, Barley, Buckwheat, Millet, Apple, Sheep	Potatoes, Maize, Livestock, Rice
Crop pattern	Upland Bari land Lowland system	Upland Bari land	Upland Bari land Lowland system
Impact	• Planting times delayed • Yield declining • Reduced natural water sources • Loss of crop diversity • Increased parasites, pests and diseases • Crop maturity shortened, reduce yield • Citrus yield declining • Time of FMD incidence changed • Certain animal's fertility affected adversely • Increase skin disease for farm animals • Fodder and forage supply decreased	• Change in precipitation led to less percolation of water, decreased rangeland productivity, affecting livestock • Transhumant owners Dhoppa affected • Water related impact led Chosher village to migration (Ward No. 9) • Upward expansion of apple, potato and vegetable cultivation • Water scarcity decreased crop yield • Damage of crops due to hailstorm • Increase in diseases	• Stream flow very fluctuating • High flow (flood) for lesser time with debris • Landslides/erosion more • Uncertainties in weather patterns leading to crop loss and food insecurity • Farming becoming uncertain despite expansion of cropping period • Extreme poverty increasing • Migration from hills

			to plains

Coping /Adaptation	• Plantation around farm lands and water sources • Crop diversification • Reduced uses of water at home and farm • Rain water harvesting • Raise voice to have access to and control over of local water sources • Seeking technical advices • Accepting crop loss and out-migrating • Started using local compost to increase farm productivity • Promoting non-timber plantation to increase food/fodder supply	• Restricted grazing • Change in crop type from apple to orange • Tapping snow, • Small scale irrigation increased to 14 VDC • Alternative energy sources-improved cooking stove; solar panel; back boiler; smoke water heater; micro hydro power are getting more attention • Forest plantation	• Seasonal/permanent migration (India is key destination for labour migration) • Alternative livelihood skills being facilitated (donor supported activity) • Poor institutional support

Mid hill ecological zone

The major crops grown across the regions include maize, rice, potatoes and millets. These crops are cultivated primarily under upland condition except rice, grown under irrigated and rain fed conditions. Some impacts of delayed rainfall (climate variability) have been reported especially crops cultivated both on upland and rain fed ecosystems. If rainfall patterns are consistently delayed it can be adjusted by changing time of crop plantation, shifting crop species or by breeding crops that are climate resilient. If the rainfall patterns are variable and does not follow certain trend it may be difficult to address climate change impacts. An increased temperature however, facilitates some crops to expand their ecological belts, an indication of climate change, could offer more potential options for hilly farmers. However, it may pose constraints especially perennial tree crop species with long gestation period. In such cases impacts of climate change cannot be adjusted by manipulating planting time. When climatic situations are becoming consistently unpredictable then the only way to address them is to chose adopt different strategic options beyond selection of certain crop varieties or practice. Hence, shifting of crop species from C3 to C4 and cropping system may be more desirable. To make such crucial decision local people need to be provided with recent climatic information that helps local people to make more appropriate adaptation decision. To deal with complex situations multiple strategies need further exploration. Further details are given in Table 1.

Table 2. Outputs from the Transect Appraisal Exercises: An initial assessment of impacts of climate change on Agriculture and Food Security

	East	**Central**	**West**
Mid hill ecological zone			
Major commodities	Maize, Millet, Potatoes, Rice and Livestock	Maize, Millet, Potatoes, Rice, Citrus and livestock	Maize, Potatoes, Millet, Barley, Livestock

Crop pattern	Upland Bari land Rain fed Lowland system	Upland Bari land Rain fed Low land	Upland Bari land Rain fed Lowland system
Impact	• Decline in productivity of crops, livestock, fishes • Decline in quality of agricultural products • Aphid attacks increased • Decrease of forest, fodder resources, • Loss of local crop diversity • Increased parasites, diseases pests incidence on livestock and crops • Delayed onset of rainfall delays cropping, reducing yields • Untimely maturity of staple food crops (rice, maize), affecting yield • Increased incidence of animal disease (e.g., skin ailment, singane etc.)	• Wetland Jaluka "wild saag" disappeared • Wild mint ,local cucumber, marshi rice, Sughanda kokil (medicinal plants) and bitter gourd disappeared • More incidents of pocket rainfall • Decrease in agricultural productivity • Early maturing hybrid rice affected • Delayed rainfall results in delays in paddy transplantation thus 40% decrease yield of early varieties • Increased lodging on paddy and maize • Delayed rain resulted yield decline in legume like cowpea • Declining yield on orange production • Size of mandarin decreased • Increasing crops disease infection, late blight in potatoes • Increase insect attacks (fruit fly and grasshoppers) • Increased intensity of wind (cyclone type winds) responsible for destroying plastic tunnels used for vegetable growing • Production of rapeseed has *increased*, some legume crops now be planted for longer periods. • Increase in Distokia and Prolapsii amongst buffaloes. • Decrease forage/fodder due to decreased rainfall	• Increase in post-monsoonal landslides • Disappearing local rices Simtharo, Jhinua, Local livestock breed Achhame cow • (Naumuthe Gai) • General decline in agricultural yields • Food production declined as a result of drought/moisture stress • Price hike of commodities adding to the existing problems • Lack of water has been discouraging to keep/rear livestock • Persisting hunger amongst the ultra poor

Coping/Adaptation	• Grow vegetable crops, toria, niger in place of potatoes • Selection of short duration and drought resistant crop varieties • Rain water collection, Lift water technology, Drip irrigation • Use of flukocide, pesticides, insecticides • Use of high potential drugs to control aphids • Food insecurity leading to out migration • Increased cultivation of fodder grasses (especially, napier, broom grass)	• Used improved varieties and fertilizers • Use water pump to pump water from downstream • Rain water harvesting at local level • Use of ground water • Changes in types of crops planted and cropping pattern; • Use of new seed varieties and seed selection to address the problem of plant lodging. • Use of small scale irrigation sprinklers, drip irrigation • Formation of farmers' cooperatives to increase vegetable, seed for market to earn cash • DADO supports small scale irrigation via plastic pond, sprinkler and surface irrigation. • Existing insurance for livestock. • DADO, DLSO and VDC provide funds for capacity building. • Funds available to train local resource persons. • Development of milk and agriculture collection centers and whole sale vegetable markets.	• Shifting to less water requiring crops (wheat, maize & millet) wasn't successful • Shifting to vegetable crops (subject to availability of assured market) • Water reservoirs for storage • Accept loss and continue to grow cereals • Provisioning of seeds by authorities (which can withstand moisture stress) • Migration (temporary) and sending remittance for family members • Permanent migration to plains • Food aid for the food insecure poor

Tarai ecological zone

Agricultural production system consists primarily of sub-tropical food crops; vegetable and cash crops and livestock. Since agriculture has been the prime basis of food security climate change impacts on agriculture directly influence peoples' livelihoods. The main climate induced changes identified include changes in precipitation; temperature (shift in agro-ecological belts); increase in climate variability; increase climatic hazards (land slides; floods; pest & disease outbreak) and more importantly water scarcity for agriculture and also for household use. These changes pose a variety of impacts on food crops; cash crops and livestock systems differently:

- Food crop systems – crop productivity is declining especially the most important staple crop paddy, winter crops like wheat, legumes due to climatic variability and increased infestation of crop pests.

Local people are responding by changing plantation time; type of crop; promoting small- scale irrigation scheme; change in sources of plant nutrients and tillage practices.

- Cash Crops – two different types of cash crops are grown in the area – fruit trees mango etc) and spice crops such as ginger, garlic etc. The tree crop species being affected by changes in temperature; timing of hot or cold waves and change in precipitation – how farmers are choosing alternative crops for fruit tree species. Little is known about alternative options local peoples are adapting if there are impacts on cash crops? Further field testing is required.

- Livestock – farmers raise serious concerns about decreasing supply of forage and fodder, which has forced livestock farmers to reduce the number of livestock. Some of the impacts reported include change on timing of animal breeding, increased cases of sterility and learn the root cause of sterility (forage supply/rainfall/poison content). Local people strongly raised the livestock insurance issue during the discussion. Further details are presented in Table 2.

Table 32. Outputs from the Transect Appraisal Exercises: An initial assessment of impacts of climate change on Agriculture and Food Security

	East	**Central**	**West**
Tarai ecological zone			
Major commodities	Rice, Wheat, Potatoes, Legumes, spring maize, Mango, vegetables, Livestock	Rice, Wheat, Potatoes, Legumes, spring maize, Mango, vegetables, Livestock	Rice, Wheat, Potatoes, Legumes, Mango, vegetables, Livestock
Crop pattern	Lowland Rain fed Upland	Low land Rain fed Upland	Lowland Rain fed Upland
Impacts	• Crop planting times delayed • Crop yield decline • Reduced recharge rate for ground water, natural streams and ponds • Increased frequency of floods • Increased cases of crop failure • Decline soil fertility • Decrease forest, fodder resources • Loss of biodiversity esp. aquatic, • Increased parasites, pests but useful insect population decreasing • Decline in crop productivity, affecting	• Changes in crop production • Blight in potato, onion and chili, blight disease in wheat, mango hopper, banana virus, lentils 'pigeon pea' with 'pod borer' • Decreased livestock and fish production • Changes in water availability/drought and flood pattern • Mango hopper destroying mango; increase banana virus, banana productivity declined • Livestock production declined due to increased infertility. • Increased cold waves	• Groundwater depletion • Floods/ landslides/ erosion increasing, • High volume flow for short time during flood • Flood with debris is observed more, erosion of land increasing, • Reduced source of surface water, ponds, micro-irrigation, • Disappearing certain animals and birds species • Appearance of certain diseases, pests and insects • Early drought affecting yield • Cost of production increased due to groundwater based irrigation • Occasional forest fires reducing potential grazing,

	food security	increasing calf mortality. • Fish stocks in decline as the 'black swimmer' (an insect pest) becomes more resistant to pesticides • Large areas of agricultural land inundated, affecting crop production	livestock • Number of livestock declining
Coping/Adaptation	• Replace shallow tube well by deep tube well • Introduced toria, niger, arahar, maize in place of potatoes, jute • Rain water collection • Short crop chosen, Hardy crops chosen • Use of flukocide, local pesticides, insecticides, • Use of high potential drugs to control aphids • Growing drought tolerant crop varieties • Applying increased amounts of agricultural inputs and technologies • Varieties with shorter crop rotation sought Assistance for changing crop calendar sought	• Reduction of synthetic fertilizers and increased use of organic manures. • Minimum or zero tillage • Farmers cooperatives established to deal market and production issues • Aeration of ponds to address lack of oxygen and have reduced the used of fertilizer • Recommended use of biological pesticides. Shift into organic farming, thereby increasing the economic return from crops • Livestock insurance reduces risk. However, current insurance provision may not be well suited to weather related risks and uncertainty. • Use of treadle pumps and shallow wells ensure access of marginalized communities to irrigation.	• Switching of cropping pattern from cereals to fruits and vegetables preferred for less availability of water and unpredictable rainfall • No micro-irrigation adopted, No irrigation system adapted • Villagers go to India seasonally • Conservation ponds for water storage • Construction and refurbishing of embankments • Switching to alternative livelihood skills • New rice variety (limited social acceptance) • District level institutions are in place, along with NGO/INGO and donor support

Discussion

The impacts of changing climate identified by the Agriculture and Food Security team clustered around water-related issues (changes in precipitation type, frequency and intensity affecting irrigation and cropping patterns); changes in agro-ecological zones (expansion of cropping seasons/areas; shifting disease/pest and parasite patterns); and implications for livestock performance (result of changes in grazing and fodder provision). These issues were reflected also in other thematic groups especially Water and Energy and the Forests and Biodiversity.

Not all the impacts of climate change were negative, however; for example, toria production was reported to be increasing in the central mountain region. The positive opportunities provided by climate

change were also highlighted in the Agriculture and Food Security stocktaking report. It is reported that CO2 enrichment studies revealed an increase in performance of many rice and wheat varieties. Closer observation of which species might thrive under changing climatic conditions will help to move communities beyond simply coping with climate change towards strategies that help than adapt in a progressive way.

Decreased in number of rainy and cloudy days but increased number of drier days that remain longer also decline relative humidity. Since water also regulates temperature and wind behavior any changes on precipitation can bring changes on wind and atmospheric temperature. Field reports have been that agriculture and forage species are affected by changed climatic factors, temperature, wind and precipitation. The direct and observable impacts were reported on timing of flowering, fruiting and maturing behavior especially citrus, and temperate fruit crop species. Changes on timing of cold and hot waves and westerly winds have direct and negative impacts on Tarai agriculture in general and on winter crops in particular.

The adaptation and coping strategies revealed were similarly cross-thematic. Adaptive strategies clustered around improved water management, including micro-irrigation systems and rainwater harvesting. Another common adaptive strategy was crop diversification and changing farming practices, which require greater attention to identifying and promoting more resilient species, , a priority also identified under Forestry and Biodiversity. Plantations were also noted as an important means of both improving water and land management and also providing ecosystem services, also identified under the Forestry and Biodiversity Group. Development and promotion of crop varieties adaptable to climate change conditions was raised throughout discussions. Crop insurance schemes were identified on a small scale but at present there are not responsive to climate change and would need further analysis**.**

Some “adaptive” strategies, however, had been noted to be unsuccessful or even poorly adaptive. Some rice varieties adopted in the eastern Terai region, for example, were not taken up by the community due to differences on cultural preferences for aroma and tradition. In the mid-hill eastern region shifting to less water requiring crops was also unsuccessful. Farmers increasing seeking advices from local institutions also suggest that local initiatives alone are inadequate. It has raised several questions about adaptive capacity of the locally available options.

These cases suggest that assessing the effectiveness of coping strategies in building adaptive capacity to deal with short-term; medium-term and long term climate change impacts; effectiveness in addressing the coping capacity of different natural and socio-economic systems. Effectiveness in addressing some of the cross cutting issues– for instance addressing the concern of food security when food crop production is declining and the challenge of agricultural growth such as enhancing cash crop production. Adaptive capacity dependant also on the degree to which people take decision on adaptation measures based on informed knowledge and relevant information.

During the Transect exercise, the Agriculture and Food Security TWG also considered many gaps and opportunities that could be addressed by NAPA. These included the need for awareness raising campaigns to inform people about the long-term nature of climatic changes and encourage greater risk-taking towards longer-term adaptive strategies rather than short-term coping to existing climatic stresses that may worsen; a focus on improved water management and soil conservation strategies, noting the cross-thematic benefits of a water-based approach for agriculture, forests, water and energy, health and sanitation, and disasters and infrastructure.

Literature review revealed that not all people of different social and economic strata are vulnerable to climate change. The degree to which people enjoying good infrastructure facilities and regions where climate change has minimal impacts are less vulnerable compared to those exposed to marginal areas with poor housing and poorly developed infrastructure including agriculture road, irrigation, technical services. The more the people are exposed to the natural but vulnerable areas the more they become vulnerable to climate hazards. These findings was supported by transect appraisal exercise conducted through Koshi, Gandaki and Karnali regions.

In terms of institutions, Framers Groups were identified as a key institution at the community level that should be engaged in adaptive planning and management. District level agricultural institutions are also in place and active, although greater outreach to vulnerable communities of agricultural extension services as well as farmer subsidies has yet been an issue. Since climate change scenario is an added dimension to local development and orientation of the officials and empowerment of local community are equally important.

3.4 Urban settlements and Infrastructures

3.4.1COUNTRY SITUATION OF URBAN SETTLEMENTS AND INFRASTRUCTURES:

3.4.1.1 Socio-economic Indicators of Nepal

Nepal is dominantly a rural country with about 85% of the population residing in the rural areas. Average per capita GDP is US $470 for the year 2007/2008 (CBS, 2008), one of the lowest among the SAARC countries.

The mainstay of the Nepalese economy is agriculture contributing nearly 40% in the national GDP. Nearly 65% of its population totally depends upon agriculture, forestry and fishery (CBS, 2002), while additional 20% are also partially engaged in agriculture for the livelihood. The agriculture is highly reliant to the seasonal weather pattern. About 66% of the cultivable land is irrigable; however, only 60% of the irrigable land is under some short of irrigation (NWP, 2005). Of the total irrigated land only 41% has round the year irrigation facility (WRSN, 2002). About 46% of the agriculture output is derived from the irrigated land; while the rest is met from the rain feed agriculture. It is for this reason, that the national GDP growth is highly dependent upon the good and timely monsoon or rain. Overall, yearly national GDP decline when there is bad monsoon, and increases in the event of good and timely monsoon.

The Human Development Index (HDI), a measure of healthy life, knowledge and decent standard of living across the ecological belts of Nepal is unequal (NHDR, 2006). The Hill Zone has higher HDI average (0.543) compared to Terai (0.494) and Mountain (0.436). Both Terai Ecological Zone and Mountain Ecological Zone HDI is lower than the national average of 0.509. The HDI difference is even highly pronounced within the ecological zone from east to west. The Hill Zone has higher HDI (0.602) in the central part of the country where the capital city of Kathmandu is located. Otherwise, there is a declining HDI from east to west (0.519 to 0.443). In the Terai Ecological Zone the lowest HDI (0.468), however, is in the western part of the zone, while it increases both towards east (0.678 to 0.519) as well as to far west (0.481 to 0.503).

The Human poverty index (HPI), a measure of income poverty and low access to opportunities, is estimated at 35.4 for Nepal (NHDR, 2009). HPI as like HDI shows spatial variation by Ecological Zones.

The Mountain, Hill and Terai Ecological Zones HPI are 43.3, 32.7 and 36.9 respectively. The HPI variation within the ecological zone from east to west in the Mountain Ecological Zone gradually increase from 37.6 to 48.1, the western, mid-western and far western Mountain Zone has the highest HPI. Similarly in the Hill HPI is least in the central and western part (28.2 and 38.1) and increase both towards east (34.3) and mid west (40), the maximum being in the far-western part (44.9). In the Terai Ecological Zone, the central Terai has the maximum HPI (41.9) and decrease both to the east (33.8), west (36), mid west (36.8) and far west (35.3).

Nearly 30.8% of the Nepalese population is below income poverty (NLSS, 2003/2004). Percentage of population below poverty in the Mountain, Hill and Terai Ecological Zone is 32.5, 34.5 and 27.6 respectively. In the country context, Mountain (7.5%) has least percentile of people under poverty compared to Hill (47.1%) and Terai (45.4%). Similar to HPI, income poverty is higher in the far-west and mid west compared to the central and eastern Nepal.

3.4.1.2 Population and Population Distribution in Nepal

The population of Nepal enumerated in 2001 was 23.15 million (CBS, 2002) with an estimated national population growth rate of 2.25. The Terai Ecological Zone revealing higher growth rate (2.62) followed by Hill (1.97) and Mountain (1.57). The population is estimated to be doubled in 31 years with about 27.5 million populations in the year 2009.

Owing to topographic and climatic extremes population distribution is not spatially uniform all over Nepal, The Terai Ecological Zone shelters 48.43% of the total population followed by Hill Ecological Zone (44.28%) and Mountain Ecological Zone (7.29%). Physiographically, the least population is in the High Himal and the Chure/Siwalik region. The general trends of population distribution percentiles in the ecological zones (1971 – 2001) shows decreasing trends in the Hill and Mountain with compensatory increment in the Terai Ecological Zone. The average population density is highest in the Terai (329.59 person/km^2) followed by Hill (167.11 person/km^2) and Mountain (32.57person/km^2). But in terms of available agricultural land, the population distribution per hectare of the agriculture land is highest in the Hill (6.2 person/ha) and decreases in the Terai (6 person/ha) and Mountain (3.3 person/ha) indicating higher population pressure in the cultivated land in the hill than in Terai and Mountain Ecological Zone (CBS, 2002).

3.4.1.3 Water Supply and Sanitation Coverage

The Tenth Plan document of GON has reported that the total water supply coverage in rural areas is 71% and in urban areas is 76%. The region wise coverage is as follows.

Water Supply Coverage (Population in '000s)

Region	Rural		Urban		Total	
	No. of Benefited	%	No. of Benefited	%	No. of Benefited	%
Eastern	2917	61	471	70	3388	62
Central	4252	65	1465	85	5716	69
Western	3216	79	412	72	3628	78
Mid-West	2284	80	168	70	2452	79

Far-West	1719	85	114	46	1833	81
Total	**14388**	**71**	**2630**	**76**	**17017**	**71.6**
Basic Sanitation Coverage			(Population In Thousand)			
Basic Sanitation	**Rural**		**Urban**		**Total**	
	4094	**20.0**	**1826**	**53.0**	**6920**	**25.0**

Tenth Five Year Plan, NPC, October 2002

3.4.1.4 Overview of Urban Settlements situation in Nepal:

The municipalities designated by the ministry of local development are the areas in Nepal formally defined as urban. The density, contiguity, and occupational structure of the population (the generally accepted criteria for defining urban areas) have not been taken into consideration in designating municipalities in Nepal. Population size, revenue generation, and availability of facilities and services appear to be the basis for designating a settlement as an urban or municipal area (EIA, Emerging Issues and Challenges, ADB/ICIMOD, 2006). These criteria, however, have not been consistently applied in assigning municipality status to a locality. Some areas have been classified, de-classified, and re-classified as municipalities over the past 50 years, and the territorial boundaries of many settlements have been re-drawn to include surrounding rural areas to meet the population size criteria. As a result, significant parts of the territories of several formally defined municipalities may not exhibit an urban character, while other settlements like small or emerging towns not yet formally defined as municipalities may show a more urban character. While urbanization is a relatively new phenomenon in Nepal, the rate of urbanization, according to the 2001 census, is among the highest in South Asia (3.3million people or 14.2% of the Nepalese population lived in 58 municipalities) (CentralBureau of Statistics 2002). Between 1991 and 2001 the municipal population increased by 94%, or 6.8% per year. Based on this, it is estimated that the total urban population in 2006 was approximately 3.8 million of the total population of 25 million. The government predicts that by 2011, 24% of the total population will be living in urban areas (NPC/MoPE 2003).

14% of the populations in Nepal live in urban areas. Nepal currently has 45 urban areas with populations between 20000 and 100000. Only Kathmandu has reached a population of 500,000 inhabitants or more, and at present only five urban areas-Biratnagar, Birganj, Kathmandu, Lalitpur, and Pokhara-have populations exceeding 100,000. There are many market towns with populations under 10,000.

However, the rapid increase in urban population is not matched by a similar increase in the provision of resources and knowledge to effectively address the growing challenges of urban environmental management. The World Bank Report on Urbanization and Service Delivery in the Context of Decentralization (World Bank 2004) found that the population pressures place enormous demands on housing markets, infrastructure systems, and environmental resources, and that the "Current urban land management and infrastructure service policies and institutions are not positioned to meet the challenge, and need to be restructured to avoid the worse case scenarios."

With increasing urbanization, the urban economy is growing at a rate of 6.4% per annum, more than double that of the rural economy, and the contribution to the national economy is estimated to be around 60% of gross domestic product (GDP) (Nippon Jogesuido Sekkei 2002). The Hill/Mountain region remains the least urbanized in the country, and Kathmandu Valley consistently remains the most

urbanized region. In general, regions with low levels of urbanization have been experiencing faster urban growth. Most urban areas are not very densely populated in terms of persons per unit area. The urban areas of Kathmandu valley are the most densely populated in Nepal. Several municipalities exhibit a more rural than urban character because of expansion of boundaries of existing towns in the process of gaining municipal status to include the population on the fringes that was hitherto classified as rural. Some municipalities are not even linked with the rest of the country by road, and the outskirts of many municipalities can be reached only by a walk of 3-4 hours.

3.4.1.5 Consequences of haphazard urban growth in Nepal

In Nepal, rapid urban growth has taken place without matching expansion of the infrastructure, services and facilities necessary for an adequate and healthy urban environment, and without adequate planning and regulation. This has caused deterioration in Nepal's urban environmental quality. Urban areas in Nepal are commonly facing shortages of safe drinking water and inadequate provision of sanitation, solid waste collection and disposal, drains, paved roads and other forms of infrastructure and services necessary for a healthy environment. These problems are manifest most acutely in the growing squatter settlements that are another aspect of urban settlement in Nepal. Other emerging problems include water shortages and poor water quality, air, water and noise pollution (Environmental Assessment of Nepal: Emerging Issues and Challenges, ADB and ICIOMOD joint publication, 2006).This has resulted in bad water and air quality, unmanaged or mismanaged waste and increasing noise pollution. Urban areas in Nepal are also facing problems in controlling encroachment into public spaces and degradation of cultural sites and heritage.

Some municipalities in Nepal are completely devoid of blacktopped roads, and some are not even linked with the national road network. In 2000 about 78% of the people living in urban areas had access to an improved water supply within 15 minutes of home (Water Aid Nepal 2004).However there is significant variation in the coverage, service level, and qualities of supplied water between and within urban areas. Ground water is the main source in the Terai and is generally adequate in terms of quantity; hill towns are served from surface sources and generally face serious water availability problems. The rising demand for water in the valley has put pressure on the quality of water. The quality of both surface and groundwater has deteriorated. (Kathmandu Valley Environment Outlook, 2007). Regarding the situation of sanitation in urban areas, most of the households do not have septic tanks and they are directly connected to the sewerage lines that also discharge into the nearby river.

One of the environmental issues in the municipalities of Nepal is the issue of Municipal Solid Waste (MSW) management. At the national level, a number of policy and legal instruments (Solid Waste (Management and Resource Mobilization) Act 1987, Solid Waste Management National Policy 1996, Local Self Governance Act 1999 and Local Self Governance Regulation 2000) were introduced to address the environmental issues related to the solid waste. However at the local municipality level, these policies and acts provisions related to solid waste management were hardly translated into action. Involvement of private sector in waste management is now a common approach adopted by many municipalities. At household level, municipal ward level, or at commercial level, some entrepreneur and NGOs are practicing limited composting of MSW. (NESS, 2009)

Air and water pollution are also major hazards in urban settlements in Nepal. The deterioration in urban air quality results from vehicular emissions, industrial emissions, burning solid waste including plastics, construction work, poor maintenance and narrow roads, and adulteration of fuel. Pollution of water bodies such as rivers, lakes, ponds, groundwater, and drinking water supplies are common. Major polluting industries are invariably located in or near urban areas and often dispose their waste, including toxic waste to roadside drains and open spaces. Ground water in most urban areas is contaminated due to seepage from pits and septic tanks, and open defecation. Studies of water quality from shallow aquifers throughout Nepal have found that fecal coliform contamination consistently exceeds WHO guidelines for water for human consumption (ADB 2000). Sewage is the primary cause of drinking water pollution. Nearly one third of the urban populations of Nepal do not have direct access to a piped water supply (ADB/ICIMOD, 2006).

The water quality of the snow-fed and rain-fed/spring-fed rivers is good to fair for all type of consumptive uses with limited treatment intervention. The snow-fed rivers carry high amount of sediment loads with the rapid melting of snow and glaciers in the summer and show high turbidity levels. Whereas in the monsoon, all the rivers are loaded with high suspended sediment and are very turbid. The sediment load and turbidity in the river is directly related to the monsoon rainfall and its intensity. Intense rainfall is usually associated with the high suspended sediment load and turbidity.

Microbial contamination is invariably found in all most all surface water bodies of Nepal. Such contaminations are high during the monsoon compared to winter. Lack of adequate sanitation facilities in the river catchments, and practices of open defecation in all the rural settlements cause higher degree of contaminations as rainfall runoff bring the wastes to the river system. In these periods, the communities consuming river water directly often face water borne diseases outbreaks of epidemic scale. In the summer, the maximum water scarcity period in the Hill Ecological Zone the small rivers of Hill Ecological Zone get polluted due to multiple use of water.

The rivers passing through the cities and townships in all the ecological zones are also contaminated with the organic and microbial contaminants. Direct discharge of sewers without treatment into the river is the prime cause of river water contamination. In some areas, such as river Bagmati in Kathmandu, Sirsaiya Khola in Birgunj, Singhiya in Biratnagar have been turned into open sewers and are not fit for any type of consumptive uses. The riverine ecosystem of such rivers is completely destroyed for 10s of kilometers in the downstream areas. Due to low level of industrial development, the problem of heavy metal and organic solvent pollution in the rivers is not observed except in few areas as in Birgunj.

The groundwater in the Terai Ecological Zone, particularly in the flooded alluvial plain, shows concentration of arsenic above WHO guideline value. Recent arsenic testing in the wells and tube wells of Terai shows contamination of about 10% of the wells. Most of the contaminated wells are shallow tube wells.

Drainage to cope with surface runoff is often deficient in Nepalese urban areas. This is most evident during the rainy season, when the limited lengths of drains that exist in urban areas are often filled with waste, including plastics and dirt. Urban areas in Terai often experience serious drainage problems.

Traffic congestion is also a problem in urban settlements in Nepal, and the number of motor vehicles in larger urban centers has increased rapidly in recent years. This has not been matched by provision of roads and infrastructures leading to persistent traffic congestion, particularly in Kathmandu valley towns.

3.5 Rural Settlement:

Officially, the rural population of Nepal refers to those residing in localities lying within the designated village development committees (VDCs) areas (GON, 1999). However, the definition of a VDC as “rural” is purely administrative. The VDCs contain all settlements with populations below the threshold for designation as a municipality. A VDC contains government offices and development activities to serve the inhabitants. A VDC generally contains more than one settlement locality.

Infrastructure and services related to the rural environment include roads, electricity, irrigation, health and education. Data on these infrastructures and services are available at district level.

3.6 Migration:

According to Nepal Living Standard Survey (NLSS II), 2004, about 37 percent of the enumerated population aged 5 years and above are found to have been migrated from another VDC or municipality or from outside the country. The rate of migration is higher for females (50 percent) than for males (22 percent). Most of the movement is from the rural areas (81 percent) as against from urban areas (6 percent) and from other countries (13 percent). A large majority of migrants reported "family reason" (75 percent) as the primary reason for their movement followed by "easier life style" (12 percent) and "looking for job" (7percent).

3.7 Reasons for Migration

Among migrants, an overwhelming majority (75 percent) described the reason of migration to "family reason".This is followed by "easier life style" (12 percent), "looking for job" (7 percent), and education/training (3 percent). This pattern is also true across development regions, ecological zones, (NLSS, 2004)

The proportion of the migrants reporting "family reasons" as the primary reason for migration decreases for richer consumption quintiles. In contrast, the proportion of migrants reporting "easier life style", "looking for job" and "education/training" increases with household consumption. The hardship and difficulty for livelihood due to the effects of climate change could also have resulted for migration of people from rural to urban centers. However, the exact statistics in this regard is not available and needs to correlate with the other parameters. The reduction in availability of water, reduced agricultural productivity, flood, draught which is caused by direct or indirect consequences of the effects of climate change can be linked as a reason for rural-urban migration. It is observed that in some rural areas, when impact exceeds the autonomous or planned coping strategy adopted by the community, they tend to move towards the better environment in urban centers. Such type of migration will exert pressure on urban infrastructure facilities.

3.8 FINDINGS FROM TRANSECT APPRAISAL EXERCISE

An initial assessment of impacts of climate change on urban settlements and Infrastructures from transect visit exercise conducted by the thematic working group of urban settlements and infrastructures are highlighted below.

Fact (Climate change) • Rise in temperature • Temporal variation • Precipitation Amount • Precipitation distributions • Humidity	**Region**	**Perception**		
		Mountains	Mid-hills	Terrai
	East	• Increase in flooding • Drying Water resources	• Decrease of water resources <u>Coping strategy followed</u> • Higher floor and Ceiling height • Watershed Management • Rainwater Harvest • Climatic Hazard Awareness Programs	• Increase frequency and intensity of flood • Lowering of GWT • Drying of water resources <u>Coping strategy followed</u> • Planting different trees • Deep Boaring • Rainwater harvesting • Alternative energy
	West	• Increased flash floods • Debris deposit in agricultural land and settlement • Increased soil erosion • Deepening of river bed • Less snow fall	• Increased Flooding • Ponds and springs drying • Increased landslides • Increased migrations • Increased erosion • Increased forest fires Increased of health problem • Destruction of infrastructure (road, bridge, culvert) • Decrease of forest • Afforestation community forest • Decrease agricultural production	• Increased floods • Increased inundation • Increased river black cutting • Erratic rainfall • Increased forest fires <u>Coping strategy followed</u> • Higher plinth • Relief shelter
	Far west	• De-glaciation • Increase in flood • Increase in landslide • Drying drinking	• Increased floods • Increased landslides • Damage infrastructure • Less firewood	• Increased floods • Lowering of GWT • Drying of wells. and rivers • Decrease of forest product • Migration to safe location

		water resources • Storage tank/rain water harvesting • Drying of rivulets • Micro-hydro plant shut down • Deforestation • Infrastructure (eg road, w/s, s/w,)affected <u>Coping strategy followed</u> • Storage tank, rainwater harvesting	availability • Reduced discharge in river, spring • Lowering ground water level <u>Coping Strategy Followed</u> • Migration to safe place • Deep tube well • Rainwater Harvest • Alternative energy	during floods • Riverside plantation • Deep tube wells • Increased floor heights of • Construction of dykes, warning systems <u>Coping strategy</u> • Emergency shelter

3.9 Discussion

The settlements encountered during the transect walks would not be classified as “urban”, , many of the human settlements nevertheless share urban characteristics relevant to discussions around urban vulnerability in the context of climate variability and climate change. One issue that clearly emerges from the above analysis is the cross-thematic nature of climate change risks related to urban settlements. The impacts on urban settlements that were highlighted by respondents were most often related to climate induced disasters. The impacts are concentrated on urban water and energy resources as well as infrastructure, and health. Adaptation and coping mechanisms were similarly related to other themes, concentrating around responses to water problems such as water harvesting/small scale irrigation programmes; to the use of alternative energy sources.

From the stocktaking report and transect visit, the TWG has assessed the impact of reduced water supply quality and quantity, increased resource scarcity, and reduced service reliability and sustainability. Urban environment challenges and pollution impact, such as solid waste, water pollution, air, and land pollution, will emerge due to increased temperature and more flood/drought conditions. Basic urban infrastructure such as housing, building, drainage, transport, landfill, water supply and sanitation will be threatened due to climate change. The challenge becomes more significant given Nepal's fast growing population and urbanization. One issue that clearly emerges from the above analysis is the cross-thematic nature of climate change risks related to urban settlements. The impacts on urban settlements that were highlighted by respondents during the transect survey were most often related to climate induced disasters.

During the transect, a brief institutional analysis was undertaken to identify the key institutions relevant to adaptation in human settlements. Many of these overlap with those identified by the other thematic areas given the overlap in adaptation options. Specific institutions relevant to urban planning include: In the High Mountain region, the Nepal police and Red Cross were noted to play a role in disaster preparedness and response. The Ministry of Tourism and Ministry of Home Affairs were identified as relevant national agencies for urban development across all the regions. In the Mid Hill, FINIDA, Mercy Corps/Oxfam, Red Cross, Equality Development Center (EDC) all had a presence in the transect area; and in the Terai FINIDA was also present.

When we talk about the urban settlements and infrastructures in Nepal, the adaptation measures that are followed could be visualized at three levels they are; government, community, and individual. The possibilities of urban (metropolitan, municipality) entity having the basis for being good "climate change adaptation" depends heavily on whether the government provide the legislative, financial and institutional basis to allow them to do so . It also depends on them not pushing or shifting adaptation responsibilities to local administration that they can't fulfil.

The planned, anticipatory adaptations that are undertaken by governments or NGOs in Nepal as a policy initiative (as opposed to those that are autonomous and/or mainly reactive) are those that require the most attention. Though, as argued by Fankhauser et al. (1999), the distinction between autonomous and planned adaptation may be blurred in practice. The evaluation of adaptations must address the following question: "how good is the adaptation?" (Smit et al.2000). Furthermore, it is important to assess not only the "best' adaptation option, but also what adaptations are likely in various ecological zones of different urban settings are subject for consideration while planning adaptation measures in the context of Nepal.

Urban services also play an important role while assessing the adaptive capacity of the urban areas in order to build urban center more climates resilient. This includes water supplies, sanitation, solid waste management, electricity network, and road and transportation network. The providers should ensure that they are adequately "climate proofed". Secondly, urban services in Nepal should be expanded to ensure that they reach a great number and proportion of urban dwellers. The current available statistics shows that the urban services in Nepal are very poor.

Some of the Community Based Adaptation (CBA) model in Nepal is found to be successful. It is based on the premise that the local communities have the skills, experience, and local knowledge and networks to undertake locally appropriate vulnerability reduction activities that increase resilience including climate change. The flood relief centers constructed by the community in Banke district, and slum and squatter upgrading program in Kathmandu can be seen as good examples of CBAs.The literature also revealed a number of additional interactions between urban settlement infrastructures and climate impacts that will be taken into account in the overall analysis of adaptation. These include:

- The urban "heat island" caused by asphalt, concrete and other hard surfaces absorbing radiation from the sun may be exacerbated. This phenomenon puts pressure on electricity generation and distribution systems.
- Hard surfaces also prevent absorption of rainfall, creating runoff that carries pollution to lakes and streams and can overwhelm storm-water systems, leading to sewer backups and flooding during heavy precipitation events.

- Combined sewers that carry both storm-water and sewage are common in many city centers. Protracted or intense precipitation leads to overflows in these sewer systems, washing untreated pollutants into local water bodies.
- .
- The concentration of people in cities in Nepal creates a large demand for water and can strain local water supplies, making them more susceptible to water shortages in drought conditions.
- Urban sprawl and competition for building sites in Nepal has led to construction in locations such as floodplains or steep slopes that are vulnerable to extreme climate events
- Low-income city dwellers in Nepal are living below substandard and poorly insulated buildings that increase the risks from heat waves and other extreme weather.

3.5 Climate Induced Disasters

3.5.1 Overview of climate-induced disasters in Nepal

Nepal has been classified as one of the hotspots of multi hazards[4]. The country faces high frequency and intensity of a multitude of climate induced hazards including floods, landslides, forest fires, cyclonic winds, hailstorms, cloudburst and droughts. A number of factors exacerbate the impacts of climate-induced disasters in Nepal, including geological structure, steep slopes, unplanned settlement, deforestation and poor quality infrastructure. The vulnerability is also compounded with other impacts related to governance, natural resources management and other challenges to sustainable development (NSDRMN, 2009). Apart from these, resource constraint, inadequate technical capacity on disaster management, inadequate awareness, difficult geo-physical situation of the country and inadequate coordination among agencies related to disaster management, have been found as the major challenges in managing disasters in Nepal.

An inventory of past climate disaster events over the period of 1971-2006 reveals that landslide events are the primary cause of hazard-induced loss of life, while floods (including the flash floods) and urban or rural fires are similarly noted as principle hazards in terms of their extent and frequency of occurrence, as well as the spread and intensity of physical and socio-economic impacts (NSDRM, 2009). In addition, these disasters damage the country's transport network, which has implications for service provision and the economy.

Other major hazards include forest fires, which are particularly acute within the Terai, where the summer temperatures go as high as 45 deg Celsius (NSDRM 2009). Cyclonic wind is a hazard that destroys horticultural crops in spring, while hailstorms cause significant harm to the summer as well as winter crops, especially in the mountainous areas of the country. Glacial Lake Outburst Floods (GLOFs) and avalanches are threat of Mountains regions. GLOF hazards result from the outburst of glacial lakes due to the destruction of natural dams that withhold the lake water. Most of these lakes are dammed either by an ice-core moraine or by moraine debris (Agrawala, 2003). The damage occurs either due to the destruction of the moraine dam by backwater erosion, owing to overtopping of the dam through

[4] Natural Disaster Hotspots : A Global Risk Analysis (World Bank, 2005)

rapid melt by avalanche in the background, or by melting of the ice-core of the damming moraine. Climate change is causing accelerated melting of the glacier tongues and rapid enlargement of the glacial lakes contained by natural moraine dams. Several lakes have been mapped with high risk in the Nepali Himalayas (NSDRM, 2009).

Vulnerable groups are equally exposed to post-disaster damage, when people are relocated from the affected area or forced to move from their place of origin to the vicinity of protected areas, natural forests, riverbanks or hill slopes. Unplanned resettlement can further exacerbate environmental degradation and increase vulnerability (NSDRM, 2009).

The Ministry of Home Affairs (MoHA) is the nodal l agency responsible for coordination of various aspects of disaster management. The focus of disaster management in Nepal is changing from reactive (relief and response) to proactive (preparedness) risk reduction, as can be seen in the "National Strategy for Disaster Risk Management" [5]prepared by the ministry. A Central Disaster Relief Committee under the chairmanship of the Minister for Home Affairs and district-level disaster committees under chairmanship of the Chief District Officers have been formed to coordinate and execute the activities relating to disaster preparedness and reconstruction as well as rehabilitation as per the 'Natural Calamity Relief Act' 1982. A Central Calamity Relief Fund has been established under the Act.
The Department of Water Induced Disaster Prevention (DWIDP) under the Ministry of Irrigation, in collaboration with MoHA, is involved in the mitigating impacts of floods and debris flow, and also carries out river training, hazard and risk mapping, community awareness, and capacity building. Disaster Management focal points have also been appointed in key line ministries, coordinated by MoHA. In addition to this National Platform for Disaster Risk Reduction has also been established. Civil society is also involved in these efforts, for instance Disaster Preparedness Network (DPNet), is an informal network of individuals and organisations involved in the disaster management.

3.5.2 Outputs from the Transect Appraisal Exercises: An initial assessment of impacts of climate change on climate-induced disasters;

[5] Approved by the Government of Nepal in 2009

	East	Central	West
Mountain Ecological Zone			
Impacts	• Increase in occurrence and intensity of landslide events • Increase in forest fire/bush fire • Increase in lightning strikes • Uncertainty in how snow melting trend will affect ponds and water resources in low land areas	• Floods and landslides • Destruction of physical infrastructure • Decreasing water resources • Increasing forest fire • Soil erosion • River bed level upraised • River side cutting • Agro climatic shift	• Flash floods • Landslides • Erosion • Prolonged dry periods pre-rainfall resulting in moisture stress • Forest fire • Lightening • Diarrhea • Agro climatic shift – growth of banmara (forst killer) weeds due to favorable weather conditions, reducing grazing opportunities • Prevalence of mosquitoes even in Himalaya
Coping/Adaptation	• Tree plantation • Gabion wires for slope protection • Establishment of community forestry committees • Joint efforts are taken to protect and control landslides with government sector and community	• Embankment construction to reduce floods • Financial assistance • Plantation and soil conservation • Replacement of mud roof with tin roof • Tapering the water way • Alternative energy reduces dependency on fuel wood. • Emphasis on alternative livelihoods and diversification, quick cash generation programmes • Disaster Risk Reduction activities through DDC/Govt. (limited coverage)	• Lack of early warning systems • Public awareness has to be enhanced • Plantation • Mineral resources have to be managed • Avoiding of steep slopes for dwelling

Hill Ecological Zone			
Climate related impacts	• Landslides (entire hamlet wiped out in one single event) • Hailstorm hazards in harvest time cause substantial loss (particularly for fruit) • Increase in flood events • Uncertainty in the characteristics and timing of precipitation and heavy wind events	• Erosion • Landslides • Floods/flash floods • Drying of water sources • Declining forested areas • Decrease in agriculture production • Impacts of landslides and extreme weather events on infrastructure • Increase in water pollution during flood events	• Drying of the water resources but increase in flash floods • Decrease in agricultural production • Decline of the medicinal plants • Vultures, eagles are decreasing • Increase infestation of pests • Changing disease patterns
Coping/Adaptation	• Tree plantation and community forestry groups increasing in number • Construction of walls • Construction of proper building foundations • Rainwater harvesting/water reservoir creation • Public awareness and activities ongoing regarding landslide protection	• Community awareness • Community forestry and plantation • Weak relief operation • Several district-level offices and programmes, also NGOs/INGOs	• Reconstruction materials provided after hazards occur • Buildings constructed on foundations • Gavin wires used for slope stabilization but only limited support available • Community plantation programs to stabilize slopes • No early warning systems in place
Terai Ecological Zone			
Impacts	• Early drought • Increase in flood hazards during monsoon • Uncertainty in timing and character of flood events • Increase in high	• Landslides • Increased flooding • River site cutting • Decrease ground water table • Siltation and bank cutting changing the path of river flow • Forest fires	• Increases in major floods and inundation (intensity and extent) • Droughts are increasing • Landslides (although a smaller hazard than in the hill regions) • Forest fires • Erosion by intense

	wind events in harvest period causing damage and loss of crops • Increased frequency of forest fires • Land slides • Declining natural water sources • Siltation, soil degradation, bank cutting	• Soil erosion following rainfall • Impacts on settlement infrastructure especially that close to river banks • Impacts on agriculture from changing water patterns • High winds impacting on settlement infrastructure especially poor quality housing	rainfall • Less agriculture production • Pest infestation patterns changing • Water sources are drying and declining • Sand/debris casting/debris flow
Coping/Adaptation	• Efforts taken to plant bamboo and "kash" on the river banks • Construction of river embankments • Mass public awareness campaigns by various agencies, besides NGOs • Reservoirs, conservation ponds and water harvesting for irrigation and domestic purposes • Existence of micro-irrigation/irrigation • Indigenous technology of makeshift platforms to avoid inundation • Pilot coverage of elevated shelters • Relocation to safer places (minimal)	• Certain buildings are constructed that can be used as a relief shelter (limited coverage) • Elevation of plinth/tube wells • Community managed emergency funds: These collect paddy and cash from households and put this into the fund that can later be used in case of emergency. • Community food banks • Early warning system in case of floods (in Marchwar) • Using different variety of rice seed • Planned settlement projects such as *Janata Avash Yojana* - should be implemented so that there are better management of storm water, drains	• No early warning systems in place; one being developed in collaboration with MOE • Community watch towers for flood warning (limited coverage) • Embankment to protect against flooding • Reconstruction support from official sources post-disaster • Conservation ponds for irrigation to reduce drought impacts • Afforestation for bank stabilization (bamboos, *kash* etc) • Awareness raising programmes being undertaken by NGOs and Government

		and sewerage	

3.5.3 Discussion

Climate induced disasters causes various kinds of impacts in all the thematic areas, and in this sense climate induced disasters is itself a cross-cutting theme. As such, many of the impacts and adaptation options identified are the same as, or relevant to, those identified under other thematic areas, for example agriculture, health, and urban settlements. Further, many of the coping strategies identified draw on ecosystem services provided by forests and biodiversity. Of particular interest are the coping strategies being implemented at the community level that draw on indigenous knowledge and experience of managing past disasters. These include strategies such as building on raised platforms and increasing the height of boreholes.

Many factors were identified at the local level that exacerbated vulnerability to climate-related hazards. These included no institutional guidance or land-use regulation; failure to implement building construction codes; for community organization and mobilization; lack of public awareness on climate related disasters and how to reduce community exposure; limited reach of early warning systems.

The existing coping strategies to climate-related disasters were noted to be inadequate both currently in terms of outreach, and in the future in terms of assisting vulnerable communities in the face of increasing climatic hazards. However, many suggestions for supporting future adaptation were received from communities themselves and discussed during the transects for strengthening resilience to climate-induced disasters. These include:

- Expansion of community-based afforestation programmes to stabilize slopes
- Creating and maintaining hazard maps and vulnerable locations, and making these available for settlement and livelihood planning
- Assisting the relocation of vulnerable communities especially those at risk of GLOF
- Livelihood diversification, income enhancing agricultural programmes
- Formulation of plans on climate change and disaster management in the community level
- Awareness raising and capacity building at the community level on disaster preparedness and also response.
- Construction of cascade conservation ponds in the hills to prevent soil erosion and control gullies
- Reinforcement of building codes
- Skill development for building of community housing
- Proactive efforts to increase gender equality, noting the important role of women in disaster preparedness and response.

The disasters group also focused on identifying institutions for adaptation. Many of the national-scale institutions are discussed in the overview of this section. At the community level, relevant institutions that are currently supporting coping and adaptive strategies include: District Soil Conservation offices; District Agricultural Development Offices; District Irrigation Offices; VDCs; NGOs and INGOs; and CBOs. Food for Work was identified as a positive programme that can help reduce vulnerability. Again, these institutions are relevant for building adaptive capacity under all the NAPA themes. The community-

managed watch towers and community-managed disaster relief funds are good examples of effective community-based institutions that could be supported.

3.6 Public Health

Climate change is one of the public health threats affecting the health status of the communities. Its impact varies with temporal and spatial changes. However, few people are aware of the real consequences of climate change. Public health refers the approaches to protect and improve the health of communities.

The basic characteristics of public health are to prevent diseases and promote health status of the communities. The prevention may be primary involves the control of the causes of disease, secondary involves detection of early cases of disease through screening and treatment at a stage at which cure is likely and tertiary prevention is the domain of clinical medicine, treating patients with clinically manifest disease. Disease control concept of public health proposing that mitigation is analogous to primary prevention and that adaptation is comparable to secondary and tertiary prevention, as it involves the efforts to anticipate and prepare for the effects of climate change, and thereby to reduce the associated health burden (WHO 2007).

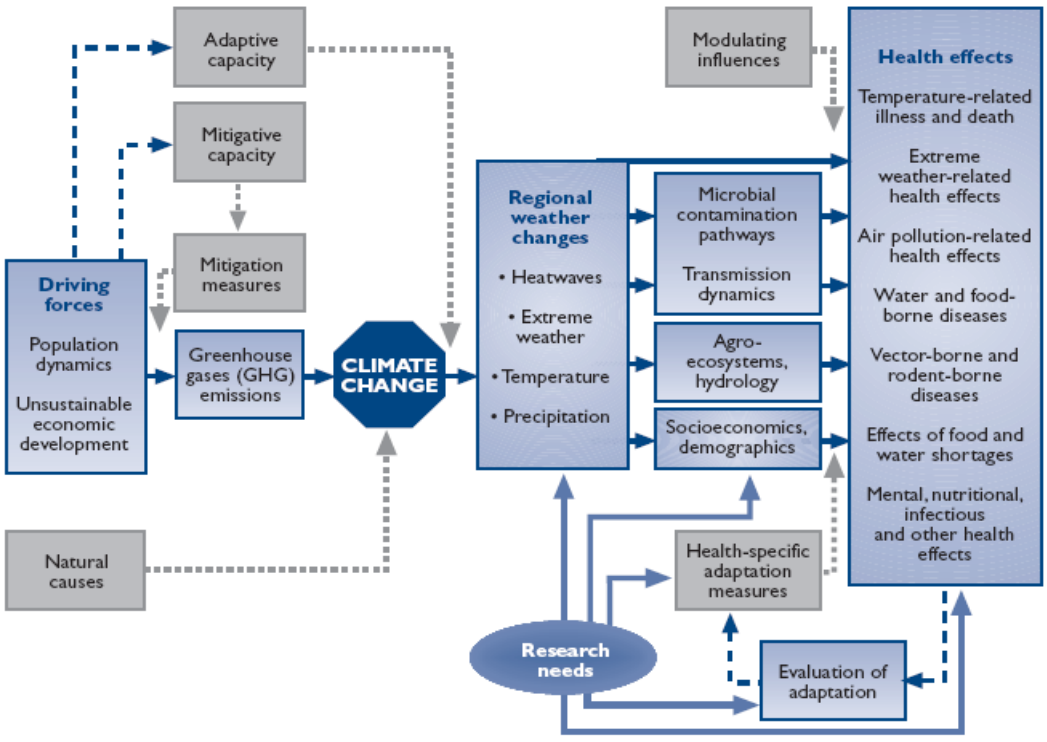


Figure1: Pathways of Climate Change and Health Impact *(Source: Mc Michael A.J et.al 2003)*

There is broad consensus that climate changes can affect human health. The IPCC fourth assessment report concluded that climate change currently contributes to the global burden of disease and premature deaths. At this early stage the effects are small, but are projected to progressively increase in all countries and regions" (IPCC 2007). The health impacts of climate change in the context of Nepal are obvious. However, studies in health impacts of climate change in Nepal are limited. Climate change will act through regional weather changes to affect health directly (temperature-related illness and death; and extreme weather-related health effects) and indirectly (air pollution-related health effects; water- and food-borne diseases; vector- and rodent-borne diseases; and mental, nutritional, infectious, and other health effects) (Michael et.al 2003). The extent to which health impacts will be realized depends on the effectiveness of adaptation measures and on modulating influences (other drivers of health outcomes, such as population density in regions vulnerable to flooding). Figure1 shows the pathways by which climate change and other drivers can affect human health.

The impact of climate change on health is not well defined owing to lack of adequate information and etiological studies. There is uneven distribution of climatic phenomena like temperature and precipitation across different geographical regions and during various seasons in a year in the country which has direct bearing on the health of the people.

Direct impacts of climate change and variability on human health in Nepal

Major health impacts of climate change at the national and sub-national levels are described under the following sections:

(a) **Extreme weather related health effects**

Table 1 shows that the number of mortality due to heat stroke - hyperthermia was greater than that of cold stroke- hypothermia (DOHS 2009). The impact of the extreme weather conditions are seen increasing which is related to climate change (IPCC 2007). The phenomenon of heat waves has also been recognized by the communities during summer in most of the districts of Terai region but information of its impact is not available.

Table 1: Mortality due to extreme temperature events

Stroke	2004	2005	2007	2008
Heat	20	80	60	75
Cold	9	10	18	30

Source: DOHS (2004-2009)

(b) **Climate induced disaster**

Department of Water Induced Disaster prevention (DWIDP) report (2008) has indicated that the climate related events like floods, drought, windstorms, and extreme temperature caused casualties like deaths, injuries, homeless, affected, and damaged. The report indicated that those climatic events from 1983 to 2007 has caused casualties of a total of affected families of 1,013,465 (by water-induced and others) and

deaths of 22,215 people (by water-induced, epidemic and others). The major climate induced casualties are seen due to water induced like flood and landslide and epidemics of climate sensitive diseases like water and vector borne diseases. The sum of the casualties of water induced and epidemic accounted more than 80% of the total casualties (Table 2).

- Table 2: Climate induced disaster and mortality, Nepal

Events	1998	1999	2000	2001	2002	2007
Epidemics	840	1207	141	154	151	200
Avalanches	0	5	0	0	0	0
Fires	54	39	38	26	11	12
Flood/land slides	273	193	173	196	441	216
Earthquakes	0	0	0	1	0	0
Thunderbolts	17	16	23	36	3	46
Wind and hailstorm	6	6	3	2	3	
Total	1190	1466	378	415	609	474

(c) **Air pollution-related health effects**

ARI is one of the top five diseases in Nepal (DoHS 2008). ARI and chronic bronchitis are accounted for 8.72 and 3.04 percent respectively of the total out-patient department (OPD) visits in the health institutes (DOHS 2008). The diseases in the mountain region have shared 13.65 percent of the total OPD visits, as compared to 10 percent of the Terai. The hospital record shows that the deaths among the children below five years of age by these diseases account for over 30 percent.

(d) **Water and food borne diseases**

Water sources have dried up due to extreme temperature/heat and as a result, the level of water in springs, rivers and groundwater has reduced. Water shortage is the main cause for poor sanitation, water-washed diseases like skin disease, worm infestation, eye infections, etc. Limited and poor quality drinking water also causes typhoid, diarrhea, dysentery, cryptosporidiosis, giardiasis, amoebiasis, gastritis and infectious hepatitis (IPCC 1996, 2001). Studies indicate that heavy rainfall events transport terrestrial microbiological agents into drinking-water sources resulting in outbreaks of these infectious diseases (Pradhan 2007). Incidence of diarrheal diseases per 1000 new cases children under 5 years of age has increased consistently from 131 in 1995 to 204 in 2005 and slightly declined to 185 in 2006, while case fatality rate has decreased remarkably from 2.56/1000 new cases in 1995 to 0.17 in 2006 (DoHS 2007). Further, morbidity with an average of over 3.3 episodes per child has been recorded. Likewise, there has been an increased trend of typhoid fever, from over 400 cases in 2001 to nearly 1000 cases in 2005. A hospital record in 2005 has shown a close relationship between temperature and precipitation and typhoid cases; both climatic phenomena have risen during four months (June-September) and meanwhile typhoid cases of children under 5 years of age were among the highest

(ranged from 270 to 193/1000 new cases), while in the winter months, the cases have lowest along with low temperature and rainfall (Shrestha et al 2007, Regmi et al 2007). The outbreak of diarrhoea and cholera in mid-western development region of Nepal in 2009 may be partially blamed for climate change (Bandar et al 2009)

(e) **Vector borne diseases**

Vector borne diseases including encephalitis, *Japanese Encephalitis* (JE), leishmaniasis, malaria and Kala-azar (*Visceral leishmaniasis*) seem to have occurred in warmer districts of Nepal. The most common species of malaria parasite are *Plasmodium vivax* and *P. falciparum* (DoHS 2009). The information of Table X shows the increasing trend of *P. falciparum* (EDCD,DoHS, 2007). The increment of *P. falciparum* linked with increased temperature (WHO 2005).

Table 3: Trend of Positives Slides and Malaria Parasites

Year	Malaria positives	*P vivax*	*P falciparum*	% *P falciparum*
2000	7981	7145	836	10.4
2001	6645	6131	424	6.38
2002	12786	10620	2175	17.01
2003	9424	8200	1224	12.99
2004	4637	3879	745	7.9
2005	7068	5691	1377	19.48
2006	5349	3841	1415	26.45
2007	4220	2830	1390	32.9

Source: EDCD, 2003-2006 and presentation from Dr. Banerjee (IOM)

Similarly other vector borne diseases are Kala-azar (*Visceral leishmaniasis*), Japanese encephalitis and lymphatic filariasis are endemic and their risk districts and population are indicated in Table 4. The community people have felt that the mosquitoes are shifting in higher altitudes where there was no occurrence of mosquitoes previously in Chitwan and Dahding district (NHRC 2009). The first outbreak of dengue occurred in Nepal in 2006. The cross- sectional entomological survey conducted in 2006 identified the presence of *Aedes aegypti* in 5 major urban areas of Terai regions bordering with India i.e Biratnagar (Morang), Birgunj (Parsa), Bharatpur (Chitwan), Tulsipur (Dang) and Nepalgunj (Banke). Similarly, entomological survey conducted in Kathmandu valley in 2009 has revealed the presence of *Aedes aegypti* in Kathmandu (Gautam et.al 2009). Previously *A. aegypti* was not recorded in Nepal. One of the reasons for increasing the disease and geographical spread might be because of climate change. The increased temperatures due to climate change may create conducive environment to mosquitoes breeding. More research is certainly needed to discern the attribution of climate change (Dhimal and Bhusal 2009).

Table 4: Climate change related diseases and risk populations

Diseases	No. of Risk District	Risk population* (%)
Malaria	65	91.6
Filariasis	60	87.0
JE	24	53.9
Kala-Azar	12	29.7
Dengue	NA	NA

Source: DOHS 2007: Annual Health Report

*Risk population calculated from CBS (2002)

Risk populations by these diseases are estimated based on their current occurrence in the districts and district-population, which are shown in Table 3. Those diseases which have appeared in different parts of Nepal are believed to be due to increment of average temperature.

(f) **Nutritional, Mental and other diseases**

Due to unpredictable monsoon rain, the food deficit districts are increasing. The number of districts reached to 41, all from hills and mountains. CBS (2004) indicates that 31 percent of Nepalese households have food consumption less than adequate. Malnutrition is a serious obstacle to survival, growth and development. Nepal Demographic and Health Survey (2006) showed that 51 percent of children below 5 years of age were affected by stunting (short for their age), which could be a sign of early chronic under nutrition. The survey also found that 36 percent of the children were underweight (low weight for age).

Diseases like mental disorder exist in Nepal, but there is no study about the causes of this disease due to climate change. Other diseases like cases with Chromoblastomycosis, chronic fungal infection, are also seen predominantly in middle-aged male farmers and those from rural areas of Nepal (Pradhan 2007 et al.). A hospital based study indicated that majority of the patients were diagnosed having fungal infections with peak in summer and low in winter (Jha 2007). There is greater number of people in the Terai suffered from poisonous snake bite during summer hot and rainy season. The number of cases of snake bites reported was 2,330, 2,953, and 2,153 in 1997, 2004, and 2005 respectively, which were more than fifty percent of the total snake bite cases in the country (DoHS 2006).

Table 5: Outputs from the Transect Appraisal Exercises: An initial assessment of impacts of climate change public health

	East	Central	Far West
High Himalaya			
Impacts	• Droughts increased. • Breeding of mosquitoes and flies increased. • Diarrhoea incidences have increased • Increased cases of	• Disease vectors such as mosquitoes and flies increased since the last 4-5 years. • Higher instances of influenza at present	• Increased waterborne diseases such as diarrhea, typhoid, cholera, • Increased respiratory diseases such as

	common cold/ flu • Migraine (headache) increased in women • Increased eye infections • Increased skin diseases such as rash, itch and dry scaly skin	• School children affected influenza. • Many mountain goats, sheep died because of cold in recent years	asthma, bronchitis • Increased malnutrition and anemia • Skin diseases increased • Other diseases showing changes in patterns include: hepatitis, malaria, filaria, blood pressure, diabetes, irregularity in menstruation period, earlier menopause, uterine prolapsed, stone deposition, HIV/AIDS STD, cataract, , incidence of allergic rhinitis and psychological disease increased
Coping/Adaptation		• School in Kagbeni closed during influenza epidemics	• Immunization programs are conducted. • Awareness programs such as street drama, songs, poster, and pamphlets carried out. • Community led total sanitation and school led total sanitation programs are available. • Free health services provided.
Mid Hills			
Impacts	• Migraine (headache) has been increasing particularly in women. • Increase in eye infection. • Increase in skin diseases such as rash, itch and dry scaly skin. • Increase in flu and other viral fevers, influenza, diarrhea, jaundice,	• water related diseases increased • Skin diseases, lung diseases, respiratory disease, conjunctivitis and skin allergy increased. • Increased flies, mosquitoes, cockroaches and others insects which further can cause the	• Following diseases have increased: Diarrhea, typhoid, hepatitis, cholera, malaria, filarial, blood pressure, diabetes, anaemia, irregularity in menstruation period, earlier menopause,

	pneumonia and typhoid fever. • Mosquitoes and other insect bites have been causing skin problems. • Disease periods have increased.	epidemics. • Viral fever, hepatitis, diarrhea, amoebiasis (aau), malaria, hepatitis, encephalitis, Kala azar increased. • Increasing disasters such as floods and landslides and adversely affected psychological and mental health	uterine prolapsed, HIV/AIDS incidence of asthma, allergic rhinitis and bronchitis, Malnutrition, poisonous snake bite increased
Coping/Adaptation	• Use of mosquito nets • Hygiene and sanitation campaigns are conducted • Health education through health institutions are provided to local communities • Awareness programs related to safer drinking water are organized.	• Going to the doctors and health post for treatments of diseases. • Awareness programmes carried out.	• Immunization programs are conducted. • Awareness programs such as street drama, songs, poster, and pamphlets are carried out. • Community led total sanitation and school led total sanitation programs are available. • Free health services are provided • Use of mosquito nets (people reported that mosquito nets freely distributed have increased bugs)
Terai			
Impacts	• Increase in diabetes, blood pressure and pneumonia. • Consumption of insecticide used. • Eye problems increased • Increase in asthma and heart patients. • More amoebic dysenteries, Kalaazar, eye infections and viral fevers after flood disaster.	• Floods have resulted in the outbreak of viral fever, jaundice, typhoid. • Environmental pollution has triggered higher incidences of skin diseases, respiratory diseases. • Immunity of the people has decreased	• Water sources such as well, ponds, lakes, etc. have been drying • Following diseases have increased: • Diarrhoeal disease, typhoid, hepatitis, cholera, malaria, filarial, blood pressure, diabetes, anemia, irregularity in menstruation period, earlier menopause, uterine prolapsed, HIV/AIDS incidence of asthma, allergic rhinitis and

			bronchitis, Malnutrition, poisonous snake bite increased especially in hill
Coping/Adaptation	• Migration increased. • Wider use of mosquito nets • People are aware of hygiene. • Practice of traditional healing methods decreased. • Modern health Service utilization increased	• Reliance and dependence of the people on the nearby local health care centers/hospitals for treatment and advice. • Health care through private medical shop increased	• Immunization programs are conducted. • Awareness programs such as street drama, songs, poster, and pamphlets are carried out. • Community led total sanitation and school led total sanitation programs are available. • Free health campaigns are organized • Drinking water is treated before drinking (mostly in urban areas) • Arsenic-preventive taps are constructed by the concerned institutions.

Discussion

It is extremely difficult to relate the existing and changing prevalence of disease patterns noted in the transects specifically to climate change without greater root-causes analysis. However, many of the health-related concerns of communities encountered correlate with water, agriculture, disasters and settlements issues already raised under other thematic working groups. For example, malnutrition is likely to be impacts by declining agricultural yields. Declining domestic water supplies will have a direct impact on hydration as well as an indirect impact on health through declining sanitation. Changing settlement patterns noted in the urban settlements groups have implications for sanitation and spread of diseases. Climate induced disasters may have a direct impact on injuries and death, as well as indirectly impacts on health through damage to infrastructure and food, water and sanitation systems.

The adaptation and coping strategies identified focused around awareness raising and public health initiatives. Institutions identified included public health centres, hospitals, primary health care trusts, outreach clinics and community-based health organizations. For example, in the Mid Hill Central regions, Government Health institutions were active (including District Health Office, District Ayurvedic Health Centre, District Hospital, Primary Health Post, Sub Health Post, and Primary Health Care Centre). INGO United Mission Nepal was providing health care support, as was the Red Cross, and there was a Mary Stopes Centre providing health care training. In the Mid Hills Far Western region, there were hospitals, primary health care, health post, sub-health post, outreach clinics, private clinics, and pharmacies. Similar institutions were noted in the Terai, as were community based organizations like Aama Samuha and Clubs who were involved in providing health care.

Also noted was the strong presence of traditional and indigenous health care institutions and practices. Traditional healers provided a useful source of information on changing disease patterns given the reliance of their practices on recognizing common disease patterns. Traditional healers were encountered in all regions, either working independently or as part of private or Government Ayurvedic centers.

Given the links between disease patterns and other thematic areas, many of the adaptation options identified under other TWGs are also very relevant to the health sector. For example, rainwater harvesting identified by the water and energy group as a community-based adaptation option would increase domestic water supply and improve sanitation; early warning systems identified by the climate induced disasters TWG would reduce injury and deaths from climate-related disasters; agricultural diversification may both increase food availability and improve farming livelihoods both contributing to reducing food stress for vulnerable groups.

In transect appraisal exercise and stocktaking study shows that communities have observed the impacts of climate change. The changes are described in terms of rainfall pattern change, rise of temperature, water sources drying up, water level decrease during summer in surface as well as in ground water, increase in climate induced disaster such as landslide, flood, forest fire, drought, increase in climate sensitive disease. The impacts are also varied with the age groups, vulnerability and remoteness of the place.

Stocktaking analyses show that the types and frequency of occurrence of diseases are increasing with reference to the last 10 years. The diseases addressed in Table 6 by the communities are more than what we see in government priorities and different existing reports of government and nongovernment organizations. Drudgery of women and children has increased due to increment of fetching distance and decrease in agriculture production. Malnutrition is a common problem observed among children and pregnant women. It is a fact that poor nutrition before and during pregnancy results in poor pregnancy outcomes. About 75 per cent of pregnant women in Nepal are anemic (UNICEF 2006).

Water sources have dried up due to extreme temperature/heat and as a result, the level of water in springs, rivers and groundwater has reduced. Water shortage is the main cause for poor sanitation, water-washed diseases like skin disease, worm infestation, eye infections, etc (Pradhan 2005, Pradhan et. al 2009). Limited and poor quality drinking water also causes the occurrence of typhoid, diarrhea,

dysentery, gastritis, jaundice and infectious hepatitis. The consequences are observed malnutrition among children and especially pregnant women. Uterine prolapsed cases are also very common among the women.

Vulnerability assessment and gaps in public health sector have been identified by using shared learning dialogue (SLD) approach. Stocktaking analysis of the vulnerable people are identified as Children and women and pregnant, squatters in cities, slum dwellers in cities, dwellers of flood plain, river banks and Hill slopes, internally displaced persons, "IDPs" (due to political, socioeconomic and natural), disabled people and street children.

There is a need of research in national context to understand the actual health problems induced by climate change and formulate the evidenced based adaption strategies. However, there are a lot of research challenges in vulnerable mountainous countries like Nepal to conduct research on climate change and health The major research challenges are access of information and data, availability of trained human resources, interdepartmental coordination, financial capacity, geographical situation and research methodology (Dhimal 2008).

The following gaps have been listed from the series of stakeholder meetings and discussions with the concerned people and transect walks and relevant literatures are: inadequate health Institutions, human resource, drug, resource mobilization in the health institution, blood transfusion service, health research, institutional preparedness for disaster management, surveillance, monitoring, equality and equity in health services, less effort to fulfill the targets, not considered the primary, preventives aspects in health care management, health budget is still less than 10% of the total budget, inadequate trauma centers, quality of health service, standard of health care service, drug quality, lack of vertical and horizontal integration and coordination with different departments and institutions, sustainability of free health care service, activities are focused to fulfill the millennium development goal, inadequate emphasis on environment issues including climate change issue in health policy. Adaptation is the prime requisite for vulnerable developing countries like Nepal whose green house gases emission is negligible (Dhimal 2008). The adaptation strategies appropriate for Nepal in order to reduce the impact of climate change in human health in Nepal includes Strengthening Health System, Awareness, capacity building and promotion of local adaptive knowledge, Coordination among the concerned stakeholders and integration of health impact of climate change into broader development plans and related activities and Prompting Research on Climate Change and Health for evidence based planning
(Dhimal and Bhusal 2009).

Annex 1: Climate Change Scenarios fro Nepal. Source: NCVST, 2009.

Table 4.4. Change in mean temperature (°C, relative to mean of 1970-1999) from GCM projections.

EASTERN NEPAL					
Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2030s	1.4 (0.5, 1.8)	1.5 (0.5, 2.0)	1.3 (0.3, 1.9)	1.1 (0.3, 2.0)	1.3 (0.5, -2.4)
2060s	2.7 (1.7, 3.3)	2.9 (1.7, 4.1)	2.3 (1.1, 3.0)	2.5 (1.4, 3.2)	2.9 (1.8, 4.0)
2090s	4.2 (3.2, 5.4)	4.7 (3.3, 6.1)	3.5 (2.0, 5.6)	4.0 (2.9, 5.4)	4.7 (3.4, 6.1)
CENTRAL NEPAL					
Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2030s	1.4 (0.9, 2.0)	1.7 (0.8, 2.5)	1.4 (0.5, 2.2)	1.2 (0.7, 2.0)	1.6 (0.9, 2.8)
2060s	3.0 (1.7, 4.1)	3.1 (1.9, 4.7)	2.5 (1.0, 3.4)	2.6 (1.8, 4.1)	3.4 (1.9, 4.6)
2090s	4.9 (3.0, 6.3)	5.4 (3.5, 7.0)	4.5 (1.9, 5.5)	4.6 (3.2, 5.9)	5.4 (3.7, 7.1)
WESTERN NEPAL					
Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2030s	1.4 (0.8, 2.0)	1.8 (0.8, 2.1)	1.4 (0.5, 2.2)	1.1 (0.5, 2.0)	1.5 (0.7, 2.8)
2060s	2.8 (1.9, 3.8	3.0 (2.2, 4.4)	2.3 (1.4, 3.3)	2.6 (1.8, 4.0)	3.4 (1.7, 4.5)
2090s	4.9 (3.7, 5.9)	5.3 (4.0, 6.5)	4.0 (2.8, 5.9)	4.3 (3.3, 5.5)	5.6 (3.7-6.2)

Table 4.5. Change in frequency of hot days (%, relative to mean of 1970-1999) from GCM projections.

EASTERN NEPAL					
Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2060s	16 (12, 35)	26 (16, 45)	24 (10, 66)	24 (10, 66)	26 (19, 80)
2090s	22 (14, 45)	43 (29, 62)	35 (8, 84)	35 (8, 84)	53 (31, 91)
CENTRAL NEPAL					
Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2060s	18 (10, 41)	25 (17, 52)	25 (14, 75)	26 (9, 49)	37 (18, 65)
2090s	29 (16, 49)	48 (27, 66)	43 (14, 85)	45 (28, 61)	68 (35, 79)
WESTERN NEPAL					
Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2060s	17 (12, 39)	26 (18, 55)	21 (11, 63)	23 (7, 48)	33 (17, 89)
2090s	23 (16, 48)	40 (26, 69)	39 (16, 84)	45 (19, 58)	64 (33, 94)

Table 4.6. Change in frequency of hot nights (%, relative to mean of 1970-1999)

EASTERN NEPAL					
Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2060s	6 (7, 30)	26 (4, 37)	56 (6, 77)	27 (9, 32)	29 (9, 41)
2090s	37 (22, 44)	45 (19, 60)	85 (29, 93)	44 (31, 56)	53 (14, 88)
CENTRAL NEPAL					
Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2060s	23 (13, 26)	26 (3, 34)	55 (25, 71)	23 (16, 36)	28 (10, 40)
2090s	33 (20, 38)	45 (6, 56)	77 (44, 89)	38 (25, 51)	54 (14, 86)
WESTERN NEPAL					
Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2060s	23 (8, 26)	25 (2, 36)	48 (12, 61)	22 (8, 32)	27 (6, 40)
2090s	32 (17, 39)	42 (9, 58)	81 (40, 87)	38 (18, 51)	54 (9, 77)

Table 4.7. Change in monthly precipitation (%, relative to mean of 1970-1999)

EASTERN NEPAL Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2030s	0 (-26, 10)	0 (-36, 71)	0 (-17, 20)	-4 (-35, 24)	6 (-45, 46)
2060s	10 (-26, 44)	2 (-37, 53)	11 (-21, 71)	2 (-14, 36)	-8 (-52, 35)
2090s	15 (-43, 80)	18 (-59, 97)	25 (-52, 121)	27 (-22, 105)	-5 (-72, 22)
CENTRAL NEPAL **Time Period**	**Annual**	**Pre-Monsoon**	**Monsoon**	**Post-Monsoon**	**Winter**
2030s	0 (-34, 22)	-7 (-32, 11)	5 (-17, 40)	-4 (-26, 86)	-10 (-43, 13)
2060s	0 (-36, 47)	-10 (-45, 19)	10 (-37, 79)	4 (-15, 119)	-11 (-42, 11)
2090s	7 (-32, 64)	-13 (-54, 36)	19 (-46, 123)	4 (-42, 132)	-19 (-56, 21)
WESTERN NEPAL **Time Period**	**Annual**	**Pre-Monsoon**	**Monsoon**	**Post-Monsoon**	**Winter**
2030s	0 (-31, 16)	-10 (-40, 16)	0 (-14, 37)	-5 (-23, 125)	-12 (-40, 26)
2060s	4 (-33, 67)	-15 (-43, 29)	2 (-40, 143)	6 (-15, 186)	-6 (-50, 15)
2090s	3 (-23, 74)	-17 (-45, 32)	6 (-45, 135)	1 (-30, 205)	-19 (-49, 32)

Table 4.8. Change in precipitation as heavy events (%, relative to mean of 1970-1999)

EASTERN NEPAL Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2060s	2 (-8, 5)	2 (-13, 9)	3 (-4, 20)	1 (-5, 2)	-2 (-32, 5)
2090s	6 (-4, 23)	4 (-34, 12)	6 (-6, 34)	7 (0, 28)	-5 (-21, 9)
CENTRAL NEPAL **Time Period**	**Annual**	**Pre-Monsoon**	**Monsoon**	**Post-Monsoon**	**Winter**
2060s	4 (-7, 12)	0 (-14, 12)	4 (-6, 17)	3 (-9, 24)	-4 (-10, 6)
2090s	6 (1, 21)	-1 (-17, 16)	8 (-21, 30)	8 (-12, 26)	-1 (-13, 13)
WESTERN NEPAL **Time Period**	**Annual**	**Pre-Monsoon**	**Monsoon**	**Post-Monsoon**	**Winter**
2060s	3 (-6, 9)	-2 (-14, 14)	5 (-4, 12)	3 (-11, 26)	-6 (-15, 10)
2090s	7 (-1, 11)	-3 (-15, 16)	9 (-13, 15)	8 (-15, 30)	-3 (-27, 15)

Table 4.9. Change in maximum 1-day rainfall (mm, relative to mean of 1970-1999)

EASTERN NEPAL Time Period	Annual	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
2050	2 (-10, 57)	0 (-7, 12)	2 (-3, 61)	1 (-1, 5)	0 (-18, 5)
2090	10 (0, 91)	3 (-12, 10)	9 (-2, 98)	11 (0, 57)	-2 (-7, 7)
CENTRAL NEPAL **Time Period**	**Annual**	**Pre-Monsoon**	**Monsoon**	**Post-Monsoon**	**Winter**
2050	3 (-10, 38)	0 (-13, 7)	3 (-3, 43)	2 (-2, 13)	0 (-9, 4)
2090	12 (-1, 61)	0 (-10, 4)	5 (-4, 67)	8 (0, 20)	0 (-6, 11)
WESTERN NEPAL **Time Period**	**Annual**	**Pre-Monsoon**	**Monsoon**	**Post-Monsoon**	**Winter**
2050	4 (-9, 43)	0 (-11, 8)	2 (-3, 45)	2 (-4, 17)	-2 (-8, 6)
2090	11 (-4, 40)	-1 (-7, 5)	4 (-14, 43)	9 (-2, 16)	0 (-7, 7)

i COWI and IIED, 2009. Operation of the Least Developed Countries Fund for adaptation to climate change. COWI, Denmark; see also Agrawal, 2008. A Report on the World Development Report (WDR) Team-sponsored Workshop on National Adaptation Programs of Action in Africa.

ii The hottest 5%of days in the period 1970-1999

iii The hottest %% of nights in the period 1970-1999

[iv] NCVST, 2009

[v] These include (among others): the Pilot Program for Climate Resilience (PPCR), a new initiative of the Multilateral Development Banks (MDBs) to enable pilot countries transform their plans and investment programs to address climate risks and vulnerabilities building on NAPAs; a Technical Assistance programme under the Asian Development Bank to build national capacity on climate change; the REDD process is underway in Nepal with leadership from MoFSC; UNDP is undertaking an Investment and Financial Flows study on Climate Change; DfID recently announced 50 million GBP over the next 10 years for climate change related activities in Nepal including mitigation and adaptation; and Nepal is also in the process of finalizing its Climate Change Policy.

vi Moench, M., and A. Dixit. 2007. Working with the Winds of Change: Towards Strategies for Responding to the Risks Associated with Climate Change and other Hazards. ProVention Consortium, ISET Nepal. Kathmandu.

[vii] This approach draws on a recent study that adopted a transect approach to document experience and perceptions of climate change impacts in different eco-regions of Nepal. It has also presented scenarios of conditions of temperature and precipitation in 2030, 2060 and 2090. *Vulnerability through the eyes of the vulnerable.* NCVST, September 2009. ISET Nepal.

[viii] COWI & IIED, 2009. See ref. iii.

[ix] The Compact commits development partners to a set of principles to guide how development partners will support the Government of Nepal to implement a series of actions that identify and assess climate risks, elaborate, test, and implement adaptive responses, and establish the basis for a climate resilient economy. The Compact ensures that adaptation financing is done in a strategic manner.