Web of Resilience

Cross-scale implications of forest and water management for adaptation-mitigation and food security in the Nepal Himalayas

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ACRONYMS

AMC	Action in Mountain Community Nepal
AMS	Asian Monsoon System
AR4	Assessment Report Four
CBA	Community Based Adaptation
CBOs	Community Based Organisations
CBS	Central Bureau of Statistics
DFO	District Forest Office
DHM	Department of Hydrology and Meteorology
DoLIDAR	Department of Local Infrastructure Development and Agricultural Roads
DoS	Department of Survey
ENSO	El Nino Southern Oscillation
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
FIVIMS	Food Insecurity and Vulnerability Information and Mapping Systems
GCM	Global Circulation Model
GIS	Geographical Information System
GOs	Governmental Organisation
GPS	Global Positioning System
Ha	Hectare
HH	Households
ICT	Information Communication Technology
IFRCRCS	International Federation of Red Cross and Red Crescent Societies (Switzerland)
IIED	International Institute for Environment and Development
IPCC	Intergovernmental Panel on Climate Change
ISET-Nepal	Institute for Social and Environment Transition -Nepal
ISM	Indian Summer Monsoon
Kg	Kilogram
Km	Kilometer

LAPA	Local Adaption Plan of Action
MoF	Ministry of Finance
MoFSC	Ministry of Forest and Soil Conservation
MoSTE	Ministry of Science Technology and Environment
NAPA	National Adaptation Plan of Action
NAST	Nepal Academy of Scienct and Technology
NCAR	National Centre for Atmospheric Research
NCVST	Nepal Climate Vulnerability Study Team
NGO	Non-Governmental Organisation
NPC	National Planning Commission
NTFP	Non-Timber Forest Product
RCM	Regional Climate Model
SLD	Shared Learning Dialogue
SRES	Special Report on Emission Scenario
START	System for Analysis Research and Training
TKP	The Kathmandu Post
TRA	Threat Reduction Assessment
UN	United Nation
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VDC	Village Development Committee
WDR	Western Development Region
WFP	World Food Programme
WRF	Weather Research and Forecasting

EXECUTIVE SUMMARY

Amidst growing global concern about climate change and the need to adapt, Nepal has undertaken initiatives to translate policies on paper to activities in the field. In order to develop effective strategies for building resilience in the face of an uncertain future, it is essential to assess how on-going climate change processes ripple through regional and global systems to affect local conditions particularly the food security, forestry and other systems that sustain livelihoods.

In a bid to understand local dynamics, this study examined the on-going processes of change in six-village development committees (VDCs) along the Gandak transect of central Nepal, each with social and natural characteristics. One is in the Himalayan region, four in the mid-hills and one in the Tarai. The study had the following specific objectives:

- To explore the nature of the on-going processes of climate change processes and how they ripple through regional and global systems to affect conditions at the local level;
- To understand the implications of such processes for food security, forestry and the other systems that sustain livelihoods at the local level;
- To examine key policy issues related to existing strategies for forest, agriculture and water management that are emerging as a consequence of climate change; and
- To identify local points of entry that reflects large systemic interactions for building resilience and adapting to climate change.

The study examined the implications for food security due to climate change from the perspective of systems, agents and institutions as this approach recognises that climate change is only one driver among many that influences food security. Over two-and-a-half years period of study, collaborative work between ISET team and the local organisations, teachers, farmers and community members developed an understanding of the complex interrelationships among the drivers of change, uncertainty, and climate change and assessed the capacities of and leadership roles played by local agents and institutions. To achieve conceptual clarity among diverse approaches to assessing vulnerability, the researchers identified three crucial questions – "At what scale will climate change impacts occur?", "Where will they be most severe?", and "Who will be most affected by them?". Researchers examined climate change-related vulnerabilities using vulnerability assessment tools developed drawing upon the reasoning of a natural-hazard approach to rank wards within each VDC and determine the range of vulnerabilities from the most to the least vulnerable wards and sociological approach to assess the embedded vulnerabilities of the populations living in the most vulnerable ward. Identifying the current most vulnerable wards and the most vulnerable populations within each ward, the researchers developed scenarios that take into consideration of how current vulnerabilities will change in the future and, with the locals, prepared a resilience plan for each VDC. The study used the iterative-shared learning dialogue (SLD) method to engage local stakeholders representing different social groups.

The study focussed on Western Development Region (WDR) based on the study team's previous experience in the region. The diversity of the region – its two mountain, 11 hills, and three plains districts—and eight ecological zones—required that the researchers do considerable narrowing down to find representative locations for case studies. This was accomplished with a three-step iterative process. First, during a transect walk from the Tarai to Mustang, researchers conducted SLDs at 13 sites. Next, they synthesised the lessons from the transect walk and developed an approach

to selecting the vulnerable districts. After identifying the districts, the researchers identified VDCs for detailed study on the basis of discussions with local stakeholders. The district-level vulnerability assessment used the method suggested by the IPCC. It considers vulnerability as a function of three factors, exposure, sensitivity and adaptive capacity and using different indicators for measurement, 75 districts of Nepal were ranked. With the districts thus ranked, we focussed only on the WDR's 16 districts.

The WDR was then divided into three broad ecological regions—Trans-Himalayan, Mid hills and Tarai—even though it has eight regions. This division sufficed for the purpose. Next, the most vulnerable district in WDR from each ecological region was chosen: Mustang in the Trans-Himalayan, Arghakhanchi in the Mountains, and Kapilbastu in the Tarai. Then, SLDs with local officials and stakeholders were conducted to identify the most vulnerable VDC in each of three regions—Kagbeni, Mustang District, Hansapur, Arghakhachi District, and Dubiya, Kapilbastu District respectively. Given the diversity of the WDR, three VDCs would not be representative and it was purposively decided to include three additional VDCs. The uniqueness of the VDCs was considered to select them: Ramche, Myagdi District; Rupakot, Kaski District; and Madanpokhara, Palpa District. Ramche was selected because the community had begun experimenting with Internet use; Rupakot because of its proximity to the fast-urbanising Lekhnath Municipality and to the Rupa Lake watershed; and Madanpokhara, because it is progressive and relatively resilient. A seventh case study was also added in a watershed. The selection of Rupa Lake watershed helped explore the use of the methodology for developing an approach for ecosystem based adaptation.

The study not only met its objectives but also yielded new learning and insights into the implications that climate change and other drivers of change will have on local food production, food security, adaptation and resilience. First, the findings suggest that exposure in WDR is changing of late. Temperature trend analysis showed that both minimum and maximum temperature are increasing in some seasons at southern regions and increasing in almost all seasons at northern regions with more pronounced warming, particularly at high elevations consistent with the results of earlier studies while precipitation indicates more variability over the years with irregular distribution and more intense rainfall. The increase in temperature and variability of precipitation documented by the data analysed, GCM results and local perceptions may have affected cereal crops and vegetables as well as wild plants by altering agricultural systems. However existing data sets and network of meteorological stations are too few to permit a detailed analysis of these changes and make attribution.

Second, the study shows that food security which depended largely on localised production-consumption relationship is changing into increasingly regionalised relationships. Households now meet their food need by using income secured from both on-farm activities and off-farm activities like seasonal and long-term migration, small business, and services. As off-farm activities add to local income, the sources of income are getting diversified. Labour migration which holds long history among few ethnic groups, has been a characteristic of the WDR and Nepal as a whole and is considered as a major livelihood strategy. Traditionally, young males migrated to India however, today many go to Gulf countries and Southeast Asia and women are also joining the workforce. Currently remittance contributes around 23 per cent of the GDP with average Nepali household receiving 16 per cent of its income from abroad, twice its income from agriculture. The context of WDR is similar.

Third, the study recognises that roads, transportation and telecommunications expansion have rapidly brought about social, economic and environmental changes in the region. Understanding these changes is important because such changes have allowed individuals, households and communities to act on (together), strategise and not remain passive whether or not faced with stress. This exposure has made agents active and pragmatic and local agency more responsive. Local agents such as NGOs, CBOs and formal and informal associations of communities and their social network have worked as harbinger of change. By mediating between the locals and the national and performing key functions such as budget

planning, claiming rights, mobilising, these groups play critical role in building local resilience and promoting adaptation.

ISET-Nepal's engagement for two-and-half-years of study period provided researchers and larger stakeholders to engage in iterative shared learning dialogue and generate insights for tackling challenges that climate variability and change brings about. The engagement including SLDs, with local community, capacity building activities and immersion courses for teachers helped local stakeholders improve their understanding of global change processes. The challenges of translating climate change concepts into local context were possible only through this iterative participatory approach. Two particular insights deserve mention. The first was related to revision of local maps. During the study period, it became clear that the boundaries of the districts and VDCs prepared by Department of Survey (DoS) in 1996 did not match the present boundaries, which created discrepancy in representing vulnerability ranking. Using participatory GIS, the research team revised the maps of all six study VDCs. The second was undertaking bathymetric survey of Rupa Lake. This exercise by the study team with local stakeholders helped improve their understanding of the implications, changes in depth of lake will have on its volume, hypoxia and consequently on fisheries. This process helped bring high science to local communities. The research process provided opportunity to empower local governance and influence policy linkage by bringing local agents and government representatives in a dialogue process. Besides, research results were and are being disseminated through articles published in vernacular magazines, national English dailies, radio dramas and interviews, video documentaries, case studies, policy briefs, peer reviewed journal and international meetings (Box 16).

The knowledge generated informs that Nepal and its food system are changing dramatically. The nature of this shift is altering the impacts and sources of vulnerabilities of food systems to environmental shocks and its resilience. Food security is affected by far more than climate change; socio-economic, political and ecological systems at the local, national, and global levels are also in a constant state of flux. While identifying entry points for ensuring food security, understanding of local dynamics must deserve priority. In Nepal, these dynamics include low level of development, prolonged political transition, and emigration of active population for work, all of which add new vulnerabilities to existing ones brought about by caste, ethnic, and gender based practices. Social marginalisation has created pockets of vulnerability within the prevailing state of resilience in livelihood and food systems. Increasing reliance on regional and global food systems, demographic shifts, and decline in local agriculture and livestock-rearing further complicate matters. Issues related to food security are changing and it is important to move beyond local water and environmental management measures as central strategies for building food systems resilience to climate change. To that end it is necessary to examine fragility of the interlinked core systems that serve as gateways to higher services, including food security.

THE CONTEXT

1

Many Nepalis are vulnerable to changes in the climate due to their economic condition, reliance on agriculture and forest resource-based livelihoods, and high rates of migration. Since most agriculture is rain-fed or depends on surface irrigation, a form likely to be adversely affected by climate change, which will greatly impact food production and therefore food security. To increase understanding of climate change and its implications on agriculture, forestry, water management, and livelihoods in the Nepal Himalaya, systemic interactions from local to global level needs to be assessed. The Mid-Hills, the ecological region most vulnerable to climate change, was the focus of the study.

Adopting a systemic perspective sheds light on how climate change will impact vulnerability and food security as well as on the extant condition of systems and how their interdependence influences the functioning of society. This approach creates space to observe interactions between natural and social systems, including economies and politics. Local livelihoods and food systems depend on various macro factors such as the availability of natural resources and technology, socioeconomic conditions, changing demography, local capacity, national policies, macro-economy and politics, which, collectively, have direct local effects, some of which contribute to food insecurity. Systems, both ecological and infrastructural, particularly, transportation, energy, communication, education and finances, can help people shift strategies during times of stress. At the same time, they can also be sources of or cause new constraints. Since systems function as gateways to services, they are useful entry points to assess people's ability to adapt to shocks by taking advantage of systems. Such an approach is useful to build overall resilience. Fragile systems exposed to climate change impacts exacerbate the vulnerability of marginal populations, therefore sources of fragility must be identified and reduced. It is equally important to examine imbedded vulnerability, those characteristics of a society, such as its norms, values, politics, power differentials and exclusionary practices, which inhibit adaptive capacity.

To accomplish its goals of assessing interactions among systems and drivers of change, climate and others, and identifying points of entry to build resilience and adapt, a new methodology was called for. Shared Learning Dialogues (SLDs) enabled researchers to engage continuously with stakeholders for two-and-a-half years. The SLD approach is an iterative process of deliberation which involves the sharing of sectoral or group-specific knowledge and experience among local practitioners and external experts so that they can collectively generate new understandings that improve the quality and effectiveness of decision-making (ISET, 2011). Literature review, data analysis, GIS mapping and informal consultations conducted further honed researchers' understanding of the interactions among systems and the likely impacts of climate change on them and thereby on food security. The insights helped identify strategies to build resilience and strengthen adaptation in the study sites. The lessons are useful to examine interlinkages, assess vulnerability to climate change and build resilience and adaptive capacity.

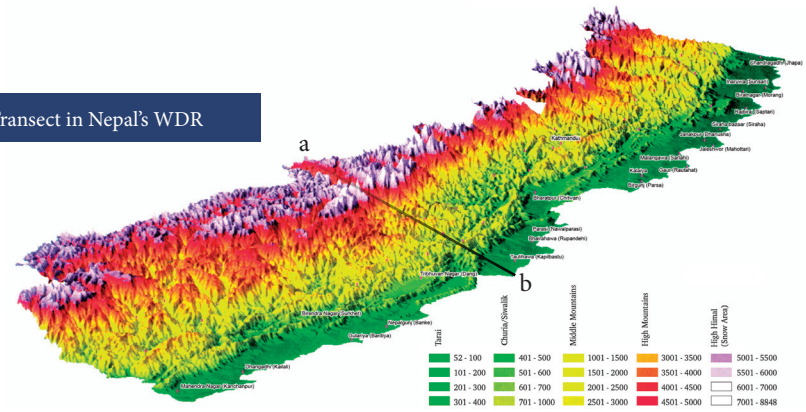
A woman collecting drinking water in mid hills, Arghakhachi District.

STUDY TRANSECT

2

The study was conducted in the Western Development Region (WDR) in the Gandak basin, which extends from the Tibetan plateau to the Indo-Gangetic plain of Uttar Pradesh, from an altitude of more than 8,000 masl to about 100 masl in just 150 km. The transect covers six major physiographic zones of South Asia: the Trans-Himalayan plateau, High Himalaya, Mid-Hills, Chure, Bhahar, and Tarai (Figure 1 a, b and c and Table 1).

FIGURE 1a: Mustang-Rupandehi Transect in Nepal's WDR



Source: NCVST (2009)

FIGURE 1b: Contour map of WDR

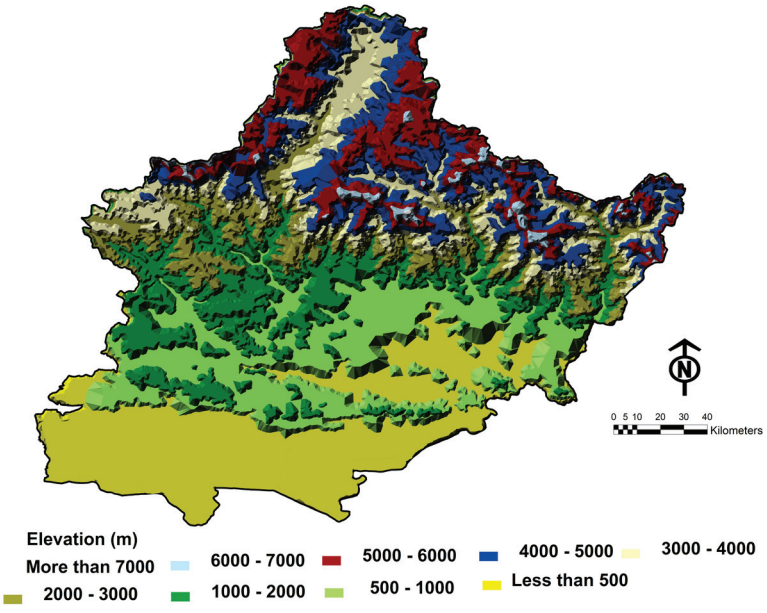
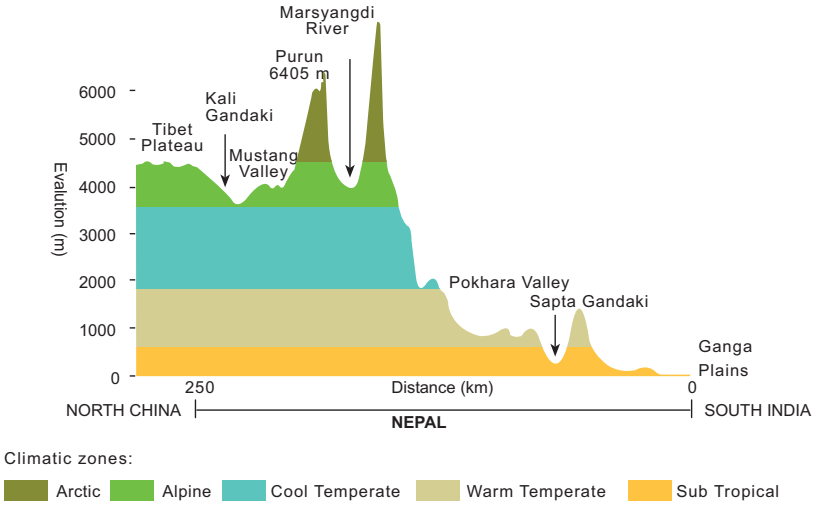


FIGURE 1c: Cross section of WDR along a-b



The WDR comprises 16 districts, three—Kapilbastu, Rupandehi and part of Nawalparasi—in the Tarai; three—Manang, Mustang and northern Gorkha—in the Himalayan region; and 10 in the Mid-Hills. It is one of the poorest regions of Nepal and South Asia. Over 80 per cent of its population depends on agriculture for their livelihood.

Three types of rivers drain the Gandak basin. The first class comprises the Kali Gandaki, Marshyangdi, and Seti, all snow-fed and originating in the High Himalaya. The second are the abovementioned river's tributaries, originating in the Mid-Hills and are fed by monsoon rain. The third type originates in the Chure range; they include the Tinau and Banaganga. The region comprises of all eight ecological zones found in Nepal, from the cold desert to the tropical Tarai and all the transitions in between. The ecological and social systems these zones support are as diverse as the zones themselves. More than 100 ecosystems, 75 types of vegetation and 35 types of forest are home to 635 species of butterflies (4.2 per cent of the global total), 185 species of freshwater fish (2.2 per cent), 43 species of

1 CHARACTERISTICS OF THE REGION COVERED BY THE TRANSECT

Region	Geology and soil	Elevation (masl)	Climate
High Himalaya	Limestone and shale. Much physical weathering. Stony soils.	> 4,000	Alpine to arctic
High mountains	Phyllite, schists, and quartzite. Resistant to weathering Shallow soils.	2,200 – 4,000	Cool to sub-alpine
Mid-Hills	Phyllite, schists, quartzite, granite, and limestone. Stony and coarse soils. Conifer forests commonly found with quartzite.	1,000-2,500	Temperate
Chure	Testing mudstone, siltstone, and sandstone. Steep slopes and weakly consolidated bedrock. High rates of surface erosion despite t hick vegetation.	200-1,500	Moist subtropical
Bhabar	Boulder zone south of the Chure. High recharge rate.	150	Humid tropical
Upper Tarai	Sloping. Recently deposited alluvium.	100	
Lower Tarai	Very gently sloping. Recently deposited alluvium.	< 100	

2 LAND-USE IN THE WDR

Land use	Forest	Shrub land	Grass land	Barren land	Cultivated land	Others
Area (Km^2)	9237	1374	4366	2266	5930	6184
Percentage	31.5	4.7	14.9	7.7	20.1	21.1

amphibians (11 per cent), 100 species of reptiles (1.5 per cent), 860 species of birds (8.5 per cent) and 181 species of mammals (4.2 per cent) (Bhuju et al., 2007).

In terms of landuse categories, 20.1 per cent of the land in the WDR is agricultural, 31.5 per cent is forested, and 14.9 per cent is grass land and 33.5 per cent is variously classified as barren land, shrub land and others (Table 2).

According to the 2011 Census, the WDR has 1,066,362 households and a total population of 4,921,775—2,292,597 males and 2,629,178 female. The sex ratio (number of males per 100 females) is highest in Manang District (127) and lowest in Gulmi District (76). Manang District has the lowest population density (3 person per sq km) and a negative decadal population growth of 31.80 per cent. The discrepancy between the proportions of households with and without food deficits for more than half the marked is in some district, like Lamjung, Baglung, Gulmi, Arghakhachi, Syangja, Nawalparasi, Rupandehi, and Kapilbastu, but not in all. The disparity in Myagdi, Tanahu, Parbat and Palpa, for example, is limited. Households which experience many months of food deficit have little incentive to continue pursuing livelihoods based on agriculture and other natural resources but have few other options.

FIGURE 2: Location of study VDCs

The study selected six VDCs in six of the 16 districts in the WDR (Figure 2): Kagbeni VDC in Mustang District of the Trans-Himalayan region, VDCs Ramche, Hansapur, Rupakot, and Madanpokhara in Myagdi, Arghakhachi, Kaski, and Palpa Districts of the Mid-Hill region, and Dubiya VDC in the Kapilbastu District of Tarai. Rupa Lake watershed was also selected.

At the end of two-and-a-half years, researchers had conducted an extensive literature review; SLDs with stakeholders; and vulnerability assessment, analysis, and ranking of the six VDCs and one watershed as well as developed local resilience plans and assessed local food baskets.

Livestock and agriculture land in Kagbeni VDC, Mustang District

RESEARCH PROBLEM

3

IPCC (2007) designated the Himalayan region as a white spot because knowledge about the impacts of climate change in this region is limited and unreported due in part to poor scientific understanding of monsoon dynamics and in part to the inherent limitations of climate modelling. A 2009 study by Nepal Climate Vulnerability Study Team and Nepal's National Adaptation Plan of Action both suggest that temperatures in Nepal have increased, the monsoon is more erratic and its spatial characteristics have changed, hailstorms are more frequent, frost is less likely, and snowfall patterns have changed. While the capacity of models to simulate climate systems have improved, models alone cannot provide sufficient insight into how climate change will affect various sub-processes of the hydrological cycle or how whatever changes occur will interact with social systems and exacerbate vulnerabilities.

The 2012 Climate Change Vulnerability Index by Maplecroft Atlas lists Nepal in the 'extreme risk' category. Millions of Nepalis, primarily the poor, women and other marginalised groups will face major impacts unless Nepal can build their adaptive capacity. Increasing resilience will not be an easy task, however, since there is little understanding of the interlinkages among climate change; a knowledge of wide range of socio-economic and ecological systems, including forest, food, and water; and the roles of the people and organisations that use and manage these systems and agents that implement adaptation activities will be needed. Developing specific strategies to reduce vulnerability, for example by reducing the impacts of floods and droughts, reducing health risks, and providing opportunities for alternative livelihoods requires building such an understanding.

In order to identify points of entry to achieve food security under changing climatic conditions, the likely impacts of climate change on the agricultural, forest, water and their interlinkages that are central to food security must be mapped. Such a mapping will reveal the nature of interactions among local, regional and global food systems within the context of on-going socio-political and economic change, specifically the development of road networks and communication systems, increasing rates of rural-urban and international migration and the shift to commercial farming.

The policy implications of cross-scale systemic dynamics are huge. There is a need to identify specific points of vulnerability and the likely interactions that create insecurity at the local level. It is also necessary to question the likely effectiveness of existing strategies for forest, agriculture and water management in the face of climate change. Local details—which geographic areas and which people within them will be most affected must be mapped—and specific strategies enabling them to deal with shocks developed. Pinpointing target groups in a given area requires assessing climate exposure, system vulnerability and, to identify imbedded vulnerability, marginalised populations. Only by examining local nuances can options for building the resilience of systems and the adaptive capacity of populations be identified and food insecu-

rity reduced.

A farmer selling fish from Rupa lake Rupakot VDC (Kaski District).

OBJECTIVES

4

The main goals of this study were to document the specific impacts of climate change on food, agriculture, forestry, water, and livelihood systems and to evaluate systemic interactions among them with a view toward identifying those interactions that make some groups more vulnerable than others. The specific objectives of the research are as follows:

- To explore the nature of the on-going processes of climate change and how they ripple through regional and global systems to affect conditions at the local level;
- To understand the implications of such processes for food security, forestry and the other systems that sustain livelihoods at the local level;
- To examine key policy issues related to existing strategies for forest, agriculture and water management that are emerging as a consequence of climate change; and
- To identify local points of entry that reflects large systemic interactions for building resilience and adapting to climate change.

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Women collecting fodder (Kapilbastu District)

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Agricultural land in mid hills Ramche VDC (Myagdi District)

METHODOLOGICAL APPROACH

5

5.1 Conceptual Framework

Our study examined the implications for food security due to climate change from the perspective of systems, agents and institutions because this approach recognises that climate change is only one driver among a number of interlinked factors that influences food security. Other changes, both natural and anthropogenic, are also occurring in the physical and biogeochemical environments. They include deforestation, urbanisation, land reclamation, agricultural intensification, freshwater extraction, water pollution and waste production. A systemic view helps us better understand these changes and how they impact climate change vulnerabilities, resilience and adaptation.

Exposure: Differences in exposure to the shocks and stresses induced by climate change result in different sources and degrees of vulnerability. Tyler and Moench (2012) suggest that stresses associated exposure to climate change is both direct and indirect. Examining exposure is an exercise in unpacking this complexity. The dependence of food security on many underlying systems, for example, exposes it both directly and indirectly to impacts from climate change.

Systems: Together, all the elements of interconnected systems, including physical infrastructure, communication and ecological systems, constitute the food system of a region. Since these component systems provide key services such as the production and distribution of food, they both enable provision and exchange and can help build resilience characteristics (Tyler and Moench, 2012).

Agents: Three main types of agents—the government, market actors and community groups—have different behavioural incentives in different circumstances with respect to the management of key system components. Understanding their behaviour is central to building resilience and adaptive capacity. Because capacitated agents are capable of deliberation, independent analysis, voluntary interaction and making strategic choices in the face of new information, capacity-development is an important part of resilience building (Tyler and Moench, 2012).

Institutions: Both informal and formal "rules in use" govern the expectations and behaviour of agents. Institutions within a society either create opportunities or introduce constraints for agents to access services from available systems. Institutions shape the behaviour of agents and modulate interactions among them in response to stress (Tyler and Moench, 2012). They can play a positive role in the development of systems but can also create hindrances.

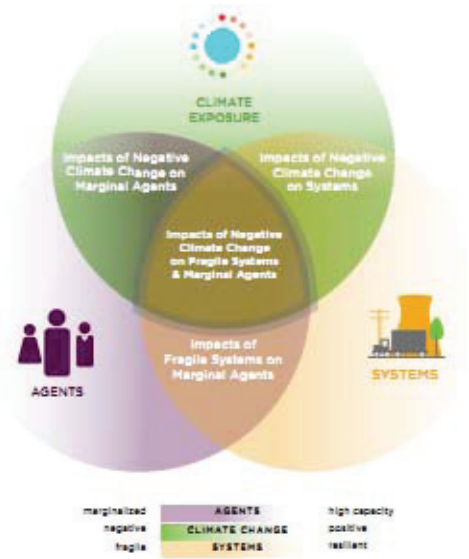
In this schema, vulnerability is conceived as a function of the exposure and robustness of systems; the social marginality of agents; and the accessibility of institutions and their capacity and willingness to empower. Vulnerability is greatest among marginalised populations that depend on fragile systems that are exposed to the negative impacts of climate change and where institutional constraints limit the ability of populations to deal with shocks. Formulaically,

Vulnerability = f (Fragility of systems + Constraining institutions + Exposure + Capacity of marginalised populations)

Developing an understanding of agents and their behaviours and the institutions that shape them does the same. This set of relationships has four core components; social marginality, system fragility, exposure, and institutional constraints (Figure 3).

Social marginality: Socially or economically marginalised populations generally have the lowest levels of access to resources and to systems and the services that they produce. As a result, they are among the first affected

Figure 3: Intersection of exposure, system and agents



Source: Catalysing Urban Climate Resilience, by Moench et al., 2011, p.37. Adapted with permission from the author.

when the flow and stock of goods and services provided by systems are disrupted. Such populations, along with similarly marginalised institutions, also have the least political, economic, and technical ability to address the failure or improve the management of a system.

System fragility: Systems that are fragile are more likely to fail under conditions of increased stress than those that function well under the range of stresses that are currently or likely to be encountered. Fragility can either be directly related to one component of a system or to the core systems on which any particular component depends. The robustness of an irrigation system, for example, depends on the condition of water resources.

Exposure: Systems that are not exposed to a potential source of disruption cannot be vulnerable to it either. A settlement on a hill slope, for example, is not exposed to flooding but is exposed to landslides. Exposure can be direct or indirect. Food systems in the WDR, for example, are directly exposed to local weather events and indirectly exposed to events that affect the production and transportation of food in areas from which it imports. Understanding the nature of exposure and potential disruptions is central to understanding vulnerability of a system.

Institutional constraints: Institutional factors can often limit the scope of action, which agents take in response to changes and stresses on systems. With regard to food security, patriarchal, caste- and ethnic-based, and other discriminatory social institutions impede actions, as do institutional constraints such as prices and policies.

The existing systems in the study VDCs were classified as core, secondary and tertiary (Table 3). Core systems are foundational: if they are of poor quality, inaccessible or exposed to climate change, then resilience or adaptive capacity will deplete. Secondary and tertiary systems provide individuals, households, communities and others with services they can use to pursue strategies to respond to various stresses including those due to climate change.

5.2 Climate System

5.2.1 Climate in the WDR

The Asian summer monsoon (ASM) dominates the annual precipitation pattern of the WDR. Its influence is due in part to the large topographic influences of the Himalayas and the height and distribution of the Indonesian and the Philippines archipelagos, without which the ASM would either be weaker or not exist at all (Hahn and Manabe, 1975; Song et al., 2009; Neale and Slingo, 2003). The climate of a location, or its 30-year average weather, is largely determined by

3 **LEVEL AND ELEMENTS OF SYSTEM**

Systems	Explanations
Core	Energy, Drinking Water, Land, Forest, Food, Ecosystem services
Secondary	Transport and mobility, Communications, Livelihood (Agriculture, Water, Forestry, Shelter)
Tertiary	Markets, Financial services, Health system, Education, Social networks, Non-farm production systems

two factors: local-scale features and large-scale climate patterns. Local-scale features encompass factors such as terrain relief, elevation, aspect, vegetation type and land use. Large-scale climate patterns include the Asian Monsoon System (ASM), El Niño Southern Oscillation (ENSO), snow-cover over the Himalaya, which govern rainfall pattern. (See Annex VII for a detailed discussion of the impacts of both factors on the spatial and temporal variability of precipitation and temperature in the WDR.) Within the AMS Nepal has four seasons:

i. Pre-monsoon (March-May)—Dry and hot, with occasional rain showers.
ii. Summer monsoon (June-September)—Very hot and rainy, with 80% of annual rainfall.
iii. Post-monsoon (October-November)—Warm and humid.
iv. Winter monsoon (December-February)—Cold and dry.

The pre-monsoon season is characterised by hot, dry weather; scattered rainfall; and moderate to strong westerlies. The pre-monsoon season also has the highest temperatures, which may reach 40°C during the day in some areas of the Tarai. The hills and mountains, however, remain cool. As the monsoon season approaches, humidity increases and thunderstorms are common. During this period, rainfall occurs in brief, heavy events over narrow bands. The post-monsoon season lasts until about November and is followed by winter, which is generally dry and cold, although the westerlies usually bring precipitation—rain in the lowlands and snow in the high mountains (Shrestha, 2000). The estimate for winter precipitation is notoriously low since much snow falls in High Himalayan regions where meteorological stations are few.

Since 1962, the Department of Hydrology and Meteorology (DHM) has regularly monitored climate-related data throughout the county. Every year, it publishes data in reports and bulletins and in electronic form. At present, there are 337 precipitation, 154 hydrometric, 20 sediment, 68 climatic, 22 agro-meteorological, nine synoptic and six aero-synoptic stations across the country, but they are not enough to capture all the diverse climate regimes in the country. In particular, the paucity of meteorological stations at 2,000-4,000 masl and their absence at higher elevations and the lack of data on snowfall make it particularly difficult to characterise the climate of higher elevations. The stations in WDR are shown in Figure 4.

According to Practical Action (2009) the annual mean precipitation in Nepal is 1,857.6 mm, 80 per cent of which falls in the four monsoon months of June, July, August, and September. The range in annual precipitation is considerable: the southern slopes of the Annapurna range get more than 5,000 mm while Tibetan plateau north of the range sees less than 250 mm. The AMS typically reaches eastern Nepal in mid to late June and advances westward, covering the whole country within a week. As the monsoon migrates, the amount of precipitation fluctuates from east to west, creating macro-scale varia-

FIGURE 4: Meteorological stations in the WDR

tions (Domoroes, 1978). While inter-annual variations are large and some years are too wet and others too dry, there is no significant trend in precipitation over the years and the swings seem to be a reflection of natural cycles (MoEnv, 2010). There is an intra-annual trend, however: July is the wettest month and November the driest. The distribution of extreme rainfall however, is different from the annual and seasonal distributions of precipitation.

Local features also cause high variations in temperatures from south to north and by elevation, which are characteristic of the WDR (Figure 5 a,b,c,d and e). In Mustang during December, January and February minimum temperatures at elevations below 3,000 m are typically are above freezing above and freezing at higher elevations. In contrast, temperatures in Rupandehi and Kapilbastu and other Tarai districts tend to be warm all months of the year: 22-27°C on average in the winter and over 37°C in the summer. In the Mid-Hills, average temperature hovers between 12-16°C. On average, temperature decreases by 6°C for every 1,000 m increase in altitude (Jha, 1992).

The marked differences in the climatic conditions of various areas in the WDR are in part a result of rapid changes in elevation within a short distance. The Himalayan massifs in the north and the monsoon climate create substantial local variations in temperature and precipitation. The Tarai plains are much hotter and wetter than the higher Himalayan regions. Local topographic features, like steep gradients both in the east-west and north-south directions, also determine precipitation, as does elevation (See Figure 6). In fact, precipitation on a valley floor can be up to eight times that on the ridge above (Lang and Barros, 2001).

To be more specific, the higher districts of Mustang, Myagdi, Manang and Kaski (2,000–4,000 masl) receive less precipitation and experience a shorter monsoon season than the lower districts of Arghakhachi, Palpa, Rupandehi and Kapilbastu (100–2,000 masl). For example, the AMS dominates both Mustang and Rupandehi but the former gets the most rain in March and April and the latter in July, when on average 650 mm falls. The difference in precipitation between the

FIGURE 5a: Mean annual average temperature in WDR

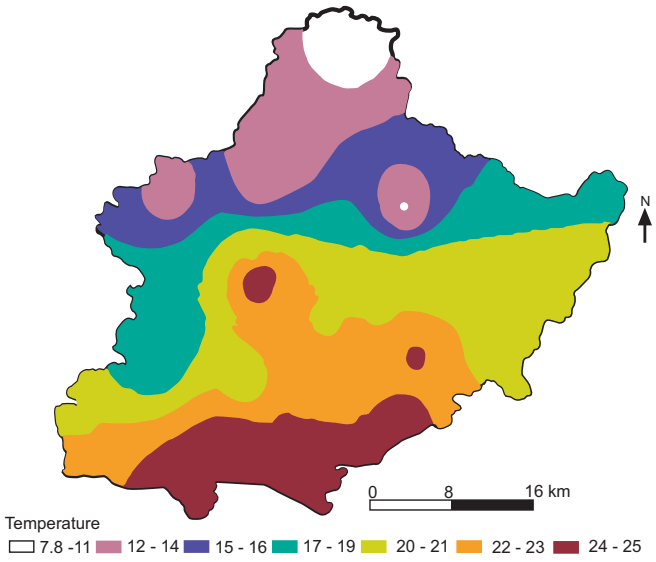


FIGURE 5b: Mean annual rainfall in WDR

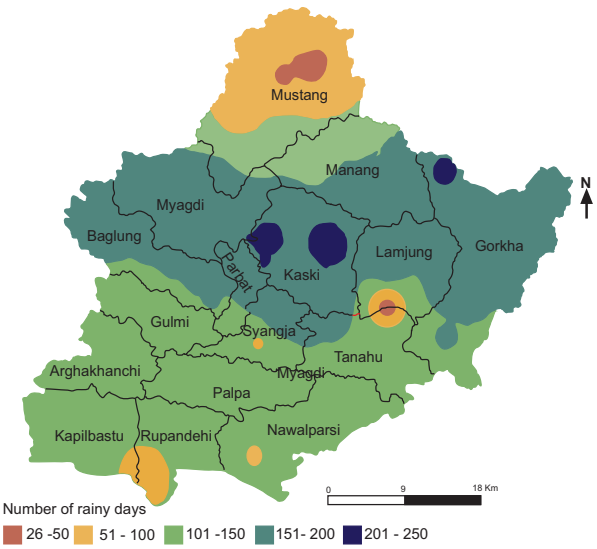


FIGURE 5c: Distributions of extreme rainfall in 24 hours in WDR

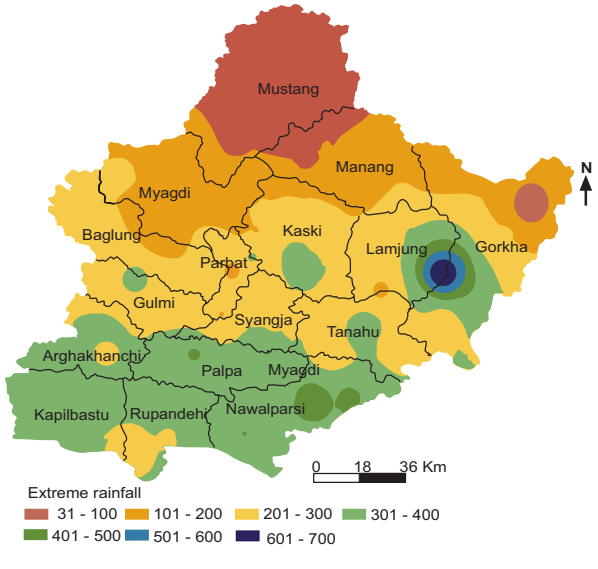


FIGURE 5d: Number of rainy days in a year in WDR

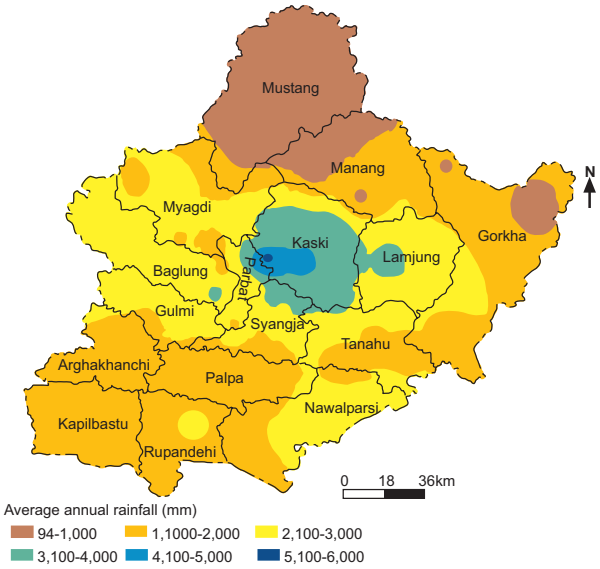


FIGURE 5e: Mean monthly rainfall in study districts of WDR

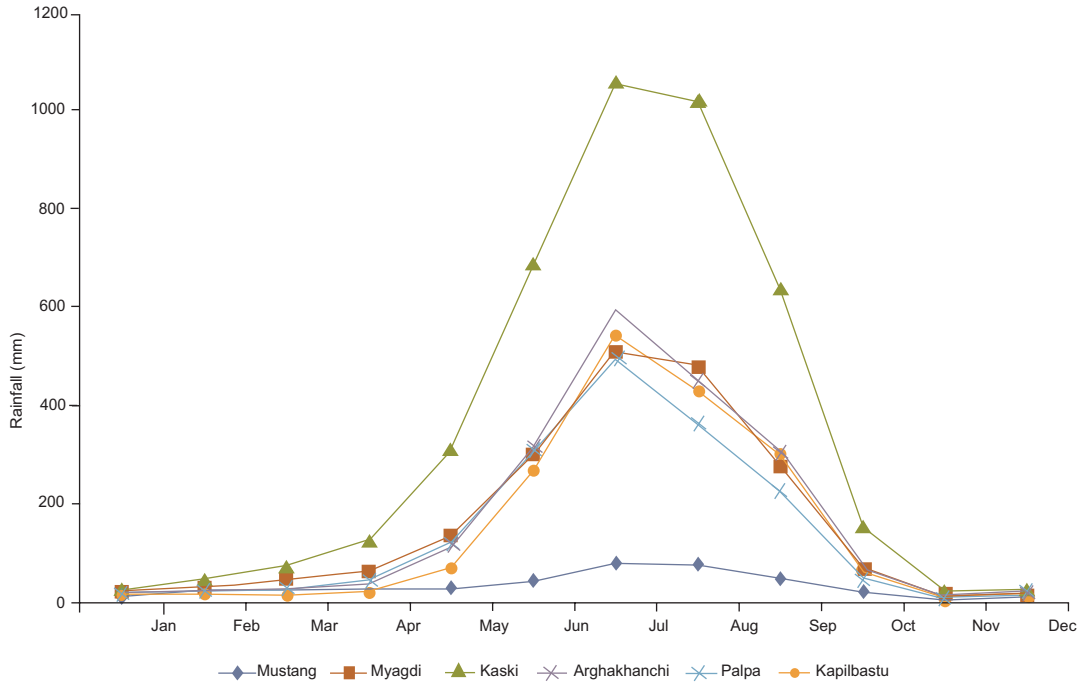
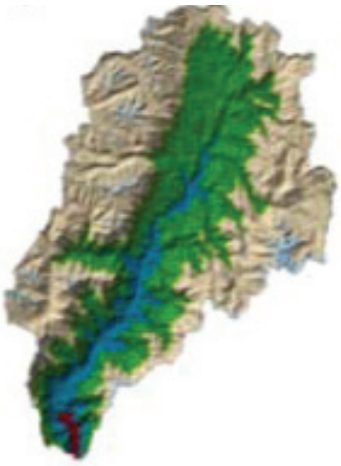


FIGURE 6: Elevation contrasts between southern (Rupandehi) and northern (Mustang) district

Rupandehi District



Mustang District

districts north and south of the Annapurna and Dhaulagiri ranges is vast: in any given month ten times more rain falls south of the mountains. Such local variations must be accounted for when assessing vulnerability and building resilience.

As is the case for the nation as a whole, the onset and withdrawal of the AMS in the WDR shows considerable variability. Inter-annual variability in the amount of precipitation is also significant: the large bars in Figure 7 a and b reflect the large inter-quartile (25th to 75th percentile) monthly precipitation range over the period 1977-2009 for two stations, one in the north of the WDR (Mustang 601) and other in the south. It is clear from the bars that monsoonal variability is high in all regions and that non-monsoonal variability is high in the north.

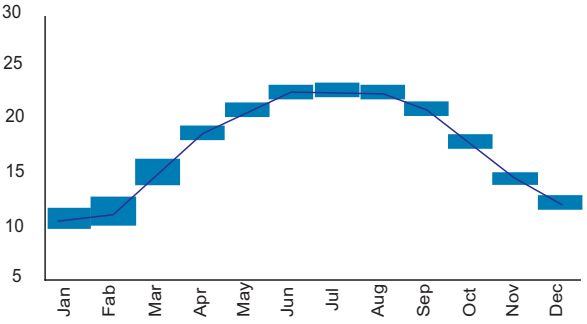
Given that there are huge local variations in climate, there is a need for much more representative data base if climate change induced local effects on vulnerable populations are to be assessed to be able to come up with the most effective strategies for adapting to the changes they will face.

5.3 Vulnerability: Concepts and approaches

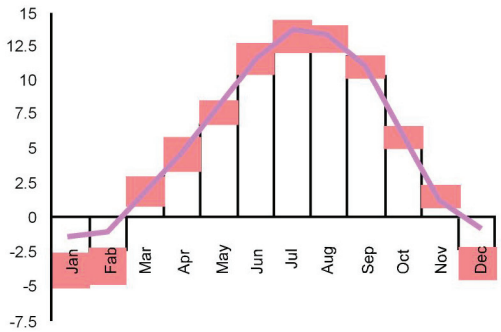
Robert Chambers makes a crucial distinction "vulnerability, or defencelessness, insecurity and exposure to risks, shocks and stress" is not the same as poverty, or "deprivation, lack or want" (Yamin et al., 2005). While Wilches-Chaux (1989) identifies 11 forms of vulnerability, ranging from natural and physical to ideological, social and technical (Smith, 2004), the Hyogo Framework defines vulnerability as "a set of conditions determined by the physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards" (cited in Ahmed and Mustafa, 2007), other theorists have narrower perceptions. Cutter (1996), for instance, adopts a positivist approach based on the natural hazards and disasters school of thought and focuses on the technological management of risk stemming from physical hazards. Wisner et al., (2004), in contrast, examine social vulnerability, the sum total of vulnerabilities embedded in a given social context and influencing the capacity of a person or household to anticipate, cope with, resist or recover from the impact of a natural hazard. Bohle et al. (1994) view vulnerability similarly: they agree that a certain "social space" determines the exposure to risk, coping capacity and

FIGURE 7a: Monthly maximum and minimum temperatures for Mustang and Rupandehi districts

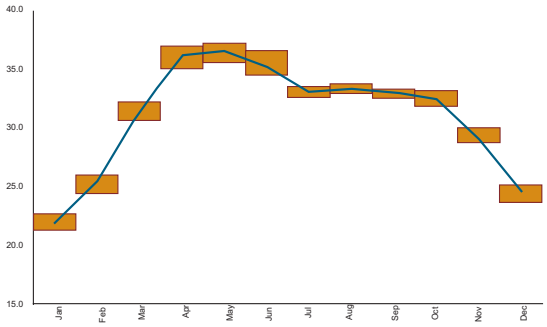
Mustang 601: Monthly maximum temperature 1975-2009



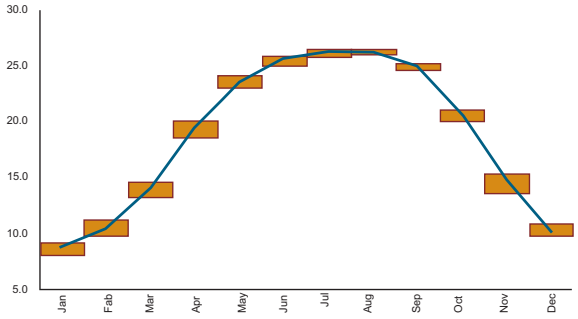
Mustang 601: Monthly minimum temperature 1975-2009



Rupandehi 707: Monthly maximum temperature 1976-2009



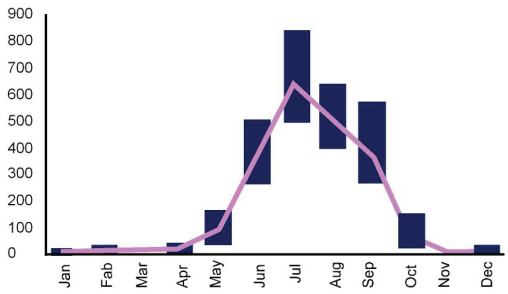
Rupandehi 707: Monthly minimum temperature 1976-2009



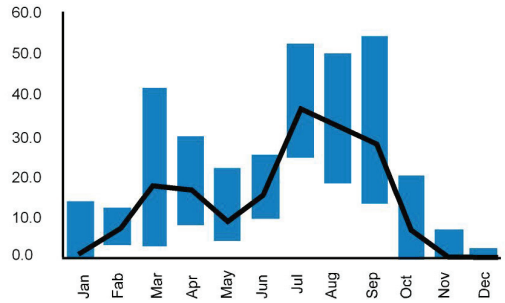
The solid line represents the median monthly temperature. The bars represent the inter-quartile range.

FIGURE 7b : Monthly precipitation totals for Mustang and Rupandehi districts

Rupandehi 703: Total monthly precipition 1977-2009



Rupandehi 601: Total monthly precipition1977-2009



The lines represent the median total monthly precipitation value. The bars represent the inter-quartile range. Note the difference in scales of precipitation. How does this characteristic relate to climate change andthe alternations it induces is an important question. This alternation is one of the factors that create new source of vulnerabilities.

recovery potential of individuals and communities. Cannon (1994) more explicitly rejects the positivist approach, claiming that vulnerability is a function not of environmental extremes but of everyday social contexts. Yet, there is no universally agreed definition of vulnerability.

Kelly and Adger (2000) examine a variety of definitions in their attempt to define the magnitude of the harm of climate change and determine an effective means of identifying coping strategies and facilitating adaptation. But just as vulnerability is difficult to define, it is also difficult to measure. Kelly and Adger (2000) define vulnerability in terms of the capacity of individuals and social groups to respond to, that is, to cope with, recover from or adapt to, any external stress placed on their livelihoods and wellbeing and

Changing house structure in Kagbeni, VDC (Musting District).

suggest that any analysis of vulnerability must consider the 'architecture of entitlements' within a community or nation that either promote or constrain options for adaptation. Schroter et al. (2004) claim that vulnerability assessments are the product of three streams of research dating back to 1960s: impact assessments and risk and hazards research, both which focus on multiple effects of a single stress, and food security studies, which focus on multiple causes of a single effect, namely hunger or famine. They propose that a vulnerability assessment must meet five criteria—a knowledge base derived from various disciplines and stakeholder participation, place dependence, multiple interacting stresses, differential adaptive capacity, and historical perspective—and offer an eight-step methodological guideline to assessing vulnerability. Their hope is that with a common framework, research outcomes will enable stakeholders to assess the effects of global change on a site-specific basis and foster cross-study comparisons (Schroter et al., 2004).

Noting that a range of methods, frameworks and approaches explain various factors that could increase vulnerability, Patt et al. (2009) argue that no single factor or, for that matter, combination of factors, is itself a measure of vulnerability. Instead, each factor is an indicator, which, combined with other indicators under a single theoretical model or multiple models, helps reveal the overall picture of vulnerability. Vulnerability is not a feature of how a system functions in the present but of how likely it is to function in the future. Because only the future can validate theoretical models, the authors caution against what they call "the vulnerability trap"—latching on to one explanation or solution to the exclusion of others—and advise engaging in reiterative consultation and open dialogue with all relevant stakeholders to avoid such a simplistic outlook (Patt et al., 2009). Nevertheless, we can agree that vulnerability is low where those facing potential harms have access to the benefits and services of systems, where core systems are resilient to disruption because exposure is low, and where

institutions enable those likely to be harmed take actions to avoid harm.

To achieve conceptual clarity among these diverse approaches to assessing vulnerability, the researchers identified three crucial questions—"At what scale will climate change impacts occur?", "Where will they be most severe?", and "Who will be most affected by them?"—and chose the method best suited to answering them, that of the IPCC, which defines vulnerability as a function of exposure, sensitivity and adaptive capacity. Thus further developed these criteria (Table 4) in order to assess and rank vulnerability of the six VDCs of the WDR as explained later. In doing so, the researchers built on the approach that ISET-International adopted in a recent assessment of urban resilience in 2012, which defined vulnerability as the intersection of exposure to climate change, the presence and performance of systems (whether fragile or robust), and the characteristics of the population, particularly their degree of marginalisation due to social and political structures and whether institutions play an enabling or constraining role. Though developed for urban context, the approach also resonated with the changing characters of Nepal's rural region where distinction between rural and urban is gradually blurring. As such assessing vulnerability, building resilience and capacity for adaptation needed a new approach as point of departure.

Vulnerability assessment began with 'place-based' (in our case,VDC) approach—rooted in a particular context—for two key reasons. First, the delineation of VDC or place matches the scale of decision-making (Schroter et al., 2004). In Nepal, budgets are allocated according to VDC, which function as the lowest level of governance. Second, while climate change is a global phenomenon, its impacts and vulnerabilities created are local and dealt most effectively at that level. Response strategies must create social, institutional and political incentives at local-level to overcome factors that create or perpetuate vulnerability. Localising strategy requires better understanding of the changing nature of climatic dynamics, the types of systems present and the interdependence and interactions between climate and systems at that scale. This starting point was central to our approach because the context was of emerging complexity where the local systems were dependent on regional and even global systems. New sources of vulnerabilities, which ripple through the systems, have emerged and require a nuanced analysis.

To identify points of entry for addressing both physical and social vulnerability, in this study we used both the natural-hazard, top-down and the sociological, bottom-up approaches to design the analytical tools. Using the natural-hazard approach, the researchers first ranked the vulnerabilities of selected wards in each VDC and determined the range of vulnerability from the most to the least vulnerable. This was done by using the concept of 'systems as gateways to services' to rank vulnerability of the ward. Once the most vulnerable ward had been identified, the researchers determined who within that ward was most vulnerable using the sociological approach, inquiring and conducting SLDs. The next step involved finding out households and groups with limited or no access to the systems that provide services and the reasons behind it. This latter approach, by providing information on embedded marginalisation, through opportunities for interaction, revision and shared decision-making, helped identify appropriate

4 FRAMEWORK FOR ASSESSING VULNERABILITY

IPCC	Our approach	Attributes
Exposure	Direct and indirect	Quantity, reliability, quality, frequency of extreme events
Sensitivity	Systems	Water, food, communication, transportation, energy, forest, ecosystem, etc.
Adaptive capacity	Marginality (Character of agent)	Caste, gender, social position, education, income, voice, representation
	Institutions	Rules, norms, policies, practices, etc.

interventions specific to the most vulnerable. The approaches thus paved the way for building resilience and adaptive capacity.

This approach was replicated at watershed scale: using the systems present within the watershed as indicators, each sub-watershed was ranked according to its vulnerability after making certain adjustments because, in Nepal, hydrological (sub-watershed) and administrative (VDC) boundaries do not correspond.

5.4 Resilience and adaptive capacity: Concepts and theories

Vulnerability is inversely related to resilience and adaptive capacity, two interrelated but somewhat different concepts. Adaptation can be conceived of as the ability of agents to shift strategies and/or modify systems as conditions change. This ability depends primarily on having assured access to drinking water and food (core systems) as well as a continuous flow of goods, services and information (secondary systems) across scales and boundaries. This notion of adaptation takes us to resilience. What is resilience is an important question. According to Resilience Alliance, "resilience is the ability to absorb disturbances, to be changed and then to re-organise and still have the same identity (retain the same basic structure and ways of functioning). It includes the ability to learn from the disturbance. A resilient system is forgiving of external shocks. As resilience declines, the magnitude of a shock from which it cannot recover gets smaller and smaller." While useful, the definition is incomplete without linking it to society and people because climate change impacts society in a context of underdevelopment, still pervasive poverty, joblessness, marginality, lack of choices and helplessness.

These deficits are the outcome of differential provisioning of and access to resources, their control, and their use for generating and sharing benefits. From the perspective of minimising vulnerability to climate change, using the concept of resilience presents challenges particularly in defining the resilient systems, and in determining the criteria of resilience and assessing distributional benefits such systems may generate. Resilience to shocks and crises is not merely about bouncing back to the original state. In fact, its literal meaning may convey a very different meaning as experienced during the course of our study (see Box 13). Resilience is a matter of progress and wellbeing when faced with shocks. Humans face shocks of many kinds and deal with them with varying degree of successes. Those individuals, households and community with wherewithal to deal with shocks and crises progress and attain wellbeing. Those incapable, lose out. Communities and individuals doing well do so because they possess the capacity to overcome sources of harm and bring about transformative changes for well-being. Since many of these underlying vulnerabilities are structural and systemic (Friend and Klune, 2013), any efforts at reducing vulnerability or building resilience must consider both systems and people as central elements of the strategy. The Social Resilience Website of the Institute of Social Anthropology, University of Basel) recognises this interdependence and suggests, "the concept of resilience is related to reactive capabilities of people to cope with, recover from and adjust to various risk and adversities and their proactive capacity to create options and anticipate responses to health risks and adversities.

Thus, presence of quality (read resilient) systems and capacity to take benefits from them are important. Where core systems are resilient to disruption because exposure is low or because, their systemic characteristics are such that institutions managing them enable agents to act to recover from disruption, and when people have access to the benefits and services that systems provide, vulnerability is low. Thus, identifying characteristics of resilience and the nature of successful adaptation is crucial for societal wellbeing. Pelling and Manuel-Navarrete (2011) suggest that the interdependence of social structure and agency governs transitioning to a stage that might enable resilience, and that stage is crucial to achieving adaptive capacity. But the relationship between resilience and adaptive capacity is not explicit and defining it is complicated by various, even contradictory notion of resilience as discussed above. While the origins of the term imply strength and resistance, recent work emphasises the notion

of flexibility, learning, and change (Twigg, 2001, Adger, et al., 2003; Prasad et al., 2008; Fields, 2009; Miller et al., 2010;). Despite the fact that several authors (Klein, Nicholls, and Thomalia, 2003; Miller et al., 2010; Leichenko, 2011) claim there is no framework for operationalising the concept of resilience, the literature, in fact, does highlights basic, often interrelated, characteristics that contribute to systemic resilience. Tyler and Moench (2012) have elaborated on characteristics of systems and agents while Friend and Klune (2013) focus on institutional attributes that foster resilience in urban context. Even in urban regions where systems are tangible, these evolving concepts are fuzzy but are useful extensions to rural areas. Because the distinction between urban and rural contexts is blurring, the use of these concepts did provide analytical basis to deal with uncertainty, planning to build resilience and adaptive capacity in WDR. In the following sections we explain the attributes of systems, agents and institutions.

Systems characteristics

We depend on many types of systems, which provide basic services, help undertake economic activities and create opportunities for people to solve problem they face. Some of such systems include water supply, food supply and the environmental system within which they function. Other systems are related with energy supply, transport and communications. Systems are present in both rural and urban contexts and their function depends on following three characteristics.

Flexibility and diversity in key system components: The flexibility of each component of a system, its ability to function under a broad range of conditions, minimises the chance that system will experience total failure when it is subjected to stress. In the case of a water system, for example, the ability to function in conditions of both very high and very low flows is an example of flexibility. Diversity, the number of qualitatively different system components that provide the same service, is another key contributor to resilience. In a food system, the ability to access grain produced in different regions and/or reliance on different types of grains are few examples of diversity.

Redundancy and modularity: Redundancy is a measure of the number of different system components that work in parallel with each other, providing an identical service and serving as spare capacity for each other. In a transport system, for example, multiple roads to the same location provide a degree of redundancy: if one is blocked another can be used. Modularity, on the other hand, is the number of system components that are identical and can easily replace each other. For example, a transport system with roads is more modular than one based on railway trains because, in the former, if one type of vehicle fails, whether trucks or cars or motorcycles, others can be used, but in the later, only trains, and trains of a fixed gauge, can ply on fixed tracks.

Safe failure: A system will experience a "safe failure," or partial and gradual failure without utter collapse, if it has buffer stocks and/or if the thresholds at which the failure of any given component will result in the sudden, catastrophic failure of the entire system are high. To take an example from flood management, systems that rely on embankments are subject to sudden failure if even a single embankment is overtopped, but those that preserve open flood plains are inundated only gradually, as flood levels rise. Where irrigation is concerned, rain-fed systems are highly vulnerable to sudden failure if droughts are common, but irrigated systems that can access groundwater have at least a temporary buffer if there is no rain.

Agents' characteristics

Agents that are resourceful, responsive and possessing ability to learn are resilient.

Resourcefulness: Agents must have access to a variety of resources, psychological, social and physical resources, all of which are inextricably interlinked, they must be able to act effectively or imaginatively, especially in difficult situations. In the case of food systems, agents who have access to social networks and financial and technical resources from which they can acquire or borrow either food itself or the money or inputs to buy or grow it respectively are more resilient than those who are isolated.

Responsiveness: How does an agent respond to stress, new information depends on worldview and of the agent and source of disruptions he or she faces and the incentives he or she has. Market agents, for example, tend to respond quickly to prices and economic opportunities but discount information about long-term conditions. They may also respond in ways that decrease overall system functioning (e.g. by hoarding during periods of food shortage). Governments, in contrast, will take into consideration long-term information but be impeded by institutional conditions and inertia. For example, the on-going political transition in Nepal has reduced the ability of local government agencies to respond effectively to many local needs to build food security.

Ability to learn: The ability to learn refers to the social, educational, and institutional factors that enable agents to learn as conditions change and to switch strategies accordingly. In case of food systems, the ability to learn is evidenced by the adoption of new varieties of crops as well as by the formation of cooperatives and other local organisations that provide major advantages to members despite the odd constraint institutional rules may impose.

Institutions characteristics

Institutional resilience requires recognising the role of access rights and entitlements, decision-making processes, information flows and application of new knowledge (Friend and Klune, 2012) discussed as follows.

Access rights and entitlements: Rights and entitlements to use key resources or access systems should be clear. Institutions that differentially constrain rights and entitlements can limit access to systems or services and thus reduce resilience. Structures of rights and entitlements should not systematically exclude specific groups from access to critical systems or capacities. They should enable collective action, and foster access to basic resources.

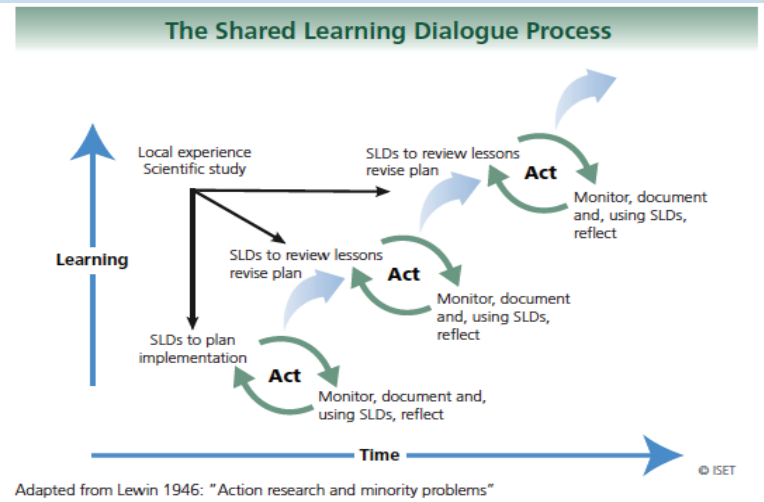
Decision making processes: Decision-making processes, particularly in relation to development and systems management, should follow widely accepted principles of good governance, mainly: transparency, accountability and responsiveness. This includes recognition of those groups most affected as providing legitimate inputs to decision-making processes that are transparent, representative, and accountable. Diverse stakeholders have ways to provide input to decisions. Dispute resolution processes are accessible and fair.

*Information flows:*Private households, community, businesses and other decision-making agents should have access to accurate and meaningful information to enable judgments about risk and vulnerability, and for assessing options for build-

BOX-1: SHARED LEARNING DIALOGUES

Shared learning dialogues (SLDs), which are simply structured discussions between researchers and local focus groups, are at the heart of a small-scale iterative process of deliberation and mutual learning. There are many benefits of SLDs. They,

- Enable researchers to assess the capacities of target groups
- Generate new information and enable the innovative use of existing information
- Establish a platform where local practitioners and external experts can work together to learn and generate knowledge
- Cross disciplinary and organisational boundaries and scales of governance
- Foster participatory planning and effective decision-making
- Translate theoretical concepts into local languages and help local insights be embraced in theories



ing resilience and making strategic choices for adaptation.

Application of new knowledge: Institutions that facilitate the generation, exchange and application of new knowledge enhance resilience. Many organisations are designed to meet single function such as build embankments for flood control and are focussed on preserving and maintaining existing structures, authority and practices. But building resilience requires innovation in order to reduce risk in the face of changing circumstances.

Thus, systems, agents and institutions that lack one or more of these characteristics are not likely to be resilient nor do they help build adaptive capacity. Lack of such characteristics deprive and often make the socially and/or economically marginalised communities more vulnerable when faced with climate change risks. They, for example, often do not have access to the finances and other key resources essential to shift strategy. In addition, they are also frequently locked in social or political relationships that limit their ability to respond to emerging constraints and to learn from experience. Understanding of vulnerability with the perspective of systems, agents and institutions provides a framework for analysis and planning for operationalising the concept of resilience. The idea of resilience itself is a potential entry point for achieving societal transformation (Pelling and Manuel-Navarrete, 2011) to adjust to different kind of shocks including that due to climate change.

After ranking VDCs and their sub-populations according to their vulnerability, the researchers moved toward an investigation of how to increase their resilience. They helped locals to contemplate future climate scenarios, future hazards and their exposure to them, and potential changes in vulnerabilities given the high levels of uncertainty regarding the future. Reminding community members that no unitary path could possibly provide all the solutions to what is sure to be a complex future, researchers facilitated the identification of as many options as possible for strengthening resilience and building adaptive capacity, keeping in mind existing systems, agents and institutions. These were compiled into local resilience plans, one for each VDC. This approach required researchers to take a shared approach to mutual learning among the analysts and local stakeholders. Clearly the future is becoming complex and to deal with uncertainty that it entails, problems could be sliced differently to identify suite of methods and pathways rather than lock one in a unitary path. The study embodied this broad philosophy.

5.5 Shared Learning Dialogues

Shared learning, mutual learning by all participants, is an approach to participatory planning and problem-solving appropriate for complex situations. The approach assumes that by fostering iterative deliberation between local practitioners and external analysts and the sharing of their sector- and/or group-specific knowledge, the quality and effectiveness of decision-making improves. The SLD process is not simply a series of meetings but rather a semi-structured, dynamic, and strategically facilitated succession of interactions. Its structure and composition can be readily adapted to meet the needs of the organisers as well as the social context, and the facilitator may choose to use any number of tools and techniques to generate discussion and interaction (Moench, et al., 2011; ISET, 2010).

Such interactions are critical and were first recognised during the 1960s and 1970s by anthropologists, social scientists and rural development practitioners considering the roles of technologies, modes of organisations and cultural practices and has evolved over time. In this study, we used SLDs to bring scientific and local knowledge and perceptions together (Dixit and Moench, 2009) and to generate new insights. Shared learning processes, when iteratively and carefully implemented, can help to break down established disciplinary and psychological divides that cause groups to reject or discount other sources of information, insights, and perspectives that are alien to them and challenge their worldview. A SLD process is especially useful for addressing challenges, which are so complex that no single source of knowledge can suffice for making strategic decisions. Resilience build adapting to climate change is one such challenge. Ultimately, a shared learning

method can assist decision-makers in public and private sectors, civil society, communities and households to identify possible interventions to overcome potential constraints, and set priorities (Moench et al., 2011; ISET, 2010).

5.6 Study implementation

The study had three stages (Figure 8). In the first, SLDs were held for to select which wards of which VDCs would serve as study sites and to assess the status of the systems in each ward. This exercise prepared the ground for the second stage: developing a method of assessing vulnerability and ranking the wards by vulnerability. At the same time, the SLDs helped researchers identify agents and assess their capacity to access resources, respond effectively, and to learn as well as to determine their roles in decision-making and interactions with institutions. The third stage was planning for building resilience of each VDC. Tangible plans were drafted, autonomous adaptation practices recognised, and viable options selected (Figure 8).

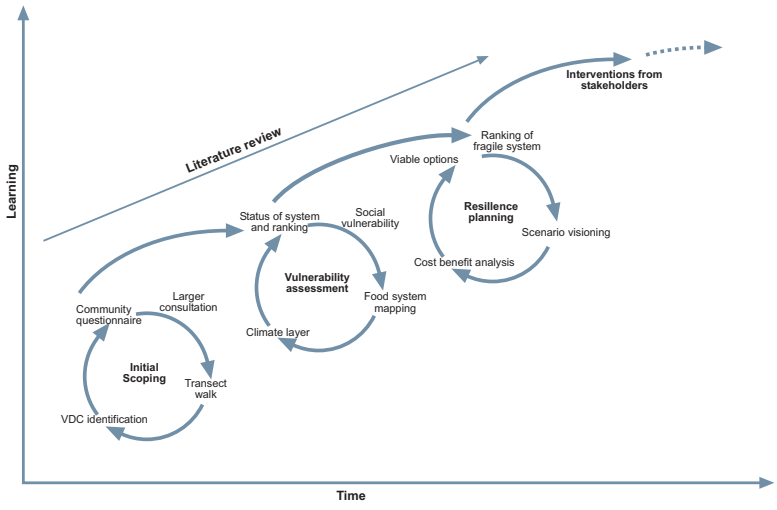
5.6.1 Scoping and selection of study sites

The WDR was chosen based on the study team's previous experience in the region and for logistical ease. The diversity of the region—its two mountain, 11 hills, and three plains districts—and eight ecological zones—required that the researchers do considerable narrowing down to find representative locations for case studies. This was accomplished with a three-step iterative process. First, during a transect walk from the Tarai to Mustang, researchers conducted SLDs at 13 sites. Next, they synthesised the lessons from the transect walk and developed an approach to selecting the vulnerable districts. After identifying the districts, the researchers identified VDCs for detailed study on the basis of discussions with local stakeholders.

The district-level vulnerability assessment used the method suggested by the IPCC. It considers vulnerability as a function of three factors, exposure, sensitivity and adaptive capacity. For each of the three factors, different indicators were selected for measurement: to assess sensitivity, researchers used human and ecological characteristics; to assess exposure, regional temperature and precipitation data; and adaptive capacity, socio-economic data and the presence of infrastructure. Thus 22 indicators from secondary sources (CBS data for each district) were used. For each indicator, the 75 districts were ranked between 1 and 75, with 1 the least and 75 the most vulnerable, and added to create a composite rank for each district ranging from 1 to 256. With the districts thus ranked, we focussed only on the WDR's 16 districts. The WDR was then divided into three broad ecological regions—Trans-Himalayan, Mid hills and Tarai—even though it has eight regions. This division sufficed for the purpose.

Next, the most vulnerable district in WDR from each ecological region was chosen: Mustang in the Trans-Himalayan, Arghakhachi in the Mid-Hills and Kapilbastu in the Tarai. Then, SLDs with local officials and stakeholders were conducted to identify the most vulnerable VDC in each of three regions—Kagbeni, Hansapur, and Dubiya respectively. Given the diversity of the WDR, three VDC would not be representative and it was purposively decided to include three additional VDCs. The uniqueness of the VDCs were considered to select them: Ramche, Myagdi District; Rupakot, Kaski District; and Madanpokhara, Palpa District. Ramche was selected because the community had begun ex-

FIGURE 8: SLD Stages of study



perimenting with Internet use; Rupakot because of its proximity to the fast-urbanising Lekhnath Municipality and to the Rupa Lake watershed; and Madanpokhara, because it is progressive and relatively resilient. A seventh case study was also added in a watershed. The selection of Rupa Lake watershed helped explore the use of the methodology for developing an approach for ecosystem based adaptation. The details of the VDCs are summarised in table 5 and case study locations are shown in Figure 9.

5.6.2 Vulnerability assessment

To assess vulnerability, the researchers, drawing upon the reasoning of a natural-hazards approach, ranked the core, secondary and tertiary systems of each ward in the six VDCs and each sub-watershed in the Rupa Lake Watershed. Then, applying a sociological approach, they used SLDs to assess the embedded vulnerabilities of the populations living in each of the most vulnerable wards and the most vulnerable sub-watershed, particularly why they were unable to access the services the systems provided.

5 DETAILS OF CASE STUDY VDCS

VDC	Elevation range (altitude m)	Temperature range (Max and Min in °C)	Annual precipitation (mm)	Population & area (ha)	Popⁿ Density/ km²	Ethnic composition	Major economic activities	Special characteristics
Kagbeni	2,785 to 6,183	Max - 16.4 to 17.9 Min - 4.6 to 6.4	198 in 90 days	1456[1], 28507[2]	5	Gurung, Thakali, Magar, Dalit and Chhetri, Gurung community dominant	Tourism, remittance and agriculture	Tourism viable area, Traditional *Mukhiya* system (village chief) is in practice
Ramche	950 to 3,263	Max - 26.4 to 28.9 Min - 11.7 to 16.85	2,797 in 163 days	2247*, 2602**	86.4	Magar 92 per cent, six per cent Dalit, and rest are Brahmin and Teli	Agriculture, tourism, remittance and local industries	Wireless internet, health treatment through telemedicine, community led eco-lodge
Hansapur	1,024 to 2,105	Max - 18.9 to 20.4 Min - 14.9 to 16.2	1,815 in 150 days	10,385* ,2851**	364.2	Gharti, Pun, and Rana Magar are the major ethnic groups	Remittance, agriculture, business and services	Most vulnerable among six VDCs, remittance flow is high, haphazard road construction
Rupakot	650 to 1,412	Max - 25.9 to 27.3 Min - 14.4 to 15.7	3,990 in 194 days	4652*, 1854.9**	250.8	Chhetri, Bhraman, Gurung, Magar, Muslim, Damai and Kami are major ethnic groups	Agriculture, service remittance, local industries and tourism	Initiation on conservation of Rupa lake establishing Rupa cooperative and biodiversity conservation centre
Madanpokhara	560 to 1,240	Max - 23.1 to 24.5 Min - 12.1 to 13.1	1,588 in 120 days	7950* ,1819.3**	436.9	Magar and Tamang 58 per cent followed by Brahmin/Chhetri 34 and Dalit eight per cent.	Commercial farming, service and remittance	Commercial vegetable farming, female literacy rate is higher than national average, diversified livelihood options
Dubiya	123 to 1,124	Max - 30.3 to 32 Min - 17.9 to 19.5	1,668 in 180 days	5598*, 7558**	74.1	Tharu are the dominant ethnic group followed by Brahmin and Chhetri	Agriculture, remittance and wage labour	Four locally built ponds to store rainwater, indigenous Tharu knowledge used in farming

1 Total population (Field survey,2011)*
2 Area in hectare (GIS data,1993)**

FIGURE 9: Location of the case study VDCs and Kali Gandaki River

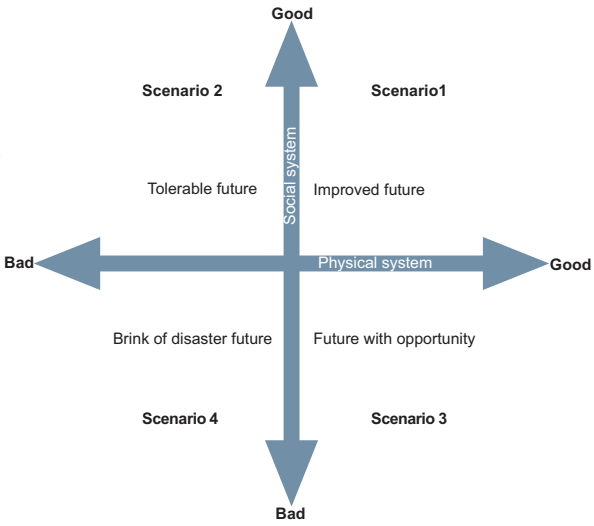
Researchers also made a local-level food production, distribution, and consumption timeline and discussed issues such as changes in local cropping patterns and farming practices in SLDs; difficulties in accessibility and distribution due to low production, the sufficiency of roads and vehicles, and politically-motivated closures. They also assessed vulnerability of forests and biodiversity because they are both resources crucial for earning a livelihood. They explored the relationship between biodiversity and food security from the perspective of adaptation to climate change using a threat-reduction-assessment tool adapted to the local context to identify key threats to local biodiversity and assess changes in livelihood patterns (Annex IX). Through informal interactions, group discussions, observations, and interviews conducted with disadvantaged households, the researchers invited a consideration of marginality as well as current and likely future challenges.

5.6.3 Resilience planning

After identifying the current most vulnerable wards and most vulnerable populations within those wards, the next step was to introduce the climate change layer, one that would exacerbate existing vulnerabilities. To get at the difficult question of how current vulnerabilities will change in the future, the researchers developed scenarios that take into consideration a larger conceptual framework, one that considers first, the nature of new vulnerabilities climate change will bring; second, the impacts climate change will have on the study districts and their populations, at the individual, household, group, and community level; and third, how vulnerabilities will ripple through interlinked systems. Once they had considered both the existing state and the future, stakeholders worked in groups to conceptualise and prepare local resilience plans for each VDC. They prepared bivariate chart with four quadrants (Figure 10) each representing four future scenarios: good physical-good social (improved future), good physical-bad social (tolerable future), bad physical-good social (future with opportunities) and bad physical-bad social (on-the-brink-of-disaster future).The process started with listing all existing physical and social systems and ranking how critical each was in the context of climate change. Two systems, one physical and one social, were selected for consideration in the next step: constructing a quadrant for uncertainty analysis.

- List all physical and social systems within the VDC
- Identify the most critical physical and social systems

FIGURE 10: Uncertainty analysis quadrant



- Use the chart to envision four future scenarios
- Draft resilience options using a climate lens for the worst scenario
- Prepare a local resilience-building framework that identifies institutions and strategies to implement each option

For the worst scenario stakeholders identified as many ways of building local resilience as they could envision, keeping in mind both present and new vulnerabilities. For those options that would increase community resilience through investment in critical systems, they carried out qualitative cost-benefit analyses. Finally, they determined the types of agents to implement each option listed in the plan. (Working Paper Series, Annexes I to VII).

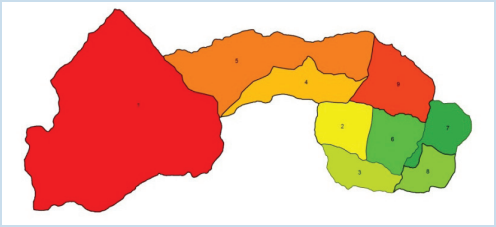
Next, the researchers analysed trends in DHM data and looked for correlations with community perceptions about changes in temperature, rainfall, cropping patterns, planting and flowering periods. This activity was carried out in conjunction with a review of literature on Himalayan meteorology, and hydrology, and the identification of gaps in knowledge and climate change uncertainties. A household survey on food production and consumption was conducted to assess the comparative food basket and income range of the most and least vulnerable wards of each of the six VDCs. To select households, researchers used stratified random sampling, with the most and the least vulnerable and one moderately vulnerable ward as strata. See Table 6 for a list of all the activities, tools and analyses used in the study.

BOX-2: MAP REVISION

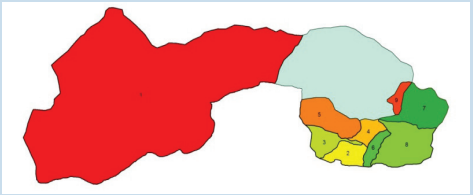
Though the study did not envision revising VDC maps, it turned out to be one of the key activities after it became clear that the boundaries of the districts and VDCs prepared by Department of Survey (DoS) in 1996 did not match the present boundaries. We discovered the discrepancy while conducting vulnerability assessments, which ranked VDC wards—the unit of analysis—on VDC maps. Local stakeholders pointed out differences and suggested the maps be revised. Making these revisions was not immediate; on the contrary, it required long-term engagement. In fact, if the researchers had not used the iterative interactions of SLDs in the first place, the need to revise might never have even emerged.

Revision began after ISET-Nepal got satellite images from Google Earth Pro and GIS layers. Consultations were held with locals using these images and adjustments were made accordingly. The revised map was presented to the locals for verification. While differences were observed in the maps of all six VDCs, the cases of Kagbeni and Dubiya VDCs are illustrative. The DoS map showed that the village of Sangta lay outside of the boundary of ward one and neglected to show the public land that had been reserved for all wards except Ward one to collect firewood and NTFPs. Other problems were that the boundaries of Ward six and seven were not clearly demarcated, nor were those of the villages of Dhakarjung and Falek, which lie in wards two-three and wards four-five respectively. The DoS map and the revised map are compared in figures as follows.

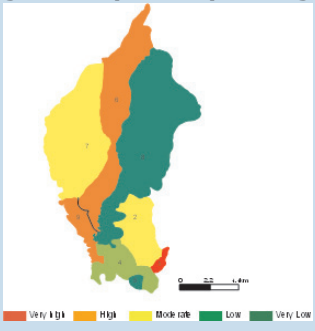
Ranking of Kagbeni VDC (existing map)



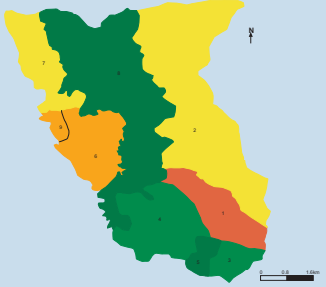
Ranking of Kagbeni VDC (revised map)



Ranking of Dubiya VDC (existing map)



Ranking of Dubiya VDC (revised map)



6 SUMMARY OF ACTIVITIES, TOOLS AND ANALYSIS

Research Activities	Tools	Analysis
Community questionnaires through SLD	Semi-structured questionnaires	Status of systems as gateways to services
Vulnerability ranking	Excel sheets and GIS maps	Identification of most and least vulnerable wards
Marginal community identification	Who and why sheets	Status of marginal community
Food system (production, consumption, distribution) charting	Cereals, vegetables and fruits production, consumption and market matrix Crop cycle mapping	Understanding of local food system and its fragility
Visioning of 2030 scenario with climate lens	Systems as gateways with temperature and precipitation change matrix	Systems as gateways in 2030 in six VDCs and a watershed unit
Assessment of threats to forest, biodiversity and livelihood	Threat Reduction Assessment (TRA) tool	Tracking of changes in dependency on forest and biodiversity and changes in livelihood options
Local resilience planning	Identifying of critical physical and social system Uncertainty Analysis and scenario development Identifying options through qualitative CBA	Local resilience plan with scrutinized options
Interaction with marginal community	Focus group interviews	Ground truthing of challenges faced by most vulnerable community
Food status survey	Household survey on food production with consumption, distribution and income details	Comparative food basket and income basket of most vulnerable, least vulnerable and moderate level wards of six VDCs

Local level interaction with marginal women in Hansapur VDC (Arghakhanchi District)

KEY FINDINGS

6

The two-and-half-years of study period was that of learning for tackling issues of climate building resilience and capacity for adaptation. Locals in each VDC face many stress and go about their lives. The learning was iterative: researchers came with field level data, analysed them and went back and presented the findings in the SLDs. Participants questioned the assumptions, made suggestions to be considered and iterative learning continued. In the process the study yielded several key insights, as discussed below.

6.1 Changing Exposure: Climate Variability and trends

Climate change vulnerability results where fragile systems and marginalised population facing institutional constraints are exposed to climate change-induced variability. Below is a discussion of how exposure in WDR is changing.

Temperature

Temperatures in Nepal have been increasing of late. Data collected by DHM from the 1977 to 2008 from 49 stations in Nepal suggest that the average temperature between that period increased at a rate of 0.06 °C per year; that the rise in temperature was greater at higher than lower altitudes; and that increases were more pronounced during the cooler months (0.06–0.08°C per year from October to February) than the warmer months (0.02–0.05 °C per year for March to September) (Shrestha et al., 1999; MoEnv, 2010; Shrestha and Aryal, 2011.), too, suggests that the observed warming is not uniform across the country and is more pronounced at high altitudes and WECS (2011) confirms that changes in temperature are marked.

Using the Mann-Kendall trend to analyse temperature data of southern and northern stations by season, ISET researchers discovered significant changes in the seasonal averages of both maximum and minimum temperatures at a number of but not all stations (Table 7). This data must be interpreted with caution as station density is very low and neighbouring stations are often at different elevations; in fact, the analysis had to be performed for each station separately and no area-averaged temperature indices were created. Similarly, it is important not to accord too much meaning to the actual quantity of change, as there was a lot of missing data that had to be extrapolated. What is valid, however, is the direction of change. Despite this caveat, it can be said with confidence that both minimum and maximum temperatures are increasing in some seasons at southern stations and they are increasing in almost all seasons at northern stations. The more pronounced warming in the north, particularly at high elevations is consistent with the results of earlier studies.

Precipitation

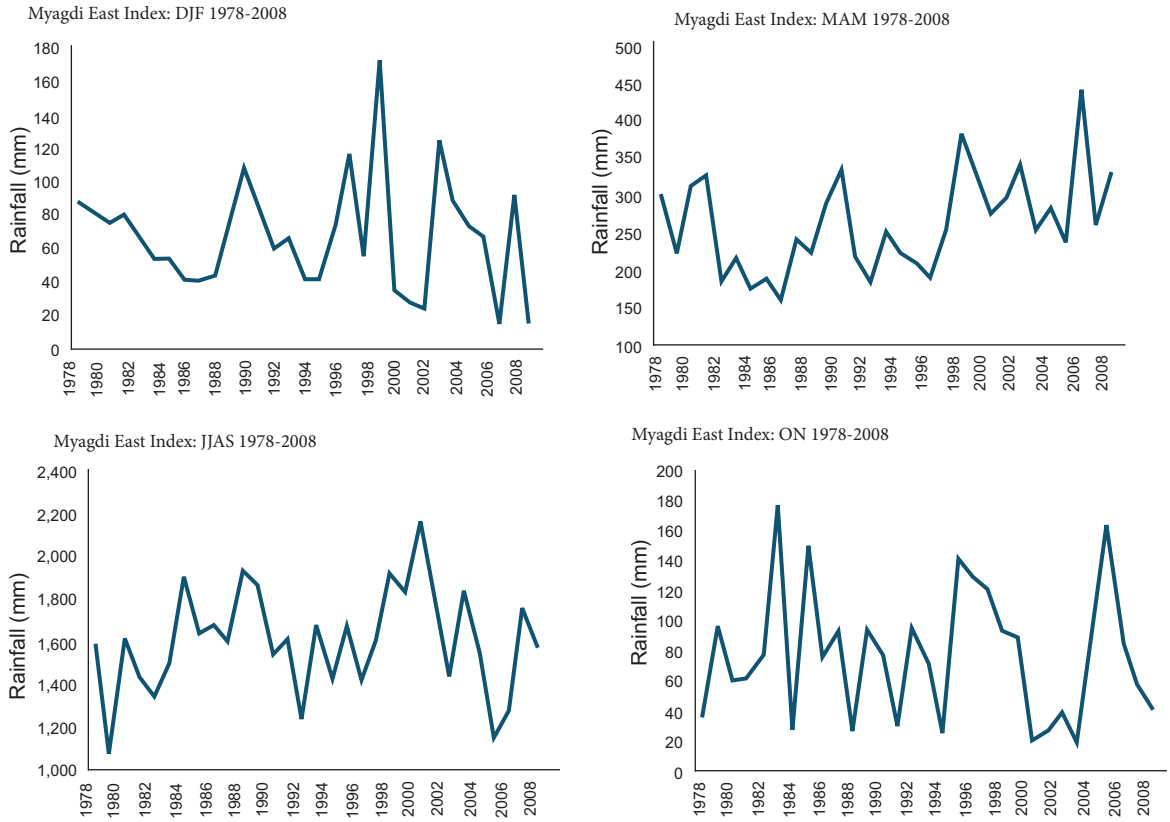
Using the Mann-Kendall trend to analyse precipitation data of stations in southern districts (Palpa, Arghakhanchi, and Kapilbastu) and northern districts (Mustang, Myagdi, and Kaski)by season revealed no statistically significant trends other than the fact the area-averaged March-to-May precipitation for Myagdi East (stations 609, 619, 621, 626 and 627) increased by a statistically-significant 3 mm, Kendallτ =0.263, p = 0.039 (Figure 11). The data of a few other station sets were close to statistical significance, suggesting that there are trends in seasonal precipitation changes, but it might take 10 more years of daily data to establish them statistically.

7 AVERAGE SEASONAL MINIMUM AND MAXIMUM TEMPERATURE TRENDS FOR STATIONS WITH STATISTICALLY SIGNIFICANT TRENDS

Station	Trend Period	Seasonal Change (°C) over period	Kendall's tau	P-value (two-sided)
Kapilvastu 716 (south)	1975 – 2009 (Tmin)	1.9 (MAM)	0.233	0.059
	1976 – 2009 (Tmax)	1.3 (MAM)	0.233	0.058
Palpa 702 (south)	1975 – 2009 (Tmin)	2.5 (MAM)	0.254	0.038
	1976 – 2009 (Tmax)			
Rupandehi 705 (south)	1975 – 2009 (Tmin)	2.3 (JJAS)	0.46	2e-3
		1.3 (ON)	0.414	8e-4
	1976 – 2009 (Tmax)	0.7 (JJAS)	0.46	2e-4
		1.8 (ON)	0.414	8e-4
Rupandehi 707 (south)	1975 – 2009 (Tmin)	1.3 (JJAS)	0.371	3e-03
	1976 – 2009 (Tmax)	0.8 (JJAS)	0.371	0.003
Myagdi 609 (north)	1975 – 2009 (Tmin)	3.4 (DJF)	0.385	0.001
		1.2 (MAM)	0.239	0.046
		-2.9 (JJAS)	-0.321	0.007
		1.3 (ON)	0.261	0.029
	1975 - 2009 (Tmax)	2.2 (DJF)	0.464	9e-5
		3.3 (MAM)	0.298	0.012
		2.5 (ON)	0.462	1e-4
Mustang 601 (north)	1975 – 2009 (Tmin)	2 (JJAS) min	0.632	1e-7
Mustang 604 (north)	1975 – 2009 (Tmin)	-0.6 (ON)	-0.2.79	0.02
	1975 – 2009 (Tmax)	2.6 (DJF)	0.239	0.047
		2.2 (MAM)	0.266	0.027
		3.6 (JJAS)	0.337	0.005
		3 (ON)	0.342	0.004
Kaski 811 (north)	1975 – 2009 (Tmin)	2 (DJF)	0.468	9e-05
		1.2 (MAM)	0.401	8e-04
		0.7 (JJAS)	0.513	2e-05
		1.7 (ON)	0.316	8e-03
	1975 - 2009 (Tmax)	2.3 (DJF)	0.291	0.015
		2.5 (JJAS)	0.409	7e-4
		1.7 (ON)	0.253	0.036
Kaski 804 (north)	1975 – 2009 (Tmin)	1.4 (DJF)	0.433	3e-4
		1.1 (MAM)	0.327	6e-03
		0.9 (JJAS)	0.469	1e-4
	1975 - 2009 (Tmax)	2.7 (DJF)	0.419	5e-4
		1.9 (MAM)	0.268	0.026
		2.4 (JJAS)	0.665	2e-16
		2.3 (ON)	0.44	2e-4
Manang 816 (north)	1975 – 2009 (Tmin)	2.3 (MAM)	0.29	0.016
		1.2 (JJAS)	0.267	0.026
	1975 - 2009 (Tmax)	2.1 (MAM)	0.256	0.033
		2.4 (ON)	0.322	0.007

Note: The actual amount of seasonal change for stations highlighted in the station should not be used as the absolute truth, as significant amounts of data were missing from these records that had to be estimated from neighbouring stations before trend analysis. Given the few number of available neighbouring stations in each climate region (north and south) with 90 per cent above complete records over the trend period, and the fact that these stations are at very different elevations, only the direction of the change should be considered accurate, especially for the highlighted regions

FIGURE 11: Precipitation trends over the period 1978-2008 in Myagdi East

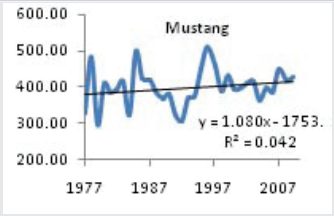
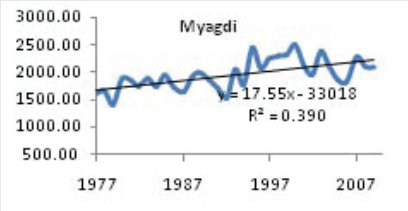
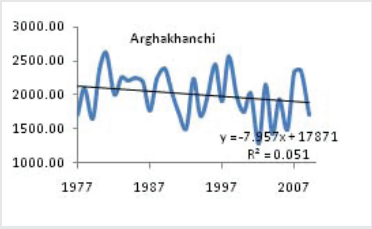
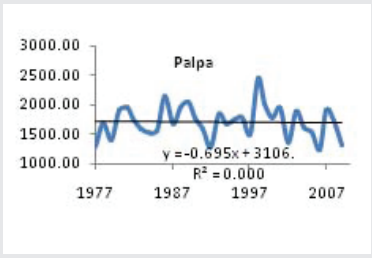
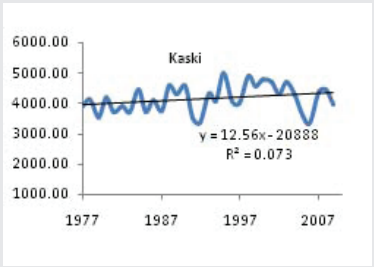
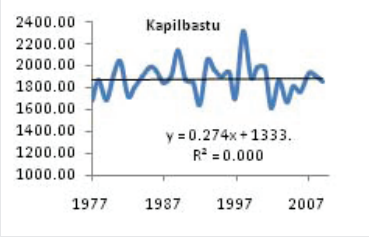


The researchers analysed precipitation changes in each of the six districts (the VDC is too small a unit) to identify current and explore possible impacts of climate variability on food and other systems and on livelihoods by applying the Mann-Kendall trend test to the averaged datasets of northern and southern stations on a seasonal basis (Table 8). Because the data set is limited spatially and temporally, it is difficult to discern changes in the patterns and characteristics of precipitation and its characteristics.

Local perceptions of climate trends

Participants in SLDs claim that temperatures have risen and rainfall patterns have changed (Figure 12 a and b). Data does strongly confirm people's assertions that both minimum and maximum temperatures have increased, but until more stations are built, especially at high elevations, it will be impossible quantify all the subtleties of that change, particular over space and time. While there is not enough data to corroborate this claim, almost all respondents reported that precipitation patterns have changed. The villagers mentioned that their behaviour have also changed as precipitation patterns have changed. One story from Dubiya is representative. It was suggested that 30 years ago, farmers used a kind of locally made bamboo cover to ward off rain while planting rice which is now almost gone. They also suggested that earlier the unpaved tracks used to be extremely muddy that made cycling difficult. It is no longer so though they also point that these days even village tracks are being paved. It could very well be the case that the frequency of extreme rainfall events is increasing, as they claim, with rainfall occurring in fewer, more intense events, but this change would not necessarily result in a change in total annual or seasonal precipitation. Unfortunately, until, either, more weather stations are established in the WDR or data collection is more

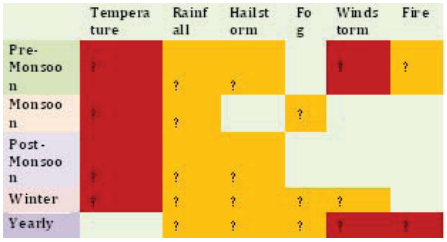
8 SUMMARY OF PRECIPITATION OF ANALYSIS TRENDS

Districts	Mean rainfall	Explanation
Mustang 601 604 607 608 610 624 625		Arid valley with dry, strong winds and high intensity sunlight. Annual precipitation ranges from 93.5-248.6 mm in the north whereas ranges from 155.5-431.4 in the south. No statistically significant trend.
Myagdi 606 609 616 619 621 626 627 628 629		Heterogeneous climate from tropical to temperate with the variation in its altitude. Annual rainfall ranging from 1,183.2 to 2,217.1 in Myagdi East while it ranges from 1,278.25 to 2,663.45 mm in Myagdi West. No statistical significant trend. Paucity of consistent and long-term data impedes the analysis.
Arghakhachi 715 730		District is tropical, sub tropical and temperate. Rainfall ranges from 1,296.4 to 2,597.65 mm. No statistical significant trend though slightly decreasing trend. Sparse availability of data impedes analysis.
Palpa 702 726		Tropical to sub-tropical climatic region. Annual precipitation ranges from 1,058.7 to 2,196 mm. No statistical significant changes in precipitation.
Kaski 804 811 813 814 818 821 824 830		Kaski district is tropical, sub tropical and temperate. Precipitation ranges from 2,881.6 to 4,799.9 mm in Kaski east while it ranges from 2,749.7 to 4,624.9. No statistically significant changes,
Kapilbastu 716 721 723		Humid and subtropical climate. Precipitation in the district ranges from 1,089.5 to 2,207.5 mm. Rainfall analysis does not demonstrate any trend.

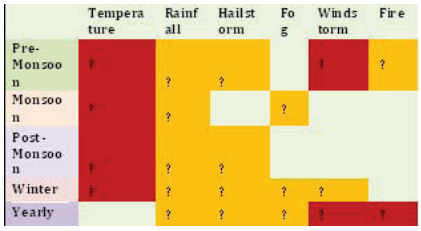
Given the paucity of data set (both spatial and temporal) it is difficult to discern changes in the pattern of precipitation and its characteristics. Yet discussion with the local stakeholders reveals that they perceive increasingly erratic precipitation, as the following section shows

FIGURE 12: Local perceptions about changes in rainfall and temperature

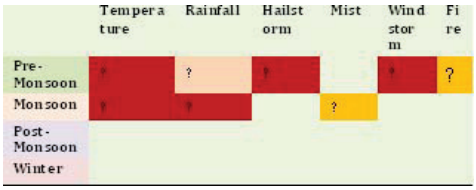
(a) Individual districts



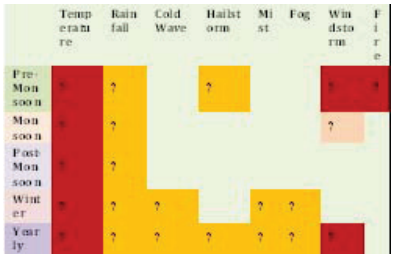
Mustang



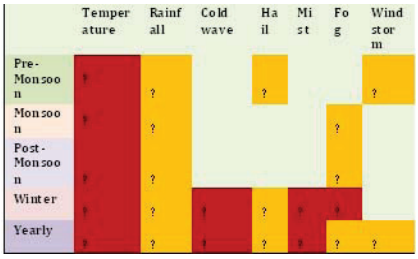
Myagdi



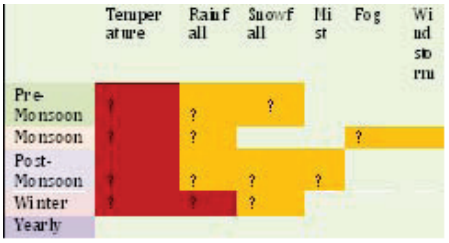
Arghakhachi



Kaski



Palpa

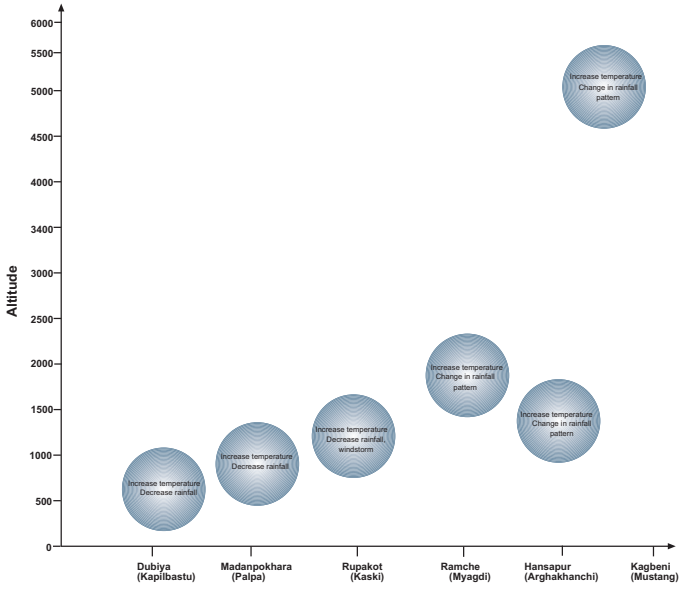


Kapilbastu

frequent (hourly, rather than daily), it will be impossible to quantitatively confirm this perception. Clearly the processes of change emanate from many drivers and make specific attribution a challenge.

People suggest that maximum daily rainfall is changing. Similarly, scientific and other grey literature suggests that instances of extreme rainfall events are likely to increase. Daily, or 24-hour rainfall is one indicator of extreme rainfall: a very high daily total suggests a tremendous downpour rather than steady rain. Although hourly rainfall is a more accurate measure of intensity, not all stations take measurements that frequently. Using 1990 as an arbitrary division (but significant in that it was about the time that global warming became an issue), 24-hour rainfall data for about two decades (Table 9 a and b) was analysed. For southern stations, where rain is heavier, 100 m was used as a threshold to define extreme events; for the north, just 30 mm. In the south, the number of extreme events was greater after 1990 in all but three stations. In the north, the number of extreme events decreased except at station 607.

(b) Summary of local perceptions



In all study districts but Myagdi, local perceptions correspond with the analysis of trends, both indicating that temperatures are increasing and rainfall patterns becoming more erratic. In Myagdi, however, that was not the case. The data here shows increasing rainfall while people perceive that rainfall has decreased.

9a and b COMPARISON OF DAILY RAINFALL EVENTS

a) In southern stations (100 mm per day assumed as threshold)

District	Data period	Rainfall >100 (Before 1990)	Rainfall > 100 (between 1991-2009)	Remarks
Kaski 804	1970-2009	112	118	
Kaski 811	1966-2009	100	115	
Kaski 814	1970-2009	200	207	
Kaski 818	1972-2008	140	128	Decreasing
Kaski 821	1976-2008	15	32	
Kaski 824	1977-2008	34	44	
Arghakhachi 715	1971-2009	39	28	Decreasing
Palpa 702	1956-2009	43	21	Decreasing
Palpa 726	1980-2009	21	40	
Myagdi 616	1979-2009	0	6	
Myagdi 619	1975-2008	8	26	
Myagdi 609	1955-2009	6	4	

(b) In northern stations (30mm per day assumed as threshold)

District	Data period	Rainfall >30 (Before 1990)	Rainfall > 30 (between 1991-2009)	Remarks
Mustang 601	1957-2009	20	11	Decreasing
Mustang 604	1967-2008	23	20	Decreasing
Mustang 607	1969-2009	108	116	
Mustang 608	1969-2009	11	1	Decreasing
Mustang 609	1973-2008	15	5	Decreasing

Climate change scenario for the WDR

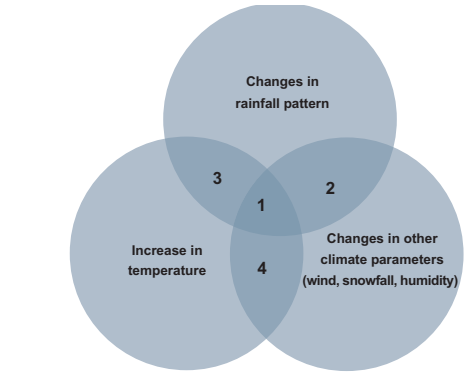
Various researchers (Shrestha et al., 1999; Practical Action, 2009; NCVST, 2009; WECS, 2011) have made climate change projections using different models and different data sets. NCVST (2009) used global and regional circulation models to predict mean annual temperature increases of 1.4°C by 2030, 2.8°C by 2060 and 4.7°C by 2090. It suggests that increase will be more in western and central Nepal than in the east and that the West will see the greatest increase. NCVST's projections for winter precipitation show no change in western Nepal and a 5-10 per cent increase in eastern Nepal, while those for summer will be 15-20 per cent across the country. MoEnv (2010) indicates increase in monsoon rainfall in eastern and central Nepal than western, higher intensity of both monsoon and post-monsoon rainfall, and decrease in winter precipitation. Recent studies by IDS and Practical Action (2012), using empirical downscaling and the regional circulation model outputs for the A2 scenario for 2040-2060, show that monthly rainfall in Kathmandu Valley will change and that changes in rainfall will vary significantly by location, such that there will be considerable differences both in the patterns of seasonal and monthly rainfall in different parts of the country and in the degree of each change. The studies provide a key lessons that the models studies suggest more uncertainties as far as precipitation is concerned. Increasing uncertainty does not mean that there will be no impact on livelihood and no need for adaptation or adjustments.

Impact on livelihoods

Either the confirmed temperature increase or perceived precipitation changes or both can precipitate further changes. It is possible that these processes have changed plant phenology or caused new human, plant and livestock diseases or incidents of pestilence. They could also have been responsible, along with market demands, for changes in agricultural patterns and harvesting strategies. Because most farmers in the WDR earn a living from rain-fed farming, we can assume that changes in precipitation, even minor ones, will have a direct impact on their livelihoods. There may be positive changes such as the predicted opportunity to plant fruit and vegetables at high elevations, including in Mustang, but it is difficult to say with any certainty. It is equally possible that new pests and diseases will have a negative impact. With any number of changes in local climate dynamics possible, the implications (Figure 13) for locals, both direct and indirect, are many and will force them to make difficult decisions about changing plantation and harvesting times, diversifying livelihoods and growing new crops.

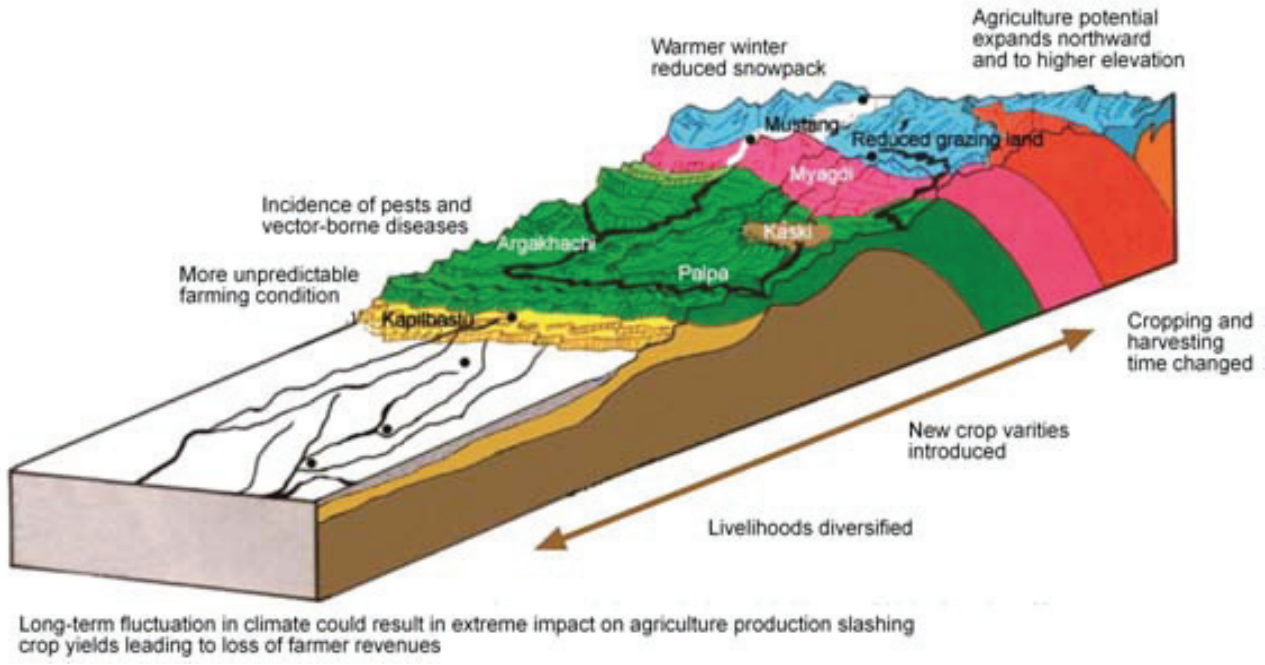
Climate change will have wide-reaching impacts on agriculture and on food systems and food security, both directly and indirectly, through their interactions with other systems. Both water-intensive cropping systems and rain-fed agriculture in all VDCs are already more vulnerable than before (Figure 14) and that trend is likely to continue. Livelihoods dependent on agriculture are vulnerable to recurring floods, landslides, hailstorms, thunderstorms, cold waves, heat waves, and drought as well as to

FIGURE 13: Conceptualising intersection among elements of local climate



1. Impact on livelihood and food production
2. Decrease in production
   Impact on livestock
   Destruction of infrastructure such as roof of house.
3. Lower production
   Increase in extreme event such as heavy rainfall within short period of time.
   Reduce access to market due to flood, landslides.
4. Increase in pest and disease
   Decrease in grazing land
   Impact on human health
   Increase in incidence of fire.

FIGURE 14: Potential local impacts of global climate change



Long-term fluctuation in climate could result in extreme impact on agriculture production slashing crop yields leading to loss of farmer revenues

minute changes in form, timing, and intensity of precipitation. Farmers who have no access to irrigation systems will be most impacted. This impact will be greater in the mountains, where precipitation changes are predicted to be more severe though in the mountains fewer people live than in the plains, where the change are expected to be less dramatic but impacts higher because more people live there. It is important to further examine this interdependence.

The exact nature of the relationship between food production and water requirement for different crops are important. Changes in temperature, evapotranspiration and rainfall will alter this relationship and need to be understood better. More detailed knowledge about water requirements would be useful to develop appropriate strategies to combat the negative effects of climate change. In fact, micro-level assessments of other factors, too, including the presence of pest and the disease resistance of crops, would help in this endeavour, as would a richer body of data. These are subjects for more detailed and targeted studies in a controlled environment.

6.2 Pests and diseases

One impact of changing climate particularly with higher temperature is rise in the incidence of pests and diseases which was also reported in our six VDCs. ISET-Nepal provided support to masters level students in conducting studies in the VDCs as part of their thesis examining some of these challenges. The research conducted by the students explored local perceptions of climate change and its likely impacts, focusing on the experiences of local residents, adaptation practices in different locations, food and water security, and temperature and rainfall data analysis. By comparing "scientific" interpretations of climate data with the perceptions of locals who are directly witnessing changing environmental conditions, we have better understanding of local climate scenarios and deepened our understanding of climate change as a global process. These studies that tracked information on pestilence and blight in selected areas provided valuable insight into the nature and impact of new pests and diseases that have emerged in recent years.

Armed with this information, we are better equipped to appreciate local autonomous adaptation practices and suggest alternatives. The central thrust of all the researchers was climate change and its likely local-level impacts in local area, some research also explored the changes in local livelihoods that occur in response to demographic, technical and economic changes. The studies explored broader issues such as information technology education, health, tourism, culture, communication and energy plays in relation to climate change in selected locations of the transect. Communication, for example, plays an important role in progressive societies and can act as an agent for social change. Our study also underscores that for a communication system to be effective, the systems underlying it must be resilient. For example, since a communication system requires a reliable source of energy to function, both local and state agencies must support the development not just of communication infrastructure but also of energy systems. Communications and energy are more tangible examples. The logic can be extended to deal with the issue of pests and diseases. Though less tangible than energy and communication infrastructures, basic systems must be in place and the capacity of agents build to deal with pests, diseases and nutrition.

In all six VDCs, pests and diseases are increasing menaces. In Hansapur, the leaves-burning disease has had a devastating effect on local maize species, destroying it one year and damaging it for three years. A new pest has destroyed the kernels and unseen pests destroy the cores of cucumbers, gourds, and maize cobs. In Ramche, stem borers and aphids attack maize plants and insect species known locally as *rato dhamira* (red spider mite), cause potatoes to rot. Farmers in Balkot, Arghakhanchi, claim that infestations of maize by stem borers, have increased so much in recent times that farmers were unable to collect any seeds in the last two years. Farmers claim that there were no insects and pests 40 years ago but that in recent times they notice many, dung beetle, sete (leaf-roller) insects infesting rice crops and stem borer infesting maize. Patero (a bug) is becoming so dominant the production of vegetables like pumpkin, local bean and cucumber have declined by two-thirds. In Kagbeni, pest and disease outbreaks occur periodically in apple orchards. Farmers mention insects and diseases were

rare in the past, when the temperatures were lower, and that rising temperatures now provide a favourable environment for pests like tent caterpillars (*Malawindica*), woolly aphids (*Eriosomalanigerum*), stink and Lygus bugs, red spider mites (*Tetranychusurticae*), and defoliating black beetles (*Brahminacoriacea*), all of which reduce production. Farmers reported that the exotic species, *Zygaena*, a moth that eats the fruit and branches of apple trees, ultimately drying them out, has had a devastating impact, as has the San Jose scale (*Quadraspidiotusperniciosus*). Diseases like apple canker (*Nectriagalligena*), powdery mildew (*Podosphoeraleucotricha*), collar rot (*Phytopthoracactorom*) and rising incidences of root rot (*Phytophthoraspp*) have affected the production of apples. Like farmers in Kagbeni, farmers in Rupakot think that warmer days and erratic rainfall may be responsible for the increasing incidence of pest and diseases.

All anecdotal evidence agree that the incidence of both pests and diseases have increased and had a negative impact on local agriculture. The findings are summarised in table 10. A number of factors however, will make it difficult to draw those links, however, including limitations in Himalayan climate science, data gaps, the inability of global models to project local scenario, and the lack of controlled studies that link climate processes with agriculture and forests in the diverse hydro-ecological regions of the WDR. Since we will never be able to say with certainty what the impacts of climate change will be, our strategy for building resilience and adaptive capacity must be a fle xible, suited to an uncertain environment.

This process of supporting students with access to literature, in developing and testing hypotheses and guiding them throughout their research yielded three benefits. First, we were able produce locally based evidence. Secondly, by employing graduate students, ISET-Nepal helped build the capacity of young researchers and used the knowledge they generated to foster discussion and support other studies. Thirdly, it created opportunity to engage academic institutions on a sustained basis.

6.3 Food systems and livelihood

According to FAO (1996), food security is a state achieved when "all people at all times have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." It can be conceived of in terms of activities related to the production, processing, distribution, preparation, and consumption of food. The four dimensions of

BOX-3: LOCAL VOICES ABOUT DETERMINANTS OF FOOD SECURITY

Political actions and development interventions determine the degree of local food security. A well-managed irrigation system, for example, boosts food security, as do goods transportation, access to markets, and timely availability of agricultural inputs. Only in a state of political stability will there be sufficient support for functioning of such systems and services.

In the SLD, participants from each of the six VDCs identified many local factors that have implications on food security from the lack of storage facilities to the use of hybrid seed.

Kagbeni
"Apple farming, which is now done on a commercial scale, is one of our main income-generating activities but without a local cold storage facility, apples cannot be stored for a long period. Such a facility would help expand business."

Ramche
"Local government officials began vacating VDC offices when the insurgency began in 1996 but still many live away from the office. VDC officials are responsible for registering birth, marriage, and death events and provide citizenship and migration certificates. Because our VDC official lives in Beni and does not visit our VDC frequently, we face many difficulties."

Hansapur
"While we do need road connectivity for the development of our VDC, the haphazard construction negatively affects our settlements, homes and agricultural land. Proper planning and implementation can meet the objectives of both road-building and local conservation."

Rupakot
"Agriculture production increases if fertilisers and other inputs are available on time."

Madanpokhara
"Our VDC is recognised as a model village in terms of vegetable production, but we are concerned about the excessive use of pesticides and chemical fertilisers to increase production as it will result in a long-term decline in soil quality, water and health. Over-reliance on chemicals will eventually affect us."

Dubiya
"Of late, we are heavily dependent on hybrid seeds. Local varieties are not available; some are even extinct. We need to preserve local varieties of seeds. Hybrids seeds do have high yield but because they cannot be stored for the following year, our dependence on the market and external actors is increasing. Because of frequent closures we cannot reach markets on time. The delay affects farming and we lose out. Investing in a local seed bank can help mitigate the problem. "

10 OCCURRENCE OF PESTS AND DISEASES

District	Variability	Incidence of pests and diseases	Crop/fruits infected	Remarks
Mustang	Increase in temperature	Tent caterpillar (*Malawindica*), woolly aphids (*Eriosomalanigerum*), stink and *Lygus* bugs, red spider mite and defoliating black beetle (*Brahminacoriacea*)		Shift from barley to vegetable farming
		Army worm (*lahurekira*)	Barley	
		Zygaena moth	Apple	Loss in production
		Apple canker (papery bark), San jose scale, powdery mildew (*Podosphoeraleucotricha*), collar rot (*Phytopthoracactorom*)		Loss in production of cash crop and apples
	Reduce snowfall and increase in rainfall			Mud roofs leak, risking assets and comfort
Myagdi	Increase in temperature	Stem borers and aphids	Maize	Reduced production
		(Rato dhamira, *khumara* and *baiselo)*	Potato	Rotting of potatoes
			Ba rley	
		Elephant beetles and larvae	Vegetables	
	Increase in extreme rainfall			Disruption in mobility and transportation
Arghakhanchi	Increase in temperature	Leaf-burning disease	Maize	Damage for the last three years and destruction of entire maize crop one year
		Seen and unseen pests	Cucumber, gourd, and maize	Affects production
		Weeds such as *Cynodon*, *Cynodondactylon*, *Cynodoniria*, and *Commelinabenghalensis*	Rice	Affects rice growth
		Viciahirsuta and *Stellaria*	Mustard, wheat, barley	Affects production
	Change in rainfall		Mustard, wheat	Production of mustard and wheat has changed
Palpa	Drying of water resources		Paddy	Switched to commercial vegetable farming
	Increase in temperature		Vegetables Potato	Blight
Kaski	Increase in temperature	*Dicladespaarmigera*(*sete*)	Rice	Zinc deficiency in rice
		Stem borers	Maize and banana	Damaged production
		Red ants	Fruits and potatoes	Damaged production
		Phytotherainfestons (blight)		Affecting the leaves of plants
Kapilbastu	Erratic rainfall	Increase in population of invasive weeds, pest and insects	Rice, wheat and maize	Damage of local crops

food security are availability, access, utilisation and stability (Gregory et al. 2005). Interactions between and within bio-geophysical and human environments influence food system activities and their outcomes (Ericksen, 2007) and contribute to environmental and other insecurities. Climate change is likely to affect all four dimensions of food security through its impacts on human health, livelihood assets, food production and distribution channels, purchasing power, and market flows. Its impacts are likely to be both short-term as a result of more frequent and more intense weather events and long-term as temperature and precipitation patterns change (FAO, 2008).

The vulnerability of food security to the impacts of climate change must be examined from the

perspective of all four food-security dimensions (FIVIMS, 2000; Parry et al., 2005; Gregory et al., 2005; IFRCRCS, 2007; Schmidhuber and Tubiello, 2007; FAO, 2008). Availability refers to the production, distribution, and exchange of goods, and is influenced by climate change impacts as well as by government controls and transport and communication systems. Access to food is contingent upon affordability, which is influenced by both global food markets and global economic activity and remittances, along with allocation and preference. Utilisation is influenced by nutritional and societal values as well as by food safety hazards. The stability of the food supply is determined by fluctuations in food prices, changes in supply-chain infrastructure, and dependency on imports and food aid. In Nepal, food supply is becoming less localised, as local foods systems are growing increasingly integrated with national and even global systems. Because of this integration, the stability of any given local food system depends on the presence or absence of many other systems. How vulnerable these other systems are to climate change and to other socio-economic and political changes must be considered in any analysis of food security (Gregory et al., 2005; Ericksen, 2008).

Agriculture is significant for food security. Not only does it provide the food people eat to survive, but for 36 per cent of the world's total work force it is the primary source of livelihood (FAO, 2008). In Nepal, 76 per cent of the population is engaged in farming and agriculture plays a critical role in assuring local-level food security. SLDs about local food system activities (mainly production, consumption and distribution) and outcomes suggest that many changes have occurred, including changes in cropping patterns and farming practices; a shift to commercial farming; and a rise in the preference for hybrid over local seed varieties and the use of fertilisers. The current status of local food types in the six VDCs including Rupa Lake Watershed are presented in table 11. In addition, processing, distribution, and accessibility have been challenged by low production, the lack of roads and vehicles, fluctuations in food prices, and politically motivated closures. Other changes they note include changes in the planting and harvesting times of many cereal crops and vegetables and changes in the flowering times of local fruits and crops (Table 12). More arable land is left fallow because of the migration of youth.

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Rupa lake Watershed (Kaski District)

11 FOOD STATUS AND LIVELIHOOD OF SIX VDCS AND RUPA WATERSHED

VDCs and watershed	Major food crops			Year round food sufficiency (% of HHs)	Livelihood source (%)	
	Cereals/pulses/oil seeds	Vegetables	Fruits		Natural resources based	Non natural based
Kagbeni	Barley, oat, buck wheat, potato and beans	Turnip, carrot, potato, cabbage, cauliflower, tomato and garlic	Apple, walnut, apricot, peach, and pears	9.3	92.7	49.9 (Business)
Ramche	Potato, maize, wheat, millet, naked barley and beans	Potato, beans, cauliflower, cabbage, soybean, tomato and pumpkin	Orange, walnut, plum and apricot	17.9	97	38 (Remittance)
Hansapur	Maize, paddy, buckwheat, millet, oat, wheat, barley, black gram and soyabean	Potato, radish, French bean, cauliflower, cabbage, onion and tomato	Orange, walnut, peach, lemon, plum and pear	5.7	71.4	48.9 (Remittance)
Madanpokhara	Paddy, millet, maize, wheat, buck wheat, oat and lentils	Tomato, beans, cucumber, broad beans, egg plant, chilli, radish, spinach, capsicum, pumpkin, bitter guard, sponge guard and ladies finger	Orange, peach, litchi, guava, pear, papaya and pineapple	13.7	62.1	18.4 (Service and remittance)
Rupakot	Paddy, maize, millet, wheat, mustard and beans	Broad leaf mustard, radish, bean, sponge gourd, bottle gourd and pumpkin	Orange, mango, lemon, guava, peach and pear	18.7	52.3	37.4 (Remittance and service)
Dubiya	Paddy, wheat, mustard, maize and lentils	Cauliflower cucumber, cabbage, tomato, radish, ladies finger, beans, bitter guard and pumpkin	Mango, lemon, guava, litchi, jackfruit and papaya	20.2	85.6	20.9 (Remittance)
Rupa watershed (Rupakot , Hansapur, Majhthana VDC and Lekhnath Municipality)	Maize, millet, paddy, wheat and beans	Potato, tomato, bean, cabbage, bitter gourd, sponge gourd and cauliflower	Mango, orange, guava, jackfruit, banana and peach	15.5	44.3	33.7 (Remittance and service)

Source: SLD (2011-12), ISET-Nepal

Most of what is produced is consumed locally though some vegetables and fruits are sold in the market. Farmers in Kagbeni export apples on a commercial scale and those in Ramche have invested more in the commercial cultivation of their traditional crop of potatoes. The farmers of Hansapur produce oranges but because they have no links to the market, there produce reach market much less and almost all farming is subsistence level. Oranges and a few vegetables grown in Rupakot are sold in local and district markets. Madanpokhara is uniquely commercial: vegetable farms established in the 1980s now engage more than 70 per cent of all households. Dubiya VDC has the highest rate of food sufficiency—20 per cent of households produce enough food to feed themselves year-round—but few households have gone commercial in agriculture. Though most rely heavily on agriculture to achieve food security, imports are also an important source of food. Market linkages, primarily to the city of Butwal, are strongest in Madanpokhara.

Non-agricultural sources of livelihood, including tourism, and remittances, also help ensure food security. Tourism is a major source of livelihood in Kagbeni and ecotourism is being promoted in Ramche. In Rupakot, fishing is a source of livelihood. The study VDCs also have a few cottage industries such as paper manufacturing, traditional crafts, processing of medicinal plants

12 CHANGES IN CROPPING PATTERNS

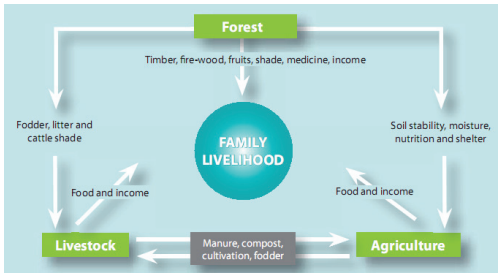
VDC		Production		Change in cropping time		Remarks
		Increase	Decrease	Shift ahead	Shift later	
Himalaya Region						
Kagbeni	Cereal crop	-	Naked barley, oat, buckwheat	Naked barley and oat	Buck wheat	Production decrease due to irrigation problem
	Vegetables	Carrot, cabbage, cauliflower	Potato	Cauliflower	Turnip, radish	Planting time changed
	Fruits	-	-	Apple, walnut, Apricot, peach, chilli, Common plum, local peach, pears, grape	-	Flowering and fruiting time changed
Hill Region						
Ramche	Cereal crop	Potato, maize and wheat	Millet	Maize, walnut	Buckwheat	Planting and harvesting time shifted ahead
	Vegetables	-	Potato, soya bean	Potato	-	Planting time changed
	Fruits	Apple, orange	-	-	-	Flowering and fruiting time changed
Hansapur	Cereal crop	-	Crop production	Maize and wheat	Paddy	Planting and harvesting time shifted ahead
	Vegetables	Radish		-	-	Planting time changed
	Fruits	Orange		Walnut, peach, orange, grape	-	Flowering and fruiting time shifted ahead
Madan pokhara	Cereal crop	Wheat, maize	Paddy, millet	Paddy	Maize, millet, wheat, oat	Wheat production increased though low
	Vegetables	-	Sponge guard, tomato, brinjal	Sponge guard, tomato	-	Planting time changed
	Fruits	-	Guava	Guava	-	Flowering and fruiting time changed
Rupakot	Cereal crop	Paddy, millet	Maize	Paddy, millet, maize, soya bean	-	Paddy and millet production increase due to shifting of planning and harvesting time
	Vegetables	-	reddish, bean, sponge guard, pumpkin	Reddish, bottle guard, sponge guard, pumpkin	-	Planting and harvesting time changed and production of vegetables decreased
	Fruits	Orange	Mango, lemon	-	Guava, lemon	Flowering and fruiting time changed
Tarai Region						
Dubiya	Cereal crop	Paddy	Maize	Paddy, mustard, Lentil	Wheat	-
	Vegetables	-	Potato	Potato, ladies finger, bottle guard	Tomato	Planting and harvesting time of only potato changed
	Fruits	-	-	Mango, Guava, Jack-fruit, Hill lemon, Black plum	-	Flowering and fruiting time shifted ahead and production rate decreased

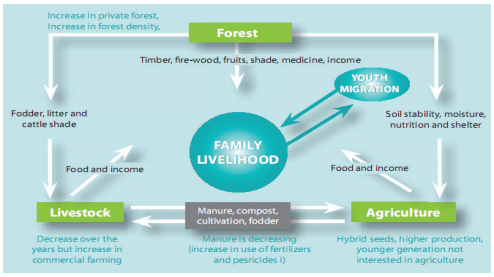
Source: SLD (2011), ISET-Nepal

and agro based. For additional income, people rely on remittances and pensions or sell land and livestock.

Food security, which historically depended on localised production-consumption relationships, now depends on regional and global relationships as well. Before imports became so prevalent, the tree-crop-livestock farming system (Figure 15 and table 13) served as the primary productive basis for the food systems on which most of the population survived and food secu-

Figure 15: Changing forest–agriculture-livestock farming systems





Adapted from Dixit et al., (2013)

13 CHANGES IN THE FOREST-AGRICULTURE-LIVESTOCK INTERRELATIONSHIP

VDCs	Forest	Agriculture	Livestock	Other interventions
Kagbeni	Dependency decreasing with road connection and *yarsagumba*[1] collection	Export apples and cereals Import rice and other food items	Decrease in livestock numbers with access to transport Increase in rearing Himalayan *Chyangra* (mountain goat) for wool and manure for apple farming	Increase in seasonal migration Increase in tourism Increase in remittance
Ramche	Dense forests rich in high-value medicinal plants	Total production reduced by 50% Preference for local potatoes declined Potato crop blighted	Decrease in livestock-rearing Increase in manure due to stall-feeding	Increase in youth migration Increase in remittance Increase in pensions
Rupakot	Increase in forest density and area under private forests	Increase in hybrid seeds Increase in production Lack of interest in agriculture among younger generation	Decrease in livestock Increase in commercial goat-raising Decrease in production of manure	Increase in youth migration Increase in remittance
Madan-pokhara	Increase in forest density due to increase in private forest Sale of NTFPs, primarily cinnamon	Shift from cereal to vegetable cultivation, Rise in use of hybrid seeds Cultivation of cinnamon Lack of interest in agriculture among youths	Decrease in total livestock and livestock-rearing limited to certain households Decrease in manure production	Increase in youth migration Increase in remittance
Hansapur	Increase in private forests Increase in forest density Increase in medicinal plants	Increase in use of hybrid seeds Increase in fallow land Decrease in interest in agriculture	Decrease in livestock Decrease in commercial goat-farming	Increase in remittance Increase in youth migration
Dubiya	Registration of community forests, Decrease in timber sales due to rise in use of modern construction materials Increase in invasive species	Decrease in agricultural production though use of chemical fertilisers has increased.	Decrease in cow- and buffalo-rearing by 95 per cent Threefold increase in goat-farming Increase in pig, rabbit and poultry farming	Increase in remittance, Increase in youth migration (at least one from each household)

Source: SLD (2011), ISET-Nepal

1 The "caterpillar fungus," *Ophiocordycepssinensis*, an NTFP sold at very high prices, particularly in China, where it is used as an aphrodisiac and general energizer.

rity at individual and household levels depended on having access to local agricultural products, livestock and forest resources. Access was determined not just by the level of production but also by other local factors such as social network, land and livestock ownership, institutions such as caste, and rules governing the use of common forest resources. It also depended on the ability to accumulate and store substantial amounts of products for consumption throughout the year. In the past, most food systems in Nepal relied on local production, local relationships, local institutions and local assets, they were threatened almost exclusively by local risks that affected local conditions.

Today, it is no longer possible to understand food systems and their vulnerabilities to climate and other changes from such a limited perspective; too many changes have occurred in the six study VDCs over the last 10-15 years, introducing drivers or change that are not just local. In recent times, community forest management in common and farmers rear livestock at a commercial scale, plant hybrid seeds, and apply chemical fertiliser, pesticides and insecticides. New species of vegetation have appeared and previously unseen diseases pose new threats to forests, biodiversity and agriculture. Migration, demographic shifts, land-use changes, and the increase in the influence and use of communication technology such as mobile phones are other drivers of change that must be recognised.

Because of these changes, any examination of the implications of climate change for food security needs must consider more than local food systems. By identifying the nature of the food system of each VDC, with its local, regional and global interconnections, strategies that will strengthen resilience of food system and strategies to build adaptive capacity can be identified. Because the study VDCs now rely on markets to meet at least part of their food requirements, they are linked into regional and even global food systems as well as the regional and global systems that these systems are interlinked with. Before that, the vulnerability of each VDC, particularly with regard to its food system, must be assessed.

6.4 Vulnerability ranking

The vulnerability of the six VDCs was ranked using an aggregate figure of the ward-level statuses of the core, secondary and tertiary systems of each. The quality and relative robustness or fragility of each of these systems is one determinant of the ability of local populations to shift strategies. The ranking of each wards of the six VDCs are shown in figure 16a and b.

Core systems: In terms of energy, Kagbeni is the least vulnerable VDC because it is least dependent on firewood for cooking and has the highest use of clean energy for lighting. In terms of drinking water, Hansapur is most vulnerable: just 6 per cent have access to a piped system. Kagbeni has the lowest population and the least arable land but the highest landholding size per household and the greatest proportion of irrigated land. Its year-round food sufficiency from its own production, however, is less than 10 per cent; both Ramche and Dubiya have higher rates (Table 14).

Figure 16a: Composite presentation of ranked wards of VDCs and Rupa watershed

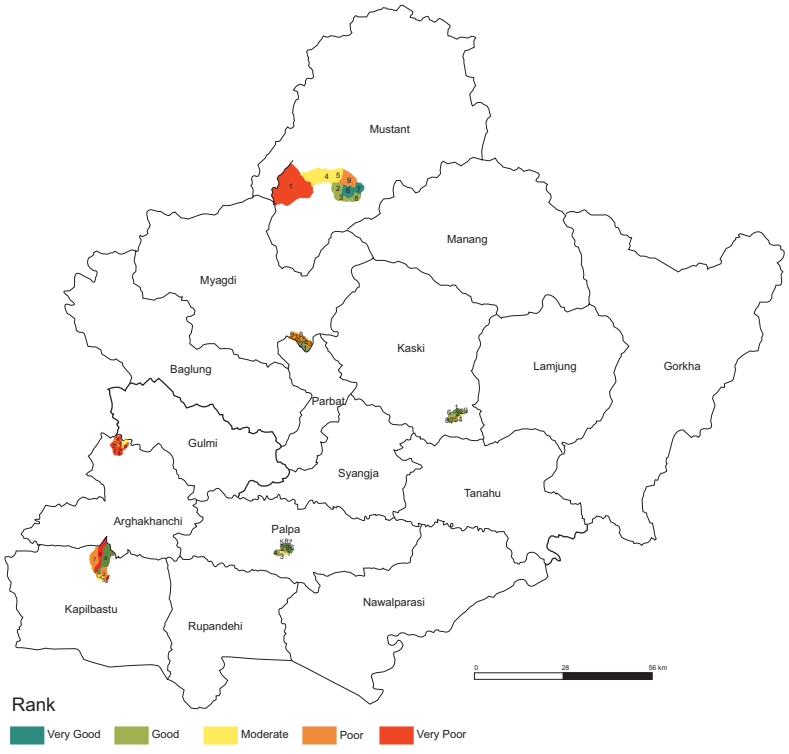
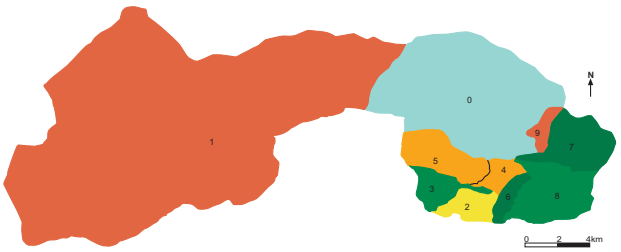
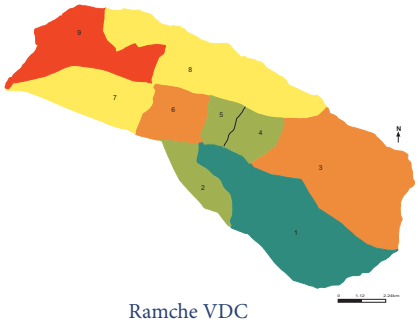


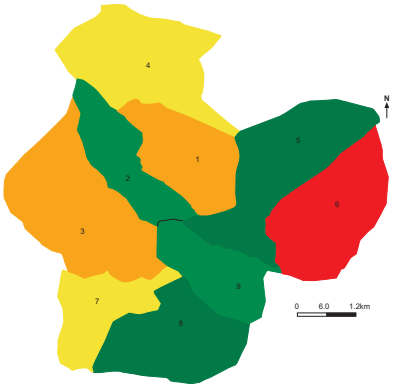
Figure 16b: Detailed ranking of VDCs and Rupa Watershed



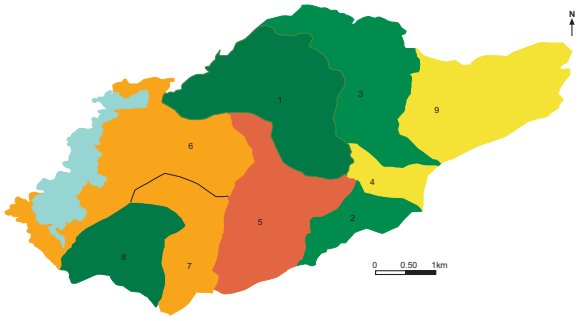
Kagabeni VDC



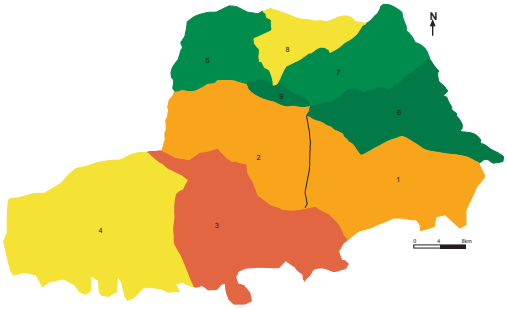
Ramche VDC



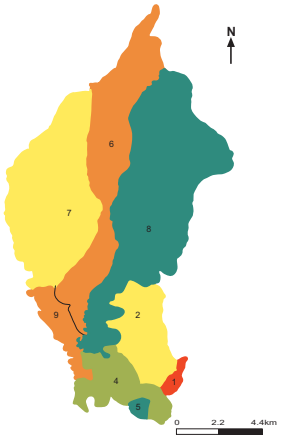
Hansapur VDC



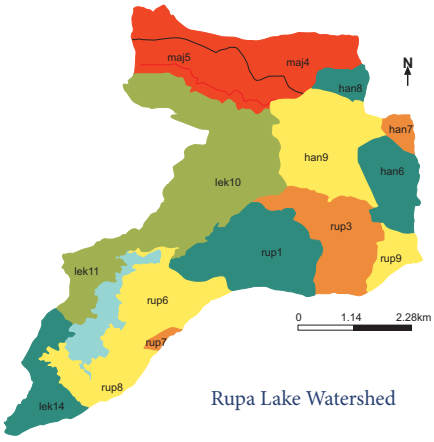
Rupakot VDC



Madanpokhara VDC



Dubiya VDC



Rupa Lake Watershed

Very high | High | Moderate | Low | Very Low

14 STATUS OF CORE SYSTEMS

VDC	Energy		Water		Land		HH with year round sufficiency with own production)
	Cooking (% HH relying on traditional sources)	Lighting (% HH using electricity or solar)	Drinking (% of engineered drinking water system)	Irrigation (% of arable land irrigated)	Average arable land holding size per HH (ha)	Disaster (flood & landslide) affected land (%)	
Kagbeni	11.1	100	100	84.8	1.4	13.4	9.3
Ramche	99.2	87.1	62.6	0	0.5	0	17.9
Hansapur	97.9	34.3	5.2	24.2	0.2	2.1	5.7
Rupakot	98.2	99.2	62.9	16.7	1.2	12.6	18.7
Madanpokhara	83.4	99.9	82.2	32.1	0.5	3.7	13.7
Dubiya	99.6	88.7	27	41.1	0.8	0.4	20.2

Source: SLD 2011, ISET-N

Secondary systems: Ramche has the lowest road density and is farthest from the main highway. Rupakot has the highest rate of mobile phone ownership but also the lowest rate of livelihoods based on natural resource system. Kagbeni is most susceptible to disasters.(Table 15)

Tertiary systems: Rupakot and Ramche VDCs have the highest literacy rates because Ramche has an on-going adult literacy programme and Rupakot is close to the western regional headquarters, Pokhara with many educational institutions.Kagbeni has apple orchards and alcohol-making tradition. Because it lies on the route to the pilgrimage site of Muktinath it offers tourist service facilities but VDC has few financial institutions. Madanpokhara has highest sanitation coverage in part because it has a high literacy rate and in part because it has the highest number of health workers. There is limited local government activity in all VDCs but a few non-government organisations are present. Local organisations such as CBOs and NGOs are present in all VDCs with the most located in Rupakot. Madanpokhara has the most resilient tertiary systems (Table 16a and 16b).

Ranking each ward of each VDC on the basis of the availability and accessibility and its systems aggregating those ranks revealed that Hansapur VDC was the most vulnerable VDC and Madanpokhara VDC the least (Figure 16a).

6.5 Social vulnerability

As discussed above, the concept of vulnerability is at the heart of our understanding of how individuals, households, communities, institutions, social relationships and natural systems are af-

15 STATUS OF SECONDARY SYSTEMS

VDC	Mobility		Communication		HH affected by disaster	HH with pakka shelter
	Average Distance to highway (km)	Road density	Mobile: HH	Other forms of communication: HHs		
Kagbeni	10.1	0	1.5	1	60.6	100
Ramche	48.1	0	0.9	1.1	2.3	95.8
Hansapur	19.6	0	0.8	0.9	22.6	24.3
Rupakot	10.9	1.6	2.6	1	22.7	83
Madanpokhara	3.1	3.5	1.8	1.9	33.3	93.7
Dubiya	7.2	1.1	0.7	0.7	24.9	38.4

Source: SLD 2011, ISET-N

16a STATUS OF TERTIARY SYSTE M S

VDC	Literacy %	Number of educational institutions	Number of local industries	Number of financial institutions	Sanitation coverage %	Number of Health workers
Kagbeni	54.8	10	190	3	20.4	13
Ramche	91.8	7	8	1	100	17
Hansapur	75.2	14	0	1	64.4	8
Rupakot	92.2	7	7	8	100	15
Madanpokhara	88.7	11	18	9	99.2	19
Dubiya	57.9	4	0	2	32.8	16

Source: SLD 2011, ISET-N

16b STATUS OF TERTIARY SYSTEM S

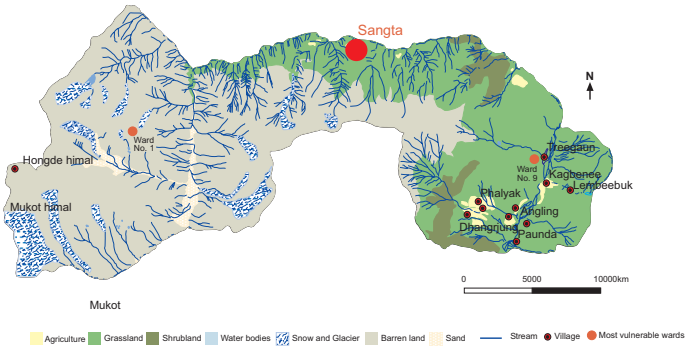
VDC	Average Distance to Headquarter (km)	Number of CBOs	Number of traditional network	Number of government organisation	Number of non government organisation
Kagbeni	10.9	35	8	6	0
Ramche	33.3	23	10	1	0
Hansapur	19.7	20	0	2	0
Rupakot	29.2	66	1	3	28
Madanpokhara	11.8	27	2	3	10
Dubiya	8.1	32	0	2	6

Source: SLD 2011, ISET-N

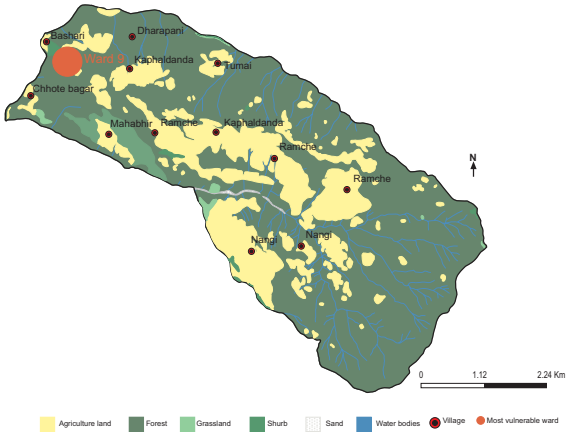
fected by climate variability and climate change and their associated risks (Ahmad and Mustafa, 2007). When planning interventions to minimise vulnerability or build adaptive capacity, the extant marginality of different groups embedded in their social context needs to be considered. In doing so, vulnerability becomes both a conceptual lens and a discourse that facilitates engagement with both the biophysical aspects of shocks (disaster risks) and the social structures that create conditions of differential risk. The method adopted for assessing vulnerability must take into account that vulnerability changes as climate changes and differentially impacts interlinkages among systems. It is difficult to capture vulnerability in its entirety in practice, but ranking wards from the least to the most vulnerable did serve as an entry point to begin an iterative process of shared learning which identified both the most marginal communities and the reasons for their marginality.

Thus the most marginal communities within the most vulnerable ward in all the VDCs were identified. The location in each VDC shown in Figure 17 and the groups identified through SLDs as the most vulnerable are listed in table 17. Asking stakeholders to consider why certain VDCs were ranked lower or higher than others was a transparent process, one, apart from limitations inherent in the approach and the data, free of the researchers' bias. Given the high levels of uncertainty in developing and localising climate scenarios, using this process is more appropriate than attempting to achieve a highly precise assessment of system vulnerability. Besides, because it is iterative, it helps capture the changing nature of vulnerability. Because shared learning produces a finely nuanced understanding of marginalisation, it creates ample opportunities to develop appropriate strategies to help identify barriers that prevent marginalised communities from accessing services from systems and to build their resilience and adaptive capacity. Lack of access to systems, their services and constraining institutions are factors that intertwine with structural context to further exacerbate vulnerability of the groups identified most marginal.

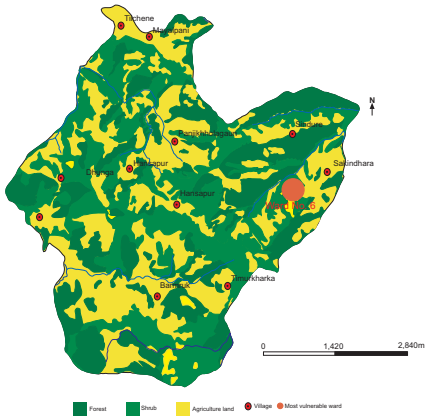
Figure 17: Location of most marginal groups/community in most vulnerable wards



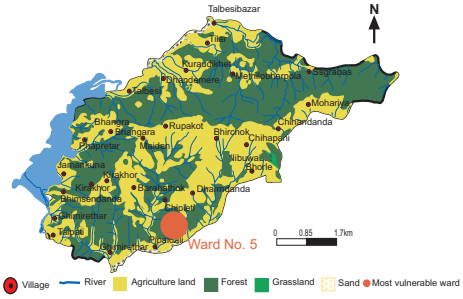
Kagabeni VDC



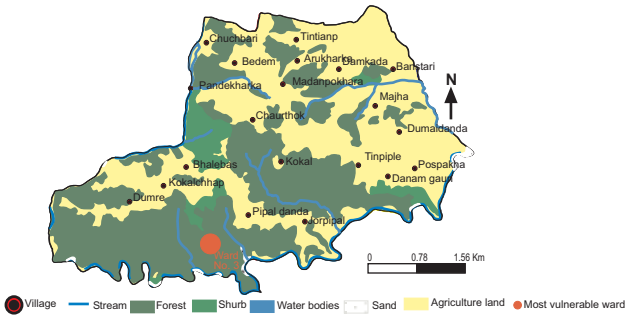
Ramche VDC



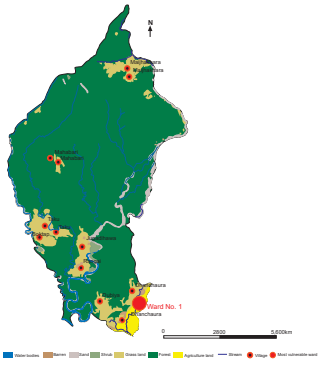
Hansapur VDC



Rupakot VDC



Madanpokhara VDC



Dubiya VDC

17 MARGINAL GROUPS IN MOST VULNERABLE WARDS

VDC	Most vulnerable ward	Marginal groups	Why marginal
Kagbeni	1	Indigenous people, especially women of Sangta village	The lack of education and employment opportunities; inconvenient transportation; difficulties in earning a livelihood; the absence of opportunities to network with other communities; low access to communication; poor knowledge about health and sanitation; and negligible understanding of socio-political issues
Ramche	9	Differently- abled, economically-inactive, and poorly-educated people of Kaule village	The absence of economically active populations and preponderance of people below the age of 15 and above the age of 60 and the presence of several physically challenged residents and the lack of income-generating opportunities and nearby clean drinking water, health and transportation facilities.
Hansapur	6	Dalits of Myalnete, Gopichaur and Arantole village	Geographical inaccessibility; high illiteracy, poverty, and unemployment rates; the lack of income-generating opportunities, and drinking water, health, and irrigation facilities; very little fertile land; and shelters made unsafe by landslides and thunderstorms.
Rupakot	5	All households in ward 5	The absence of functional drinking water systems; food insufficiency; the lack of educational institutions, health services, government organisations and transportation facilities.
Madanpokhara	3	Households of Maurikharka village	Low access to clean energy and drinking water and irrigation facilities; little cultivation of land; poor roads; few livelihood options and low remittance rates; low literacy rates; few health and sanitation facilities; and the absence of large markets, community-based organisations, and government organisations.
Dubiya	1	The Tharu of Mormi village	The lack of income; arsenic-contaminated drinking water; traditional farming systems; the lack of access to health and education facilities; and limited mobility

6.6 Existing systems and new source of vulnerability

In the following sections we discuss the details of each VDC.

Kagbeni VDC

Kagbeni is better positioned than other VDCs in terms of its use of clean energy, the quality of its drinking water, transport and communication systems, and the proportion of permanent shelters, however rate of literacy and sanitation coverage are low and there are few financial institutions with local market and an airport located in Jomsom, an hour's drive on dirt road. Land in Kagbeni is dry and snowfall is decreasing and rainfall growing more erratic. While irrigation water is available along river stretches and water is allocated by rotation using a lottery system, many plots are left fallow due to water scarcity. Drinking water pipes are encrusted with lime that impedes flow. During the monsoon months, sedimentation muddies rivers and water quality declines and in the winter, pipes and taps freeze. Though agriculture and animal husbandry are common livelihoods, people also earn a livelihood through apple farming, remittance and tourism. Not everyone benefits from tourist facilities and businesses, however.

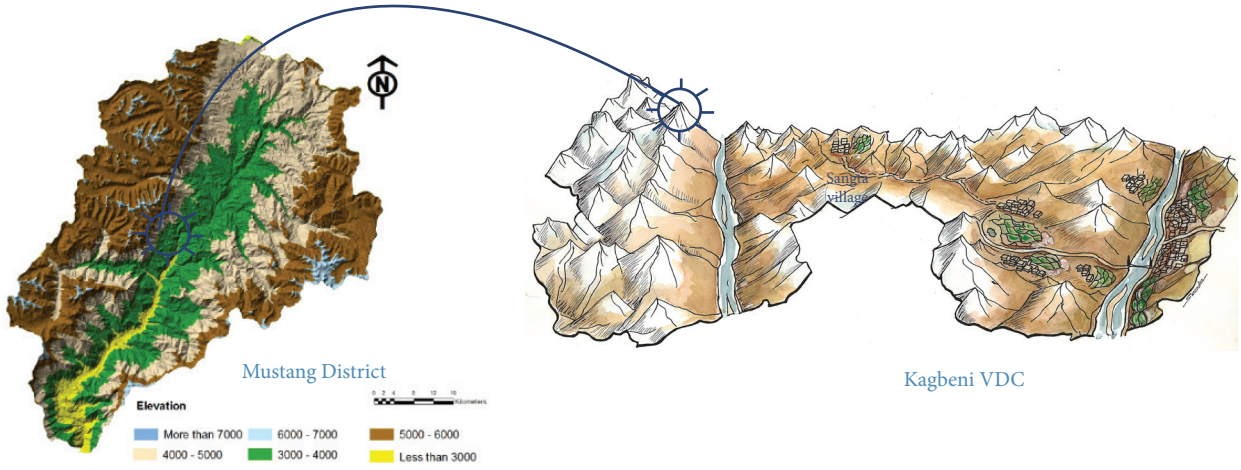
The people of Kagbeni claim that temperature is increasing and that precipitation has decreased in all seasons. The rains, they say, are more erratic and variability has increased. Along the riverbanks, flood and bank cutting are more frequent. The starkest change in climatic conditions is that in winter, rain is more common than snow, a fact that has resulted in a shift from mud to corrugated iron sheet roofs. This shift is also fuelled by two other factors: household income has risen and the completion of the Jomsom-Beni road has made it possible to import construction materials and change construction methods. It is likely that concrete houses will become the preferred choice for those who can afford them, especially if the prices of reinforcement bars and cement decrease.

These changes will create new pressure points in the sensitive landscape of Kagbeni and generate new sources of vulnerabilities that need to be iteratively assessed. Sangta village (Ward 1) was ranked the most vulnerable (Fiugre 18). It is geographically isolated and has no roads, thereby putting touristic and other local infrastructural facilities at risk and preventing residents from switching strategies in order to overcome challenges posed by climate change and other drivers of change. There isn't enough food in the winter.

BOX-4: MARGINALISED WOMEN IN HANSAPUR

The majority of the men of Hansapur have migrated to India for work and many have never returned. The women claim, "We are marginalised in every sense, geographically, economically and psychologically." One woman shared her plight: "I live with my parents in their house. I own nothing, make no earnings, and have no livelihood. Seventeen years ago my husband left for India to work as a labourer. I am still waiting for him to return though I don't even know if he is still alive. I had a son after my husband left but I could not afford to send him to school. Now, he too has gone to India to find work. Since I am married I cannot claim my parents' property. You talk about climate change and the future but I do not how I will survive today."

Figure 18: Shematic map of Kagbeni VDC Mustang District

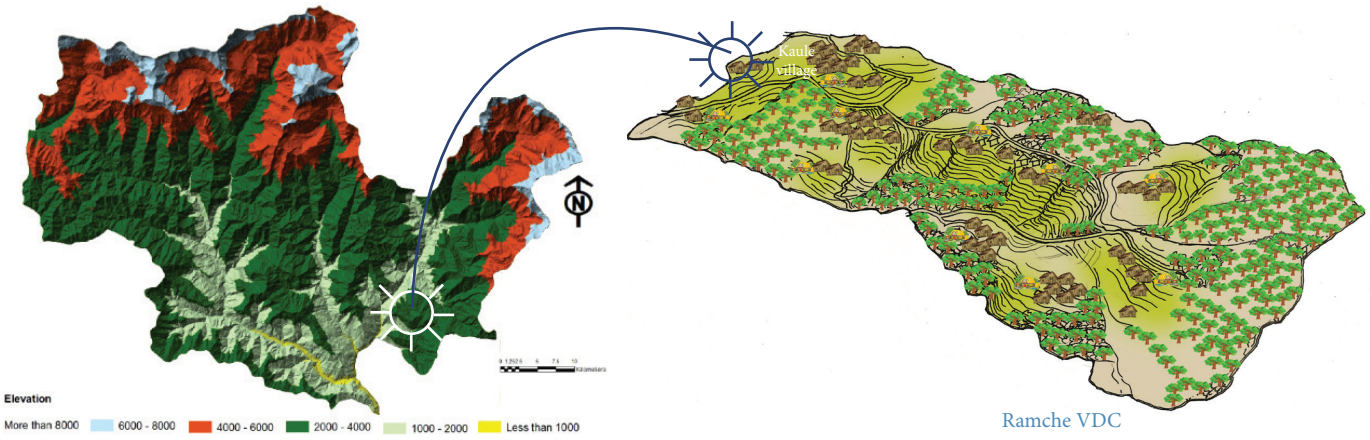


Households respond to these constraints by migrating to Pokhara, the Tarai and India, where they sell sweaters and seek odd jobs to make a living. In June and July, they collect *yarsagumba*, a strategy that has gained momentum due to the high value of the fungus in international markets (Working Paper Series–Kagbeni, 2012).

Ramche VDC

Ramche VDC has energy systems such as electricity and solar power, permanent houses, drinking water systems and sanitation facilities. Because villagers can buy food, they are better off than residents of other VDCs. However, almost all households use firewood to cook and there is no surface irrigation system. The opening of a 33 km road to Beni, the headquarters of Myagdi, in 2010 and the start of a jeep service soon afterwards improved mobility, but regular travel is difficult because the road is not paved and it passes through rugged terrain. Yet, the road has galvanised farmers into producing more potatoes and vegetables, which they sell in Beni, the main market in the district. Though agriculture continues to be a major source of livelihood for the majority of households, a significant number rely on non-natural resource-based livelihoods typically pensions and remittances. Following tradition, a large number of Magar youth join Gurkha regiments in the British and Indian armies. In recent times, greater number of youth is migrating abroad for other types of jobs, too, mainly to Gulf and Southeast Asian countries. Ecotourism was introduced recently and promises to be beneficial.

Figure 19: Schematic map of Ramche VDC Myagdi District



Myagdi District

Ramche VDC

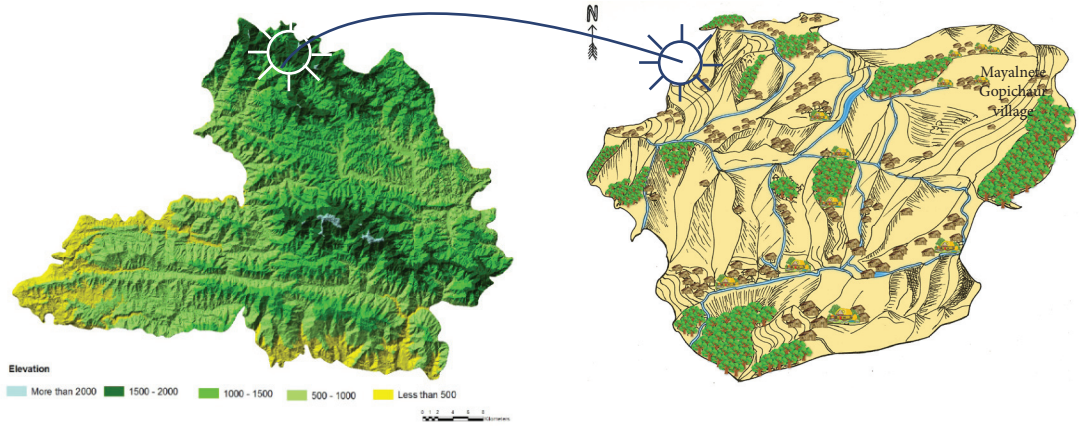
The expansion of communication system with the establishment of new landline phones and introduction of mobile phones, access to the Internet since 2004, has opened up new opportunities and improved education and health services. Though making Internet use widespread is a challenge, Ramche's telemedicine service is recognised for its use in treating minor illnesses and providing advice and most importantly for its ability to make a travel to Beni or Pokhara for such treatment unnecessary. The food system in Ramche is growing more dependent on road and transport systems and on facilities for storing food. Food availability is growing more dependent on income streams, which determine the capacity to purchase. Ramche has a local financial institution, schools, local cottage industries, and community-based organisations, which help provide services to the locals. Strong local social network helps residents address the challenges they face.

The people of Ramche claim that the local climate is changing—that days are hotter, particularly in the pre-monsoon season, and that rainfall and snowfall more erratic. While forest fires are more frequent, the incidence of hailstorms has declined and they are less devastating to crops. Though few households of Ramche are affected by climate-related disasters (Working Paper Series–Ramche, 2012), the Beni-Ramche road is operational only during non-monsoon months. During the monsoon, when transportation is disrupted, food availability is likely to decrease and prices, to increase. Ward 9 (the village of Kaule) was ranked as the most vulnerable because households lack access to basic services and are therefore likely to be affected more during periods of extreme climatic events and add to pre existing vulnerabilities (Figure 19).

Hansapur VDC

In Hansapur, basic infrastructural systems are just starting to be constructed and those that exist are fragile and provide a poor quality of service. Roads, for example, are either under construction or, if they are complete, are unpaved. About 70 per cent of households depend on subsistence agriculture and traditional sources of energy for cooking and only 24 per cent have pakka houses. Only six per cent are food sufficient for the entire year, putting Hansapur at the bottom of the ranks among the studied locations. While Hansapur was recently connected to the national electricity grid, supply is unreliable because of scheduled power outages for about 12 hours daily. About 34 per cent use solar panels for lighting. The few water sources that exist have low, and, people claim but no measurements confirm, declining discharges. The settlements in the upper sections of the VDC have limited access to supplies of both irrigation and drinking water. Sandhikharka, the district headquarters, is the closest market. In the last few years, working abroad has become a common way of earning a livelihood. Every household has a phone or mobile set.

Figure 20: Schematic map of Hansapur VDC Arghakhachi District



Arghakhachi District

Hansapur VDC

Ward 6 was ranked most vulnerable (Figure 20) because very few basic systems are available here and the services that are provided are poor, rendering marginalised households even more vulnerable to stresses, including those likely to be created by climate change (Case Study Annex XIV A, 2012).Villages claim that temperature has increased and rainfall patterns have changed. In addition, landslides, floods, drought, and erosion, which affect transport and mobility, irrigation and agriculture and local livelihoods, are more common.

Madanpokhara VDC

Madanpokhara is the most resilient of the six VDCs. Located just three kilometres away from the Siddhartha highway (Bhairahawa to Pokhara), it is connected to the regional market in Butwal, a major boon. The majority of households have access to electricity, drinking water and sanitation facilities, and communication systems and more than 90 per cent live in pakka houses. The literacy rate is high and access to irrigation is better than it is in other VDCs. There are schools, local financial institutions and a few local cottage industries in the VDC. Madanpokhara established Nepal's first community radio station owned and operated by the VDC itself. Commercial vegetable farming, which began in the late 1970s, is now a major enterprise and source of income for more than 70 per cent of the households. They have invested the income in education and health, there developing the VDC's social capital. Some have even spread this capital: teachers from Madanpokhara work in schools of other VDCs in the WDR. About 14 per cent of the households produce enough food for the entire year.

Water systems in Madanpokhara are particularly robust. After a decade of deforestation, 1962 to 1972, caused many small spring sources to dry up (Gyawali and Dixit, 1999), households turned the situation around by beginning to conserve local forests. Today 78 per cent of villagers use drinking water piped to tap stands from those very springs. The VDC pioneered the use of sprinklers for irrigation in the 1990s and rainwater harvesting and water-storing plastic ponds have grown common in recent years.

Local people claim that days are becoming hotter and rainfall more erratic. They perceive that rainfall has decreased but views vary and they all seem to agree that rainfall has become more erratic. They also suggest that, in the last few years, there have been more cold waves and less mist, hail and fog. Climate change will affect Madanpokhara's food system, particularly the sale of vegetables, not just directly, but also if climate change-induced landslides block the road to Butwal. Changes in climatic characteristics may also affect the biodiversity of the VDC, thereby affecting livelihoods and lowering household income.

From a systemic perspective, Madanpokhara is not as vulnerable as the other VDCs though some of its wards face high exposure. Ward 3 (Maurikharkha) was ranked most vulnerable since it lacks water for drinking and irrigation and most households there use traditional fuel (Figure 21).

BOX-5: VULTURE CONSERVATION

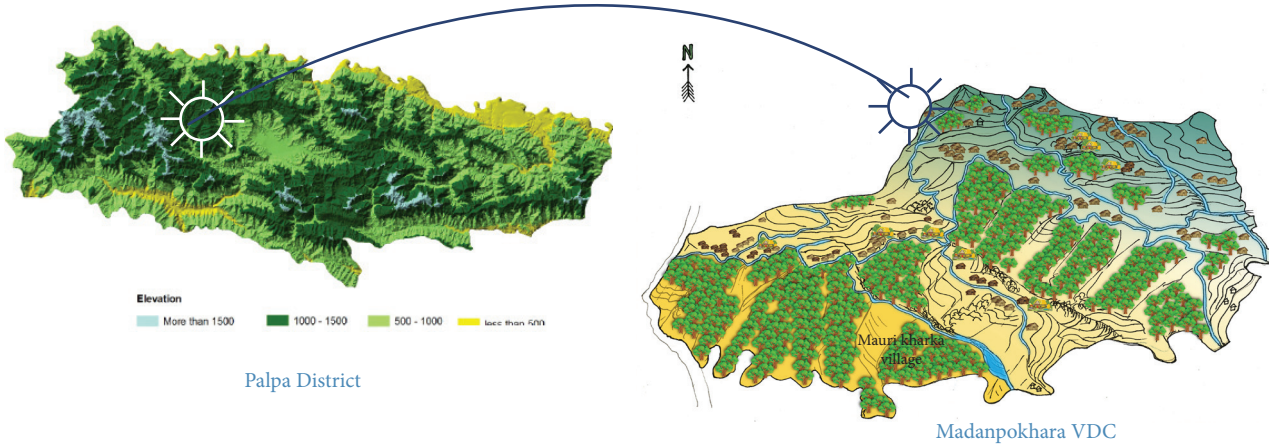
Community forestry in the Anderi Charchare region of Ward six of Madanpokhara VDC made the forest healthier and denser and helped preserve the forest including simal (Bombax ceiba) trees, where Lammergier, Egyptian and red-headed vultures nested.

But a conflict arose: at the roots of the simal trees are springs that provide drinking water to households of wards six and seven and vulture droppings and pieces of carcass were polluting those springs. The community's solution was to cut the trees but the district forest office (DFO) refused to grant permission, reminding community representatives that vultures in South Asia are likely to become extinct if serious conservation measures are adopted.

The DFO further explained that while vultures play a crucial role in keeping the ecosystem balanced, their population is declining because they are being inadvertently poisoned by the non-steroidal anti-inflammatory drug diclofenac used as a painkiller for livestock. Kidney failure, visceral gout and death are the consequences for vultures feeding on contaminated carcasses.

The DFO then suggested offered a win-win solution—a cover over the springs—and helped mobilise resources to install it. Today the simal trees serve as a nesting place for vultures and the water supply is clean. This vulture conservation centre is the joint activity of the local community, the DFO and a local NGO, Bird Conservation Nepal.

Figure 21: Schematic map of Madanpokhara VDC Palpa District



Palpa District

Madanpokhara VDC

Rupakot VDC

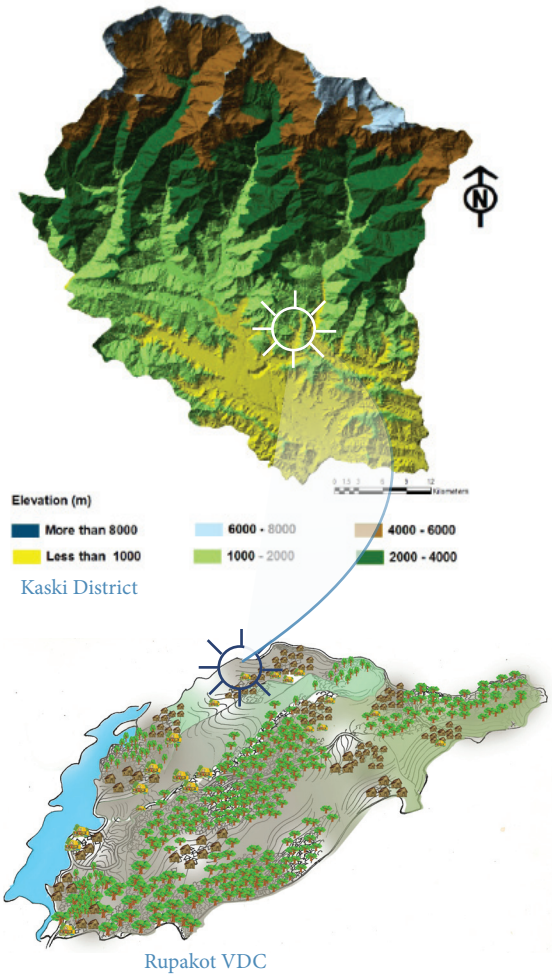
Almost all households in Rupakot have access to electricity or use solar panels. Transportation services are easily accessed so mobility is considerable, and the penetration of communication is high. Very few households depend on natural resource-based livelihoods, just 52 per cent, the lowest rate among the six study VDCs. Those who farm are quite prosperous: 18 per cent grow enough to meet their annual food needs. Some households earn a livelihood from Rupa Lake, others, from tourism. Many households have emigrated to urban centres and a significant number of youth have gone abroad, to the Gulf and elsewhere.

The literacy rate is almost 90 per cent and due to the influence of tourism and the VDC's proximity to the municipalities of Pokhara and Lekhnath, the people are relatively sophisticated. Sanitation coverage is universal. Cottage industries, local financial institutions, schools and colleges, and community-based and non-government organisations are all present in the VDC. Because of the presence of these systems, a large proportion of the population has access to the services provided by them, making the VDC, as a whole, more resilient than other VDCs studied.

Local people claim that over the last 10 years temperatures in Rupakot have risen and rainfall decreased. They say that there are more hail-

storms and, in the pre-monsoon season, more forest fires. Hazards resulting from the changing climatic conditions introduce a new source of vulnerability that may impact food production. Since, more than 80 per cent of the population has to import at least some of its food needs, transport and mobility are key determinants of local food security. Floods and landslides affect about 13 per cent of arable land and 22 per cent of households in the VDC (Field Survey 2011). Ward five, and especially the marginalised communities (Figure 22) within it, was identified as the most vulnerable and is likely to be impacted still more in the future. Livelihood diversification will be important for maintaining food security in the VDC.

Figure 22: Schematic map of Rupakot VDC Kaski District



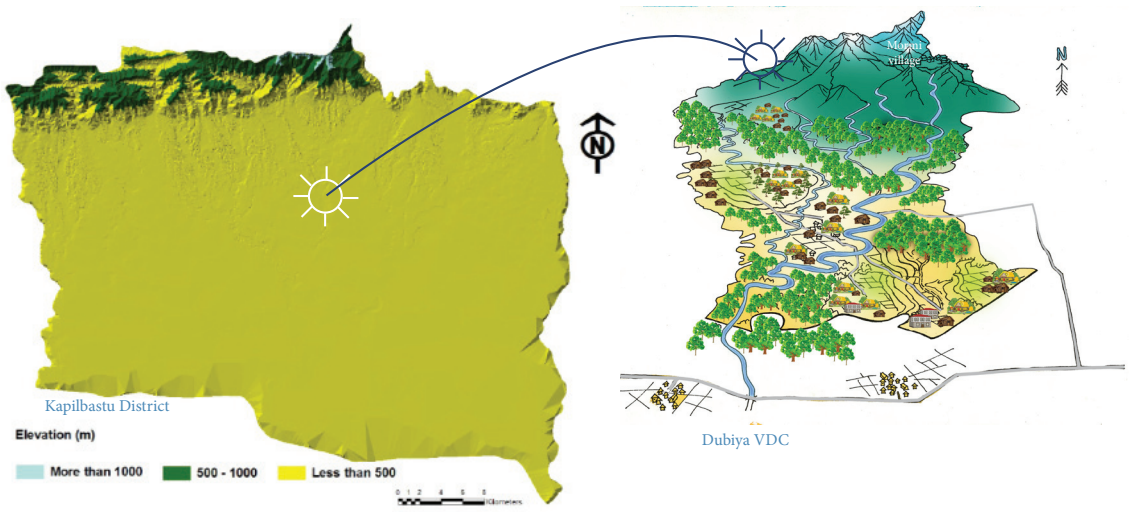
Dubiya VDC

In Dubiya VDC, 20% of households report having year-round food sufficiency. Besides agriculture, remittance is another common source of income from remittance. Access to the highway is fairly good and the district headquarters is just 7 km away. Many households use clean energy for lighting. Dubiya is still systemically vulnerable, however. Almost all households depend on firewood for cooking and 73 per cent get drinking water from ponds and hand pumps, risking arsenic contamination from untested tube wells. Only 38 per cent have pakkahouses and just 33 per cent have toilets. Because of poor network coverage the penetration of mobile phones is low. Despite its four educational establishments, the literacy rate is just 58 per cent, the lowest in the six case study VDCs. The majority of the population depends on agriculture and climate-induced hazards such as floods, droughts, and winter fog could become major threats. The food system of Dubiya depends on local production and imports, both of which are fragile.

According to local residents, flooding, bank cutting and fire are the main hazards that have affected the VDC in the past. Dubiya VDC is likely to become more vulnerable to drought, flood, fire and winter fog (Dixit, et al., 2010). Increasing dependency on hybrid seeds is another major concern of farmers of Dubiya. Delays in the supply of seeds and fertilisers affect agriculture production adversely, as do unreliable irrigation facilities, disease outbreaks and pest infestations. The stresses likely to emerge from climate change in the future could debilitate the overall condition of the VDC. Due to the poor status of its systems, Ward 1 (Mormi village) was ranked the most vulnerable (Figure 23).

The diversity of the condition in the VDCs is a function of their ecological and social context and taken into account while preparing resilience plans for each.

Figure 23: Schematic map of Dubiya VDC Kapilbastu District



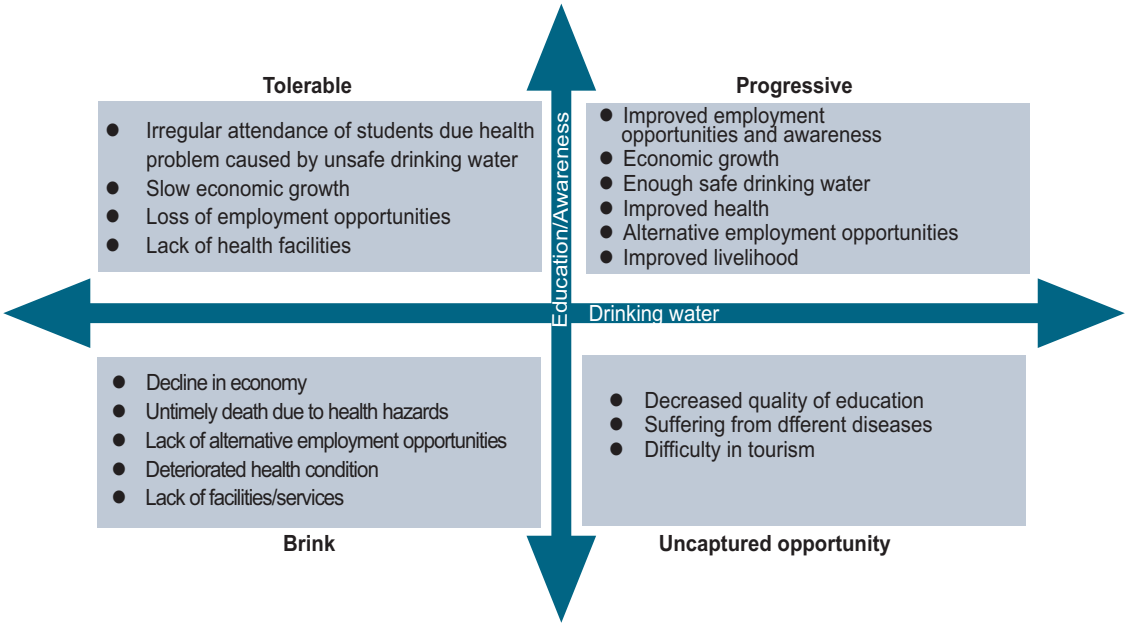
6.7 Planning for local resilience

The discussions above set the stage for developing local resilience plan using an uncertainty quadrant (Figure 11) with four future scenarios. Choosing the worst scenario the local communities proposed a resilience plan, which incorporated strategies to benefit those they had identified as the most vulnerable (See Annexes I-VII).

Kagbeni VDC

Kagbeni's resilience plan identified ways to improve water supply, enhance tourism, and improve the quality of education in local schools. By carrying these improvements, they will directly and indirectly benefit interlinked systems and thereby build local resilience. The locals identified businesspeople and the local community as the key agents who need to invest resources in tourism, and government agencies and non-government organisations as key agents in supporting improvements in water supply systems and the quality of education. They believe that donors should develop criteria for funding the development of critical system such as drinking water.

Figure 24: Uncertainty analysis in Kagbeni VDC

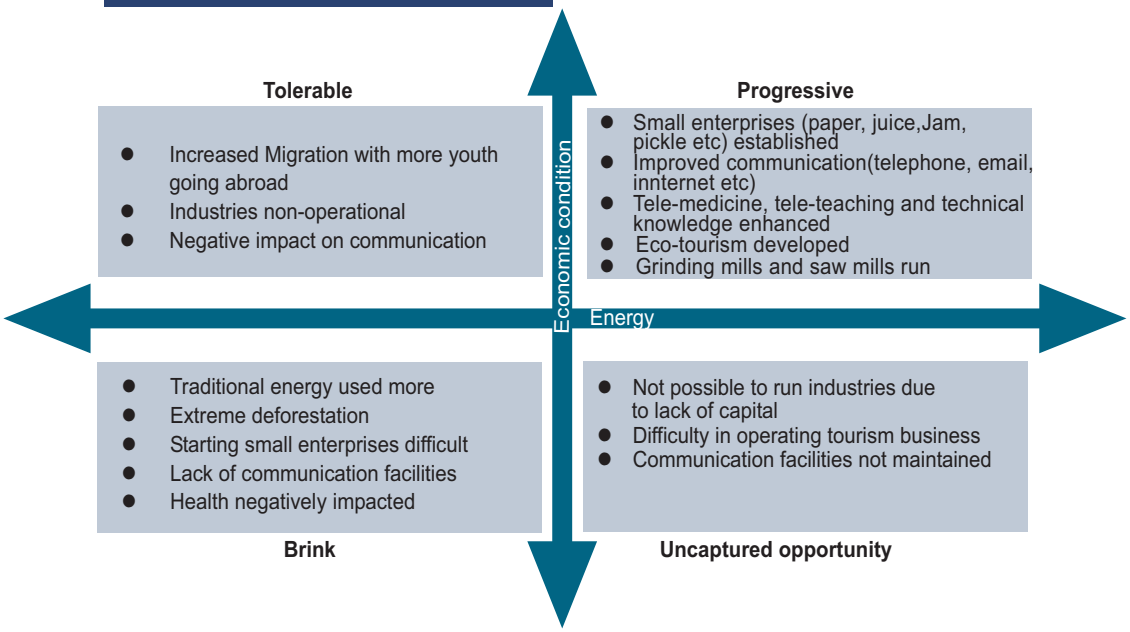


Ramche VDC

In Ramche, lack of reliable energy systems, deforestation, depleting water sources, and migration were identified as the major challenges that need to be overcome in order to build local resilience. While more households in Kagbeni use clean energy for lighting than in the other five VDCs, supply is unreliable and the lack of energy prevents them from developing micro-enterprises and renders the Internet and other communication systems dysfunctional. The lack of irrigation facilities is another limitation. Youth migration is high and those who do stay are not interested in pursuing agriculture as a source of livelihood, a fact that the older members of the VDC believe will have long-term and serious implications. Though the telemedicine service helps locals seek treatment for minor ailments, it does not reach everyone and other public health services are grossly inadequate. The local people's strategies to build resilience included constructing a micro-hydro plant, installing more solar panels, expanding the communication network and improving healthcare facilities. They identified government agencies, CBOs, NGOs and other organisations to help put the plan in action.

Participants in regional SLD, Pokhara

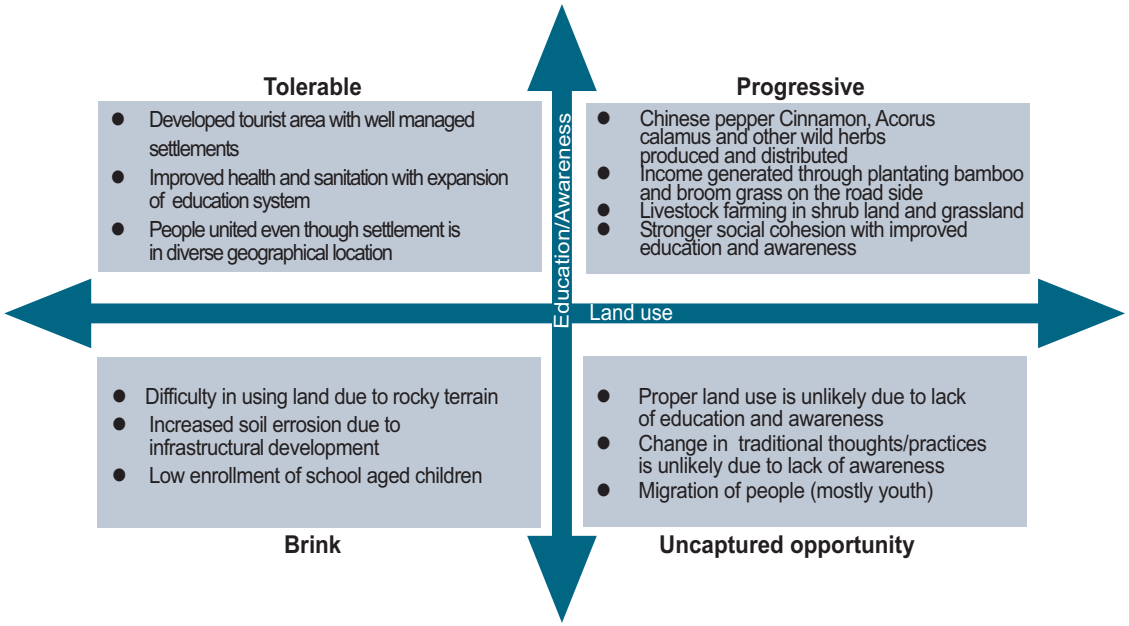
Figure 25: Uncertainty analysis in Ramche VDC



Hanspapur VDC

Hansapur VDC is more vulnerable than the other five VDCs to the impacts of climate variability and change, and its level of food insecurity is alarming. In their future scenario, locals envision increased food insecurity due to the rugged land, which limits cultivation and water supplies, and the lack of roads. They believe that what they see as an increasingly erratic climate will decrease agricultural production and food will be even shorter than it already is. Floods, erosion and landslides are likely to be more frequent in the monsoon and pre-monsoon months. Periods of drought, forest fires and new diseases will also increase. Their resilience plan prioritises education, distance education and building awareness as well as constructing roads and irrigation systems and afforestation.

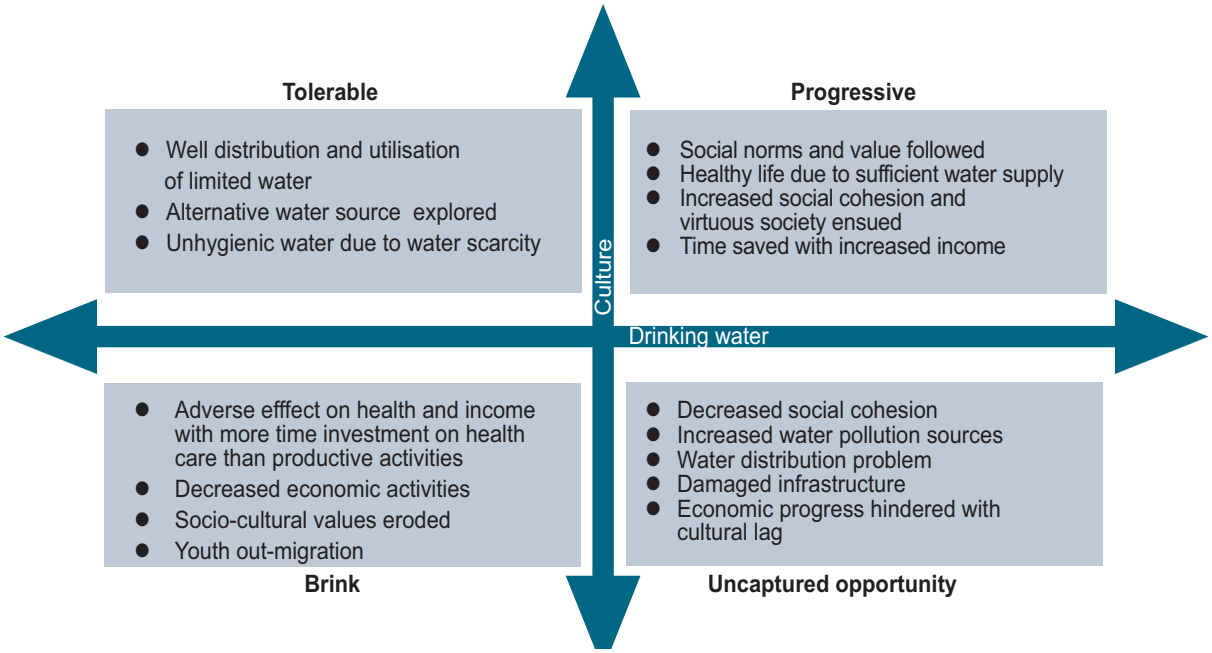
Figure 26: Uncertainty analysis in Hansapur VDC



Madanpokhara VDC

The resilience plan developed by participants from Madanpokhara VDC identified local water security as the key issue. To maintain water supply, they identified many alternatives, which include building a lift system to pump water from the adjoining river, conserving water sources, and rainwater harvesting and recycling. They identified awareness building and education as other challenges and realize that they must begin thinking about re-crafting education systems in order to create new opportunities for youths. They believe that introducing technological innovations to vegetable farming and fruit cultivation will help them develop small-scale enterprises and thereby diversify away from agriculture, a shift they see necessary to minimise risks associated with climate change. The local government, they mentioned, must support the implementation of these activities. Non-government organisations can help build capacity and generate new understanding about the changing conditions.

Figure 27: Uncertainty analysis in Madanpokhara VDC



BOX-6: LOCAL VOICES: THE IMPACT OF CLIMATE VARIABILITY IN KAGBENI

The community of Kagbeni practice animal husbandry in addition to engaging in tourism and agriculture. By rearing sheep, mountain goats (chyangra), cows (lulu) and jhopa (yak-cow crossbreed), they are able to generate income by selling their products in urban areas and produce staple items such as cheese and butter. They also use animal waste as fertiliser.

Every morning throughout spring (the last week of April to July), farmers take their livestock to graze in the upper pastures. At dusk they bring them home and feed them weeds from the fields at night. Caragana, the most abundant species of vegetation in Mustang, is used as cattle feed. Its branches and roots are used as fuel. The recent decline in snowfall and the slowness of the regeneration of Caragana species, however, have lead to shortages of both animal feed and fuel. Forty-six-year old Taklah Thakuri explained, "Our livelihood is dependent on livestock. Because there is a shortage of nutritious grasses in nearby pastures, sheep and goats are consuming unpalatable, poisonous vegetation, falling sick and dying." Women herders have been forced to travel further in search of good pastureland, a change that has simply increased their drudgery.

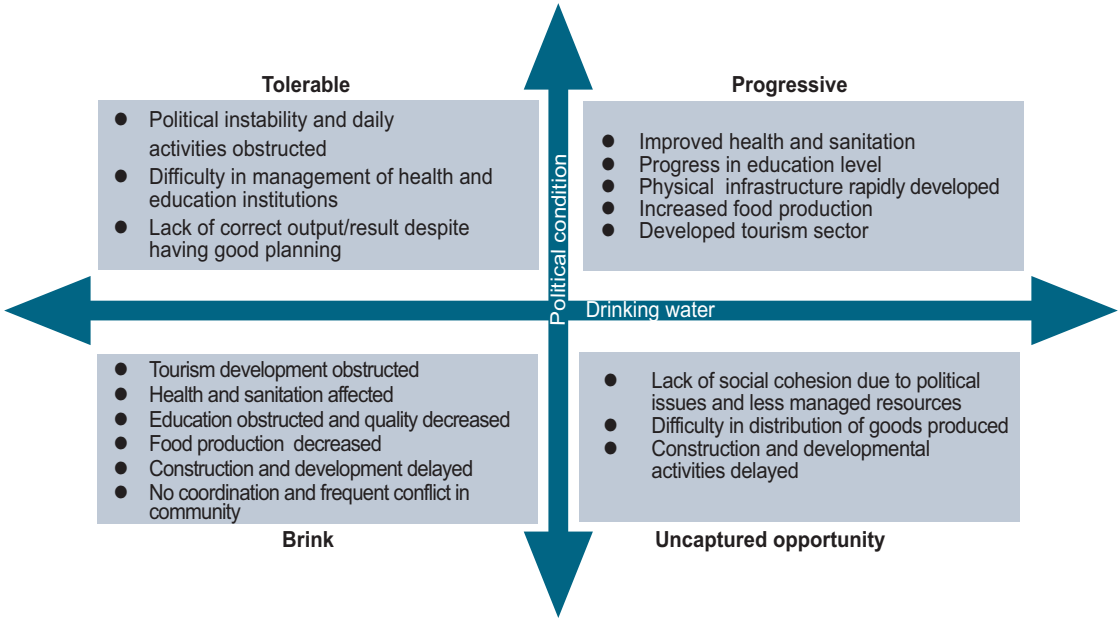
Silwal (2013)

Rupakot VDC

Because of its proximity to Pokhara, a popular destination for tourist, Rupakot VDC could expand its own tourism business. Though core, secondary, and tertiary systems in the VDC are in relatively good condition, there are few reliable water sources in settlements at high elevations and they are seasonal. Since only 60 per cent of households in these settlements use piped drinking water and since a reliable supply of water is a prerequisite for tourism, improving the supply of drinking water is a priority.

Keeping in mind the scenario of their future, Rupakot locals identified drinking water, tourism, agriculture and education as the key elements of their plan to build resilience. They suggested that public policies must support technological innovations, which make farming a productive enterprise, and provide incentives to attract youths to farming. Tourism needs to be developed in conjunction with the conservation of RupaLake, which supports the livelihoods of some locals (RupaLake Watershed Working Paper; Dhakal and Dixit, 2012).

Figure 28: Uncertainty analysis in Rupakot VDC

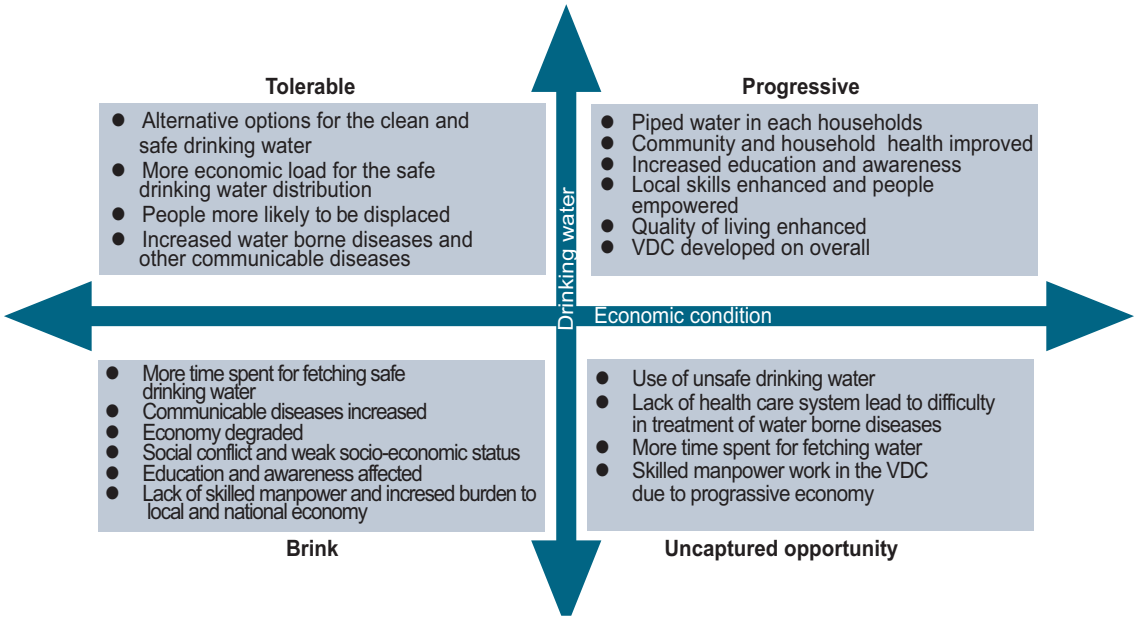


Dubiya VDC

Arsenic-contaminated is a major problem in Dubiya VDC: its impact is a scar visible in legs and palms of many individuals. The villagers use water from poorly maintained tube wells. Locals believe they can build resilience by developing irrigation systems, upgrading roads, conserving forests. New initiatives, the result of collective efforts at local, regional and national scale, are needed to diversify livelihoods. Since such opportunities are not being created, the social system in Dubiya risks becoming increasingly fragile. Low levels of awareness and education are manifested in the low rate of sanitation coverage and the widespread practice of open defecation, another challenge to overcome. Locals believe that national politics and the migration of youth continue to undermine the creation of local opportunities.

Using uncertainty analysis (Figure 10), they prepared a local resilience plan which prioritised two activities: (i) irrigation and agriculture and (ii) health and sanitation. They intend to harvest rainwater, rehabilitate ponds and conserve water sources as well as construct toilets and organise public awareness programmes focusing on improving health and sanitation. Similar to other VDCs participants from Dubiya VDC also identified those organisations and agents who can help implement the plan (Annex VI). The plans thus prepared are summarised in table 18.

Figure 29: Uncertainty analysis in Dubiya VDC



Plastic pond in Madanpokhara VDC (Palpa District) .

18 RESILIENCE PLANS FOR VDCS

Name of VDC	Issues	Strategies to strengthen resilience
Kagbeni	Lack of alternative income-generating sources	Promote quality education Create opportunities for self-employment Improve tourism
	Problem of health and water	Use filter to purify water Improve water delivery and water management
Ramche	Dependence on traditional energy	Enhance use of alternative source of energy
	Limited livelihood options	Create incentive for small enterprises Become actively involved in social networks Enhance quality of communication systems in order to access and use information
Hansapur	Land degradation	Capacitate human resources Discourage use of machines in road construction Construct ponds for storing water for irrigation Construct green belts along roads and promote forest conservation
	Low levels of educational achievement and awareness	Organise awareness campaigns, workshops and programmes for education and skill trainings Establish mobile schools Access distance education
Rupakot	Inability to develop tourism	Begin construction of view tower for tourists Focus on conservation of Rupa Lake
	Lack of development	Improve drinking water system Improve quality of education Take measures to build and maintain social cohesion Begin improving farming systems
Madanpokhara	Water scarcity	Integrate the use and management of water sources Build more rainwater-harvesting systems
	Migration of youth	Create incentives for technological innovation in vegetable farming Promote small enterprises based on value addition to agricultural and other products to begin diversification Encourage improved animal husbandry and poultry farming Diversify income Promote cash crop and organic farming Ensure the sustainability of vegetable farming
Dubiya	Lack of education and awareness	Conduct awareness program
	Unreliable irrigation and lack of irrigation	Manage existing irrigation systems systematically and develop new methods

6.8 Interactions: Systems, institutions, and agents

Using an iterative shared learning process to undertake vulnerability assessments and engage in resilience planning local stakeholders identified many strategies for strengthening resilience options (Table 18) and provided critical insight into the nature and robustness of systems, the empowering and constraining characteristics of institutional structures, and the capacity and agency of agents within each VDC and Rupa Lake watershed.

In all six VDCs studied, systems are fragile, so access to services is limited. From a systemic perspective, Hansapur, with its low infrastructural development, fewer economic opportunities and significant dependence on global systems like the labour market, is the most vulnerable VDC, while Madanpokhara, with its vibrant economy is least vulnerable despite the emerging challenges of water shortage and the emigration of youth.

Food security rests on the robustness of local, regional, and global systems, both infrastructural

BOX-7: COST BENEFIT ANALYSIS

A cost-benefit analysis (CBA) is a systematic process used to compare the costs and benefits of an intervention, decision or public policy in order to determine its outcome over a period o f time. The nature of those outcomes, positive or negative, indicates whether it is advisable to pursue the planned action. Indicators such as net present value, benefit-cost ratio, internal rate of return and payback period are used to aid decision-making. A CBA approach used in Rupa Watershed suggests that the following timeframe should be employed.

Key steps and timeframe in stakeholder-focused CBA

Step	Stakeholder-focused CBA	Timeframe (months)	ISET-Nepal approach
1	Use future climatic trends to assess the impacts of climate change in the area	1.5	Vulnerability assessment of selected VDCs
2	Identify and engage stakeholders impacted directly or indirectly by climate change	0.5	Identification of communities impacted by climate change
3	Identify adaptation strategies and actions to include in the analysis	2	Identification of options for resil-ience planning
4	Measure costs and benefits and determine their distri-bution among stakeholders	3	To be conducted

Now that we have identified options that would help their users adapt to the likely impacts of climate change, we will conduct a CBA of the identified options. It will take three months and help to maximise the benefits for the targeted groups (the most vulnerable households).

The following points are important to keep in mind when implementing a stakeholder-focused approach to CBA.

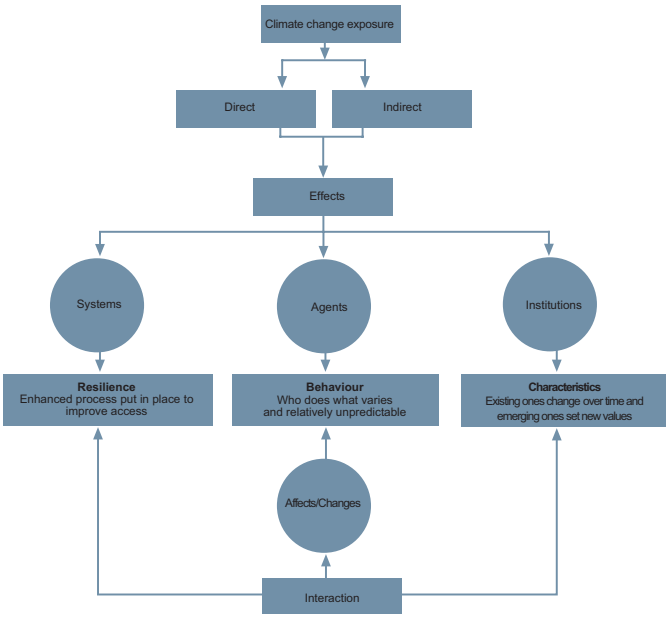
- Quantitative measure of costs and benefits should be ascertained at the aggregate level and at the level of the stakeholder group.
- Stakeholders should achieve consensus on the activities they will pursue using a participatory assessment of costs and benefits.
- The share of the total costs that each stakeholder group will meet should be based on the benefits that they expect.
- There is a need for a range of adaptation actions that maximise the benefits for all stakeholder groups.

and ecological, any of which could be rendered more fragile by a natural occurrence like a flood or by a stress in the social fabric, like a politi-cally motivated closure. Assessing the status of systems and the quality of services they provided establishes the current state of vulnerability of a VDC. The uncertainty analysis helps assess the future vulnerability in the VDC. With both of these states clear, stakeholders can develop plans to build the resilience of systems.

Building systemic resilience rests on our ability to build institutional resilience (see Figure 30). Institutions, though their influence is not always explicit, are nonetheless crucial for their role in either enabling or stifling the development and operation of systems and in shaping the behav-ioural changes of agents. In each of the six study VDCs institutions with different architectureis present as outcome of the diverse ecological and social contexts (Table 19).

In Kagbeni, the traditional Mukhiya (traditional village leader) system is one of the key regulators of society but tourism has brought new values and norms that are increasingly playing a

FIGURE 30: Interactions among climate change exposure, systems, agents and institutions



19 STATUS OF SYSTEMS-AGENTS-INSTITUTIONS

VDCs	Key agents	Influential institutions	Fragile systems	Likely exposure	Likely impacts
Kagbeni	Apple farmers and their trading network; tourism industry	*Mukhiya* (traditional village leader) system; values from traditional north-south trading, norms and values emerging from tourism	Roads and transport Houses with mud-roofed	Rainfall (floods and landslides)	Disruption of mobility affects the transport of food and goods, the apple trade, tourism, and communication Leakage of mud roofs
Ramche	Social entrepreneurs, local community, teachers, pension- holders (British and Indian Army)	Homogenous caste dominance, shared norms and values, sense of collective responsibility, ecotourism	Roads and transport during the monsoon	Rainfall (floods and landslides)	Disruption of mobility affects the transport of food and goods and discourages recent initiatives like potato and other vegetable farming, poultry farming and ecotourism
Hansapur	Teachers, ex-army personnel, migrant workers (remitters)	Religious norms and values, tradition of British and Indian army enrolment,	Infrastructure (roads, transport, shelter) Water system	Rainfall (Floods, landslides) Temperature (drought)	Mobility disrupted affects food and goods transport, communication and remittance collection Local agricultural production affected
Rupakot	NGOs, Rupa Lake Watershed Cooperative members, teachers, tourism industry	Rupa Lake conservation and dynamics shape larger interactions and decisions, tourism	Water system (drinking and irrigation in upper settlement)	Rainfall (less) and increase in temperature (drought)	Food production affected, tourism impacted negatively, high rates of emigration
Madanpokhara	Local community, vegetable farmers, teachers, community radio, local organisations	Market system and long history of education, traditional norms and values	Water system (drinking and irrigation)	Temperature (increasing)	Water sources dry up, local production affected, livelihood highly impacted
Dubiya	Farmers, remitters, local ethnic communities	Indigenous knowledge, practices, norms and values	Water system (drinking and irrigation) and sanitation	Temperature (increasing)	Health impacted, food production affected

role. Kagbeni's long history of trading with southern regions of Nepal is another crucial institution for its contributions to the nature of local livelihoods of Kagbeni. Tourism-based entrepreneurship dovetails nicely with the individualistic trading styles of the past. In Ramche, the sense of collective identity is strong; it lays out both the rules of the game and the mechanisms to enforce them. In Hansapur, the key institution that shapes local lives is religion and tradition, both of which affect behaviour, particularly of marginal communities. Two institutions shaping the future of Madanpokhara are the market system and education, which together form the foundation of sustainable household-level income and wellbeing, giving the community confidence, and provide the capacity to deal with changing social, economic, and political dynamics.

The emergence of tourism in Ramche and initiatives such as the conservation of Rupa Lake by forming a cooperative (Rupakot) and development of pond for irrigation (Dubiya) are autonomous responses that have contributed to the institutional characteristics of the VDCs. The incentive local population have has provided the basis guiding these autonomous responses to stress such as water shortages. While systems and institutions play a critical role, the third

and the most important element in building resilience is capacity of the agent. Examining agents, both their behaviour and their agency, can suggest why, under the same circumstances, one group of people or community can adapt while other cannot. The behaviour of agents at both local and higher levels is also shaped by the presence and robustness of systems, the constraints they face, support they receive from institutions and their capacity. The agents' capacity to resourcefulness, responsiveness and capacity to learn can guide adaptation strategies. Agent's autonomous behaviour and action provide basis on which strategic approaches to building resilience to climate change can be integrated.

Autonomous adaptation can be conceived to include actions that individuals, communities, other organisations and businesses undertake on their own in response to the opportunities and constraints they face to new challenges. These actions may involve new behaviour, pursuing new practices or technology, diversifying livelihood systems, increasing access to financial resources such as micro-insurance and micro-credit, migrating, reconfiguring labour allocation or resource rights and engaging in collective action to access services, resources or markets (Dixit, et al. 2010). Social capital and access to skills and knowledge are particularly important in enabling autonomous behaviour and are evident to varying degrees in all the case study VDCs. These actions remain valid and central in dealing with stress imposed by climate change. When the uncertainty inherent in climate science and projection renders the adoption of measures, which, by design, tackle specific impacts—attribution—impossible, planned, adaptive strategies can be adopted. By establishing resilient systems and mechanisms, planned measures can enable individuals or groups to adapt. The presence of systems will help strategy switching to achieve well-being. Such planned measures by facilitating a shift to strategies that help people make adjustments to stresses including those due to climate change even without specific attribution. This approach will work under range of climate change and serendipitously, enable strategy switches and autonomous adaptation.

In all VDCs, agents are trying to become more capacitated to act, but in different ways, shaped by the corresponding development of infrastructural systems and institutions. Kagbeni's increasing emphasis on tourism and trade has made locals more resourceful and responsive. They tend to respond to opportunities as individuals and many have set up their own enterprises. Tourism has not had as empowering effect in Ramche, where agents are still bound by the norms of the community to launch independent initiatives; instead, in Ramche, tourism is a collective enterprise. Agents in Madanpokhara and Rupakot are more active than those in the other VDCs. In Madanpokhara, agents are better informed and deeply engaged in the vegetable market, and have been for years; both education and vegetable business enable people to seek strategies to achieve wellbeing. In Rupakot, it is its proximity to Pokhara, where tourism flourishes, as well as the presence and support of NGOs that have built the capacity of local agents. The collective capacity of farmers in Dubiya was central to building of community ponds to respond to water stress they faced. The lack of strong agents within Hansapur VDC itself can perhaps be traced to the long history of seeking employment abroad in the British and Indian armies, a successful livelihood strategy that has continued to support this VDC's avidity for international migration.

The capacity of agents to address future vulnerability is built through their engagement in their assessments of systemic vulnerability and institutional constraints, which together lead logically to the development of resilience plans. Involving locals in preparing those plans not only generates a sense of ownership in the plans, but the process itself becomes a medium for generating and sharing knowledge. Such sharing is crucial because implementing options for building resilience requires local stakeholders to engage with many agents beyond the local scale.

BOX-8: LOCAL MAIZE THREATENED

The majority of the population of Hansapur depend on agriculture, cultivating maize, buckwheat, wheat, soybean, millet and potato but little paddy. Farmers complain that "leaves-burn disease" is destroying local maize species two months after they are planted. For the last three years, production was almost zero. A farmer in Sakindhara, Hansapur-6, says, "Since maize depends on rain, it will be difficult to cultivate if rainfall becomes erratic. Maize cultivation is our life. If there is any delay or decline in maize cultivation, we will face starvation." It isn't just this disease which is a threat: there is also a new pest that attacks the core of the growing maize plants and prolonged droughts have results in the loss of maize, wheat and mustard crops. Because these new pests and diseases damage local seeds, farmers have grown more dependent on hybrid seeds. However, though hybrids seeds are indeed more resistant towards pests and diseases, their supply is irregular and relying on them makes farmers become dependent on outside sources. These changing dynamics create new sources of vulnerabilities.

Adapted from Khanal (2011)

Strategies to build resilience and adaptive capacity will succeed only if they are sensitive to local norms and values, power differentials and priorities and if they rest on a detailed assessment of what local systems, institutions and agents can bring to the table to work with and in what areas they will need buttressing. While characteristics such as flexibility, modularity, and fail safe add to resilience of systems, they need to be supported by strengthening capacity of agents to get resources, respond and to learn while at the same time, building on the institutional characteristics. The process of building resilience and adaptation should reinforce each other and pave the way to identify new pathway to achieve wellbeing.

Irrigation canal in Dubiya, Kapilbastu District.

CONCLUSIONS

7

The study pursued a practical, forward-looking objective of building a resilient and secured food system, one that can respond effectively to the uncertain dynamics of climate change. It attempted to do so by examining changing nature of systemic interdependence and generating data sets to assess vulnerability of an area and people within that area and plan for resilience. In doing so the study developed a systematic approach to assessing vulnerability that will assist while making decisions. The study provides the following lessons.

Climate

- In terms of both space and time, precipitation is becoming more irregular. However, existing data sets and network of meteorological stations are too few to permit a detailed analysis of these changes. There are many uncertainties regarding the way climate is likely to change in the Himalayan region and very little is known about how these uncertainties will play out on regional and local scales.
- SLDs revealed that people perceive that changes have occurred in both natural and human-built systems. They mention that they have experienced the following changes in temperature, snowfall, rainfall and wind.

  Wind: In Mustang, the wind used to blow only from the north and only during specific months. Now it blows throughout the year and comes from both the north and the south.

  Temperature: Temperature in general has increased. In particular, daytime temperatures are hotter than they were in the past.

  Rainfall: While the volume of rainfall has not changed, it has become more variable over the years. Its distribution is irregular and it is more intense than before.

  Snowfall: The volume of snowfall and its duration has decreased. It also falls at different times and is more erratic. Rainfall seems to have supplanted snowfall.

- The increase in temperature and variability of precipitation documented by the data analysed, GCM results, and local perceptions has affected wild plants as well as cultivated cereal crops and vegetables. The changes in temperature and rainfall may lower agricultural productivity since the nature of exposure will be different, both directly and indirectly. From the perspective of food security, these impacts have to be analysed at farm level because they have implications on nature and the management of agricultural systems. Increase in temperature will impact the incidence of pestilence and blight, give rise to new types of weeds and crop diseases, and also affect livestock health, but requires in-depth examination. It is likely that these impacts together will exacerbate vulnerability but we do not yet even know what those impacts are.

Water, agriculture and food

- Agriculture and other land-based activities in the WDR are changing as more households depend on imported food. There are fewer livestock and more are stall-fed and reared for milk and meat production rather than, as was traditional, for manure. Farmers rely on chemical fertilisers subject to a volatile external market instead of traditional nutrient-recycling. They also use fewer non-timber forest products except if they have a high market value. These change processes have directly impacted rural livelihoods. In particular, the market has emerged as a

dominant actor. Because markets transmit the effects of climate change in one place to another, they introduce new vulnerabilities to local food systems and add to insecurity. Changes in prices, external production, and government policies can, to cite one example, add to insecurity if the export of basic food commodities is restricted.

- During the 1970s Nepal was a net exporter of food but from the 1990s onwards it has been a net importer. At the national level, the total share of agriculture to GDP is 36 per cent and declining. Few households in the study can meet their annual food needs solely from local agricultural production. They are forced to seek alternatives. For a short-term shortage, borrowing food from neighbours is common, but if it is long-term, they engage in wage labour within or outside the district or migrate, often abroad. While migration is a traditional strategy, in the changing circumstances, in which world labour and commodity markets are growing increasingly significant, the most marginalised families are growing more vulnerable. In many places, families seek alternative livelihoods to meet their food deficits.

- In the past, food security in the region depended on localised production-consumption relationships (Moench et al., forthcoming), which in turn were was based on linkages among local water, land and agriculture systems. Today, the stock and flow of food is becoming increasingly dependent on regional and market systems. In fact, such large-scale systems are now as important as local and national factors. Infrastructure and organisational systems responsible for its functioning are important for achieving food security since they provide the services needed to acquire food.

- Though the VDCs studied are mostly rural, the divide between the urban and the rural is gradually blurring: in particularly, the asset baskets of rural households are similar to those of urban households. Families are gradually shifting away from farm-based livelihoods to other types because farming is seen as unattractive drudgery. Encouraging a return to agriculture, especially among the disaffected youth, needs a deep analysis of changing social dynamics.

- The demand for irrigation water is increasing in areas where rainfall has become erratic. Some farmers are autonomously introducing technological and institutional innovations and creating water storage systems of different capacities.

Biodiversity

- SLDs, literature review, and grey sources and oral histories reveal that certain vegetation and animal species are disappearing or appearing from various places. The emergence of weeds and other invasive species has become common. Poor management and lack of regulation of the collection and trade of NTFPs has made some forest products vulnerable or endangered and even pushed some into extinction. Changing dynamics are likely to add to the existing stress.

Diversification of livelihoods

- In all VDCs, households attempt to achieve food security by engaging in both on-farm activities like producing marketable vegetables and fruits and off-farm activities like seasonal and long-term migration, small business, and service in government and private sector agencies. While the emigration of economically and socially privileged groups creates some wage employment opportunities for landless and marginalised households, it has also created a labour shortage.

Migration

- Migration has been a characteristic of the WDR and is considered as a major livelihood strategy. Magars and Gurungs of Syangja, Palpa, Gorkha, and Baglung districts have access to outside earnings (Adhikari, 2008). Earlier studies, focus-

ing on Gandak river region, also indicate similar conclusions. Pignede in 1958 (1993, cf. Adhikari, 2008) has revealed that about 62 per cent of the male workforce is absent from a village in Mohoriya (Kaski District): these are men from Gurung households employed in British and Indian armies. Macfarlane (1976) found that 27 per cent of the village income of Thak, Kaski District, was derived from remittance and pension. In a more recent study, Adhikari (2008) points that although migration is a common feature in the mid-hill region of Central Nepal, there are many variations in strategies and earnings among inter- and intra-district and inter- and intra-villages. Previously, migration was the strategy of young males migrating to India; today many go to Gulf countries and now women are in labour migration. Views about the nature of households, which pursue emigration as a strategy varies. Macfarlane (1976) argues that migrant households are lower class, but Adhikari (2008) suggests that in recent times lower-middle class households are also involved. Regardless of these distinctions, the increases in long-term migration and remittance are triggering multiple changes at household and national levels. The migration of young men has created a demographic shift as many families move to roadside settlements, leaving increasingly depopulated rural hamlets. Both types of settlements are more dependent on distant ecosystems for food and both face new sources of vulnerabilities. Women, for example, are forced to do both household and farm chores, some which were once performed by men. These changing dynamics should be central considerations in any approach adopted to build resilience and adaptive capacity.

Remittance

- The average Nepali household receives 16 per cent of its income from abroad, almost twice its income from agriculture. Currently, remittance contributes around 23 per cent of the GDP and amounts to a large resource pool for investment. This inflow of cash has increased both purchasing power and the desire to spend. Since remittance allows households to buy food from regional markets, it indirectly contributes to declining agricultural production. In addition, remittance decreases the economic divide between the rich and poor to some extent, but because cashing a check is so easy, provides little incentive to take part in local economic activities. Remittance is an important source of cash to invest in the education of children and health but it is also spent on consumer goods. The role remittance can play in autonomous adaptation needs further examination in pilot studies.

BOX-9 THE DEPOPULATION OF THE COUNTRYSIDE

In recent years, many villages in the hills and mountains of Nepal have been depopulated. The village of Kulab-6 in Baitadi District in Nepal's far-western development region has jus t one family; a decade ago, there were 35. The rest migrated because of low levels of development and the lack of basic facilities such as health and education. According to Baitadi District Development Committee, in the last three years 3,500 families have emigrated. Many do not believe their villages will ever have roads or electricity. They migrate to cities, where they fit into a low rung of the economic system. Back home their small farms languish fallow.

Adapted from Kantipur Daily (March 12, 2013)

Expansion of transportation and telecommunication systems

- In most VDCs the social, economic, and environmental changes brought about by the expansion of roads and transportation and telecommunication services was clear. The annual budgets of VDCs and DDCs are often spent on constructing roads and with road connections come many structural changes, especially in household and village economies and the distribution aspect of agricultural production. For example, traders now visit the region to buy apples; the villagers of Ramche have invested more in potato farming, and in Kagbeni, locals have reduced their dependence on fuel wood because they can buy LPG. Everywhere, mobility has

BOX-10: INCOME SOURCES IN SIX VDCS

Local level food system (mainly production, consumption and distribution) in the six VDCs showed changes in local cropping patterns and farming practices, irregularity in processing and distribution, and accessibility owing to low production, lack of road and transport system and political closures. Change in planting and harvesting time of cereal crops and vegetables and flowering time of local fruits were reported. Similarly change in variety cultivated with focus on commercial products, use of hybrid seeds and decrease in production of local varieties was reported.

METHODOLOGY

The study VDCs are located in all the ecological regions: Mountain, Hill and Tarai. The population distribution in all the VDCs of the study area is uneven. The VDCs, which are located in mountain regions, are least populated with sparse settlement while in case of Tarai densely populated. The range of vulnerability assessment to each component of all the wards of selected VDCs was completed before this study was initiated. The purpose of this survey was to analyse food basket at household level amongst the least, moderate and most vulnerable wards of the selected VDCs.

Because of the uneven distribution of population, sample size of each ward did not have the same number. The sample size ranged from 10 to 40 per cent. The ares with lowest numbers of household carried highest number of sample size (in per cent) and the areas with highest number of household carried the lowest.

Number of households	Percentage of sample size
Below 25	40
26 - 50	30
51 -100	20
101 - 200	15
Above 200	10

51 per cent mentioned agriculture as their main income source, while 17 per cent stated it was service/pension. Only 15 per cent suggested that was remittance from their family members work abroad (Figure 1). However, the amount of income from different sources reported by the households revealed that only 17 per cent of households get major income from agricultural enterprise. While remittance, salary/pension and business remain as the higher three sources of income, 39 per cent, 23 per cent and 15 per cent respectively (Figure 2). The data suggest that though population still practice agriculture and livestock farming, off farm activities add to their income and that these sources are getting diversified.

Figure 1: Major occupation source of sampled households

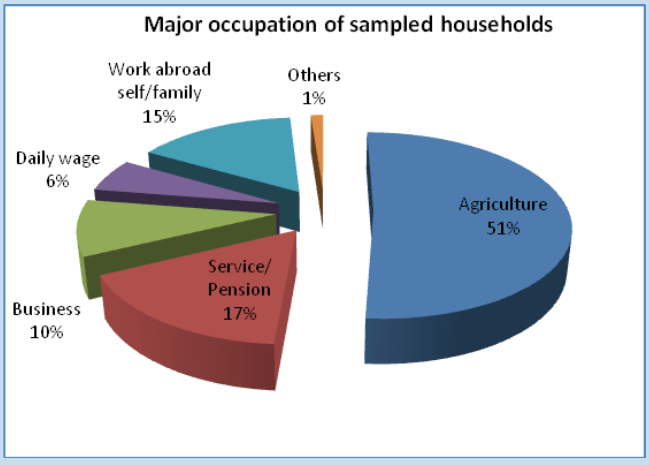
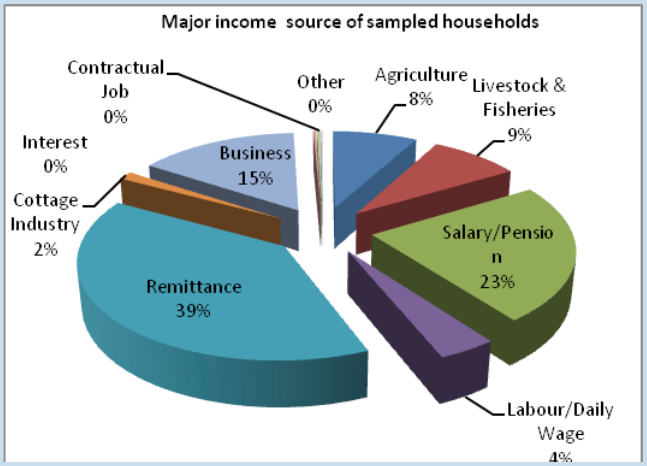


Figure 2:Major income source of sampled households



increased and food systems have become more diverse, and students find it easier to commute. Communication systems such as telephone sets and mobiles phones also have penetrated deeply into rural lives. Farmers in Madanpokhara communicate on the phone rather than travel to Butwal to enquire about prices.

- Roads attract settlers, altering traditional settlement patterns and leading to haphazard urbanisation since people construct houses on roadsides. Often roads are aligned with rivers, making people who settle there vulnerable to flash floods. Land prices rise, and those with land, including once disadvantaged households, can become affluent overnight by selling or renting, often large concrete structures that are neither green nor sensitive to local architectural styles. Stakeholders feel that roads have threatened Nepal's trekking-based tourism industry, as there is little pleasure in tramping down a motorable road.

Growth of built-up areas

- Now that farmers have more cash, real estate has boomed (though it is currently in a slack period) and rapid and unregulated construction has made built-up areas still more haphazard. Interactions and inter-linkages between rural and urban spaces have significantly multiplied, a process which is restructuring information, education, employment, income—in short, the very lives of rural youth—and created a world of hope and aspirations significantly different from what it once was (Mishra, 2007).

Role of local users' groups

- With the adoption of the Local Self-Governance Act and Rules of 1998 and 1999 respectively, Nepal saw a surge in the number of local users' groups managing irrigation, forest, water, electricity and lake. The act formalised traditional practices, like those of *guthibihar*, *dhikur*, and *parma* and defined the roles of various types of groups, including myriad of non-profit, voluntary and self-help organisations, NGOs, formal and informal associations of people and their social movements in serving as agents of change. These groups include CBOs such as farmers' cooperatives, saving and credit organisations, mother's groups and a variety of political and ethnic groups. By meditating between the base and super-structure of society and performing key functions, these groups can play a positive role in supporting resilience adaptation dynamics and building adaptive capacity.

Changing social values and aspirations

- The factors that shape the identities and aspirations of all Nepalis, including those in the WDR, are changing. Inborn and ascribed social markers such as caste and clan are gradually giving way to new personal and social identities. The new generation employed in the urban, migratory and non-traditional sector is not bound by the old political, cultural and economic norms and limits (Mishra, 2007). Changes in roads, education, telecommunications, health services, civil society, banks, CBOs, and political parties have affected livelihoods and many other socio-economic structures that influence the worldviews of people. These factors will be important determinants in designing strategies for building resilience and adaptive capacity because the role of agents and institutions is changing as their responsiveness, resourcefulness and capacity to learn increase.

Dynamics of ecological and livelihood systems

- A change in one subsystem also affects other, related subsystems. The impact of the changing climate, particularly changes in precipitation, is felt on hydrological systems across the WDR. Besides, the intensification of economic and human activities is affecting water and agricultural systems. In the study VDCs and in the WDR as a whole, livelihood and land-use patterns as well as access to and the utilisation of natural resources are rapidly changing.

Vulnerability assessment: A conceptual and practical challenge

- While the above points make the necessity of assessing vulnerability clear, more thought has to be given to deciding what types of analysis will be most useful and to defining the term itself, which in its most general sense captures the disproportionate impacts climate change will have on high-risk groups and fragile ecosystem. The current focus on vulnerability stems from the need to see global funding for climate adaptation target restoring ecosystems and people at risk as well as the need to document the effectiveness of investments in adaptation. More analysis over recent decades has highlighted the different impacts climate change will have on the poor, women and children who suffer from pre-existing vulnerabilities rooted in complex context. Since social differences interact with and magnify the impacts of climate hazards on basic life-support, ecosystem and support systems, the factors that concentrate the impacts of climate change on particular groups and build resilience need to be identified.
- Understanding vulnerability is problematic. While current analysis details the link between climate and poverty, environmental degradation and development, the lack of clarity in concepts and methodologies skews the assessment according to the disciplinary orientation of the analyst. Consequently, most vulnerability assessments cannot be replicated and do not provide a baseline against which change can be marked.
- Identifying vulnerability must consider both a hazard-based and a social perspective. The latter perspective lens is required because it reveals why certain individuals, households, and communities experience food insecurity risk while other in the same geographical locations do not. The reasons for vulnerability to food insecurity are both biophysical and socio-economic and have both nutritional and livelihood effects.

BOX-11: CONDITIONS FOR SUCCESSFUL VULNERABILITY ASSESSMENTS

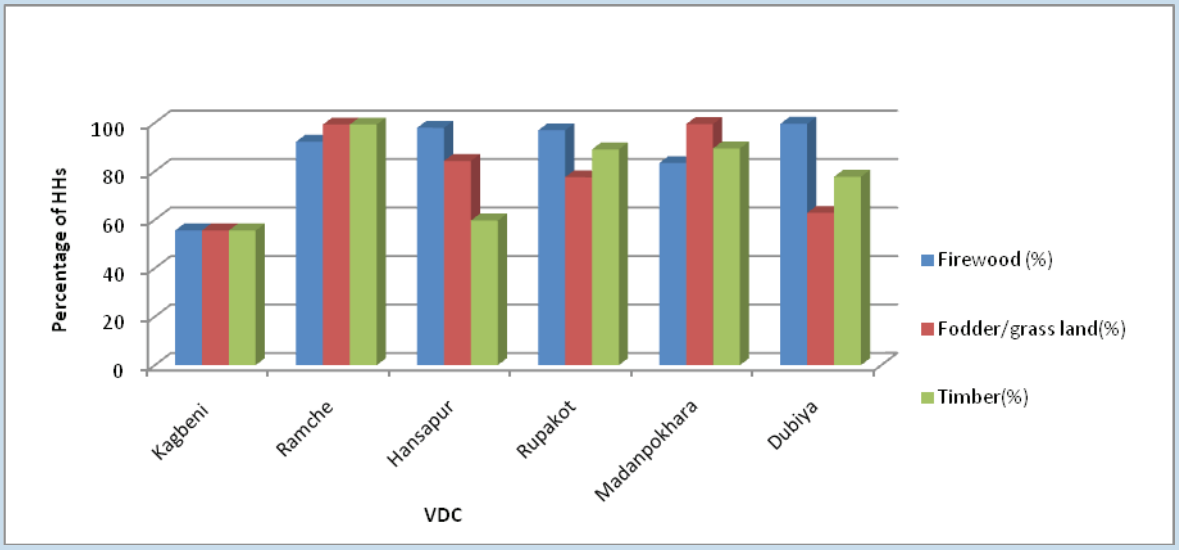
Through vulnerability assessment, VDC wards can be ranked from the most and to the least vulnerable. To make sure the approach succeeds, the following conditions should be met:

- VDC-level data on core, secondary and tertiary systems should be available or acquired.
- Local network for support.
- Rapport with locals established based on the legitimacy of earlier work.
- Climate data and climate change scenario studies at national and sub-national scales.
- Intermediate agents such as teachers who can facilitate.
- Appreciation of local conditions, ability to adapt to local knowledge and sensitivity to local context.
- Good listening skills and ability to paraphrase and thereby promote iterative learning.
- Understanding of that the need for iteration arises from the embedded nature of vulnerabilities.
- Participation of diverse groups such as farmers, teachers, women's groups, saving and credit groups, vendors, and local government officials.
- Continuous participation basis and allocation of time.
- Coordination with and engagement with local government bodies.
- Facilities to hold meetings.
- Access to electricity and Internet to promote participatory GIS.
- Maps and GIS layers with in-house capacity.
- Flip charts and cards.

BOX-12 : DEPENDENCY ON LOCAL SYSTEMS

Agriculture and forests together serve as the primary sources of livelihood for two-thirds of Nepalis who farm. Forests provide food, energy, shelter, medicine, bedding and mulching materials, and timber and non-timber products. They also help modulate local climates and support farming. Overall, about 84 per cent of the households surveyed depend on local forests. Dependency is lowest in Kagbeni because this VDC has little forest area (Figure 1).

The study's assessment of biodiversity and livelihood changes revealed local dynamics in the six study VDCs and promoted greater understanding of their implications for food security and climate change adaptation. People reported that their dependency on forestry, livestock-rearing and agriculture has decreased in the last 10-15 years and that, to some extent, livelihoods have diversified. All six VDCs import food to overcome shortfalls and all are more dependent on food systems beyond the local. Dubiya has the greatest proportion food sufficient households (20 per cent) and Hansapur the least (six per cent). The high rate of migration, especially of youth, and the declining interest in farming has eroded local production and introduced new challenges.



Transportation service in Kagbeni VDC, Mustang District.

© Kamal Thapa

Financial institutions in Sandhikharka, Arghakhachi District.

© Srisit Silwal

A Dalit woman communicating through mobile phone in Hansapur VDC, Arghakhachi District.

RECOMMENDATIONS

8

Responding effectively to the impacts of climate change presents a major challenge to our existing knowledge systems. However, our institutions involved in making such responses are compartmentalised, fragmented and are designed to perform under the assumption of a future that is certain. Other limitations include: lack of organisational incentives, weak implementation and research and poor technological capacity. In addition to changing this conventional approach, we need to be able to unpack the complexity of variable climate induced vulnerabilities, their impacts on individuals, households, communities and environments. On the basis of the discussions, we make the following recommendations

Hydro meteorological processes

1. *Monsoon dynamics:*Both monsoon and westerly rains sustain life and economy in the WDR as well as Nepal as a whole. Detailed studies are needed to generate evidence on the interaction of inter- and intra-annual variations in rainfall regimes and its impact on natural systems, including agricultural systems and forestry, and on the existing vulnerabilities of farmers, particularly the marginalised. Studies should ascertain the relative importance of changes over and within years as well as disaggregate data according to season—pre-monsoon, monsoon, post-monsoon, and winter—and daily extremes. Three questions are important: why is any given monsoon season more active than another, what is the frequency with which a wet monsoon and cloudburst coincide, and what is the link between macro and micro hydro-meteorological processes? For example, the impact of the El Nino and La Nina on the micro scale needs exploration, as does the impact of the passage of low-pressure systems. Explanations of such linkages are necessaryto clarify the changing nature of climate-related hazards and to anticipate future impacts, thereby minimising social and economic vulnerabilities.

2. *Extreme rainfall:* Questions regarding extreme rainfall need to be tackled and their answers communicated to communities so that they can minimise the impacts of climate change on their life. Cloudbursts are a regular phenomenon during the monsoon period, but how they will be affected by climate change—whether their intensity and duration will increase or not, for example, and what the magnitude of such increases might be—is unknown. If, for example, mean normal rainfall increases 15 per cent, would the total number of cloudbursts or intensity of each individual cloudburst increase proportionally? Knowing that, for example, the previous 24-hour rainfall high of 500 mm would increase to 575 mm is invaluable.

3. *Local models:* Detailed studies must examine the interface between meteorological and hydrological processes as well as the impact climate change can have on vegetation cover, evapo-transpiration and overland flow. Since temperature and wind speed affect rainfall intensity and volume, a single, universal model is unlikely to explain the changes. On the contrary, the type of model most suitable will depend upon the characteristics of the catchment and process under evaluation. GCMs need

to be scaled down so that their scenarios applicable to localised settings can be generated.

4. *Flow and sediment:* Since any change in rainfall pattern will affect sediment responses and, as a result, flow systems, river behaviour and flood hazards, both the sediment process and the morphology of river needs to be studied in detail and on a long-term basis. By virtue of natural characteristics, the WDR and, indeed, the Himalayan region as a whole, have very high sediment yields and many landslides and other mass movements occur. Currently, assessing the likelihood of such hazards is limited by the many assumptions that scientists, in the absence of evidence, are forced to make. Intuitively, we might expect climate change to increase the rates, but defining that additionality needs more work if we are to boost disaster mitigation efforts. Local community should participate in the studies because, if capacity for adaptation is to be increased and scientific understanding of natural processes must be enhanced at all levels.

5. *Snow:* Upper WDR contains many patches of snow, which store the water that locals rely on for drinking and irrigation and that support local ecosystems. With the opening of roads, carbon emissions and the concentration of particulate matters will increase. How this change affects local and regional climates needs to be studied.

6. River hydrology: Because the hydrology of rivers of Nepal is governed by climate, the full range of predictions made by climate scenarios must be related to the hydrology of rivers and communicated well to end users and to disciplines other than just hydrology. The proportions of river flow derived from snowmelt, glacier melt, monsoon and the westerly need to be assessed. Data about the stock and flow of Nepal's three types of river basins (snow-fed Himalayan, non-snow-fed Mid Mountain, and non-snow-fed Chure) will help assess the inherent elasticity and vulnerability of catchment hydrology to climate change.

7. Dry season: Changes in climate has led to a perceived increase in the dry season, but the exact duration and spatial scale need to be assessed. There is a need for information on whether droughts occur randomly over landscapes, particularly whether they occur across an entire basin or multiple basins.

Variability: Data and network

8. Prevailing rainfall characteristics, particularly of micro spatial regions, must be captured so that monitored hydro-meteorological processes are representative of the general pattern. Capturing the high spatial variability in rainfall is important for forecasting floods and mitigating their harmful impacts. Data must be spatially representative, of good quality and collected over a long period and stations must monitor rainfall on hourly basis.

9. Data on the discharge of rivers flowing in smaller catchments must be improved: unmeasured rivers should be included and the quality and duration of data for measured rivers must increase. Rainfall data for micro regions must see a similar improvement as the extrapolated data currently used introduce spatial and temporal scale effects that render it less useful because it has to be adjusted. More stations must be established and they must have the capacity to a) detect weather systems that produce cloudbursts, b) warn appropriate authorities (local, regional and national) and the public about the likely severity and timing of extreme weather events that such systems may cause, and c) assess river flow conditions using hydro-meteorological data.

10. Stations forecasting meteorological and hydrological events must be operated and maintained efficiently. Data collection need not be a high cost endeavour using sophisticated methods: acceptable quality can be ensured by engaging forest and water users'

groups or school children, who themselves get the chance to link classroom education with a real-world situation. Information collected by the community can provide important data to supplement the national network.

Weather events: Analysis and forecasting

11. When flow data is available, a return period is used to indicate the probability of the occurrence of projected extreme events such as floods. Local people, however often misunderstand this concept, believing, for example, that a flood with a return period of 50 years will occur every 50 years but that a flood is likely to be less than the stated magnitude 49 out of 50 times. Policymakers and members of communities living along riverbanks need to be made aware of the truth about return periods and dispel their false sense of security. At the same time, climate professionals, hydrologists and natural resource specialists need to develop a practical way to convey the possibility that an extreme event will occur measured within an individual's life span. There is also a need to establish practical, readily understandable hydrological warning systems that

- Produce information for forecasting,
- Transfer information among various levels and link various actors,
- Use specific values like water level,

Occupational entrepreneurship in Hansapur VDC, Argakhachi District.

discharge or days without rain,and
- Understand and highlight the degree of uncertainty.

12. In communicating messages about potential hazardous events to local governments, the public and members of communities likely to be affected we need to focus on

    - Maintaining dialogue among climate scientists, hydrologists and meteorologists when developing and operating forecasting methods,
    - Establishing two-way communication between members of the scientific comunity and local authorities,
    - Promoting dialogue among researchers on different aspects of management,
    - Making information available to communities likely to be affected in languages they understand, and
    - Creating response arrangements and implementing forecasting and warning systems, which suit local contexts.

13. Local-level preparedness and post-events support measures must back up warning activities, which themselves are insufficient. The emphasis must be on

    - Developing the capacity of communi ties and local governments to respond to the impacts of potential extreme events,
    - Increasing public communication and education about actions that need to be taken when disasters like floods, droughts and landslides occur,
    - Coordinating warning measures and re sponse arrangements and supporting those likely to be affected.

14. Data access and dissemination: Having daily rainfall records improves the quality of information needed for forecasting hydrological process such as floods and is useful to hydrologists, engineers, planners, and ecologists since they design infrastructures. Local communities will become accustomed to receiving accurate information daily, which will enable to disseminate that information more effectively during an emergency. There is a need to test the possibility of using technology such as mobile phones and internet to improve access to information.

15. Agricultural data meta analysis: The agricultural biodiversity of the WDR is considerable and its unique niches many. A meta-review of data, particularly that related to the impact of climate change on farming systems, will promote our understanding of vulnerabilities and our ability to suggest strategies to address them. The review should gather evidence regarding the role key ecosystems, particularly grass, forest and wetlands, play in maintaining livelihoods, resilience, and adaptation. Such a study is especially crucial considering that many farmers are switching to high-value cash crops, a strategic change with its own set of vulnerabilities that need to be identified and minimised.

BOX-13 : LOCALISING THEORETICAL CONCEPTS

Translating climate change concepts into local languages in a manner fully understood by the locals is a challenge. "Resilience" is defined by as the capacity to bounce back to the original state. However, locals were confused by the meaning of this term and wanted to know if, for them, resilience meant being able to bounce back to their current state: 14-hour power cuts, landslides, and no roads and limited mobility. During a regional SLD held in Pokhara in September 2011, Mr. Tam Bahadur Bishwakarma of Hansapur asked, "Does being resilient mean that we return to poor living standards without electricity, roads, or health facilities? That we move backward?" The locals understanding of resilience was clearly not what the researchers intended to convey. The essence was lost in translation.

Not only is it difficult to capture ideas from one language to another vernacular, each society has its own linguistic architecture used to express concepts such as adaptation, resilience, coping and risk. To overcome this communication challenge and make knowledge transfer more effective and broad-based, ISET-Nepal is working with Nepali language specialists to develop an appropriate lexicon.

16. Health: Specific targeted research is needed to generate evidence of the impact climate change will have on vector-borne diseases and pathogen ecology in order to assess the extent to which disease patterns will change.

17. Development, resilience and adaptation: Development models of the past produced winners and losers. Those who lost were in the social and economic margins then and remain so today. This model depended on a social-political system that evolved with a fossil-fuel based pathway and while it did improve education, health and hygiene, and income, it now needs to change because of its major externality in the form of climate change. The current need for green energy will require a re-crafting of development pathways so that they produce win-win outcomes that are pro-poor. The wisdom needed to develop such an inclusive pathway will come through many evidence-based trials and innovations.

@ Deebraj Rai

Fishing community in Dubiya VDC, Kapilbastu District.

18. Vulnerability assessment: For vulnerability assessment to play a useful role in minimising the different impacts climate change will have on various populations and systems, it needs to be systematised. Specifically, concepts and methodologies of vulnerability need to be defined to provide a consistent basis for assessment across contexts, and barriers to using the results of vulnerability assessment in the design, implementation and monitoring of programmes need to be identified and overcome. There is also a need to improve the mechanism by which results feed into the programme design. Only with this foundation can targeting and documenting effectiveness measures be made pragmatic. Approaches that differentiate among and define the factors that contribute to vulnerability and resilience are necessary. Methodologies should draw on concepts appropriately scaled to the local context. The goal of vulnerability assessment must shift from problem identification to solution identification and approaches to minimise it.

19. Policy issues: Nepal's climate change policy (2011) envisions a country "spared from the adverse impacts of climate change, by considering climate justice, through the pursuit of environmental conservation, human development, and sustainable development [with] all contributing toward a prosperous society". Making Nepali society more resilient to climate change is a laudable objective, no doubt, but there is a danger in prescribing policy from the top. Building adaptive capacity effectively relies on knowledge of local diversity, the evidence of good practices, and the capacity to fine-tune policy to suit changing circumstances. Nepal already has a number of policies whose elements are useful for adaptation process though they are not labelled as such. Promoting cooperatives and users' groups are examples in that they enable communities, like those, which conserve fish in Rupa Lake, to organise in order to respond to stress. Hundreds of such autonomous responses in the WDR and in Nepal as a whole reflect the inherent resilience of societies and people to respond to constraints. Public policies that support or allow local responses to be dovetailed with planned are useful.

Participatory labour contribution for community work in Ramche VDC, Myagdi District.

Box-14: Resilience Planning Sequence

Context Setting		
Global		
	Steps	Explanations
	Highlight climate change as a global phenomenon	Compelling evidence that green house gas concentration is leading to rising temperature (there are naysayers though)
	How will climate change?	Scenarios are the basis, Special Report on Emission Scenario (SRES) of AR4. New scenarios are being developed for AR5.
	Rise in global temperature will lead to	Changes in rainfall, snow fall, glaciers, sea level rise, ecosystems and bio diversity, agriculture, health etc.
	Because condition will be different than the past or present, adjustment/adaptation to the potential changes will be necessary	Who, where adapts to what changes? are important questions? We need to get to regional level first.
	Regional level	
	Assess implictions at regional level	
	Example: Nepal has varied geography from the snow capped mountains to tropical Tarai and many in between. This variation is associated with social and cultural variations. How will climate change affect them?	According to Maplecroft Nepal is the 4th most vulnerable country in the world to Climate Change. The country is development deficit due to historical, political, and other reasons. Though all of the country is vulnerable some approach will be needed to rank to prioritise resource allocation. We need to get to local scales.
	Local scales:	
	Assess impact at district and lower scales	
1	Example: In Nepal District, VDC and wards. The country's 75 districts can be ranked helping reach district but that is not sufficient. A district may contain physical and social diversity, which can be dramatic in the mountains and hills. Tarai in the plain. A district also many VDCs. For assessing vulnerability and adaptation needs it will be necessary to get to the scale of the VDC.	Based on secondary information, use IPCC's criteria of exposure, sensitivity and adaptive capacity for ranking. Will give the most vulnerable district. A district embodies diversity and may contain more than 75 VDCs. How do we decide which VDC is more vulnerable?
2	Village scale within a distriict	Use Shared Learning Dialogue (SLD) with district stakeholders to identify vulnerable VDC in the district.
3 4	Ward level Example; In Nepal a VCD has nine wards which are diveres. Identification of most vulnerable ward and those vulnerable in tha ward is important.	Use concept of "systems at gateways to services" available at each ward of a VDC to rank them. Systems considered core, secondary and tertiary scales. Conduct SLD to assess status of systems and access services from those systems. (Example, percentage of population with access to drinking water supply: highest coverage would get 1 and lowest would get 9). Work out composite ranking for all systems for each ward. This step helps identify the most and least vulnerable ward in the VDC. Need to know who in that ward are likely to be more vulnerable than the other.
5	Use community based or other social tools for assessing marginality.	Criteria: education level, income, social position, caste, ethnicity, gender and other structure.
6	Step 5 gives a vulnerable area (using natural science based top down approach), details of systems within that area, and marginalised population within that area. This context reflects current variability. Status of systems and marginality also yield baseline condition helpful in monitoring and evaluation.	
7	How will Climate Change alter the context? Introduce climate change lens to assess new hazards (and new vulnerability)	
8	Climate change vulnerability is an outcome of exposure, systems, marginality and institutions.	
9	District level climate change scenario	GCM scenarios, downscaling, trends, and local perception: Needs nuanced and creative approaches for generating synthesesed scenario.
10	On the basis of the scenario envisioned plan for uncertainties	How will Climate Change (new exposure) alter systems and affect those depending on them?
11	Identify options to build resilience and adaptive capacity. Assess systemic linkages and interdependence (Local, regional and global)	
12	Perform qualitative cost benefit analysis for prioritisation (to assess distributional impacts).	
13	Select option/s for implementation	
14	Define roles and responsibilities for implementing the option.	Agents: Government at all levels, private sector, CBOs, NGOs, individuals households
15	Estimate/revise resources needed	Financial, material, human, informational, knowledge
16	Develop monitoring and evaluation framework	Link the framework to the base line collected in step 6
17	Implement the option	As set out in step 14 and 15
18	Monitor and evaluate	Link to the base line collected in step 6
	Revisit strategy (Follow steps 1 to 18)	

Energy system serves as gateways to services, Mustang District.

WAY FORWARD

9

The study used an evolving set of concepts and methodological principles developed by ISET-N and ISET in their prior work on adaptation. Its methodological framework focused on understanding the interactions among agents, environmental and infrastructural systems, and institutions when all are exposed to shocks, including those from climate change. Systematised shared learning methods used during the study ensured that key stakeholders were engaged and involved in all aspects of the research process, and that efforts made to integrate activities across scales and disciplines.

Conducting fieldwork in selected rural locations along the transect of the WDR provided the opportunity to systematically examine local conditions and link them to the watershed and regional levels. Data was generated and relationships with local organisations, communities and policymakers were established. In all VDCs studied, multiple drivers of change are at work. Climate change is only one of the drivers, and from the perspectives of local agents, not the most pressing one. This is so in the WDR, in Nepal and in many regions of other countries. While examining the interactions among different systems, this study attempted to unpack the concepts of vulnerability, resilience and adaptive capacity. The insights it has generated can help improve practice, inform policies and add to emerging knowledge on building resilience and capacity to adapt.

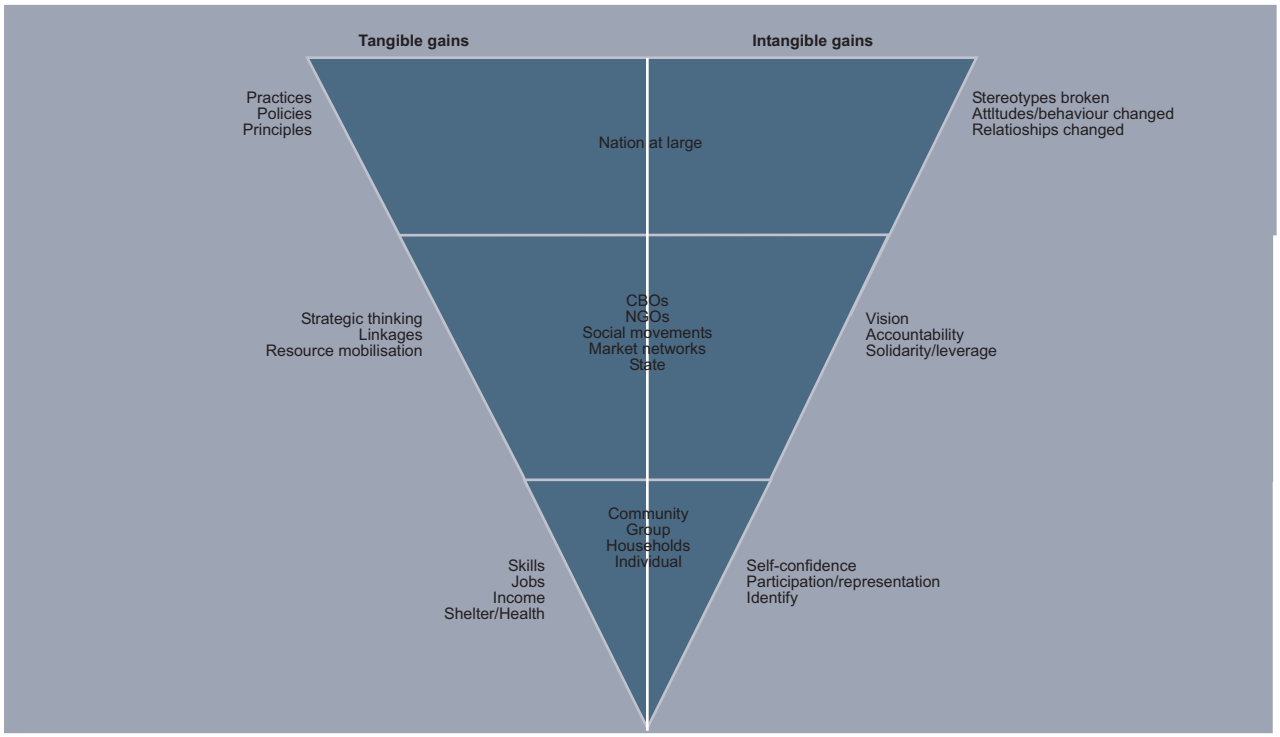
Understanding the emerging sources of vulnerability is challenging and complex but without such knowledge it is difficult to build resilience and adaptive capacity. It is critical to understand the different factors working at different scales that enhance the resilience of systems and of agents and enable institutions to adopt strategies to thrive in the face of future changes, climatic or otherwise. Such understanding needs to recognise that power relations, gender differentials, and institutional norms influence access to and the management of systems and thereby determine exclusion, poverty and vulnerabilities. The nature and resilience of systems also shapes the scope of behaviour of three important agents: government, private sector and civil society. Each group's incentives can help reveal effective entry points for building resilience. This identification requires integrating insights from the social sciences (anthropology, sociology, political science, and economics), engineering, natural sciences (ecology, hydrology, climate), and local knowledge.

The study highlights three interrelated issues with bearing on building resilience and adaptive capacity. The first is that WDR's climate is highly variable and existing climate knowledge does not explain the wide-ranging unevenness in temperature and precipitation. We know that the continued addition of green house gas in the atmosphere due to the burning of fossil and other sources will exert influence on the regional climate such as the AMS, westerly and other rains producing systems. However, the prevailing knowledge on regional climate dynamics cannot fully explain the processes. In other words, attribution of local climate variability to global climate change remains a gap and overcoming it completely will remain an unachievable goal in the immediate future. We need to design strategies that can adapt to high climatic variability in a situation of limited data and scientific knowledge.

The second challenge is related with development, conceptualised broadly as a combination of tangible and intangible gains (Figure 31). The issues identified in the figure are all important, though the basic factors, equivalent to elements of core systems used in our study's framework, are more critical. As box 15 recapitulates, the status of core systems in the 16 districts of the WDR are deficient: people seek to improve their access to services such as drinking water, health and energy while expanding the choice available to them for pursuing well being. The third issue is that of autonomous behaviour. As active cognising individuals, people act on and undertake strategies and do not remain passive when faced with stress. The incentives they face are influenced by real or perceived and increasingly pervasive opportunities abroad, in urban areas and in non-agricultural based livelihoods. Today the households in the VDCs of WDR are linked to urban areas within the country and outside by the flow of information, goods and services, by seasonal and long-term migration, tourists and by the shared use of natural resources.

Many however, cannot respond even to the existing constraints they face because systems do not exist, are fragile, because people have poor capacity to benefit from or pre-existing conditions prevent them from benefitting from existing or new systems. They can lack skills, relevant information maybe limited or they possess no knowledge, while existing structures exclude them from jobs and education. At the same time, they may lack voice, their role and participation in decision-making limited or non-existent. These conditions depend on the political institutions and quality of governance as the broad contours of the pathway that promotes wellbeing. Good governance is depended on recognition of balance of power of organisations and specific interest groups at scales that range from local to national. In reality, Nepal's existing governance arrangements have little relation to the theoretical ideal of balance in power. At a

Figure 31: Conception of overall wellbeing



Adapted from grass roots

A school in Dhakarjung, Kagbeni VDC, Mustang District.

more practical level, local capacity for budgeting, resource prioritising and creating the social-political regime with incentive for making adaptive responses and learning from the efforts made are grossly limited. The tendency is to maintain existing structures, authority and practices that stifle iterative learning. Crossing disciplinary and institutional boundaries is difficult.

Yet, in the case study sites the nature of resource use is changing within rapidly transforming social and economic realities. Satellite television, mobile phones and internet have made direct communication accessible to individuals in even the most remote parts of the WDR. Economic globalisation in the forms of wage migration and remittance income has introduced new dimensions making the social political landscape more dynamic, even while challenges of meeting basic needs remain. In this changing context, climate change brings in new stress layers. How does one reconcile this complexity? While specific targeted proposals are needed to respond to specific constraints, dealing with increasing complexity requires processes and framework that enable solutions to be identified and implemented as new constraints emerge and contexts change (Moench et al., 2003).

Specifically targeted actions may include provision of assured drinking water, reliable irrigation, public health services and new roads. In a future made uncertain by climate change, for example, roads will have to accord attention to peak floods likely to be triggered by extreme rainfall and inadequate drainage. The approaches to designing new bridges need to include parameters that accommodate higher magnitude of sediment and debris-laden flood peaks in rivers. This shift in approach needs to bring road designers and road builders in a dialogue with climate scientists and development practitioners. Road building is only one input

for improved mobility but will be insufficient without the development of alternative modes of transportation like ropeways. By introducing diversity and flexibility, such combinations can help make a transportation system more resilient, while mobility helps in building societal resilience and increasing adaptive capacity.

The role energy, banking and transportation play in increasing resilience is critical. Without energy, there can be no communication or transportation and without which social networks, local finance institutions and markets cannot function. A fragile system will not be able to adjust to increasing variability. If a system is resilient it should be able to withstand shocks while those operating the system must be able to propose new strategy to deal with the shock. Equal attention needs to focus on improving the quality of other services like health, education, banking, agriculture, food, secure livelihoods and employment and communication, as cornerstones that help build resilience to climate change. Robust, low-cost communication systems have enabled the emergence of new social networks and labour markets that are used to respond to stress. For example, communication and other types of systems help youths to access international work opportunities and send their earnings home through local banking systems.

Access to systems and the benefits such systems provide is not universal, however. In many cases, women, lack access to education, livelihoods, basic health and many basic services due to social norms and power relations; they, like the poor, are often too marginalised to be able to adapt. Migration supplements natural resource-based livelihood strategies and provides a measure of livelihoods security in the face of droughts, floods and other climate-related shocks. Even those less vulnerable individuals whose access to basis systems enables them to adapt, for example migrating, face new vulnerabilities. Their new employers, for instance, exploit many young men who find jobs abroad. Migration has a flip side too: it increases social stress, breaks up families, and feminises agriculture. WDR while experiencing fast paced social changes and challenges has many on-going local actions. In all study VDCs, for example, local institutions undertake many activities some with support of government, international and bilateral donors. Some are in nascent stage. They reproduce social ills such as elite domination, internal inequity and are not truly representative.Some groups have higher capacity than others. But generally all have very little resources and no executive authority. The challenge is in helping these mechanisms become forward looking to deal with emerging constraints to build resilience and adaptive capacity.

In these endeavours, systems play important role. They help meet developmental needs such as water, energy, food, communication and education. They also help individuals, groups and communities take actions for switching strategies to respond to stress. Characteristics such as flexibility, modularity and fail-safe that contribute to systems resilience are important but so are capacity of agents and institutions that are resilient. Such approach can fit into the conception of planned strategies. It must be important to recognise that such strategies would be ineffective without capacitating agents and consolidating institutional attributes of resilience that help articulate concerns and priorities of local stakeholders help in avoiding total elite capture while furthering autonomous strategies.

Through the millennia humans have adapted to natural climate variability, faced shocks, dealt with changing contexts and problems. Those seeking to devise strategies for a more resilient future in which people can adapt and adjust to emerging constraints such as those induced by climate change need to focus on deeper understanding of these attributes. Exploring them further, drawing lessons, putting them into practice, learning from the experience to improve practices, policies and revisit principles are the central challenges.

BOX-15: IMMERSION COURSE: BUILDING OF THE CAPACITY TEACHERS

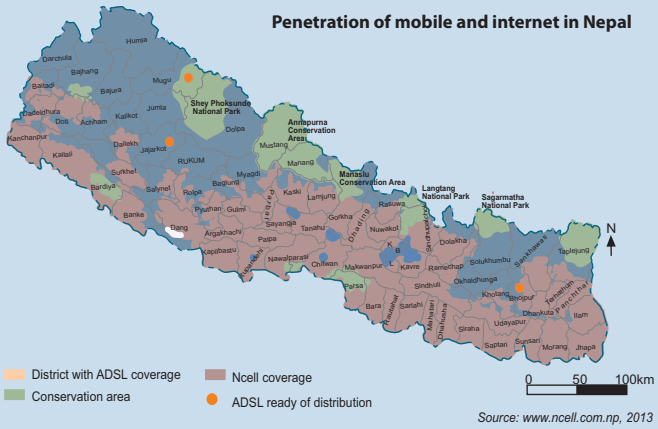
After evaluating the input of SLDs, ISET-Nepal decided to mobilise teachers to liaise between local organisations and the community. Teachers were chosen for several reasons: they are respected, knowledgeable, and able to disseminate knowledge. By reaching the larger community through their students, they can become agents of change. For example, a teacher from Madanpokhara VDC is a local resource person who organised few local-level training programs on climate change and food security. Other teachers have also participated in district-level programmes and shared their learning with their colleagues and students.

BOX-16a: STATUS OF REGIONAL SYSTEMS IN WDR

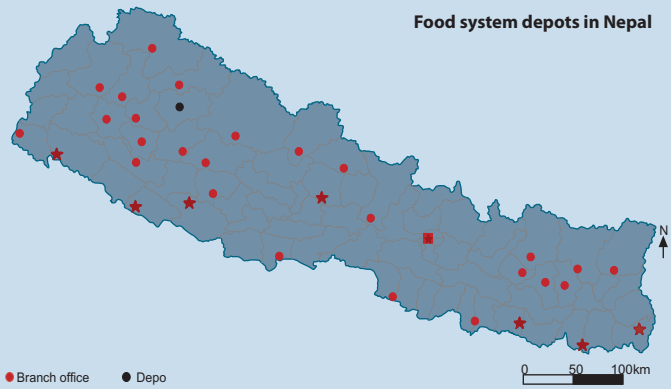
The status of core, secondary and tertiary systems in the WDR are presented in this box. While the core systems are deficit, the secondary systems (road, energy, food distribution and communications) are still fragile (see the following table). Clearly the density and quality of systems need to be increased, and needs to be conceived within the resilience framework of systems, agents and institutions. The capacity of population to adapt is equally about these later attributes as much as about physical systems that function as gateway to services (see the following four figures which shows penetration of internet, food system depots, powern system and road system).

Details of system in west Nepal (16 districts)

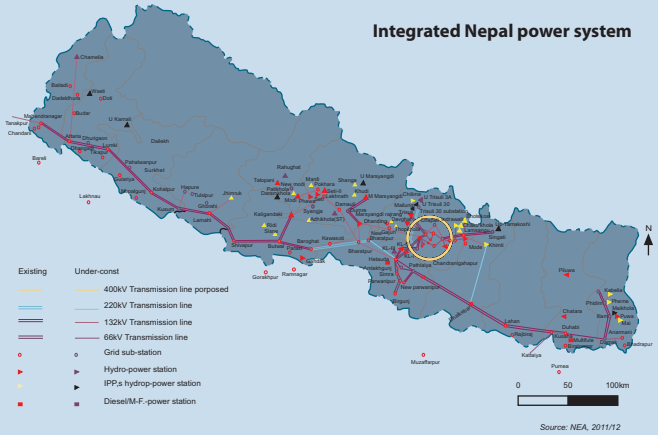
District	Education	Literacy rate		Coverage (%)		Energy					Communication	Mobility	Food	Bank
	No. of education institution	Average	Female	Drinking water	Sanitation	Electricity (%)	No. of Solar home system	% of HHs using firewood	Population using LPG (%)	Number of Biogas plants	Number of phone lines	Length of road	Cereal production (MT)	
Arghakanchi	690	74.76	67.95	76.5	46.2	59.4	5,639	93.45	5.55	89	827	170.9	63233.00	2
Baglung	995	74.44	67.88	88.9	79.8	81.8	2,253	88.54	10.45	109	2,767	154.1	107365.00	10
Gorkha	898	68.76	61.87	62.9	72.7	76.4	3,415	73.76	18.19	2558	1,699	177.2	111768.00	9
Gulmi	995	57.8	46.56	88.6	81.4	64.2	7,537	92.23	6.77	244	993	127.0	87634.00	5
Kapilbastu	822	58.54	48.61	95.2	57.6	63.7	414	54.31	7.29	3106	2,852	223.0	325893.00	5
Kaski	1357	83.92	77.03	92.5	87.5	95.5	929	32.51	61.12	5376	29,755	113.0	150577.00	58
Lamjung	680	73.58	65.96	88.3	80.5	76.8	2,792	80.60	12.13	4364	983	72.0	87467.00	9
Manang	58	75.5	64.96	97.6	65.1	88.9	121	97.93	1.59	0	114	60.0	1435.00	0
Mustang	98	68.63	58.63	91.7	62.9	71.2	842	54.01	18.12	0	222	181.0	2366.00	2
Myagdi	466	74.2	66.98	87.4	81.2	68.6	3,135	86.55	12.12	190	1,037	31.0	53827.00	5
Nawalparasi	1321	72.8	64.84	86.9	62.0	80.9	5,411	70.99	17.03	6574	4,921	203.9	260781.00	12
Palpa	893	66.22	72.11	79.1	76.0	73.0	4,537	61.63	11.48	20096	2,554	199.6	84010.00	6
Parbat	614	76	68.60	82.5	90.1	80.2	1,589	86.25	12.56	151	1,212	85.6	66235.00	4
Rupandehi	1286	72.07	63.13	97.5	44.0	80.6	388	34.34	34.22	5171	24,038	163.7	392120.00	64
Syangja	1127	78.24	71.20	82.8	89.4	86.5	2,054	82.10	14.17	1839	2,146	156.9	187913.00	9
Tanahu	1101	76.74	69.89	75.2	83.3	77.1	7,414	69.20	21.39	6639	4,543.0	161.5	136960.00	15



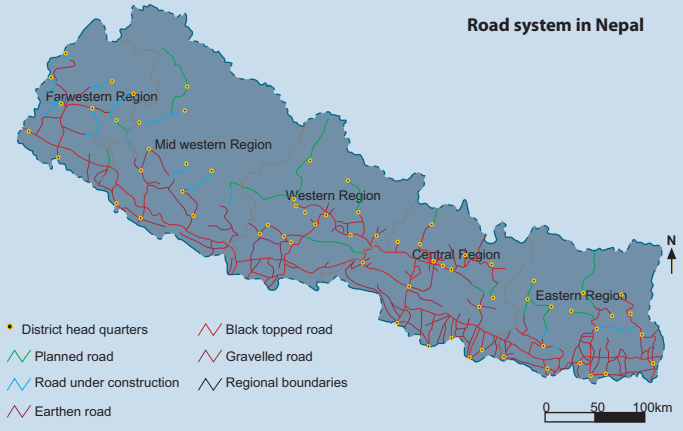
Source: www.ncell.com.np, 2013



Source: Based on ogranisation chart of Nepal Food Corporation, 2013



Source: NEA, 2011/12



BOX-16b: MESO PERSPECTIVE OF FOOD, SYSTEMS, AGENTS AND INSTITUTIONS

Geological zone		Higher Himalayan	Hill	Mid hill			Tarai
District		Mustang	Myagdi	Argakhachi	Palpa	Kaski	Kapilbastu
VDCs		Kagbeni	Ramche	Hansapur	Madanpokhara	Rupakot	Dubiya
Physical system							
Forest		Sub alpine and alpine	Temperate	Sub tropical	Sub tropical	Sub tropical	Sub tropical and Tropical
Agriculture	Cereals	Barley, oat, buck wheat	Potato, maize, wheat, millet, naked barley	Maize, paddy, millet, buck wheat, oat, wheat and barley	Paddy, millet, maize, wheat, buck wheat and oat	Paddy, maize, millet, wheat and mustard	Paddy, wheat, mustard, maize, lentil and pulses
	Vegetables	Turnip, carrot, potato, cabbage, cauliflower, tomato, garlic	Potato, beans, cauliflower, cabbage, soybean, tomato and pumpkin	Potato, radish, cauliflower, cabbage, onion and tomato	Tomato, beans, cucumber, broad beans, egg plant, chilli, radish, spinach, capsicum, pumpkin, bitter gourd, sponge gourd , ladies finger and pumpkin	Broad leaf mustard, radish, bean, sponge gourd, bottle gourd and pumpkin	Cauliflower, cucumber, cabbage, tomato, radish, ladies finger, beans, bitter gourd and pumpkin
	Fruits	Apple, walnut, apricot, peach and pears	Orange, walnut, plum and apricot	Orange walnut, peach, lemon, plum and pear	Orange, peach, litchi, guava, pear, papaya and pineapple	Orange, mango, lemon, guava, peach and pear	Mango, banana, jack fruit, and papaya
Water source		Glacier and snow	Snow fed river	Stream sources	Ground water and stream sources	Stream sources	Ground water
Energy	**Cooking**	Firewood, LPG	Firewood	Firewood	Firewood, LPG, biogas	Firewood, biogas, LPG	Firewood
	Lighting	National grid (NEA) , solar	National grid (NEA)	Solar, kerosene, National grid (NEA)	National grid (NEA)	National grid (NEA)	National grid (NEA)
Communication		Mobile, TV and radio	Mobile, TV, radio and CDMA	Mobile, radio and CDMA	Mobile, radio, TV, CDMA, landline, mobile tower and community radio station	Mobile, radio, CDMA and TV	Mobile, radio and TV
Mobility		Fair weather road	Fair weather road	Fair weather road	Pitch road and fair weather	Fair weather road	Gravel and fair weather road
Agents		Apple farmers trading and tourism	Social entrepreneurs, local community, teachers and pension holders	Teachers, ex-army personnel and remitters	Local community, vegetable farmers and teachers	NGOs, Rupa lake watershed cooperative teachers and tourism	Farmers, remitters and local community
Institution		Mukhiya (traditional village leader) system; values from traditional north-south trading, norms values emerging from tourism	Homogenous caste dominance, shared norms and values, sense of collective responsibility, ecotourism	Religious norms and values, tradition of British and Indian army enrolment	Water system (drinking and irrigation), community radio, local organisation	Water system (Drinking and irrigation in upper settlement of VDC)	Water system (drinking and irrigation) users group, traditional community
Major issues		Increasing water scarcity due to source depletion, Change in social dynamic due to tourism	Use of traditional energy Fragile road and transportation Road and transport crucial for food security (18% locally grown) Initiation of potato and vegetable farming and poultry	Poor local production, rocky terrain, low access to drinking water, irrigation, Very high migration (women, children and elderly left behind) Haphazard road construction	Vibrant vegetable farming Use of excessive fertiliser/ pesticides/dependency on hybrid seed Migration of youth population	Youth attracted to foreign employment or off farm jobs Decrease in food production Increase in fallow land	Very poor sanitation, arsenic contaminated water, traditional farming

BOX-17: PROJECT ACTIVITIES AND OUTPUTS

A. International programmes

Year	Programme	Location	Participants	Link/References
2011	Bhutan Summit for Living Himalayas" organised by Bhutan Government and CANSA	Thimpu, Bhutan	Mr. Arjun Dhakal	http://www.cansouthasia.net/news-and-events/43-bhutan-set-for-climate-summit.html
2011	River Waters: Perspectives and Challenges for Asia (Foundation for Non-violent Alternatives)	Delhi, India	Mr. Ajaya Dixit	http://fnvaworld.org/presentations-a-papers
2011	NCSP – NWP Technical Backstopping Workshop on Vulnerability and Adaptation	Bangkok, Thailand	Mr. Ajaya Dixit	http://ncsp.undp.org/news/ncsp-workshop-va-assessments-asia-pacific-region
2011	Presentation on "Saving the Himalaya for Saving Life on Mother Earth" (The Asia Foundation)	JNU, New Delhi India	Mr. Ajaya Dixit	http://www.thehimalayantimes.com/fullTodays.php?headline=Concerted+fight+can+save+Himalayas&NewsID=290247
2011	Workshop on XIV International Water Resource Association (IWRA)	Brazil	Mr. Ajaya Dixit	http://iwlearn.net/events/xivth-iwra-world-water-congress
2011	Conference organised by the European Science Foundation in Partnership with Leopold-Franzens-Universität Innsbruck (LFUI) (Poster presentation)	Austria	Mr. Kamal Thapa	http://www.esf.org/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/be_user/activities/research_conferences/Docs_NEW/2011/364posters_final_01.pdf&t=1365426641&hash=931fe72cb14502bee04dae1fff8a336df893f2cf
2012	Second Regional Think Tank Initiative (TTI) Meeting	Mysore, India	Mr. Ajaya Dixit & Mr. Jayendra Rimal	http://www.thinktankinitiative.org/
2012	Planet Under Pressure (Poster presentation)	Excel London, UK	Ms. Minakshi Rokka Chhetri	http://www.planetunderpressure2012.net/pdf/poster_session_1.pdf
2012	Sixth International Conference on Community Based Adaptation (Poster Presentation)	Hanoi, Vietnam	Mr. Arjun Dhakal	http://ccafs.cgiar.org/node/1038
2012	Synthesis Workshop: Economic Analysis of Climate Change Adaptation in the Water Sector	IIED Office, London	Mr. Arjun Dhakal	http://www.iied.org/analysing-cost-adapting-climate-change
2012	Adaptation Future: 2012, International Conference on Climate Adaptation (Poster presentation)	University of Arizona, Tucson Arizona, USA	Mr. Kamal Thapa	http://adaptation.arizona.edu/files/public/post%20conference%20uploads/Kamal_Thapa_poster.pdf
2012	UPA Assessment Workshop for Africa and South Asia, organised by International START Secretariat	Conference centre, Addis Ababa, Ethiopia	Mr. Ajaya Dixit, Mr. Yogendra Subedi, Mr. Deeb Raj Rai, Ms. Mela Aryal Lama, Ms. Minakshi Rokka Chhetri & Ms. Rabi Wenju	http://start.org/
2012	Methodology Design and Discussion on "Sheltering from Gathering Strom", organised by ISET-International	Bangkok, Thailand	Mr. Arjun Dhakal	http://i-s-e-t.org/
2012	Think Tank Initiative (TTI) Meeting	Cape Town, South Africa	Mr. Ajaya Dixit & Mr. Jayendra Rimal	http://www.thinktankinitiative.org

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2012	Experience Sharing Workshop "Towards Climate Resilient Communities in South Asia: Emerging Policies and Practices", organised by Centre for Science and Environment (CSE)	New Delhi, India	Ms. Shuvechha Khadka	http://www.cseindia.org/userfiles/schedule_final_final.pdf http://www.cseindia.org/userfiles/report_adap-meeting.pdf
2012	The World Water Week (Forum)	Stockholm, Sweden	Mr. Ajaya Dixit	http://www.ewash.org/en/?view=79YOcy0nNs3Du69tjuhzy1wkyeayxx%2B7%2FAnzyAHkXWeIT92MUaQWTTGG
2012	Annual South Asian Technical Workshop	Colombo, Sri Lanka	Ms. Anustha Shrestha	https://www.facebook.com/media/set/?set=a.447700395272452.95560.153984491310712&type=1
2013	Catalyst Project Regional Workshop for South and Southeast Asian Region", organised by the Economic and Social Commission for Asia and the Pacific (ESCAP)	Bangkok, Thailand	Ms. Shobha Kumari Yadav	http://www.catalyst-project.eu/news/01news-008.html
2013	Sub Regional Workshop on "Climate Change Issues and Priorities in South Asia: Assessment and Ideas for Future Engagement"	Marawila, Sri Lanka	Ms. Emma Karki	http://www.asiapacificadapt.net/sites/default/files/resource/attach/cansa-apan-proceedings-conference-feb-2013-sri-lanka.pdf
2013	Third Regional Think Tank Initiative (TTI Meeting)	Marawila, Sri Lanka	Mr. Ajaya Dixit & Ms. Shuvechha Khadka	http://www.thinktankinitiative.org/news/third-south-asia-regional-meeting-sri-lanka
2013	Think Tank Initiative (TTI) Resource Mobilisation Workshop	Marawila, Sri Lanka	Mr. Ajaya Dixit	http://www.thinktankinitiative.org/news/up-coming-learning-event-resource-mobilization-workshop
2013	Seventh International Conference on Community Based Adaptation to Climate Change (Poster Presentation)	Dhaka, Bangladesh	Mr. Ajaya Dixit, Ms. Shuvechha Khadka & Mr. Yubaraj Satyal	http://www.iied.org/cba7-7th-conference-community-based-adaptation-climate-change

B. Presentation/participation in national workshops/seminar

Year	Programme	Location
2011	"Managing Knowledge to Respond to Climate Change Stress: Example of Autonomous Adaptations from Nepal Tarai" organised by ICIMOD	Kathmandu, Nepal
2011	Role of Moderator in "Expanding Space for Development: The Role of Key Stakeholders in the Present Context of Nepal" organised by AIN Nepal	Kathmandu, Nepal
2011	Presentation on "Finding on Use of Gateway Indicators for Vulnerability & Adaptation organised by WFP-Nepal	WFP, Gokarna Resort, Nepal
2011	'Media Capacity Building Training to Promote Climate Smart Development and Disaster Risk Reduction Covering Climate Change' facilitated by BBC Nepal	Bhaktapur, Nepal
2011	"South Asia Regional Stakeholder Workshop on the Climate Change- Urban Agriculture Knowledge Assessment" organised by ISET-Nepal, START and BCAS	Hotel Yak and Yeti, Kathmandu
2012	Workshop on Economics of Climate Change: Livelihoods Challenges and Stakeholders Based Cost Benefit Analysis of Adaptation Options.	Hotel Yak and Yeti, Kathmandu
2012	"Climate, Food and System" a Collaborative Workshop organised by ISET-Nepal and ISET-International	Hotel Summit, Lalitpur Nepal
2012	Conference on "Himalayan System in a Changing Climate: Futur and Media's Role" organised by The Kathmandu Post/KAS/ANN, Nepal	Kathmandu, Nepal
2012	National Seminar on Sustainable Development: Growth Equity and Sustainability, organised by MOSTE, NPCS and supported by Niti Foundation and ISET-Nepal	Everest Hotel, Kathmandu
2012	Climate Change Adaptation "Exploring Suit of Methods /Global Climate Change Challenge: Thoughts and Reflection of Younger Professionals", organised by NAST and ISET-Nepal	Kathmandu, Nepal
2012	Workshop on "Strengthening the Nepal Food Security Monitoring System (NeKSAP) to Measure Vulnerability and Adaptive Capacity at the Local Level for Informed Climate Change Planning and Policies" organised by ISET-Nepal, WFP-Nepal and CDKN	Hotel Summit, Lalitpur Kathmandu

C. Capacity Building traning (ISET staffs)

Year	Training	Location	Participants
2011	Climate Resilient Planning Methods	Gorakhpur Environmental Action Group , India	Mr. Yubaraj Satyal & Ms. Urmila Dangol
2011	Data Analysis, Proposal Writing with Log Frames and Discussion with ISET-International's Staff	ISET -International offices in Boulder, Colorado, USA	Mr. Kanchan Mani Dixit & Dr. Santosh Shrestha
2011	Interaction with Local Researchers and Field Visit to Learn Community Based Approaches to Climate Change Adaptation Practiced in Bangladesh	Bangladesh Centre for Advanced Study (BCAS), Dhaka, Bangladesh	Mr. Deeb Raj Rai & Ms. Rabi Wenju
2011	GIS Training	NIIT GIS Limited, New Delhi, India	Mr. Kanchan Mani Dixit & Mr. Kamal Thapa
2012	Methodology and Writing Workshop (ISET Consortium)	Prachuap Khiri Khan, Thailand	Mr. Ajaya Mani Dixit, Mr. Jayendra Rimal, Mr. Madhav Devkota, Ms. Shuvechha Khadka, Ms. Mela Aryal Lama, Mr. Yubaraj Satyal, Mr. Kamal Thapa, Ms. Rabi Wenju & Ms. Sristi Silwal
2012	Writing Workshop for Publication of "Understanding the Cross Scale Implications of Forest and Water Management for an Adaptation and Mitigation in the Nepal Himalaya"	Boulder, Colorado, USA	Mr. Ajaya Dixit, Mr. Jayendra Rimal & Ms. Shuvechha Khadka
2012	Field Study on Rural Areas of Gorakhpur in CDKN Disaster Shelter Project	Gorakhpur, India	Mr. Arjun Dhakal
2012	Nuffic Training Programme in Climate Change Adaptation and Mitigation	Wageningen University & Research Centre (Wageningen UR), Netherland	Ms. Shobha Kumari Yadav

D. Local/Regional level Shared Learning Dialogues

Year	Programme	Location	Participant Number
2010	SLD and Transect walk for VDCs selection	Mustang, Myagdi, Kaski, Palpa, Arghakhachi & Kapilbastu	110
2011	SLD for gathering information on Systems as Gateway to Services	Kagbeni, Mustang; Ramche, Myagdi; Rupakot, Kaski; Madanpokhara, Palpa; Hansapur, Arghakhachi & Dubiya , Kapilbastu	57
2011	SLD for Sharing of VDC Ranking and Identification of Marginal Community; Food System Charting	Kagbeni, Mustang; Ramche, Myagdi; Rupakot, Kaski; Madanpokhara, Palpa; Hansapur, Arghakhachi & Dubiya, Kapilbastu	137
2011	Regional SLD for preparation of Draft Local Resilience Framework	Kaski, Pokhara (Representation from Kagbeni, Mustang; Ramche, Myagdi; Rupakot, Kaski; Madanpokhara, Palpa; Hansapur, Arghakhachi and Dubiya, Kapilbastu)	44
2011	SLD on Biodiversity and Livelihood	Kagbeni, Mustang; Ramche, Myagdi and Rupakot, Kaski	56
2012	SLD on Biodiversity and Livelihood	Madanpokhara, Palpa & Dubiya, Kapilbastu	36
2012	SLD on Biodiversity and Livelihood SLD for interacting with Marginal Community	Hansapur, Arghakhachi	36
2012	SLD for gathering information on Systems as Gateway to Services, Rupa Lake Watershed	Hansapur, Majhthana, Rupakot VDCs and Lekhnath Municipality, Kaski	105
2012	SLD for preparation of Draft Local Resilience Framework for Rupa Lake Watershed	Kaski, Pokhara (Representation from Hansapur, Majhthana, Rupakot VDCs and Lekhnath Municipality)	23
2012	Regional Dissemination and Validation Workshop	Kaski, Pokhara (Representation from Kagbeni, Mustang; Ramche, Myagdi; Rupakot, Kaski; Madanpokhara, Palpa; Hansapur, Arghakhachi; Dubiya, Kapilbastu & Nawalparasi, Gulmi & Syanja districts)	40

E. Capacity Building activities for local community

Year	Programme	Location	Participant Number	Remarks
2011	Immersion Course I	Naxal, Kathmandu	19	Local Teachers of Gandak Transect (Representation from Kagbeni, Mustang; Ramche, Myagdi; Rupakot, Kaski ; Madanpokhara, Palpa; Hansapur, Arghakhachi & Dubiya, Kapilbastu)
2011	Immersion Course II	Kaski, Pokhara	22	Local Teachers of Gandak Transect(Representation from Mustang, Myagdi, Kaski, Palpa, Arghakhachi, Kapilbastu, Nawalparasi, Rupandehi,Gulmi, Syanja, Gorkha, Lamjung, Parbat, Manang, Baglung & Tanahu)
2012	Immersion Course III	Dillibazar, Kathmandu	84	Local Teachers and Resource Persons of Kathmandu Valley (Bhaktapur, Kathmandu & Lalitpur districts)
2012	Capacity Building Training for Action for Mountain Community (AMC), Kaski Pokhara	ISET-Nepal Office, Chundevi, Kathmandu	4	Enumerators training provided for partner organisation
2012	Capacity Building Training to representatives of VDCs of Kathmandu Valley	ISET-Nepal Office, Chundevi, Kathmandu	18	Enumerators training (Representation from Ramkot, Tokha Chandeshowri, Pukulachi, Suntole, Lubhu, Madhyapur Thimi VDCs & Kirtipur Municipality)
2012	Capacity Building Training to representatives of six VDC for conducting food basket survey	ISET-Nepal Office, Chundevi, Kathmandu	12	Enumerators Training (Representation from Kagbeni, Mustang; Ramche, Myagdi; Rupakot, Kaski ; Madanpokhara, Palpa; Hansapur, Arghakhachi & Dubiya, Kapilbastu)

F. Other outputs

Particulars	Number/Episode	Publication (paper/electronic media)
Articles Published in Vernacular Magazine	16	Teachers Magazine (*Sikshak*)
Articles in National English Daily	2	The Kathmandu Post
Radio Drama	27	Aired by ten National FM
FM Interviews	2	Gorkha FM and Radio Sagarmatha
Video Documentary	2	Disseminated in SLDs and uploaded in YouTube and Facebook
Case Studies	4	To be Published
Policy Briefs	2	To be Published
Peer Reviewed Journal	1	To be Published
Thesis Grants Awarded	9	Thesis (unpublished)

GLOSSARY

Adaptation:	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
Adaptive capacity:	The whole of capabilities, resources and institutions of a country or region to implement effective adaptation measures (IPCC).
Afforestation:	Planting of new forests on lands that historically have not contained forests (UNFCCC).
Alpine:	The biogeographic zone made up of slopes above the tree line, characterized by the presence of rosette-forming herbaceous plants and low shrubby slow growing woody plants (IPCC).
Atmosphere:	The gaseous envelop surrounding the Earth. The dry atmosphere consists almost entirely of nitrogen and oxygen, together with trace gases including carbon dioxide and ozone (IPCC).
Autonomous	Adaptation: Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.
Biosphere:	The part of the Earth system comprising all ecosystems and living organisms in the atmosphere, on land (terrestrial biosphere), or in the oceans (marine biosphere), including derived dead organic matter, such as litter, soil organic matter, and oceanic detritus (IPCC).
Capacity building:	In the context of climate change, the processes of developing the technical skills and institutional capability in developing countries and economies in transition to enable them to address effectively the causes and results of climate change (UNFCCC).
Climate change:	Climate change refers to any change in climate over time, whether due to natural variability as a result of human activity. UNFCCC defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.'
Climate scenario:	A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models. A climate change scenario is the difference between a climate scenario and the current climate.
Cloudburst:	Aan abnormally heave down power of rain usually associated with a thunder storm; in temperate region it is necessarily short-lived, for the available supply of water vapor is soon exhausted by it. During this time, however, it may cause considerable damage, tearing up the ground and transforming gullies into raging torrents. Cloudburst,

	though possible anywhere that rainfalls, are most frequent in mountainous regions.
Cold wave:	Cold waves are specially prevalent of Tarai region of Nepal in winter season. The term cold wave signifies a specific fall of temperature over twenty-four hours to a minimum below a certain temperature. Cold waves are always damaging to winter crops.
Core System:	Core systems are the fundamental systems in the society. The systems determine the resilient capacity of the society.
Dalits:	In the Nepali caste system dalits are the so called "untouchable" or outcasts. The term is not the name of traditional caste. Dalits are occupational caste in Nepalese culture.
Debris:	Fragments of material removed by disintegration or other process from the surface of rocks (Moore W.G, 1968).
Deforestation:	Conversion of forest to non-forest (UNFCCC).
Flood plains:	A plain, bordering a river which has been formed from deposits of sediments carried down by the river. When a river rises and overflows its banks, the water spreads over the flood-plains; a layer of sediments is deposited at each flood, so that flood plain gradually rises (Moore W.G, 1968).
Food security:	A situation that exists when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development and an active and healthy life. Food insecurity may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level (IPCC).
Frost:	The particles of frozen moisture formed on the earth surface when the air temperature has fallen as far as or below zero degrees centigrade (Moore W.G,1968).
Grassland:	Those regions of the world where the natural vegetation consists of grass; the rainfall is too light to permit forest growth, but is a less scanty and irregular than that of the deserts, and the grass lands are thus normally situated between the forest belts and the arid regions (Moore W.G,1968).
Landslide:	A mass of material that has slipped downhill by gravity, often assisted by water when the material is saturated; the rapid movement of a mass of soil, rock or debris down a slope (IPCC).
Livelihood:	A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recovered from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.' (Adapted from Chambers, R. and G. Conway (1992).
Marginality:	The state where one is considered to be at lower or outer limit, as of social acceptability.
Mitigation:	In the context of climate change, a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Examples include using fossils fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings, and expanding forest and others "sinks" to remove greater amount carbon dioxide from the atmosphere (UNFCCC). Technological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with

	respect to Climate Change, mitigation means implementing policies to reduce greenhouse gas emissions and enhance sinks (IPCC).
Monsoon:	A monsoon is a tropical and sub-tropical seasonal reversal in both the surface winds and associated precipitation. June, July, August and September are monsoon period in Nepal.
National adaptation programmes of action (NAPA):	Documents prepared by least developed countries (LDCs) identifying urgent and immediate needs for adapting to climate change.
Planned adaptation:	Adaptation that is a result of a deliberate policy decision, based on an awareness that condition
Post-monsoon:	October and November are post-monsoon period in Nepal. Most of the festivals lie during this period.
Winter:	December, January and February are winter period in Nepal.
Pre-monsoon:	March, April, and May are pre-monsoon period in Nepal.
Remittances:	Remittances are transfers of money by foreign workers to their home countries.
Resilience:	The ability of a social and ecological system to observe disturbances while retaining the same basic structures and ways of functioning, the capacity for self organisation, and the capacity to adapt to stress and change.
SaptaGandakiRiver:	Kaligandaki, Marsyangdi, Seti, Madi, Daraudi, Budhigandaki and Trishuli rivers are the tributaries of Sapta Gandaki River. When all these tributaries meet at Devghat is called Sapta Gandaki River. Devghat is situated about 8 kg to North from Narayanghat Bazzar, Chitwan district.
Snow fed rivers:	Rivers originate from the high-himalayan regions are accounted as snow fed rivers.
Uncertainty:	An expression of the degree to which a value (for example the future state of the climate system) is unknown. Uncertainty can result from lack of information or disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projection of human behavior. Uncertainty can therefore be represented by quantitate measures or by qualitative statements (IPCC).
Urbanisation:	The conversion of land from a natural state or managed natural state to cities, a process driven by net rural to urban migration through which an increasing percentage of population in any nation or region come to live in settlements that are defined as 'urban centers' (IPCC).
Vulnerability:	Vulnerability is the degree to which a system is susceptible to, unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of a character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC).
Watershed:	The elevated boundary lines separating the headstreams which are tributary to different river systems or basins. It often has an extremely irregular course and does not necessarily follow the ridge of a range of hills or mountains. As rivers encroach upon each other's territory, any watershed should be regarded as temporary.

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