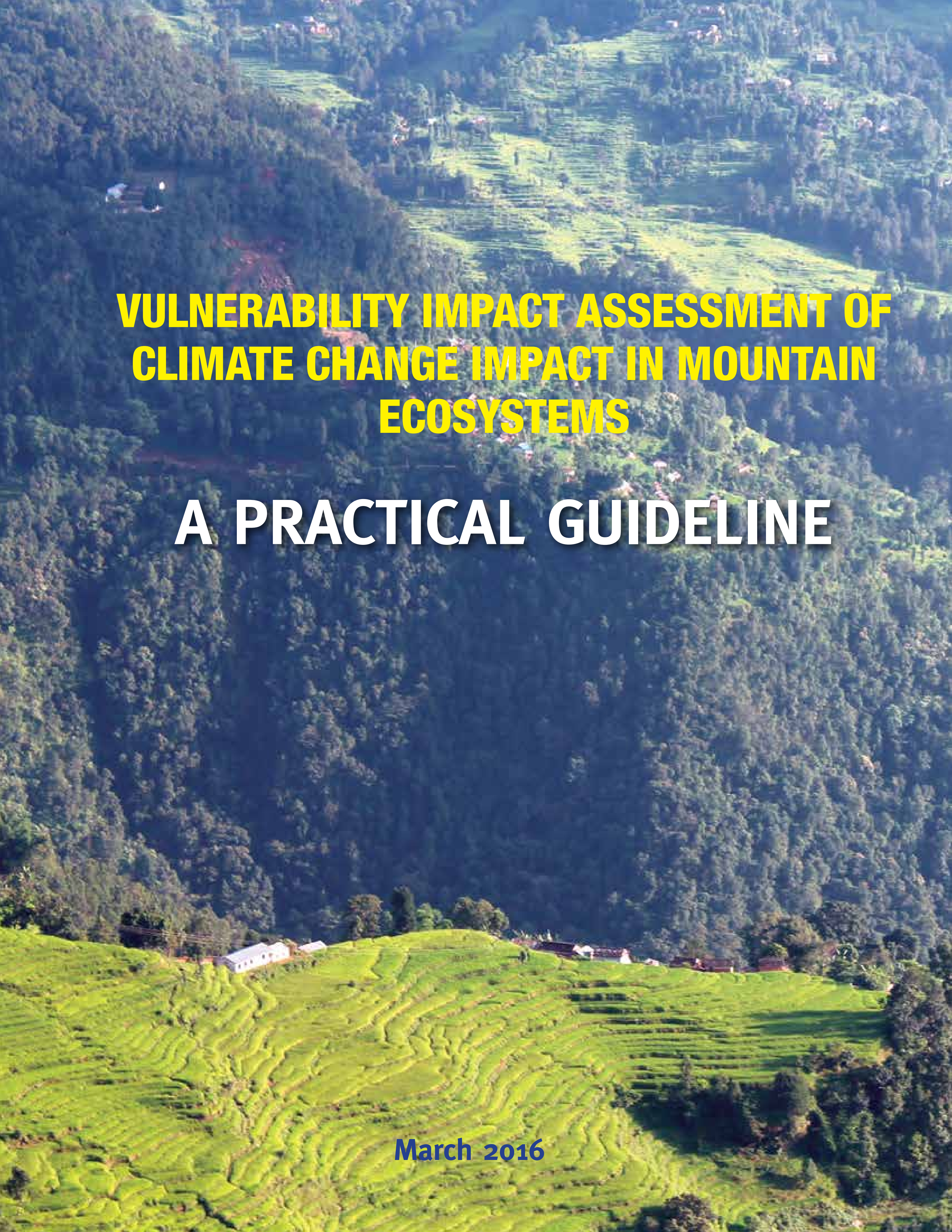
# VULNERABILITY IMPACT ASSESSMENT OF CLIMATE CHANGE IMPACT IN MOUNTAIN ECOSYSTEMS

# A PRACTICAL GUIDELINE



March 2016

# VULNERABILITY IMPACT ASSESSMENT OF CLIMATE CHANGE IMPACT IN MOUNTAIN ECOSYSTEMS

# A PRACTICAL GUIDELINE

CENTRAL DEPARTMENT OF ENVIRONMENTAL SCIENCE
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Kirtipur Nepal

**Citation:**
TU-CDES (2016). Vulnerability Impact Assessment of Climate Change Impact in Mountain Ecosystems: A Practical Guideline. Central Department of Environmental Science, Tribhuvan University and Ministry of Forests and Soil Conservation, Kathmandu

**Published By:** Government of Nepal (GoN)/United Nations Development Programme (UNDP)

**Photo:** EbA Project/Nepal

**Designed and Processed by:** Print Communication Pvt. Ltd.
Tel: (+977)-014241355, Kathmandu, Nepal

**ISBN:** 978-9937-0-0730-6

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# Acknowledgement

Vulnerability Impact Assessment (VIA) is an essential component of an adaptation plan. The Central Department of Environmental Science, Tribhuvan University took an initiative to prepare a comprehensive manual of VIA focused to the adaptation plan, the ecosystem based adaptation (EbA) in specific. We are pleased to bring out this manual in a form of book so as to disseminate among the wider sectors of the researchers at the academic institutions and practitioners as well. One can find similar reports, published and unpublished, used and practiced according to certain requirements; one specialty of this publication is that it has included details of the formulae with examples. Moreover, this manual has been tested in a sub-watershed of Bagmati in Shivapuri-Nagarjun National Park in mid-mountain region of central Nepal.

The EbA Project has generously been supporting us in carrying out research activities and trainings at various levels in its pilot site, Panchase Protected Forest. This Project is an undertaking of the Government of Nepal (MOFSC and MOPE), which has been funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMUB) through its International Climate Initiative, and jointly implemented by the United Nations Environmental Programme (UNEP), the United Nations Development Programme (UNDP) and International Union for the Conservation of Nature (IUCN). We are thankful to the Project and its partners for the support.

TU-CDES constituted an expert team of VIA preparation with Dr Dinesh Raj Bhuju as its technical adviser. The team painstakingly went through the available VIA reports, reviewed and prepared parameters suitable to mountain ecosystems facing challenges of climate change impacts. A workshop was conducted to familiarize with the parameters and exercise the tool. The draft of the VIA manual was shared among the practitioners, including university faculties and officials of national parks. Then a group of young researchers (graduates of environmental science) were involved in the testing of the prepared VIA. On behalf of the Department, I thank all of them for their valuable contributions.

It would be our great pleasure if the researchers and practitioners find this manual useful in their projects while preparing adaptation plan. We would highly appreciate for any comment or suggestion that will give us opportunity to improve this tool of VIA for EbA.

**Kedar Rijal,** PhD
Professor and Head of Department

# Foreword

Ecosystem based Adaptation (EbA) in Mountain Ecosystem is a part of the Global Mountain EbA Project that is being piloted in Nepal, Peru and Uganda. In Nepal, the Ministry of Forests and Soil Conservation (MOFSC)/Department of Forests (DOF) is the implementing agency at the national level in partnership with UNDP, IUCN and UNEP, while Ministry of Population and Environment (MoPE) plays an overall coordination role. As a pilot project, EbA has been working to build resilient ecosystems that reduce climate change impact vulnerabilities and enhance adaptive capacities of local communities through livelihood option.

The EbA Project would like to extend our sincere appreciation to the team of experts from Central Department of Environmental Science (CDES), TU led by Dr Kedar Rijal and Dr Dinesh Raj Bhuju supported by a team of young researchers for undertaking the rigorous research in developing the VIA tool. We would also like to thank UNDP for collaborating with the Government of Nepal to address the challenges brought by climate change.

We would also like to share that the present guideline captures the most fundamental details and critical and pragmatic analysis of the VIA tool which was validated in Shivapuri Nagarjun National Park. We are hopeful that the VIA tool, as presented in the guideline, will be useful in assessing the impacts and vulnerability of climate change in other mountain areas of Nepal.

**Gauri Shankar Timala**
Deputy Director General/National Project Director
EbA Nepal Project/Department of Forests

# Foreword

For developing countries like Nepal, it is of utmost necessity to monitor the current and future climate change impacts because ultimately these countries are the ones projected to face the fierce brunt of climate change impacts. Adaption to these changes seeks ways and means to reduce the vulnerability posed by the impacts of climate change.

I appreciate that UNDP has been working very closely with the Government of Nepal for addressing the challenges of climate change using ecosystem based adaptation approaches, which is cost-effective and sustainable way of adapting to climate.

The first step towards addressing the impacts of climate change is to assess climate vulnerability on the ecosystem and identify key adaptation options that support ecosystem resilience. In this regard, the Ecosystem based Adaptation (EbA) in Mountain Ecosystems in Nepal project supported to develop a Vulnerability Impact Assessment (VIA) tool which was further simplified by the Central Department of Environmental Science (CDES) of Tribhuvan University of Nepal.

The current Guideline of VIA developed by CDES highlights the VIA methodology validated within Shivapuri watershed of Shivapuri Nagarjun National Park by the team of (CDES), Tribhuvan University (TU).

I'm confident that the VIA tool will be useful for the government and others to assess the vulnerability and impacts of climate change on ecosystem and devise efficient ways of climate adaptation using ecosystem based approaches.

**Vijaya P. Singh**
Assistant Country Director
UNDP Nepal

# Executive Summary

Our climate is changing. In recent years, studies have indicated increased temperature and erratic rainfall patterns in Nepal that can affect the biodiversity, perturb the ecosystem services, increase climate induced disasters and aggravate food insecurity. For a mountainous low-income country like Nepal where communities rely on ecosystem goods and services, any change in climatic conditions will not only have severe impact on the ecosystems, but also on those who directly depend upon such ecosystem as well as people in downstream.

Vulnerability impact assessment is the precursor of preparing adaptation plan and programmes. With this in view, with the support of the EbA Project, the Central Department of Environmental Science, Tribhuvan University (TU-CDES) has developed this guideline explaining the step-wise processes to assess the climate change vulnerability of the mountain ecosystem. This guideline also cites case study of its test in one of the sub-watersheds of the Shivapuri Nagarjun National Park. This methodology guideline is primarily based on the detailed Vulnerability Impact Assessment (VIA) study undertaken by UNEP/ISET-Nepal.

The assessment in this tool focuses on current vulnerability to both climate and non-climate related factors, sensitivity of the ecosystem and its adaptive capacity. It makes use of the model based impact assessment as well as the participatory methodology. The central of the tool is focus group discussion with the community dependent on the ecosystem. Their experience in relation to climate variability or change over time, and observed impacts make basis of further analyses. Such information acquired from the community, however, is validated scientifically through data from the meteorological stations, field surveys and climate modeling. It then includes ranking of the individual component and evaluation of vulnerability to future climate related risks involving key stakeholders in the evaluation process. This eventually supports to the formulation of management plan and adaptation strategies.

The present guideline highlights the outlines of VIA methodology with details of ranking and examples. It was then validated in Bagmati sub-watershed of Shivapuri Nagarjun National Park (SNNP). The data contents provided here are based on the field surveys conducted during the validation.  As it presents a general guideline for the climate change vulnerability assessment of the mountain ecosystem, it also can be used in other mountain ecosystems with minor revisions as per the niche requirement.

# ACRONYMS

| | |
|---|---|
| CBS | Central Bureau of Statistics |
| CDES | Central Department of Environmental Science |
| DDC | District Development Committee |
| DHM | Department Hydrology and Meteorology |
| EbA | Ecosystem based Adaptation |
| IPCC | Intergovernmental Panel on Climate Change |
| PDSI | Palmer Drought Standardization Index |
| SPI | Standardization Precipitation Index |
| TDVI | Temperature Vegetation Dryness Index |
| UNEP | United Nations Environment Programme |
| USGS | United States Geological Survey |
| VIA | Vulnerability Impact Assessment |
| VDC | Village Development Committee |

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# Introduction

**The very first step towards addressing the impacts of projected climate change in an ecosystem, is to make the assessment of climate impacts and vulnerability. Without having the understanding of local vulnerability to climate change, it is almost impossible to address the climate change impacts on ecosystem and make its dependent local community resilient to climate change.**

Vulnerability is the degree to which a system is susceptible to—and unable to cope with—adverse effects of climate change; including climate variability and extremes. It is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007).

Vulnerability assessment can be conducted either based on historically observed changes in climate, future modeled projection or combination of the two. Historic changes will generally indicate current vulnerability as compared with the past, while the future climatic projection will give assessment of future vulnerability. The basic and direct types of exposure are from changes in climate: temperature, precipitation, wind, humidity, cloud cover and solar radiation. The changes in mean values of the basic variables can be used in vulnerability analyses. The extreme variables are also important in determining vulnerability. These basic climatic variables can be measured for different time periods as annually, seasonally, within specific month or even day (Glick et al., 2011).

The vulnerability assessment to climate change is conducted to understand the potential threats of climate change, to identify priorities and actions for climate change adaptation planning and implementation and to enhance the success of both current and future conservation investments, thus securing the investments. Therefore, VA is not only necessary to recognize perilous geographic regions and populations at risk, but also to enable them to be provide with timely help (UNEP, 2002).

Vulnerability assessments are essential in responding to future climate risks and the assessment process itself can help to combat with current climate risks. Although assessments are scale-specific (e.g., local, national, regional scale), cross-scale interactions occur given the interdependency of social and ecological systems and the relationship to national and sectoral policies and decisions (UNEP, 2009).

## Related Terminologies

**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. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

**Anticipatory adaptation –** Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.

**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. Also referred to as spontaneous adaptation.

**Planned adaptation –** Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

**Adaptation assessment –** The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility.

**Adaptation benefits –** The avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures.

**Adaptation costs –** Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs.

**Adaptive capacity –** The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

**Adaptation technologies** include both scientific and traditional technologies. Most adaptation technology focuses on local innovations, knowledge and practices that have proved effective in adapting to climatic hazards.

**Biodiversity –** The total diversity of all organisms and ecosystems at various spatial scales (from genes to entire biomes).

**Biome –** Major and distinct regional element of the biosphere, typically consisting of several ecosystems (e.g., forests, rivers, ponds, swamps) within a region of similar climate. Biomes are characterized by typical communities of plants and animals.

**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.

**Carbon sequestration –** The process of increasing the carbon content of a reservoir/pool other than the atmosphere.

**CDM (Clean Development Mechanism) –** The CDM allows greenhouse gas emission reduction projects to take place in countries that have no emission targets under the United Nations Framework Convention on Climate Change (UNFCCC) Kyoto Protocol, yet are signatories.

**Climate –** Climate in a narrow sense is usually defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years.

**Climate change –** Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity.

**Climate change adaptation** consists of initiatives and measures to reduce the vulnerability of natural and human systems to actual or expected climate change effects. They can be spontaneous or planned responses to actual or expected conditions.

**Climate change mitigation** refers to strategies and policies that reduce the concentrations of greenhouse gases in the atmosphere either by reducing their emissions or by increasing their capture.

**Climatic hazards** are the harmful effects of climate change on livelihoods and ecosystems. They can be caused by gradual climate variability or extreme weather events. Some hazards are continuous phenomena that start slowly, such as the increasing unpredictability of temperature and rainfall. Others are sudden but relatively discrete events such as heat waves or floods.

**Climatic risk** is the likelihood that the harmful effects will happen. It is a measure of the probability of harm to life, property and the environment that would occur if a hazard took place. Risk is estimated by combining the probability of events and the consequences (usually seen as losses) that would arise if the events took place.

**Climate sensitivity –** The equilibrium temperature rise that would occur for a doubling of $CO_2$ concentration above pre-industrial levels.

**Climate variability –** Climate variability refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events.

**Coping** refers to the use of existing resources to achieve desired goals during and immediately after climate-induced hazards.

**Ecosystem –** A structural and functional unit of biosphere or segment of nature consisting of community of living beings and the physical environment, both interacting and exchanging materials between them. It usually has a boundary within which the component parts function together as one unit. An ecosystem may be natural (like forest, lake, ocean, etc.) or man-made (such as an aquarium, a crop field, etc.), temporary (like a rainfed pond) or permanent (like a lake, forest, etc.), aquatic (such as pond, ocean, etc.) or terrestrial (like grassland, forest, etc.). An ecosystem may be as small as a drop of water and as large as an ocean. Ecosystems can be recognised as self - regulating and self - sustaining units.

**Ecosystem-based adaptation –** The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. Ecosystem-based adaptation uses the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. Ecosystem-based adaptation is most appropriately integrated into broader adaptation and development strategies (CBD, 2009).

**Ecosystem services –** Ecological processes or functions having monetary or non-monetary value to individuals or society at large. There are (i) supporting services such as productivity or biodiversity maintenance, (ii) provisioning services such as food, fiber, or fish, (iii) regulating services such as climate regulation or carbon sequestration, and (iv) cultural services such as tourism or spiritual and aesthetic appreciation.

**Epidemic –** Occurring suddenly in incidence rates clearly in excess of normal expectancy, applied especially to infectious diseases but may also refer to any disease, injury, or other health-related event occurring in such outbreaks.

**Erosion –** The process of removal and transport of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, winds and underground water.

**Exposure –** Exposure is the degree or magnitude of stress placed upon a species or habitat due to changing climate conditions or increased climate variability.

**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.

**Keystone species –** A species that has a central servicing role affecting many other organisms and whose demise is likely to result in the loss of a number of species and lead to major changes in ecosystem function.

**Maladaptation** refers to an action or intervention that increases vulnerability to climate change.

**Resilience –** The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

**Sensitivity –** Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

**Vulnerability –** Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

**Weather –** Weather refers to the behavior of the atmosphere on a day-to-day basis in a relatively local area. A description of the weather would include daily temperatures, relative humidity, sunshine, wind and rainfall.

CHAPTER II

2

# COMPONENTS OF VULNERABILITY

**Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed to as well as the system's sensitivity and capacity to adapt with minimal disruption (Glick et al., 2011). Exposure is usually treated as an external dimension of vulnerability, while sensitivity and adaptive capacity represent its internal dimension. A highly vulnerable system would be very sensitive to modest changes in climate, while its capabilities to cope with significant negative effects are limited. There is no unique methodology of vulnerability assessment; it has to fit for specific objectives (Glick et al., 2011).**

## 2.1 EXPOSURE

Exposure is the degree or magnitude of stress placed upon a species or a habitat due to changing climate conditions, or increased climate variability (IPCC, 2007). This may be represented as either long-term change in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events (O'brien et al., 2004), often depicted by analysis of historic climate or climate projection data. Observations and estimates of exposure—past, present and future—serve as a foundation for assessing the vulnerability of natural features. Before one can understand or project the effects of climate change on species and ecosystems, one must first understand the magnitude, frequency, extent, seasonality and duration of exposure to changes in temperature, precipitation and other biologically meaningful climate variables (McCarthy et al., 2010). Use of climate projection at various scale can help managers get a sense of where and how much change might be expected to affect a given conservation target. Depending on the availability of data, vulnerability assessment can take advantage of regional climate change projection or geographically explicit data from downscale climate projection. In this study, exposure by changes in climate variables are focused.

### 2.1.1 CLIMATIC VARIABLES

#### 2.1.1.1 Direct Indicators

**A. Temperature**

The Intergovernmental Panel on Climate Change (IPCC) forecasts that the average global temperature could rise up to 2.6-4.8°C by 2100 (according to the IPCC highest emission scenario) (IPCC, 2014). Regardless of action taken now to reduce emission, the climate will change until around the middle of the century and global warming by the end of the 21st century is likely to be at least 1.5°C (IPCC, 2014). A general increasing trend in temperature has also been found all over Nepal. The maximum temperature was found to be increasing at a greater rate (0.05°C/year) than the minimum temperature (0.03°C/year). The mean maximum temperature ranged between 22° to 26° C in the mid-hills and reached below 22° C in the high hills and the Himalayas or the mountains (Practical Action, 2007).

**B. Precipitation**

There is a large spatial variation in annual rainfall over Nepal ranging from less than 150 mm to more than 5,000 mm. As per the observed data, Nepal receives the highest monthly precipitation in July and the lowest in November. The analysis indicates that 79.6 percent annual precipitation occurs during monsoon season whereas 4.2, 3.5 and 12.7 percent occur during post monsoon, winter and pre-monsoon season respectively. The annual precipitation pattern is dominated by monsoon. The inter-annual variations of precipitation are very large which makes some years too wet and some years too dry resulting in no significant trend of precipitation over the years (Practical Action, 2007).

### 2.1.1.2 Methods and Tools

**A. Data Source and Unit**

Basic climatic variables are the minimum and maximum daily temperature, maximum and minimum rainfall, evapotranspiration, sunshine duration, etc. More complex indices and indicators require significant modeling efforts, resources and expertise. Climate data include: (i) precipitation—mean annual precipitation; monthly, seasonal and daily precipitation rates; runoff; maximum 5-day precipitation; consecutive dry days (for example, 7 days with <1 mm rainfall) and (ii) temperature–mean annual temperature, maximum temperature (monthly), minimum temperature (monthly), frost days, etc.

The daily, monthly and seasonal data are available at Department of Hydrology and Meteorology (DHM). DHM maintains nation-wide networks of 337 precipitation stations, 154 hydrometric stations, 20 sediment stations, 68 climatic stations, 22 agro-meteorological stations, 9 synoptic stations and 6 aero-synoptic stations. Data are made available to users through published reports, bulletins, and computer media outputs such as hard copies or diskettes. DHM publishes data on an annual basis (Shrestha, 2010).

The data provided by the climatic station may include the gaps and loopholes. Hence, the climatic data has to be homogenized following the standard method. The trend in the data more than 30 years period is determined. If the ranking is not suitable, the indirect and proxy indicator can be validated by the data of weather station.

When climate data is insufficient for the desired area, one may consult the regional and global databases to obtain at least monthly averages for most climate parameters.

See, for example: IPCC Data Distribution Centre, http://www.ipcc-data.org and Climate Forecasting and Monitoring database, worldclim.org, etc.

**B. Calculation and Ranking**

The climatological data are not sufficient to determine the distinct change or trend. It is difficult to rank the variable in terms of obtained result. Hence the data can be used to validate the result obtained from the focus group discussion.

**BOX 1:** List of the climatological stations selected from DHM for the analysis of climatic data (case for SNNP)

| | Station No | Elevation (m) | Latitude (N) | Longitude (E) |
|---|---|---|---|---|
| Budhanilkantha | 1071 | 1350 | 2747 | 8522 |
| Kakani | 1007 | 2064 | 2748 | 8515 |
| Kathmandu | 1030 | 1337 | 2742 | 8522 |
| Nagarkot | 1043 | 2163 | 2742 | 8531 |

Source: DHM, 2015

**BOX 2:** Average precipitation of different seasons recorded at four climatic stations and the trend of the precipitation

| Stations | Average Precipitation (mm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Annual | Trend | Pre monsoon | Trend | Monsoon | Trend | Post monsoon | Trend |
| Budhanilkantha | 1981.1 | -0.552 | 280.5 | -0.84 | 1599.9 | 1.119 | 55.1 | 0.195 |
| Kakani | 2850.8 | -5.925 | 336.9 | -7.778 | 2360.9 | -6.641 | 93.7 | 2.692 |
| Kathmandu | 1484.5 | 6.839 | 223.6 | 1.347 | 1159 | 6.808 | 53.9 | -1.204 |
| Nagarkot | 1903.2 | -2.663 | 257.5 | 0.042 | 1526.5 | -2.303 | 69.7 | -0.524 |
| Average | 2054.9 | -0.574 | 274.6 | 0.038 | 1661.6 | -0.086 | 68.1 | 0.357 |

Source: DHM, 2015

## 2.1.1.3. Indirect Indicators

Indirect indicators are used when there is no availability of meteorological data, and also to understand the local perception about climate change. For temperature and precipitation, separate indicators are used. Change in duration (time-period) of various indicators are estimated and ranked.

**A. Temperature**

a. Duration of hot days/summer days
b. Duration of cold days/winter days
c. Duration of cold waves
d. Duration of hot waves

**B. Precipitation**

a. Pre-monsoon/monsoon/post-monsoon/winter rainfall duration
b. Frost (amount/time duration)
c. Dew (amount/time duration)
d. Hailstone (amount/time duration/size)
e. Fogs (time duration)
f. Thunderstorms (amount/time duration)
g. Snowfall (amount/time duration)

## 2.1.1.4. Methods and Tools

**A. Data Source and Unit**

The data source for above mentioned indirect indicators are communities. Quality of data completely depends on the knowledge of local people. The unit of all the indirect indicators is in the time duration i.e. days, weeks or month. Seasonal calendar is also used to acquire the information on indirect indicators.

The purpose of generating a seasonal calendar is to identify the seasonality of the (i) weather patterns, i.e. summer months, rainy season, winter, etc.; (ii) the community's livelihood activities, which are often connected to resource use and resource abundance; and (iii) seasonality of hazards. Communities identify different activities (agriculture, aquaculture, seasonal migration) that occur throughout a year and the guided discussion will seek to identify how the climate change will affect overall activities and whether it will alter the seasonality of community's livelihood activities.

The discussion will also seek to provide understanding of historical changes in seasonality that the community has already experienced, and the social mechanisms that the community has employed to mitigate their effects.

Applicable Scale: Landscape/Watershed/VDC/Community

**Table 1: Example of seasonal calendar for indirect indicators**

| Month Indicators | | Baishakh | Jestha | Asar | Shrawan | Bhadau | Asoj | Kartik | Mangsir | Poush | Magh | Falgun | Chaitra |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hot days/ Summer days | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |
| Cold days/ Winter days | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |
| Pre-mon-soon | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |
| Monsoon | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |
| ……… | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |

**Note:** The months are in Bikram era: Baishak starts from mid-April.

Seasonal calendar showing changes in timing and duration of hot days, cold days, rainy days.

**B. Calculation and Ranking**

The information obtained through seasonal calendar are calculated and analyzed in data spread sheet. These indicators are ranked as following table 2.

**Table 2: Ranking of indirect indicators for exposure**

| Indicators | Rank |
|---|---|
| **Temperature** | |
| Hot days/Summer days | No or negligible change felt or less than 10% (Low) or varies 7 days=1; Slight change felt or 10%-30% (Medium) Or varies by 8 to 15 days=2; Change felt or 30%-50% (High) or varies by 16-21 days =3 & Significant change or >4% change or varies >21 days (Very High)=4 |
| Cold days/ Winter days | |
| Cold waves | |
| Hot waves | |
| **Precipitation** | |
| Pre-monsoon rainfall | No or negligible change felt or less than 10% (Low) or varies 7 days=1; Slight change felt or 10%-30% (Medium) or varies by 8 to 15 days=2; Change felt or 30%-50% (High) or varies by 16-21 days =3 & Significant change or >4% change or varies >21 days (Very High)=4 |
| Monsoon rainfall | |
| Post-monsoon rainfall | |
| Winter rainfall | |
| Frost | |
| Dew | |
| Hailstone | |
| Fogs | |
| Thunderstorms | |
| Snowfall | |

## 2.1.1.5. Proxy Indicators

Proxy indicators are used to get the information on climate change in unavailability of climatic data set, and also to understand the local perception about climate change. There is no distinct separation in proxy-indicators for temperature and precipitation. Change in duration (time period) of various indicators are estimated and ranked.

**Indicators**

a. Major cereal crops
b. Major vegetable crops
c. Fruit crops
d. Phenology of plant species
e. Migration of birds
f. Diseases (human/animal/birds)
g. Insects (human/animal/birds)
h. Water availability (drinking/irrigation)

## 2.1.1.6. Methods and Tools

**A. Data Source and Unit**

The data source for above mentioned proxy indicators are communities. Quality of data entirely depends on the knowledge of local people. Focus group discussion is a useful tool for primary data generation. The unit of all the proxy indicators is in time duration i.e. days, weeks or month. Seasonal calendar is used to acquire the information on proxy indicators.

**Table 3: Example of crop calendar for proxy indicators**

| Month Indicators | | Baishakh | Jestha | Asar | Shrawan | Bhadau | Asoj | Kartik | Mangsir | Poush | Magh | Falgun | Chaitra |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maize | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |
| Wheat | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |
| Millet | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |
| Barley | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |
| ……… | Before | | | | | | | | | | | | |
| | Now | | | | | | | | | | | | |

Crop calendar showcasing changes in timing and duration of sowing, transplanting and harvesting periods of different crops.

**B. Calculation and Ranking**

The information from crop calendar are calculated and analyzed in data spread sheet. And these indicators are ranked as given in table 4.

**Table 4: Ranking of indirect indicators for exposure**

| Proxy-Indicators | Rank |
|---|---|
| a. Major cereal crops<br>b. Major vegetable crops<br>c. Fruit crops<br>d. Phenology of plant species<br>e. Migration of birds | No or negligible realization of change or < 1 week deviation (Low)=1; Slight deviation or 1-2 week deviation (Medium)=2; Clear change or 2-3 weeks deviation (High)=3 & Significantly change or >3 weeks deviation (Very High)=4 |
| f. Diseases (human/animal/birds)<br>g. Insects (human/animal/birds) | No observation or only one disease/species change observed (Low)=1; Little change in disease/ species or 2 disease/species change observed (Medium)=2; Clear change or 3 disease/species change observed (High)=3 & Significantly change or >3 diseases/ species change observed (Very High) = 4 |
| h. Climate induced hazards<br>i. Water availability (drinking/irrigation) | No or negligible change in hazard events or less than 10% (Low)=1; Slight realization in hazard events or 10-20% (Medium)=2;Clear change observed in hazard events or 20-30% (High)=3 & Significant change observed in hazard events or >30% (Very High)=4 |

## 2.1.2. CLIMATIC HAZARDS

### 2.1.2.1. Indicators

**A. Drought**

Changes in temperature and precipitation can influence drought frequency and or severity. In general, it is thought that under climate change, there will be an increase in incidence, intensity and duration of drought, but this will differ according to geographical locations. Two most commonly used indices are palmer drought standardization index (PDSI) and standardized precipitation index (SPI).

**B. Forest Fire**

Climate change is expected to contribute to significant changes in forest fire regimes in some regions, including shift in timing, intensity, frequency of wild fire events.

**C. Landslide**

Due to change in climate elements i.e. temperature and precipitation, there might also be change in characteristics of landslide in extent, intensity, magnitude and frequency.

**D. Flash Flood**

Changes in precipitation pattern (duration and intensity) affect the flooding pattern. Due to intense or heavy rainfall in short span of time in specific locality, flash flood may occur and damage huge property and life in a very short period of time.

### 2.1.2.2. Methods and Tools

**A. Data Source and Unit**

Data source can be secondary sources like national disaster database and Disinventar database. Data used in exposure is basically frequency and return period of specific hazard. By using historical timeline analysis, the trend of a specific hazard can be found out. Understanding the history of past extreme events and a community's reaction to these events can serve as very important information for vulnerability assessment. The historical trend analysis will give insight into past climate hazards, their trends, intensity, and impacts to ecosystem services and communities. The trend analysis can be done either just through discussion or by drawing a line to mark the passage of time (10-20-30 years) based on the available data.

For historical timeline analysis, following table 5 can be used.

**Table 5: Example of historical timeline**

| Year | Hazard | Area/Place | Loss | Contribution of Local Community (Post-Hazard) | Activity from Local Government |
|---|---|---|---|---|---|
| 2028 | Landslide/ Flash flood | Chilaune-3 | Loss of livestock<br>Loss of agricultural land | No | Plantation activity and Gabion wall protection held from Department of Forests |
| 2035 | Epidemic | Chilaune | Death of Livestock-4 | No | No |
| 2060 | Forest Fire | Chilaune-4 | Loss of forest | Help extinguish fire | No |
| …. | ……… | …… | | | ….. |
| …. | ……… | …… | | | …… |

**B. Calculation and Ranking**

For exposure, the frequency of a specific hazard should be analyzed and its return period is identified. This gives the changing pattern of hazard in occurrence. Based on the changing pattern, the specific hazard is ranked as given in table 6 below.

**Table 6: Ranking of climate induced hazards**

| Indicators Direct | Rank |
|---|---|
| 1. Forest fire | No or negligible change in hazard events or less than 10% (Low)=1; Slight realization in hazard events or 10-20% (Medium)=2; Clear change observed in hazard events or 20-30% (High)=3 & Significant change observed in hazard events or >30% (Very High)=4 |
| 2. Drought | |
| 3. Landslide | |
| 4. Flash flood | |

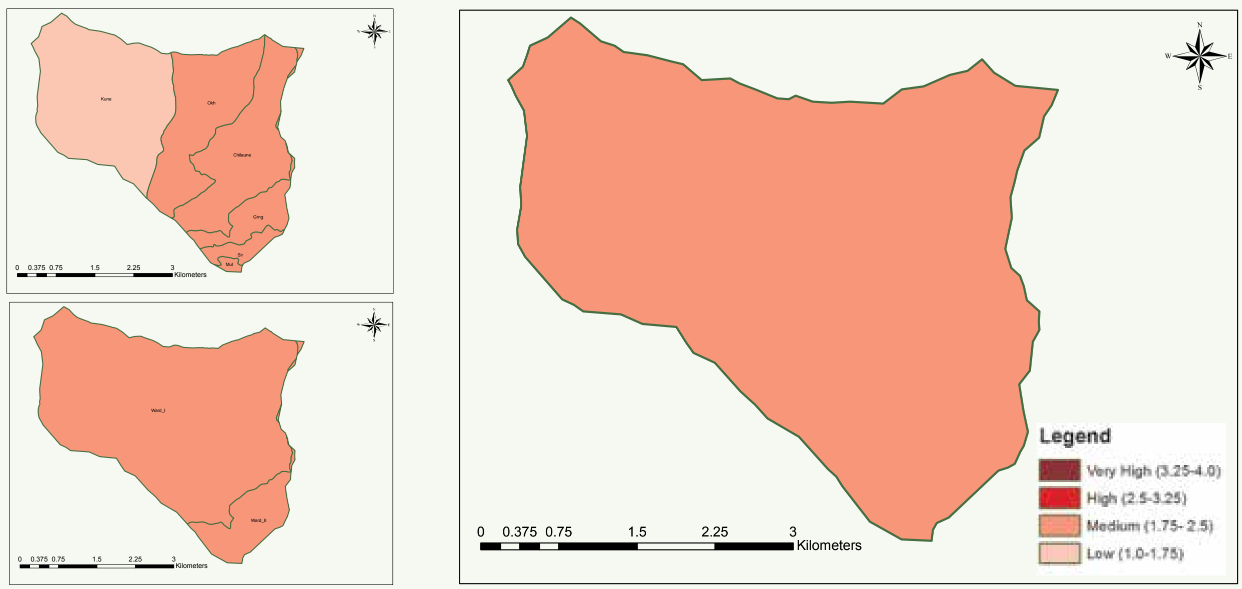
Exposure component can be scored and calculated as given below in table 7 (the data has been taken from the VIA Methodology Field Validation at Shivapuri Nagarjun National Park- TU, CDES).

**Table 7: Exposure score of the Shivapuri Nagarjun National Park (Bagmati watershed)**

| Components | Indicator | Site | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Exposure** | **Temperature** | **K*** | **O*** | **C*** | **G*** | **S*** | **M*** | **Average** |
| | Hot days/Summer days | 4 | 4 | 4 | 1 | 1 | 4 | 3.0 |
| | Cold days/ Winter days | 4 | 4 | 4 | 4 | 4 | 2 | 3.7 |
| | **Precipitation** | | | | | | | |
| | Pre-monsoon rainfall | 1 | 4 | 4 | 2 | 2 | 2 | 2.5 |
| | Monsoon rainfall | 1 | 4 | 3 | 4 | 4 | 2 | 3.0 |
| | Post-monsoon rainfall | 1 | 4 | 4 | 4 | 4 | 4 | 3.5 |
| | Winter rainfall | 1 | 4 | 4 | 4 | 4 | 1 | 3.0 |
| | Frost | 2 | 2 | 3 | 2 | 2 | 1 | 2.0 |
| | Dew | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| | Hailstone | 1 | 2 | 1 | 2 | 2 | 3 | 1.8 |
| | Fogs | 2 | 3 | 2 | 3 | 3 | 1 | 2.3 |
| | Thunderstorms | 3 | 3 | 3 | 3 | 3 | 1 | 2.7 |
| | Snowfall | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| | **Proxy-Indicators** | | | | | | | |
| | Major cereal crops | 1 | 2 | 1 | 2 | 2 | 3 | 1.8 |
| | Major vegetable crops | 1 | 2 | 1 | 2 | 2 | 1 | 1.5 |
| | Fruit crops | 2 | 2 | 1 | 2 | 2 | 2 | 1.8 |
| | Phenology of plant species | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| | Migration of birds | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| | Diseases (human/animal/birds) | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| | Insects (human/animal/birds) | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| | **Climate Induced Hazards** | | | | | | | |
| | Forest fire | 1 | 1 | 1 | 2 | 2 | 2 | 1.5 |
| | Drought | 1 | 1 | 1 | 3 | 3 | 4 | 2.2 |
| | Landslide | 3 | 3 | 3 | 1 | 1 | 1 | 2.0 |
| | Flash flood | 1 | 3 | 2 | 1 | 1 | 1 | 1.5 |
| | **Average** | **1.6** | **2.3** | **2.1** | **2.1** | **2.1** | **1.8** | **2.0** |

*K-KuneGau; *O-Okhreni; *C- Chilaunegaun; *G- Gurung tole; *S- Siranetole *M- Mulkharka

**Figure 1:** Exposure of upper Bagmati sub-watershed




## 2.2. SENSITIVITY

According to IPCC, sensitivity is defined as the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise). Thus, sensitivity is the effect of local climate change and related hazards on the local system—biophysical and socioeconomic. Highly sensitive systems will be more impacted compared to low sensitive systems even with a same level of climate change or hazards. Therefore, the more the system is sensitive to climate change and related hazards, the more the system is vulnerable to climate change. Sensitivity of a system is evaluated through assessment of effects or impacts or damages of the system from climate change and related hazards. Thus, various indicators are selected from different ecosystems.

**BOX 3:** Sensitivity of vegetation in Shivapuri Nagarjun National Park

Climate change and habitat destruction are two of the greatest threats to biodiversity (Travis, 2003). Changes in biodiversity are linked to habitat loss and perhaps the greatest threat to organisms (Barbault and Sastrapradja, 1995). Plants and animals being associated with a particular type of habitat become displaced or die as a result of habitat loss, which therefore, reduces the overall biodiversity of an ecosystem. As plants and animals have a huge diversity and live in a close association and affiliation with specific habitats, when habitat loss occurs it will not only affect the individual species, but can also affect many, as of the ecological interactions and processes between the different species within the ecosystem. Habitat destruction is currently ranked as the most important cause of species extinction worldwide (Pimm and Raven, 2000). Thus we took into account, the change in the biodiversity focusing the vegetation type. The ranking of the sensitivity of the vegetation type is done on the basis of two variables: (a) Spatial Shifting (SS) and (b) loss of habitat.

First, we modeled the potential current suitable habitat of a vegetation type. Then, we modeled potential future suitable habitat of a vegetation type (Refer Annex 1 for the detail procedure).
We calculated spatial distribution of vegetation in two sub-categories:
Suitable to unsuitable (S –U)
Unsuitable to suitable (U-S)

These two terms are known as "Spatial shifting". In our data, spatial shifting ranged from 0- 40. The shifting can be positive (e.g., unsuitable to suitable) or negative. We, however, did not consider it. The Spatial shifting category was reclassified into 4 classes in an interval of ten points (0-10, 10-20, 20-,30….etc) and ranked them in a scale of 1-4 for both sub-categories. They are X for positive and Y for negative.

Suitable area for a vegetation type might change due to climate change. We calculated proportion of suitable habitat that would be unavailable in the climate change scenario. This is termed as "habitat loss" denoted as (EX). It ranged -100 (extinction) to +165. The positive value indicates the overall gain of suitable habitat. Therefore, we ranked all positive values as 1 (poor vulnerable) and negative values are ranked into four classes (0-25, 25-50, 50-75, 75-100) and classified in a scale of four vulnerable indices (e.g. 1, 2, 3 and 4). This is Z.
We developed a final composite index as (X+Y)*Z.

The vulnerability indices ranged from 3 to 18, which were again ranked into four classes as:

| Variables | Class interval | Rank |
|---|---|---|
| Sensitivity | 0-5 | 1 |
| | 5-10 | 2 |
| | 10-15 | 3 |
| | 15-20 | 4 |

Change in the spatial distribution of a vegetation type and its decrease in available suitable habitat produces synergistic effect and make it more vulnerable. Higher the value, higher is the risk of the extinction. If the minimum habitat area and quality requirements are not met, species cannot persist (e.g. large carnivores in protected areas). Area-sensitive species require habitat patches many times larger than their home ranges (the minimum area that satisfies all life history requirements); the area we might predict they need to survive. Fragmentation creates new or makes available old ecological niches, making it easier for invasive species to colonize areas; thus once established invasive species can themselves further increase fragmentation by displacing native species. Sometimes this leads to homogenization of the community as native species that often remain more tolerant of or can effectively compete with invasive species.

Overall, however, biodiversity usually declines.

| | S-U | X | U-S | Y | EX | Z | Weight | Rank |
|---|---|---|---|---|---|---|---|---|
| CPF | 0 | 1 | 23 | 3 | 51.62 | 1 | 4 | 1 |
| CPBLF | -40 | 4 | 15 | 2 | -52.45 | 3 | 18 | 4 |
| MOLF | -20 | 2 | 35 | 4 | 61.01 | 1 | 6 | 2 |
| SCF | 0 | 1 | 18 | 2 | 162.5 | 1 | 3 | 1 |
| TMOF | -30 | 3 | 0 | 1 | -100 | 4 | 16 | 4 |

**Note: The potential vegetation maps show five types of vegetations in the park: (1) chir pine forest (CPF), (2) chir pine broad leaved forest (CPBLF)**, (3) mixed oak laurel forest (MOLF), (4) Schima castanopsis forest (SCF), and (5) temperate mountain oak forest (TMOF).

From the analysis, chir pine broad leaved forest and temperate mountain oak forest are more vulnerable to climate change.

## 2.2.1. Forest and Biodiversity

### 2.2.1.1. Indicators

It is indeed challenging to assess the changes in forest ecosystem due to climate change related stimuli. Three indicators were chosen for forest ecosystem—invasive species, endemic species and area. Change in quantitative parameter of the species and their habitat can be predicted using appropriate model. Box 3 presents sensitivity of vegetation in SNNP.

**A. Species Composition**

**a. Invasive Species**

Invasion of new and/or alien species are easily noticeable and can be measured quantitatively in short time period. Thus, the account of invasive species can be considered as a good indicator of climate change in forest and biodiversity sector.

**b. Endemic Species**

Endemism is mostly due to geographical location, special climate and habitat niche. Distribution and abundance of endemic species are noticeable in changing climate and can be a good indicator of climate change.

**B. Forest Area**

Impact of climate change on forest area might be direct or indirect. Climate induced hazard such as landslide, forest fire may affect the forest area.

### 2.2.1.1. Methods and Tools

**A. Data Source**

The data sources could be field survey (primary sources) and other relevant publications (secondary sources) for species composition. Land use map is the major data source for area.

**B. Calculation and Ranking**

The data obtained either through primary sources or secondary sources are analyzed in spread sheets and the changes (impacts) on both species composition and area are compared with past database, and ranked as given in table 8 .

**Table 8: Indicators ranking of forest and biodiversity ecosystem**

| Indicators | Rank | Remarks |
|---|---|---|
| Species composition (Invasive and Endemic) | No or negligible change or less than 10% change (Low):1; Slight change or 10-20% change (Medium):2; Clear change or 20-30% change (High):3; Significant change or >30% change (Very High):4 | |
| Area | | |

## 2.2.2. WATER RESOURCES

### 2.2.2.1. Indicators

It is difficult to get time series data on water resources. Discharge (runoff) and number of water resources could be indicators of climate change. Change in discharge can be calculated directly when the data on discharge is available. Otherwise discharge (runoff) can be predicted with using appropriate model.

**A. Runoff (Discharge)**
Impact of climate change in runoff is direct. Change in temperature and precipitation affects water discharge and is selected as an indicator of water resources.

**B. Water Sources (No.)**
Natural springs or water holes are common in mountain areas of Nepal. Thus, drying of such natural water sources is used as an indicator of climate change.

### 2.2.2.2. Methods and Tools

**A. Data Source**
Primary Sources: Field measurement and modeling
Secondary Sources: Relevant publications

**B. Calculation and Ranking**
Indicator of water resources are ranked as per table 9.

**Table 9: Indicators ranking of water resources**

| Indicators | Rank | Remarks |
|---|---|---|
| Run off (Discharge) | No or negligible change or less than 10% change (Low):1; Slight change or 10-20% change (Medium):2; Clear change or 20-30% change (High):3; Significant change or >30% change (Very High):4 | |
| Water sources (No.) | | |

## 2.2.3. SOIL

### 2.2.3.1. Indicators

**A. Soil Moisture Index**
Soil moisture can be a good indicator of climate change as change in climatic elements influence the soil property, especially soil water content.

### 2.2.3.2. Methods and Tools

**A. Data Source**
Soil moisture index is calculated from remote sensing images. The Land Sat image can be used for this purpose.

**B. Calculation and Ranking**
The soil moisture can be calculated from the different Land Sat images. The required images can be obtained from USGS website. Soil moisture can be calculated through the Temperature Vegetation Dryness Index (TVDI) from the Land Sat images. Thermal band (known as band 6) are used to find the soil moisture content.

**Table 10: Indicator ranking of soil parameter**

| Indicators | Rank | Remarks |
|---|---|---|
| Moisture content | No or negligible change or less than 10% change (Low):1;Slight change or 10-20% change (Medium):2; Clear change or 20-30% change (High):3; Significant change or >30% change (Very High):4 | |

## 2.2.4. HUMAN DIMENSION

### 2.4.4.1. Indicators

In human system, the climate change sensitivity is on agriculture production, population density and population flux.

**A. Agriculture Production**
Fluctuations in climatic elements have direct impact on agriculture productivity especially in Nepal where rain-fed agriculture is practiced. Thus, agriculture production is taken as indicator.

**B. Population Density**
Human population is another system that gets directly affected by climate related stimuli. Thus, population density was taken as one of the indicators of human system.

**C. Population Flux**
Due to climatic variability, many cases of internal migration have been reported from many rural areas of Nepal. Considering this, population flux was taken as one of the indicators of sensitivity of human system.

#### 2.2.4.2. Methods and Tools

**A. Data Source**

Secondary sources for the indicators of human dimension are CBS, Ministry of Agriculture Development, VDC, DDC and other related publications while focus group discussion, crop calendar and social survey could be primary data sources.

**B. Calculation and Ranking**

Data obtained from primary and secondary sources are calculated as per need of ranking system.

**Table 11: Indicators ranking of human dimension**

| Indicators | Rank | Remarks |
|---|---|---|
| Agriculture production | No or negligible change or less than 10% change (Low):1;Slight change or 10-20% change (Medium):2; Clear change or 20-30% change (High):3; Significant change or >30% change (Very High):4 | |
| Population density | | |
| Population flux | | |

Sensitivity component could be scored and calculated as given in table 12 (The data has been taken from VIA Methodology Field Validation at Shivapuri National Park- TU, CDES)

**Table 12: Sensitivity scores of the Shivapuri Nagarjun National Park (Bagmati watershed)**

| Components | Indicators | Site | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sensitivity | Forest and biodiversity | K | O | C | G | S | M | Average |
| | Species composition (Invasive and Endemic) | 2 | 2 | 2 | 2 | 2 | 1 | 1.8 |
| | Area | 2 | 2 | 3 | 2 | 2 | 1 | 2.0 |
| | Water resources | | | | | | | |
| | Run off (Discharge) | 1 | 2 | 1 | 2 | 2 | 2 | 1.7 |
| | Water sources (No.) | 1 | 2 | 1 | 2 | 2 | 2 | 1.7 |
| | Human dimension | | | | | | | |
| | Agriculture production | 3 | 2 | 2 | 2 | 2 | 2 | 2.2 |
| | Population density | 2 | 3 | 3 | 3 | 3 | 3 | 2.8 |
| | Population flux | 2 | 2 | 1 | 2 | 2 | 3 | 2.0 |
| Average | | 1.9 | 2.1 | 1.9 | 2.1 | 2.1 | 2.0 | 2.0 |

**Table 13: Overall sensitivity on the basis of perception and modeling**

| Components | Indicators | Rank |
|---|---|---|
| Sensitivity | Vegetation analysis from modeling | 2.4 |
| | Field survey and community perception | 2.0 |
| Overall average | | 2.2 |

**Figure 2:** Sensitivity of Bagmati watershed


## 2.3. ADAPTIVE CAPACITY

Adaptive capacity refers to the potential or capability of a system to adjust to climate change, including climatic variability and extremes, so as to moderate potential damages, to take advantages of opportunities, or to cope with consequences (IPCC, 2007). It is the capability of a system to adapt to impact of climate change. Adaptive capacity is determined through assessment of livelihood assets possessed by community which are vital for responding to climate change and its impacts. Assessment of adaptive capacity looks into the assets of the community which are required to respond to the effects of climate change. Such assets are both materials and immaterial assets. However, the assessment of adaptive capacity will focus on assessment of three livelihood resources of the communities namely 1) Social 2) Economic 3) Environment based on sustainable development pillar.

### 2.3.1. SOCIAL RESOURCES

The analysis of social resources helps in determining the adaptive capacity of the community or society. Social resource includes population, education, employment, skilled human resource, social institution, etc. Social resources of the community are further categorized into two assets: Human Resource and Social capital.

#### 2.3.1.1. Human Resources

Human is one of the social resources in the assessment of adaptive capacity. The intellectual capability of human being is helpful in the period of disasters. More numbers of educated and knowledgeable people in the community directs the society towards better adaptation mechanism. Followings are the indicators that determine the human resource.

### 2.3.1.1.1. Indicators

**A. Population Structure (Elderly (60+) and Young (<15))**

Population structure (Elderly (60+) and Young (<15)) shows the dependent population which influences the adaptive capacity of the community. The greater, the number of dependent population, more vulnerable will be the community.

**B. Education and Literacy (Population% with secondary education)**

Education and literacy rate enhances the adaptive capacity of that community.

**C. Vulnerable HH to CC (% of HH)**

Climate induced hazard makes the society more vulnerable and reduces the adaptive capacity.

**D. Employment (% of HH)**

Non-agriculture employment increases the adaptive capacity of the household.

**E. Skilled Human Resource (% of population)**

Skilled human resource can create opportunities for employment, which ultimately enhances the adaptive capacity of the community.

### 2.3.1.1.2. Methods and Tools

**A. Data Source**

The data on human resource can be found through secondary sources like VDC profile and CBS database. The primary data source is a social survey.

**B. Calculation and Ranking**

As the discussion goes on, the information is documented and consensus is recorded in the sheet. The assessment should address the quality, quantity and availability of the resources to the communities. All indicators are ranked as in table14.

**Table14: Ranking of indicators of human resources**

| Indicators | Rank | Remarks |
|---|---|---|
| Population structure (Elderly (60+) and Young (<15)) | > 30% =1;20-30%=2;10-20%=3 and <10%=4 | |
| Education and literacy (population% with secondary education) | <10% =1; 10-30 %=2; 30-50%=3 & >50%=4 | |
| Vulnerable HH to CC (% of HH) | >30% =1; 20-30 %=2; 10-20%=3 & <10%=4 | |
| Employment (% of HH) | <5% =1; 5-10 %=2; 10-15%=3 & >15%=4 | |
| Skill human resource (% of population) | <5% =1; 5-10 %=2; 10-15%=3 & >15%=4 | |

### 2.3.1.2. Social Capital

Social capital implies the social networks that can be accessed by the people in the community. Strong institutional arrangement in the community enhances the adaptive capacity of the community.

#### 2.3.1.2.1. Indicators

**A. Formal and Traditional Institutions (% of affiliated HH)**

Formal and traditional institutions can provide support for household to adapt to climate induced disaster.

**B. Service Providers (No. of GOs, I/NGOs)**

Service providers can support households in case of emergency such as disaster and stressful times.

**C. Access to Various Institutions (provision for poor and disadvantaged)**

Access to various institutions can provide support in the time of emergency such as disaster and stressful times.

#### 2.3.1.2.2. Methods and Tools

**A. Data Source**

The data on social capital can be found through secondary sources like VDC profile and CBS database. The primary data source is social survey.

**B. Calculation and Ranking**

The data are calculated to find the number of institution and are ranked as in table 15.

**Table 15: Ranking of social indicators**

| Indicator | Rank | Remarks |
|---|---|---|
| Formal and traditional institutions (% of affiliated HH) | <10% =1;10-30 %=2; 30-50%=3 & >50%=4 | |
| Service providers (No. of GOs, I/NGOs) | £5=1; 6-10=2; 11-15=3 & >15=4 | |
| Access on various institutions (provision for poor and disadvantage) | No provision for all categories=1; Few provisions (e.g. Poor and Disadvantage)=2; Enough but not covered all categories=3 & Covered all categories=4 | |

## 2.3.2. ECONOMIC RESOURCES

Economic resources are the fixed and liquid asset of the household in the community. In general, household can be categorized as rich and poor in terms of the asset they possess. The richer households have more adaptive capacity relatively to the poor ones.

### 2.3.2.1. Indicators

**A. Bank Account (% of HH)**

Generally, the bank account of households indicates saving and transaction of money. The saved money can be used in difficult time thus enhances the adaptive capacity of households.

**B. Finance (banks/cooperatives/saving group)**

Availability of loan (with and without collateral) can increase adaptive capacity during climatic extremes condition and thus help local communities to revive or revitalize after the extreme condition.

**C. Agriculture Land Holding Size (ha)**

Agricultural land holding size increases adaptive capacity of households.

**D. Food Sufficiency**

Food sufficiency indicates higher capacity to adapt.

**E. Disaster Affected Agriculture Land (%)**

Affected agricultural-land increases vulnerability and limits agriculture production.

**F. Drinking Water Availability**

Safe drinking water facility enhances the adaptive capacity of community.

**G. Energy Source (Cooking)**

Dependency on firewood for cooking decreases the adaptive capacity.

**H. Energy (Lighting)**

Access to the electricity increases the adaptive capacity.

**I. Household Type**

Household type is an indication of wellbeing and cemented households may survive hazard.

**J. Information and Communication (TV/Radio, internet, post office, telephone and mobile)**

Availability of information technology increases response capacity by accessing and sharing information.

### 2.3.2.2. Methods and Tools

**A. Data Sources**

The data can be found through secondary sources like VDC profile and CBS database. The primary data source is social survey.

**B. Calculation and Ranking**

The data are calculated and are ranked as in table 16.

**Table 16: Ranking of economic indicators**

| Indicator | Rank | Remarks |
|---|---|---|
| Bank account (% of HH) | <10% =1;10-30 %=2; 30-50%=3 & >50%=4 | |
| Finance (No. of banks or cooperatives) | Up to 2 =1; 3-4 = 2; 5-7 = 3 and >7 = 4 | |
| Agriculture land holding size (ha) | Less than 0.5=1; 0.5-1.5=2; 1.5-3=3 & More than 3 | |
| Food sufficiency | Food sufficient households less than 15=1; Food sufficient households 15-30=2; Food sufficient households 30-50=3 & Food sufficient households more than 50=4 | |
| Disaster affected agriculture land (%) | More than 75%=1; 60-75%=2; 30-60%=3 & Less than 30%=4 | |
| Drinking water availability | Number of households with drinking water …. Less than 20%=1; Number of households with drinking water ….20-50%=2; Number of households with drinking water …. 50-85%=3 & Number of households with drinking water …. >85=4 | |
| Energy source (Cooking) | Cooking % relying on traditional sources more than 90=1; Cooking % relying on traditional sources 70-90=2; Cooking % relying on traditional sources 50-70=3 & Cooking % relying on traditional sources less than 50=4 | |
| Energy (Lighting) | % access to solar and electricity less than 20=1; % access to solar and electricity 20-50=2; % access to solar and electricity 50-85=3 &% access to solar and electricity more than 85=4 | |
| Household type | Households living in cemented house less than 5 %=1; Households living in cemented house 5-10%=2; Households living in cemented house 10-20%=3 & Households living in cemented house more than 20%=4 | |
| Information and communication (TV/ Radio,internet, post office, telephone and mobile) | <10% =1;10-30 %=2; 30-50%=3 & >50%=4 | |

## 2.3.3. PHYSICAL RESOURCES

Physical resource includes household type, physical infrastructure, communication and information and availability of construction materials. Community with more physical resources will be less vulnerable.

### 2.3.3.1. Indicators

**A. Physical Infrastructures**

Physical infrastructures such as schools, health post, veterinary service center, electricity, access to road, trails are primary inputs, helping individuals and household to adapt.

**B. Construction Materials Availability and Status**

Construction materials available in local level increase the adaptive capacity of local people.

#### 2.3.3.2. Methods and Tools

**A. Data Source**

Secondary data on physical resources can be found in VDC, DDC and CBS publication, and other relevant publications. Primary data can be obtained from survey.

**B.Calculation and Ranking**

The data obtained from secondary and primary sources will be analyzed as per need and ranked as per table 17.

**Table 17: Ranking of physical asset indicators**

| Indicator | Rank | Remarks |
|---|---|---|
| Physical infrastructures (Schools, health post, veterinary service center, electricity, road, trails, etc.) | Service availability and access of HH <25%=1; 25-50%=2; 51-75%=3 & >75%=4 | |
| Construction materials availability and status | | |

### 2.3.4. ENVIRONMENT

Environment is one of the pillars of sustainable development. Prosperous environment and resilient ecosystem enhances the adaptive capacity of community. Natural resources reduce the vulnerability of the community by providing ecosystem services. Following are the indicators of environmental resources.

#### 2.3.4.1. Water Resources

Availability of water resource enhances the overall development and betterment of the community and significantly contributes to the poverty alleviation and economic growth, thus increasing the adaptive capacity of the community.

##### 2.3.4.1.1. Indicators

**A. Freshwater Availability and Status**

Freshwater availability and status show the adaptive capacity of the ecosystem.

**B. Irrigation Water Availability**

Sufficient irrigation water for agricultural land increases production and helps to adapt the people.

**C. Drainage Density**

High drainage density can contribute to increase the adaptive capacity of the system till certain threshold.

### 2.3.4.1.2. Methods and Tools

**A. Data Source**

The data can be found through secondary sources like VDC profile and CBS database. The primary data source is social survey.

**B. Calculation and Ranking**

As the discussion goes on, the information is documented and consensus is recorded in sheet. The assessment addresses the quality, quantity and availability of the resources to the communities. All indicators are ranked as in table 18.

**Table 18: Ranking of water resources indicators**

| Indicator | Rank | Remarks |
|---|---|---|
| Freshwater | < 15% = 1; 15-30% = 2; 30-50%=3 & > 50% = 4 | |
| Irrigation water | < 15% = 1; 15-30% = 2; 30-50%=3 & > 50% = 4 | |
| Drainage density | <0.001 = 1; 0.0010-0.0015 = 2; 0.0016-0.0020 = 3 & >0.0020 = 4 | |

### 2.3.4.2. Forest and Biodiversity

Forest and biodiversity increases the resilience of the ecosystem as such. The community will also be benefited from the forest and biodiversity by the availability of food, fodder, fuel, medicines, etc. Following are the indicators of forest and biodiversity.

### 2.3.4.2.1. Indicators

**A. Area**

Large forest area helps to buffer ecosystem services by minimizing erosion and maintaining natural resources integrity.

**B. Fodder Availability**

Fodder availability increases the adaptive capacity of people.

**C. Fuelwood Availability**

Fuelwood availability helps to adapt the people.

**D. NTFPs Availability**

NTFPs availability helps to adapt the people by income generation and gets support (in case of emergency such as disaster and stressful times).

**E. Grazing Land Availability**

Grazing land availability increases the asset of the household in forms of cattle.

**F. Endemic Plants**

More number of endemic species shows more resilient ecosystem.

**G. Resilient Species**

Availability of resilient species increases adaptive capacity of ecosystem.

## 2.3.4.2.2. Methods and Tools

**A. Data Source and Unit**

Secondary data on physical resources can be found in VDC, DDC and CBS publication, and other relevant publications. Primary data can be obtained from survey.

**B. Calculation and Ranking**

The data obtained from secondary and primary sources will be analyzed as per need and ranked as in table 19.

**Table 19: Indicators ranking**

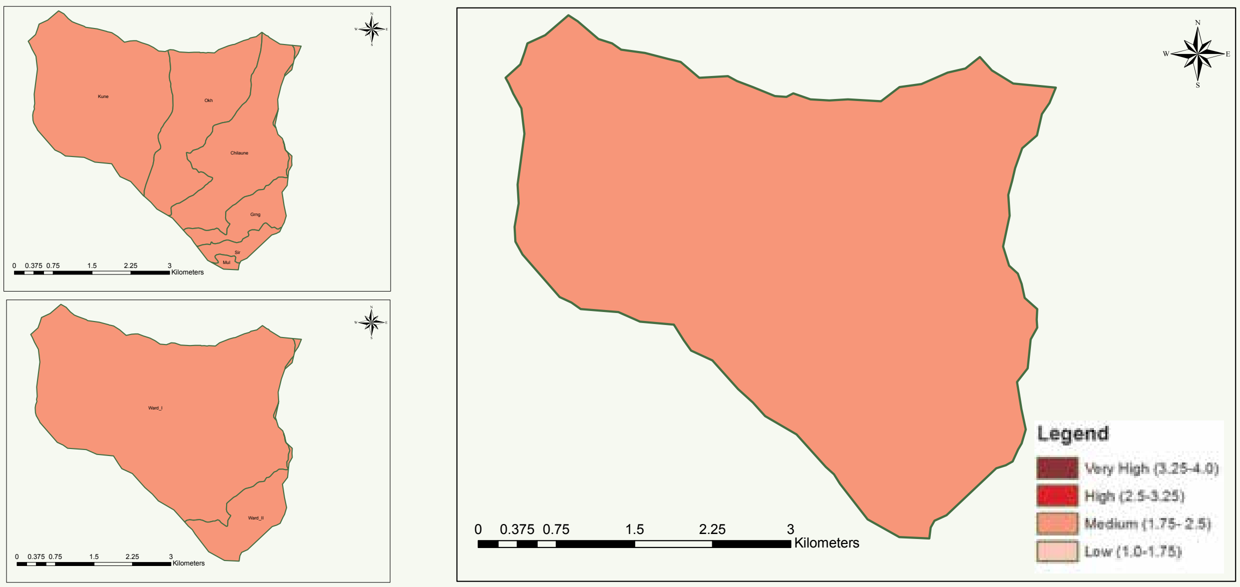
| Indicator | Rank | Remarks |
|---|---|---|
| Area | <20%=1; 20-30%=2; 30-40%=3 & >40%=4 | |
| Fodder availability | < 15% = 1; 15-30% = 2; 30-50%=3 & > 50% = 4 | |
| Fuel wood availability | < 15% = 1; 15-30% = 2; 30-50%=3 & > 50% = 4 | |
| NTFPs availability | < 15% = 1; 15-30% = 2; 30-50%=3 & > 50% = 4 | |
| Grazing land availability | < 15% = 1; 15-30% = 2; 30-50%=3 & > 50% = 4 | |
| Endemic plants | Up to 2 =1; 3-4 = 2; 5-7 = 3 and >7 = 4 | |
| Resilient species | <5%=1; 5-7%=2; 8-10%=3 & >10%=4 | |

Sensitivity component could be scored and calculated as given in table 20 (The data has been taken from VIA Methodology Field Validation at Shivapuri National Park- TU, CDES).

**Table 20: Scores of adaptive capacity of the Shivapuri Nagarjun National Park (Bagmati watershed)**

| Components | Indicators | Sites | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | K | O | C | G | S | M | Average |
| Adaptive Capacity | **Human Resources** | | | | | | | |
| | Population structure | 2 | 1 | 1 | 1 | 1 | 1 | 1.2 |
| | Education and literacy | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | Vulnerable HH to CC (% of HH) | 3 | 3 | 4 | 3 | 3 | 2 | 3 |
| | Employment (% of HH) | 4 | 4 | 4 | 4 | 4 | 1 | 3.5 |
| | Skill human resource (% of population) | 2 | 2 | 4 | 2 | 2 | 1 | 2.2 |
| | **Social Resources** | | | | | | | |
| | Formal and traditional institutions | 2 | 1 | 3 | 1 | 1 | 1 | 1.5 |
| | Service providers (No. of GOs, I/NGOs) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Access on various institutions | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | **Economic Resources** | | | | | | | |
| | Bank account (% of HH) | 2 | 1 | 1 | 1 | 1 | 3 | 1.5 |
| | Finance (No. of banks or cooperatives) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Agriculture land holding size (ha) | 1 | 1 | 3 | 1 | 1 | 1 | 1.3 |
| | Food sufficiency | 2 | 2 | 3 | 2 | 2 | 2 | 2 |
| | Disaster affected agriculture land (%) | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | Drinking water availability | 4 | 4 | 4 | 4 | 4 | 3 | 3.8 |
| | Energy source (Cooking) | 1 | 1 | 1 | 1 | 1 | 3 | 1.3 |
| | Energy (Lighting) | 4 | 2 | 3 | 2 | 2 | 4 | 2.8 |
| | Household type | 1 | 1 | 1 | 1 | 1 | 3 | 1.3 |
| | Information and communication | 4 | 4 | 4 | 4 | 4 | 3 | 3.8 |
| | **Water Resources** | | | | | | | |
| | Freshwater | 4 | 4 | 4 | 4 | 4 | 3 | 3.8 |
| | Irrigation water | 1 | 2 | 1 | 2 | 2 | 1 | 1.5 |
| | Drainage density | 2 | 2 | 2 | 2 | 2 | 3 | 2.2 |
| | **Forest Resources** | | | | | | | |
| | Area | 1 | 1 | 2 | 1 | 1 | 1 | 1.2 |
| | Fodder availability | 1 | 1 | 3 | 1 | 1 | 1 | 1.3 |
| | Fuelwood availability | 2 | 1 | 3 | 1 | 1 | 1 | 1.5 |
| | NTFPs availability | 2 | 1 | 1 | 1 | 1 | 1 | 1.2 |
| | Grazing land availability | 2 | 2 | 1 | 2 | 2 | 1 | 1.7 |
| | Endemic plants | 1 | 2 | 1 | 2 | 2 | 2 | 1.7 |
| | Resilient species | 1 | 1 | 1 | 1 | 1 | 2 | 1.2 |
| | **Physical Assets** | | | | | | | |
| | Physical infrastructures | 1 | 2 | 3 | 2 | 2 | 3 | 2.2 |
| | Construction materials availability and status | 2 | 1 | 1 | 1 | 1 | 3 | 1.5 |
| **Average** | | **2.1** | **1.9** | **2.3** | **1.9** | **1.9** | **2.0** | **2.0** |

**Figure 3:** Adaptive capacity of Bagmati watershed



# VULNERABILITY CALIBRATION AND INTERPRETATION

**Each value of vulnerability components i.e. exposure, sensitivity and adaptive capacity, calculated from assessments of the elements ranged between 1 and 4. Based on the ranking of the elements, vulnerability was calculated as follows:**

$$Vulnerability\ (\boldsymbol{V}) = \frac{Exposure\ (\boldsymbol{E}) \times Sensitivity(\boldsymbol{S})}{Adaptive\ Capacity\ (\boldsymbol{A})}$$

Thus calculated value ranges from 0.25 to 16. Based on the obtained value from the calculation, V is categorized as LOW, MEDIUM, HIGH and VERY HIGH as indicated in table 21.

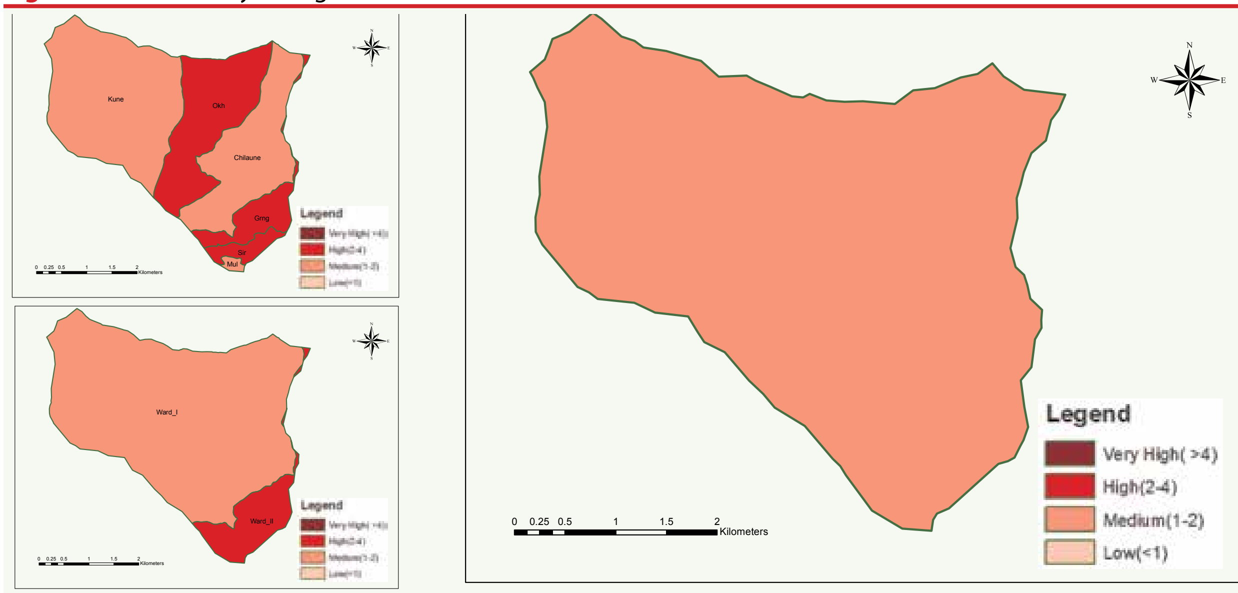
**Table 21: Vulnerability calibration**

| SN | Value of V | Vulnerability |
|---|---|---|
| 1 | ≤1 (One or below) | Low |
| 2 | 1 – 2 (Two or below, but greater than 1) | Medium |
| 3 | 2 – 4 (4 or below, but greater than 2) | High |
| 4 | >4 (Greater than 4 until the highest possible number, 16) | Very high |

**Table 22: Vulnerability calculation of Bagmati watershed**

| Components | Site | | | | | |
|---|---|---|---|---|---|---|
| | Kunegaun | Okhreni | Chilaunegaun | Gurungtol | Siranetol | Mulkhark |
| Exposure | 1.7 | 2.1 | 2.0 | 2.1 | 2.1 | 1.9 |
| Sensitivity | 1.9 | 2.1 | 1.7 | 2.1 | 2.1 | 2.0 |
| Adaptive capacity | 2.1 | 1.93 | 2.33 | 1.933 | 1.933 | 2.06 |
| Vulnerability | 1.4 | 2.5 | 1.5 | 2.3 | 2.3 | 1.9 |
| Rank | Medium | High | Medium | High | High | Medium |

**Figure 4:** Vulnerability of Bagmati watershed



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# Annex 1:

## Example of Questionnaire survey for the Focus Group Discussion

**Mulkhark-6 (Bagmati watershed)**

### Exposure

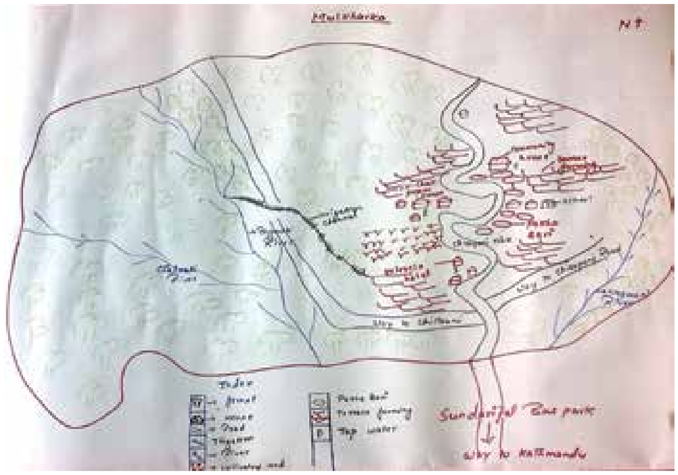
**A. Historical Timeline**

| Year | Hazard | Area/Place | Loss and damage | Community input to adapt the hazard | Government input |
|---|---|---|---|---|---|
| 2045 | Earthquake | Mulkharkha | Village and agricultural lands | Community help each other to build houses | Nothing has been done by rescue teams |
| 2056 | Hailstone | Mulkharkha | Loss of beans and potato fields | Not any input | Not any input |
| 2057 | Hailstone | Mulkharkha | Loss of maize field | Not any input | Not any input |
| 2062 | Hailstone | Mulkharkha | Agricultural lands | Not any input | Not any input |
| 2065 | Hailstone | Mulkharkha | Agricultural lands | Not any input | Not any input |
| 2068 | Hailstone, Diarrhoea | Mulkharkha | Agricultural lands | Treatment provided by health posts | For diarrhoea Zinc capsule were used in water |
| 2069 | Drought | Mulkharkha | Loss of paddy seeds | Tries to irrigate lands | Village development committee provides drought resistant seeds |
| 2070 | Hailstone | Mulkharkha | Loss of maize and millet | Not any input | Not any input |
| 2071 | Forest fire | Mulkharkha | No loss and damage | Not any input | Not any input |

**B. Climatic Hazard Ranking**

| Hazard | Landslide | Hailstorm | Drought | Forest fire | Epidemic |
|---|---|---|---|---|---|
| Landslide | × | Hailstorm | Drought | Forest fire | Epidemic |
| Hailstorm | × | × | Drought | Forest fire | Hailstorm |
| Drought | × | × | × | Drought | Drought |
| Forest fire | × | × | × | × | Forest fire |
| Epidemic | × | × | × | × | × |
| Scores | 0 | 2 | 4 | 3 | 1 |

## C. Climatic Hazard and Resource Mapping



## D. Livelihood Resource Assessment

**Livelihood Resource Assessment**

| | |
|---|---|
| **Natural Resource / Ecosystem Services**<br>Forest<br>Medicinal Plant<br>NTFPS<br>Wetland<br>Water Resources<br>Etc. | **Economic Resources**<br>Cash<br>Pension<br>Jewelries<br>Saving |
| **Physical resources**<br>Road<br>Drinking water (Tap, Tube well, Well)<br>Irrigation<br>Factories and industries<br>Market<br>Communication | **Human Resources**<br>Education<br>Health<br>Skill and Knowledge |
| Social resources<br>Social infrastructure<br>Social Organization | |

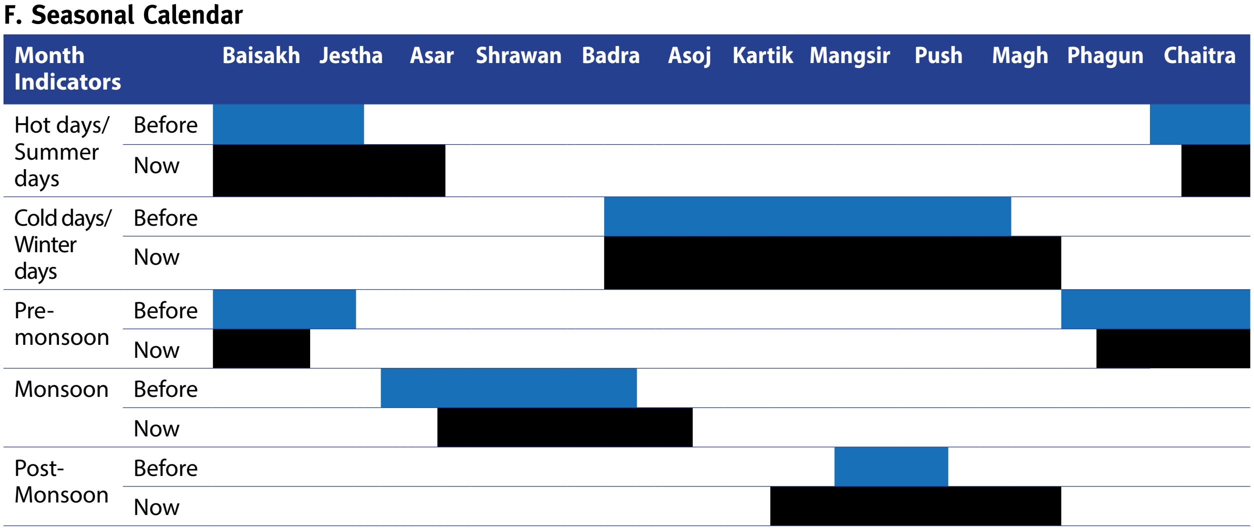
## E. Livelihood Resource Vulnerability Assessment

| Livelihood Resources | Drought | Hailstorm | Forest Fire | Thunderstorm |
|---|---|---|---|---|
| Natural Resources | | | | |
| Forest | 3 | 1 | 3 | 1 |
| Water Resources | 3 | 0 | 0 | 0 |
| Wetland | 2 | 0 | 0 | 0 |
| Medicinal Plant | 3 | 1 | 3 | 0 |
| NTFPS | 3 | 1 | 3 | 0 |
| Crops | 3 | 3 | 1 | 0 |
| **Economic Resources** | | | | |
| Saving | 0 | 0 | 0 | 0 |
| Cash | 1 | 0 | 2 | 0 |
| Jewelery | 0 | 0 | 2 | 0 |
| Pension | 0 | 0 | 0 | 0 |

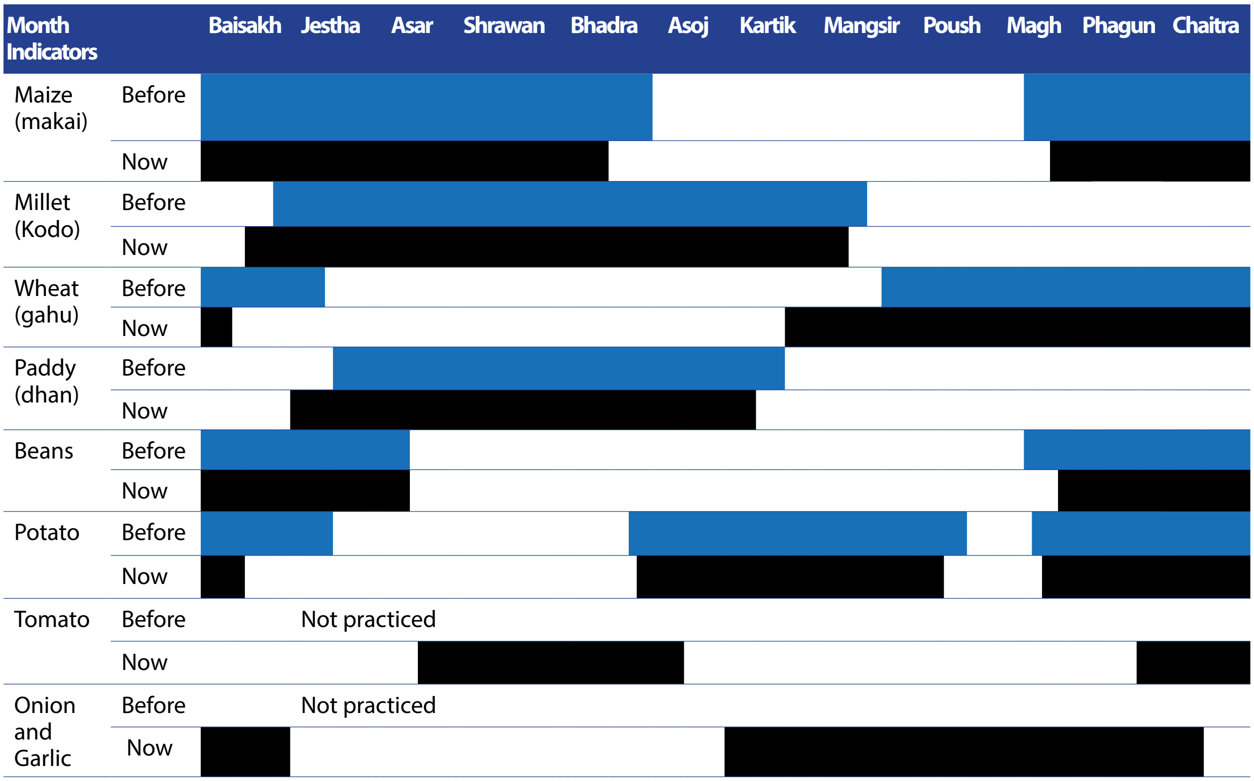
| Rating | |
|---|---|
| 0 | No effect |
| 1 | Less effect |
| 2 | Medium Effect |
| 3 | High effect |

| Livelihood Resources | Drought | Hailstorm | Forest Fire | Thunderstorm |
|---|---|---|---|---|
| **Physical Resources** | | | | |
| Houses | 0 | 1 | 3 | 0 |
| Road | 0 | 0 | 0 | 0 |
| Schools | 0 | 0 | 0 | 0 |
| Drinking water (Tap) | 3 | 0 | 0 | 0 |
| Electricity | 0 | 0 | 0 | 0 |
| Mobile | 0 | 0 | 0 | 0 |
| Dish Home | 0 | 0 | 0 | 0 |
| **Human Resources** | | | | |
| Teachers | 0 | 0 | 1 | 0 |
| Carpenter/ Mason | 0 | 0 | 0 | 0 |
| Government service | 0 | 0 | 0 | 0 |
| Social resources | | | | |
| Social health worker | 0 | 0 | 0 | 0 |
| Health post | 0 | 0 | 0 | 0 |
| Social organization | 0 | 0 | 0 | 0 |

## F. Seasonal Calendar



### G. Crop Calendar




## Sensitivity

### A. Invasive species

- *Bidens pilosa, Artemisia vulgaris, Ageratum conyzoides, Oxalis corniculata*

### B. Water resources

- *Kuwa, Tap water-Nagmati river ,Bagmati river and Kartike river, etc.*

### C. Agriculture

- *75% have agricultural land and the production of cultivated land sufficient only for 3 months*

## Adaptive Capacity

### 1. Human Resourse

A. Population structure/ Education and literacy/ Employment/ Skill Human resources

| SN | | F | M | Age | Education | Employment | Skill |
|---|---|---|---|---|---|---|---|
| 1. | Nima Sherpa | 3 | 4 | | +2 | Business | |
| 2. | Sunil Tamang | 1 | 2 | 1 | +2 Above | Agriculture | |
| 3. | DamberTamang | 3 | 2 | 3 | +2 Above | Agriculture | |
| 4. | BirBahadurGurung | 3 | 2 | 2 | +2 Above | Business | Driving |
| 5. | Sangden Sherpa | 4 | 7 | 2 | Upto SLC | Business | |
| 6. | SherBhadur Lama | 5 | 4 | 2 | +2 Above | Business | |
| 7. | Narayan Shrestha | 2 | 2 | 1 | +2 Above | Agriculture | |
| 8. | Gautam Lama | 2 | 2 | 3 | Upto SLC | Agriculture | |
| 9. | Jira Ram Lama | 3 | 3 | 4 | +2 Above | Agriculture | |
| 10. | BirBahadur Lama | 3 | 3 | 3 | +2 | Business | |
| 11. | Shanker Lama | 2 | 1 | 1 | Illiterate | Agriculture | Driving |
| 12. | Suman Lama | 1 | 2 | 2 | Illiterate | Agriculture | |
| 13. | Dawa Sherpa | 2 | 1 | 1 | +2 Above | Business | |
| 14. | BuddhiBahadur Lama | 2 | 2 | 3 | Illiterate | Agriculture | |
| 15. | SurendraShrestha | 2 | 2 | 1 | +2 Above | Business | |
| 16. | SeteTamang | 1 | 1 | 1 | Illiterate | Agriculture | |
| 17. | Dal BahadurTamang | 1 | 3 | 1 | Below SLC | Agriculture | |
| 18. | Suresh Nepali | 2 | 1 | 1 | Illiterate | Agriculture | |
| 19. | LalBahadurTamang | 4 | 5 | 3 | +2 Above | Job Holder | |

### 2. Social capital

A. Vulnerable Household to CC%

- NO

B. Formal and traditional institutions

- Women's Group ( Mulkharka): Most of the women are active member of Womens Group

C. Service Providers (No. of GOs, I/NGOs)

- There are no GOs and I/NGOs because the area lies within National Park

D. Access on Various institutions (provision for poor and disadvantage)

- NO

### 3. Economic resources

A. Bank Account

- YES

B. Number of Financial institutions

- nearby your area.-1(Mahilasamuha)

C. Agriculture land holding Size.

- In hectares 25-26 Ropani/each household (for rich/mukhiyaa)

D. Food sufficiency

- For 3 months

E. Disaster affected agriculture land

- No

F. Drinking water availability
- All households are provided with tap

G. Energy Source
- Fuel wood Rank 1
- LP gas Rank 2
- Electricity Rank 1

H. Household Type
- Mudstone
- Cement (Most of the houses are cemented n few are mixed of mud,)

I. Information and communication

| | |
|---|---|
| Mobile | Yes/No |
| Telephone | Yes/No |
| TV | Yes/No |
| Radio | Yes/No |
| Post Office | Yes/No |
| Internet Access | Yes/No |

J. Construction materials Availability and Status
- No

**4. Environment**

a. Water resources

A. Freshwater availability
- River
- Spring

B. Irrigation water availability
- Rainfed agriculture. As the area lie inside National Park, irrigational canal is prohibited though there is presence of sufficient water resources

C. Drainage density
- 3 rivers (Kartike ,Bagmati,Nagmati)

b. Forest and biodiversity

A. Fodder Availabity

a. How far do you go to collect the fodder?
- About 20 minutes

b. What is the time interval for fodder collection?
- Half an hour

c. Has the amount of the fodder increased/decreased?
- Decreased

B. Fuel wood Availability

a. How far do you go to collect the fuel wood?
- Nearly 45 minutes

b. What is the time interval for fodder collection?
- Half an hour

c. Has the amount of the fodder increased/decreased?
- Decreased

C. NTFPs Availability
- There are NTFPs available but they do not use NTFPs

D. Grazing land Availability

a. Is there any grazing land near by your area?
- Yes

b. Is the grazing land sufficient for your community?
- No

# Annex-2

**Species observed in the Bagmati watershed**

| SN | Species | IVI | Elevation (m) | Genera | From different literatures | Nepali name |
|---|---|---|---|---|---|---|
| 1 | Alnus nepalensis D. Don | 0.15 | 2047, 1550 | Alnus | 1463 | उतीस |
| 2 | Castanea indica Roxb. ex Lindl. | 10.21 | 2047m | Castanopsis | 1380 | ढाले कटुस |
| 3 | Syzygium cumini L | 14.46 | 1550m | Syzygium | | जमुना |
| 4 | Eurya cerasifolia (D. Don) | 0.26 | 2047m | Eurya | 2060-2200 | |
| 5 | Lyonia ovalifolia (Wall.) Drude | 0.26 | 1550m | Lyonia | 1780 | अंगेरी |
| 6 | Myrica esculenta Buch.– Ham. | 1.87 | 2047m | Myricaceae | 1463-1780/2300 | काफल |
| 7 | Prunus Cerasoides D. Don | 1.13 | 2047, 1550 | | 2450 | पैंयु |
| 8 | Pyrus pashia Buch.-Ham. ex D. Don. | 4.32 | 2047m | Pyrus | 1700-1900 | मयल |
| 9 | Quercus glauca Thunb. | 52.42 | 1550m | | 1900 | फलांट |
| 10 | Quercus lamellosa Sm. | 0.33 | 2047m | Quercus | 2121-2550 | ठूलो फलांट |
| 11 | Quercus semecarpifolia Smith | 92.19 | 2047m | Quercus | 3780 | खस्रु |
| 12 | Rhododendron arboreum Sm. | 0.5 | 2047, 1550 | Rhododendron | 1463-2750 | लाली गुराँस |
| 13 | Schima wallichii (DC) | 24.07 | 1550m | Schima | 1515 | चिलाउने |
| 14 | Taxus wallichiana Zucc. | 20.23 | 2047m | Taxus | 2500-2780 | लौंट सल्ला |

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