Draft Final report

Conduct a climate change risk and vulnerability assessment of agro ecological zones of Nepal and appraising climate change adaptation measures in agriculture

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Acknowledgement

First of all, we would like to convey our sincere gratitude to the Government of Nepal Ministry of Finance, United Nations Development Programme (UNDP), Food and Agriculture Organization of the United Nations (FAO) for taking the initiative of conducting climate change vulnerability and disaster risk assessment of agro-ecological zones and appraising the cost of *adaptation* solutions to address climate risks.

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We take this opportunity to thank the entire project team led by the National Project Director of Green Climate Fund Readiness Programme, Nepal and Project Management Unit- NAP-Ag project for their continuous support and guidance during the execution of the entire assignment.

Last but not the least, we would like to express our heartfelt gratitude to all the experts and team members who have helped in various ways for the completion of this assignment.

Acronyms

ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Center
AEZ	Agro-ecological zones
AF	Adaptation Fund
BFI	Bilateral Financial Institutions
CAPEX	Capital Expenditure
CBS	Central Bureau of Statistics
CDKN	Climate and Development Knowledge Network
CTF	Clean Technology Fund
DAEs	Direct Access Entities
DDRC	Disaster Risk Reduction Portal
DFIs	Development Finance Institutions
DoI	Department of Irrigation
DoLIDAR	Department of Local Infrastructure Development and Agricultural Roads
EbA	Ecosystem based Adaptation
FGD	Focus Group Discussion
ECBA	Economic Cost Benefit Analysis
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
GCF	Green Climate Fund
GEF	Global Environment Fund
GLOF	Glacial Lake Outburst Flow
GoN	Government of Nepal
KII	Key Informant Interview
LAPA	Local Adaptation Plans for Action
LDCF	Least Developed Country's Fund
MDGs	Millennium Development Goals
MFI	Multilateral Financial Institutions
MoALMC	Ministry of Agriculture, Land Management & Cooperatives

MoF	Ministry of Finance
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NDC	Nationally Determined Contributions
NIBL	Nepal Investment Bank Limited
NPR	Nepalese Rupee
NTNC	National Trust for Nature Conseravation
SDGs	Sustainable Development Goals
SAM	Sustainable Agriculture Management
SCF	Strategic Climate Fund
SCCF	Special Climate Change Fund
SFM	Sustainable Forest Management
SLM	Sustainable Livestock Management
SWM	Sustainable Water Management
TDF	Town Development Fund
UNDP	United Nations Development Programme
WACC	Weighted Average Cost of Capital

Glossary

- **Agro-ecological zones (AEZs):** AEZs may be defined as geographical areas exhibiting similar climatic conditions that determine their ability to support rained agriculture. At a regional scale, AEZs are influenced by latitude, elevation, and temperature, as well as seasonality, and rainfall amounts and distribution during the growing season (IFPRI, 2010).

- **CAPEX** - Represents the Capital Expenditure of a project. It is the initial investment required for implementing a project.

- **Climate:** Climate of an area or country is known as the average weather over a long period of time. It refers to the characteristic condition of the atmosphere deduced from repeated observations over a long period. More than a statistical average, climate is an aggregate of environmental conditions involving heat, moisture and motion. Climate studies must consider extremes in addition to means, trends, fluctuation, probabilities and their variations in time and space. Full potential of climate in agricultural resource has not been used or very often realized. It is inevitable to make adjustment with the weather to extract the maximum benefit from this resource. In this context, knowledge on agro-climatology of a region is a valuable tool in crop planning and Management.

- **Economic Internal Rate of Return (EIRR) -** Is the rate of discount at which the ENPV=0. This is the rate at which net economic benefits accrue from a project annually.

- **Economic Net Present Value (ENPV)** - Economic net present value is the measure of net economic gains accruing to the economy and society from a project over the entire economic life of the project. It is calculated as the present discounted value of net economic benefits (i.e. economic benefits – economic costs), discounted by economic opportunity cost of capital.

- **Ecosystem Based Adaptation (EbA) -** Climate change adaptation measures that are more aligned to the livelihood and have promising approaches to reduce social vulnerability for sustainable and efficient adaptation to climate change. EbA is a part of an overall adaptation project and takes into account multiple social, economic and cultural co-benefits for the local communities. It encompasses adaptation policies and measures that take into account the role of ecosystem services in reducing societal vulnerability, through multi-sectoral and multi-level approaches. (Andrade, et al., 2012).

- **Extended Cost Benefit Analysis (ECBA) -** An Extended Cost-Benefit Analysis (ECBA) is a special tool (for economic analysis of project[1]s) that captures the range of economic, social and environmental impacts together with factoring in external costs and benefits, if any, throughout the life of the project, to arrive at an overall 'net impact' of the intervention. The results are used to facilitate an informed and sound decision making (GGGI, 2014).

- **Financial Net Present Value (FNPV)** - Is the present discounted value of the net cash flow from a project over the entire economic life of the project. The net cash flow is equal to the difference between cash inflow and cash outflow. A suitable discount rate, expressed as the percentage per annum, is used to discount the net cash flows to arrive at the FNPV.

- **Financial Internal Rate of Return (FIRR)** - Is the discount rate at which the FNPV=0. It is a metric used in capital budgeting to ascertain the profitability from projects over its economic life.

- **Hurdle rate** - Is the targeted internal rate of return for the entity implementing the project. In other words, it is the anticipated rate of return from the project.

- **Watershed:** A watershed is an area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel. The word watershed is sometimes

[1] The word "project" in this document means any climate change adaptation and /or mitigation intervention

used interchangeably with drainage basin or catchment. Ridges and hills that separate two watersheds are called the drainage divide. The watershed consists of surface water--lakes, streams, reservoirs, and wetlands--and all the underlying ground water. (USGS, 2016)

- **Weighted Average Cost of Capital (WACC)** - Is calculated as the weighted average of the costs of debt and equity, weights being proportional to the share of debt and equity in the capital structure designed to finance the project.

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Executive summary

The Green Climate Fund (GCF) is a global fund established within the framework of the United Nations Framework Convention on Climate Change (UNFCCC) to assist developing countries in implementing adaptation and mitigation practices to counter the impacts of climate change. The objective of GCF is to "support projects, programmes, policies and other activities in developing country Parties using thematic funding windows"

The investment by GCF is based on the assessment of the six key criteria namely, 1) Impact potential, 2) Paradigm shift potential, 3) Sustainable development potential, 4) Responsiveness to recipient's needs, 5) Promote country ownership and 6) Efficiency and effectiveness. The methodology used for calculating the indicators against each criterion and the corresponding values may be provided as a part of the funding proposals for individual adaptation and or mitigation measures. The project proponents may complement the quantitative indicators with the qualitative ones. However, not all indicators are applicable to all adaptation/mitigation activities and the funding proposals are to focus only on those relevant to the proposal, country context and the priorities of GCF that the project focusses upon.

With Government of Nepal (GoN) deciding on accessing funds from GCF (and other allied institutions) it is important that the Government embarks upon designing policies and institutions to increase its readiness to access such funds and maximize the benefits from utilization of such funds. The facilities from GCF are attached with specific objectives. Accordingly, the existing policies of GoN need be reformed or new policies need to be designed to address such specific objectives. This requires the Government to roll-out a comprehensive and effective investment framework with strategies aligned to the objectives of such funds.

This report has been developed to demonstrate the process of developing a GCF investment proposal for Agro-ecological Zones through case studies of the pilot watershed – Mugu Karnali, Lohare and Babai representing the three existing ecological zones of Nepal namely Mountains, Hills and Terai respectively.

Identification of adaptation measures was carried out as part of this assignment and was based on scientific, GIS based spatial analysis of climate change risks and vulnerability in the pilot districts in line with the framework proposed in Nepal's National Adaptation Plan (NAP) and as per the definition of climate change risk provided by the 5th Assessment Report of Intergovernmental Panel on Climate Change (IPCC-AR5). The identified adaptation measures (Sustainable Agriculture Management, Sustainable Water Management, Sustainable Livestock Management and Sustainable Forest Management) were validated through field surveys in the districts of Mugu, Dailekh and Bardiya for developing a case study. Subsequently, the feasibility of the measures were assessed based on the environmental and social impacts, gender inclusivity, sustainability and scalability of the measures. While assessing the feasibility of the measures emphasis was put on the fact if the adaptation measures could be categorized as Eco-System Based Adaptation (EbA) i.e., if the adaptation measures are aligned to the livelihood and take into account the role of ecosystem services in reducing societal vulnerability, through multi-sectoral and multi-level approaches. Once the feasibility of measure were ascertained, a thorough Cost Benefit Analysis (CBA) was carried out on all identified measures for their prioritization.

As part of this assignment, a training manual has also been developed to guide and facilitate the functionaries of Ministry of Agriculture Land Management and Cooperatives (MoALMC) & related line departments/ stakeholders who would be involved in developing project proposals for GCF. This final report is a consolidation of the sub-deliverables that were submitted to the NAP-Ag team during the course of the assignment.

This final report has been structured in a way to present the background to the assignment, details of the methodologies adopted for the various analysis such as identification of watersheds, delineation of agro-ecological zones in the watersheds, vulnerability assessment/ cost benefit assessment, results of vulnerability assessment, cost benefit analysis, stock-taking of the existing climate change/ associated policies & functional modalities to capture the entry points for GCF proposal development process. Finally, a strategic investment framework has been prepared,

that presents key considerations related to project financing, policy and departmental restructuring required to facilitate GCF funding for Govt. of Nepal. The Strategic Investment Framework (SIF) was prepared keeping in mind the outcomes of the CBA analysis and the short. Medium, long term returns of the identified adaptation measures. The investment framework was also based on a series of consultations with policy makers, regulators at various Ministries and discussions with financial intermediaries and civil service organizations.

1. Background

Nepal's political and economic scenario has been in a state of transition over the last couple of years due to frequent change in Government, thereby causing changes in the policy outlook. Due to this transitory nature, effective long term investment planning was limited in the Country. However, given the adoption of a new Constitution and an enabling federal structure of the Government, Nepal is well poised to adopt elements of climate financing in its departmental programmes, planning and budgeting process. This would not only facilitate an investment grade policy regime but is also expected to bolster the GoN's constrained resources for climate and developmental projects.

The assignment aims at developing national capacities of Nepal to identify, prioritize and appraise the costs of adaptation options in Agro-ecological Zones (AEZ) that would lead to reduction of climate-induced disaster risks. For the purpose of the assignment three pilot districts Mugu, Dailekh and Bardiya have been selected that fall in three ecological zones of the country namely, Mountains, Hills and Terai respectively.

Due to climate change, the communities residing in agro-ecological zones and dependent of agriculture and allied systems are expected to face extreme weather events like downstream flooding, intense rainfall episodes and shifting monsoons. Such communities are especially vulnerable to climate change because they are dependent on ecosystem services for their livelihoods and survival. Given the urgent need for adaptation, paucity of funds and the suitability to local conditions, eco-system based adaptation (EbA) is being seen as an answer to increasing climate change related risks posed to these communities. EbA is the conservation, sustainable management and restoration of natural ecosystems to help people adapt to climate change (UNEP, 2018). A number of EbA initiatives have been launched by UNDP, MoFE (formerly MoPE), The Mountain Institute and IUCN in Nepal and this project is a part of UNDP's initiatives. The scope of the assignment entails the following steps:

Table 1: Scope of the Assignment

S. No.	Steps	Outcome
1	Selection of watersheds in the pilot districts	Well-defined watersheds in the pilot districts with clear delineation of their boundary and climatic characteristics
2	Identification of AEZs within the watersheds	Delineation of AEZ boundaries based on Agro-Climatic and Agro-Edaphic Zones
3	Climate change risk assessment as per framework followed in National Adaptation Plan in line with the 5th Assessment Report of intergovernmental Panel on Climate Change at watershed level based on Arc GIS	Spatial distribution of climate change risks at the watershed level for different hazards
4	Interpretation of climate change risks at AEZ level	Identification of climate change risks and impacts for each AEZ
5	Validation of climate change risks and understanding of coping mechanisms from field interaction with local stakeholders	Identification of adaptation measures based on step 3,4 and 5 for the AEZs
6	Environmental, social impacts and gender assessment of identified adaptation measures	Proposing adequate measures for mitigating adverse environmental, social and gender impacts if any for the identified adaptation measures

S. No.	Steps	Outcome
	Assessment of the adaptation measures in the light of the UN criteria for Ecosystem Based Adaptation (EbA)	Justifying the EbA criteria for the identified adaptation measures.
7	Cost benefit analysis of the adaptation measures	Prioritization of adaptation measures based on cost benefits
8	In-depth consultation with policy makers, planning bodies , private and public financing institutes around the policy, institutional and financing arrangements of the identified adaptation measures	Development of Strategic Investment Framework with an aim towards development of an enabling policy, institutional and investment environment to accessing Green Climate Fund (GCF)

The consideration for climate financing objectives, for e.g. as stipulated by global funds like the Green Climate Fund (GCF) could be ingrained in the business-as-usual processes for climate change/ development project design/evaluation, financing, implementation and monitoring. Any GCF funding proposal is expected to meet certain key investment criteria as laid down by the fund (fig 1).

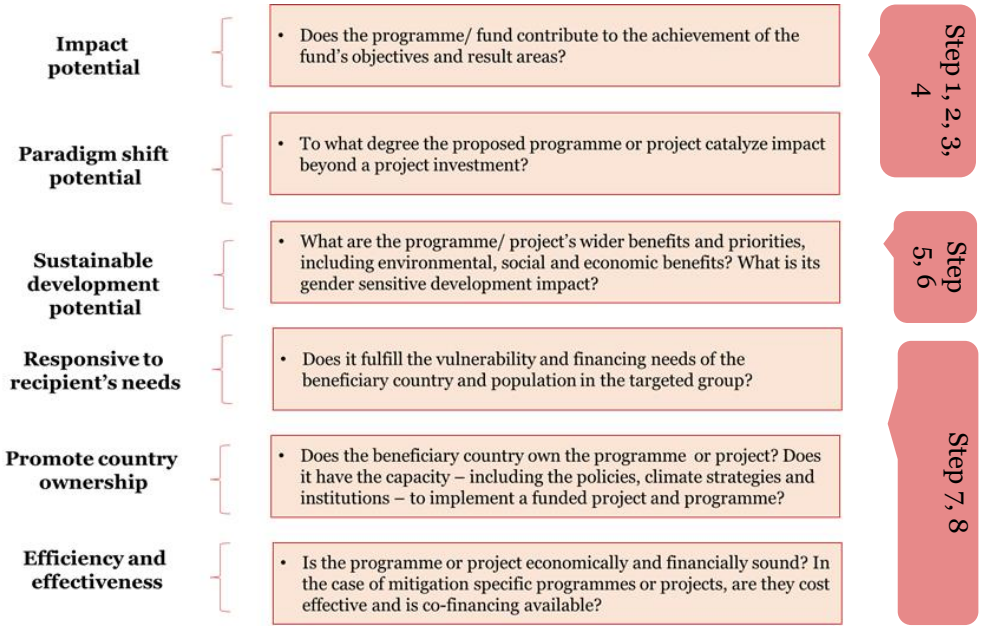


Figure 1: Investment criteria of GCF

Therefore, adequate consideration for each of the above criteria can essentially form a part of the Government's decision making process. However, to achieve the above, each project has to undertake a set of activities as part of the GCF proposal development process. It is a step wise activity, starting from a scientific assessment (vulnerability assessment in this case) to identify the climate induced vulnerabilities/ developmental needs of the society to Cost-Benefits Analysis of the identified interventions followed by developing an investment plan. There are number of sub-steps (or smaller activities) that are subsumed under the broader activities and the same is presented in the chart below.

All these steps were carried out keeping in mind the six investment criteria of GCF as presented in Figure 1 to ensure that for each of the identified and prioritized adaptation measures in the assignment a GCF proposal may be developed in future to access the Fund for implementation of the measures.

With this background, the objective of the present study was to demonstrate the process of and steps involved in developing a GCF investment grade project proposal through case studies (in this case the pilot watershed – Mugu Karnali, Lohare and Babai). This final report is consolidation of the sub-deliverables submitted as part of this assignment and presents and overall approach to developing a GCF investment proposal.

1.1. Detailed scope of the assignment

The key overall objectives of the assignment were to:

1. **Identify and appraise adaptation options for agricultural practices** in agro-ecological zones in the pilot watersheds – Mugu Karnali, Lohare and Babai based on their incremental cost/benefits, taking into account climate change.

2. **Prioritize adaptation measures in agriculture** to reduce climate risk and climate change-induced disaster risks, in the context of current agricultural practices and strategies as well as valuation of watershed ecosystem services.

3. **Prepare an Investment Framework** for the prioritized, most viable agricultural adaptation options that are congruent to GCF investment criteria and Nepal National Adaptation Plan (NAP) priorities.

4. **Strengthen capacities within MoALMC and local governments** to make use of tools such as applied economic valuation of ecosystem support services and cost benefit analysis as a means to evaluate and prioritize agricultural CCA options.

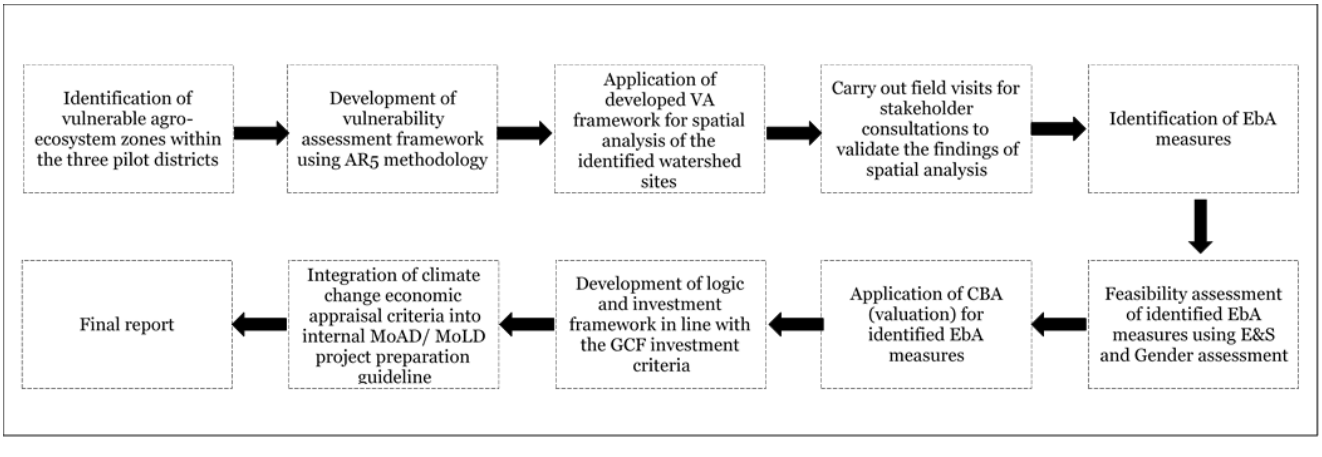


Figure 2: Activities carried out as part of the study

2. Methodology

Agro-ecological Zones (AEZs) highly vulnerable to climate change and climate-induced natural disasters based on the vulnerability assessment indicators across the river basins covering each of the three pilot districts namely Dailekh, Bardiya and Mugu. To study the climate change risk impact on the AEZs, the watershed concept is adopted.

Nepal has a varied climate mainly due to presence of valleys and high altitude mountain ranges transitioning within a short distance. Climate risk assessment studies carried out by Asian Development Bank (ADB) indicated three major risks for the country- i) threat to quantity and quality of water ii) impacts on agricultural yield and food security iii) threat to biodiversity and natural resources. Below is an assessment of predictions made by different climate models till 2030, 2050 and 2080.

Table 2: Climate scenarios for Nepal

Climatic phenomenon	Projection	Impact
Rainfall	Intensify (but highly uncertain due to altitude variation)	• Increased extreme events, flood, landslides
Temperature	Rise	• Water scarcity, alteration in vegetation pattern in high altitude • Increased invasive species in forests • Increased incidence of forest fire • Increased burden of vector borne diseases
Retreating glaciers, glacier melt	Increase	• Reduced flow of water for agricultural use • Flash floods due to Glacial Lake Outburst Flood

Agriculture is a major sector of the country's economy. The sector depends on water sourced from snow, ice, and glacial melt. Due to retreating glacier, the prospects of reduced water supply during the dry season are becoming imminent, posing long term threat to the sector. Also, increased temperature and rainfall variability have resulted in shifts in Nepal's agro-ecological zones, prolonged dry spells, and higher incidence of pests and diseases. (Ahmed, 2014)

The present assignment is a natural extension of activities already being carried out by UNDP in agro-ecological zones of Nepal. UNDP is implementing EbA in the watersheds of Harpan in Panchase area, identified as a hotspot due to severe impacts of climate change observed in terms of water scarcity, pest infestation in crops, the area's proximity to Phewa lake (a Ramsar site) and the diversity of orchid species in the region.

UNDP considers Ecosystem based Adaptation (EbA) in the watersheds of Nepal as one of the most appropriate solutions to some of these climate change adversities as it is more aligned to the livelihood and the EbA options are promising approaches to reduce social vulnerability for sustainable and efficient adaptation to climate change. Moreover, EbA is a part of overall adaptation and takes into account multiple social, economic and cultural co-benefits for local communities. It encompasses adaptation policies and measures that take into account the role of ecosystem services in reducing societal vulnerability, through multi-sectoral and multi-level approaches. (Andrade, et al., 2012). In the current study, the focus will be given on integration of EbA approaches in climate change adaptation measures. The core principles of EbA approach can be a foundation for considering EbA in overall policy making and planning and they build on the Cancun Adaptation Framework Principles established at the UNFCCC COP16. The key aspects of EbA principles include:

- **Is about promoting the resilience of both ecosystems and societies:** ensuring that local stewardship enhances both livelihoods and ecosystem management

- **Promotes multi-sectoral approaches, and will ensure:** cooperation across multiple levels and sectors to avoid conflicting priorities and mandates
- **Operates at multiple geographical scales:** landscape-scale approaches and impact assessments are important to identify cumulative and indirect drivers of vulnerability
- **Integrates flexible management structures that enable adaptive management:** decentralized management to the lowest appropriate level to foster greater efficiency, effectiveness, equity and ownership
- **Minimizes tradeoffs and maximizes benefits with development and conservation goals to avoid unintended negative social and environmental impacts:** participatory planning, recognizing the needs of the poorest and most vulnerable is essential. Current vulnerabilities and needs for resources and development need to be balanced with the preparation for longer-term climate change impacts, which take into account the limits of ecosystem functioning and the varying temporal scales and lag effects of ecosystem processes
- **Is based on the best available science and local knowledge, and should foster knowledge generation and diffusion:** agencies implementing EbA should facilitate networks to ensure that information is regularly updated and provided in easily usable forms, and that the media used for knowledge sharing are culturally appropriate and understandable
- **Is participatory, transparent, accountable, culturally appropriate and actively embracing equity and gender issues:** planning should focus on equality and the special needs of marginalized social groups and promote active, free, meaningful and full participation of stakeholders

Some of the key considerations for EbA approach (Best Practices on Planning, Implementing and Monitoring & Evaluating Ecosystem-based Adaptation to climate change):

- EbA measures lack proof of their effectiveness. Hence, conventional grey infrastructure, already known, is often favoured by decision-makers. Furthermore, there is an already established market-system for the construction and implementation of hard/grey infrastructure, while only few implementing agencies and constructing companies are engaged in EbA measures.
- Knowledge about the EbA approach, risks and impacts of climate change as well as the interaction of climate change and ecosystems needs to be disseminated among decision makers and public administration technicians. The capacity building about the EbA concept must be fed with action and real implementation to demonstrate the effects of the measure
- The EbA approach considers human beings as the focal point. Therefore, the involvement of the civil society and the acceptance of the EbA measures by the civil society are crucial for a successful implementation of EbA measures and for upscaling pilot measurements.

The subsequent sections discusses the methodologies applied for each of the key activities/ steps carried out as part of this study.

2.1. Selecting watersheds as the unit of analysis

For the purpose of this study three pilot districts Mugu, Dailekh and Bardiya, which fall in three geographic zones of the country namely, Mountains, Hills and Terai respectively, were selected. However, there was a stronger case for treating watersheds as the unit of study for this assignment instead of political/administrative units. The reasons for this are enunciated below:

- There are direct linkages between upstream and downstream regions, within watersheds, in various geo-physical, socio-economic, and other morphometric aspects.
- The social conditions and livelihood of people are more related within watershed boundaries than within political boundaries.
- Climate change impacts could be more effectively analysed within watershed boundaries than within political boundaries.

- Besides direct rainfall, the major source of water for agriculture in the three districts are the rivers flowing through them.
- Any agro based structural intervention (e.g. check dams) at upstream of watershed is beneficial to downstream of the watershed.
- Water availability for agriculture depends on ecological and biodiversity condition of the upstream of watershed.
- Major disasters such as flood and drought disaster risks, could be more effectively mitigated through interventions in the upstream areas of a watershed.

However, a watershed boundary may not necessarily align with the political/ administrative boundaries. From the point of view of this study, this implies that one watershed may cover more than one district and may range beyond the pilot districts chosen for the current study. Additionally, it was noted that smaller watersheds (with area <1000 sq.km) may not provide an actual representation of the entire district and therefore a reasonable size of watershed (>= 1000 Sq.km) that has maximum coverage in these three districts should to be considered. Keeping such factors in mind, the following criteria were identified for selecting a reasonable sized watershed:

- The river basin selected should be of significance for agricultural purpose as majority of the population in these districts are dependent on agriculture.
- Perennial and most significant rivers from agricultural perspective should be considered
- Watershed that could intervene at upstream for the agro benefit in a district
- Rivers that could be used for gravity flow advantage so that they provide direct benefit to the districts

Considering the above factors, the regions of the three river systems, Babai, Lohare and Mugu Karnali that lie within the three pilot districts for the present study - Bardiya, Dailekh and Mugu – were selected. The districts and the selected watersheds are presented in the figures below. It can be observed that while the Lohare watershed of Dailekh district lies within the district boundaries, the rivers systems of Mugu Karnali and Babai encompass more than one districts. However, for the study, as already mentioned earlier, only the regions of the watersheds that lie within the administrative and political boundary of the districts as per the new federal system has been considered.

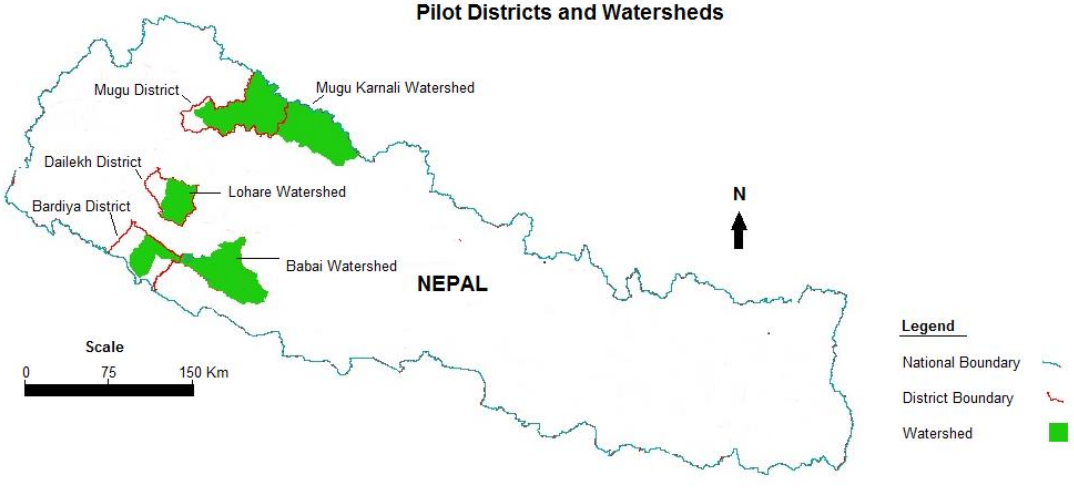


Figure 3: Watersheds and pilot districts

The watersheds are situated in different Physiographic zones of Nepal. While, the Mugu Karnali and Lohare watersheds are situated in the mid-western region of Nepal, Babai Watershed is situated in the mid-western part of Nepal. Post the Constitutional Administrative changes in Nepal, the Mugu Karnali and Lohare watersheds now lie inside province No 6, while the Babai watershed lies within province no 7. The watersheds and the new administrative boundaries are shown in Figure 3. The watershed size and altitudinal location is shown in Table 2. The population distribution across the watersheds is not uniform. It is observed that the district headquarters lying within the watersheds are heavily populated and areas farther away from the headquarters are thinly populated. The location of watersheds in physiographic zones is shown in Figure 5 and the population distribution of the watersheds is shown

in Figure 4. As watersheds lie in different geographies and at different altitudes, the climatic trends observed in these regions differ. The geographic orientation of watersheds, non -uniform rainfall distributions, road accessibility, and rugged mountain terrains play a crucial role in shaping the livelihoods of those residing in these watersheds. Since they are located in different physiographic regions, the land use practices are vary across the three watersheds. While the Babai watershed is rich in terms of arable land, the land in Mugu Karnali watershed, on the other hand, is mostly covered with snow and glaciers. The land cover map of the watersheds is shown in Figure6.

Table 3: Details of Watersheds

Selected watershed	Districts covered	Elevation range (m)	Area (Sq km)
Mugu Karnali	Mugu and Dolpa	1900 to 6859	5780
Lohare	Dailekh	1060 to 3300	1015
Babai	Bardiya, Dang and Salyan	130 to 2015	3550sq

Watersheds & Administrative Boundary:

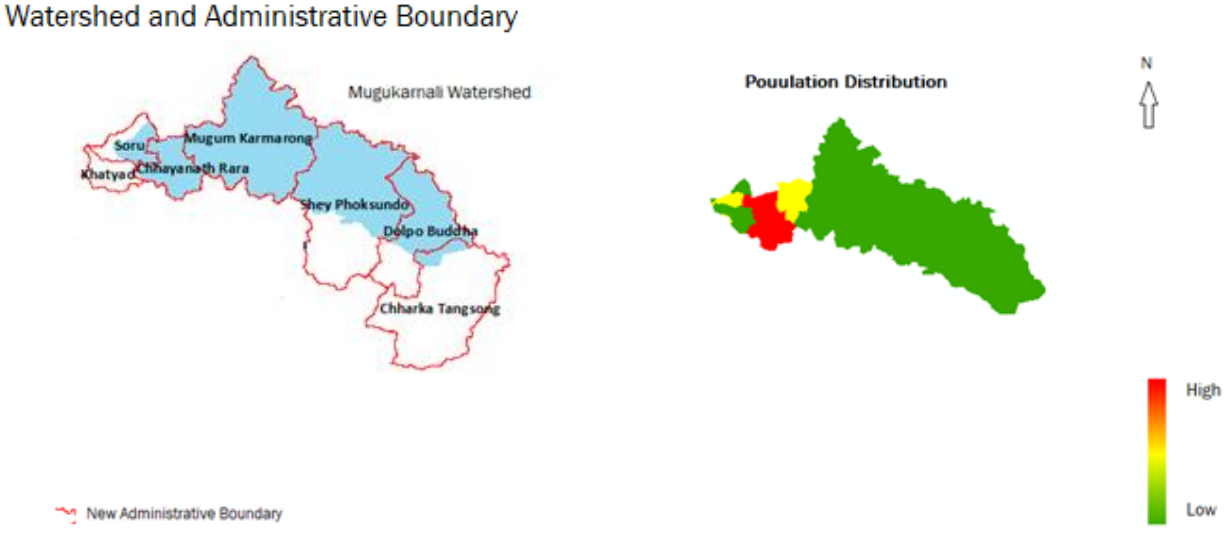


Figure 4: Administrative boundary and population distribution Mugu Karnali watershed

Figure 5: Administrative boundary and population distribution Lohare watershed

Figure 6: Administrative boundary and population distribution Babai watershed

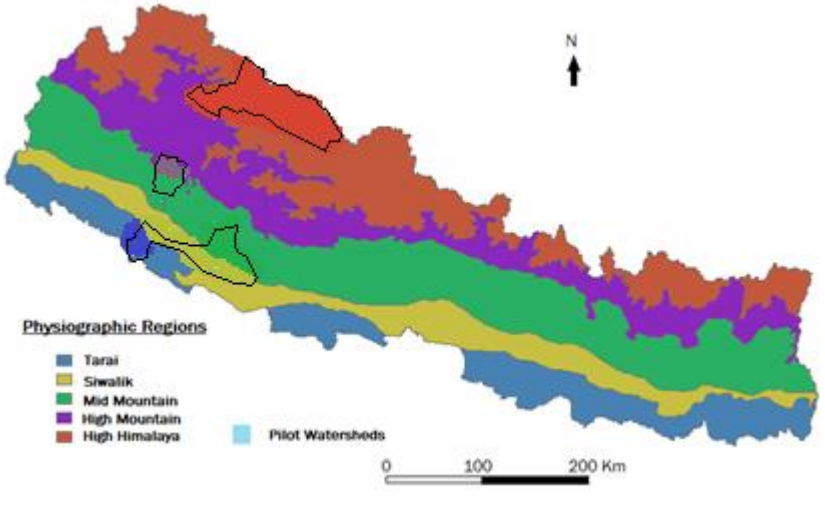


Figure 7: Pilot Watersheds & Physiographic Zones of Nepal (Megh Raj Dhital, 2014)

2.1.1. Climatic and Agricultural characteristics of the Watersheds

Since the three pilot watersheds are located in different physiographic regions with contrasting climate, the climatic trends and the agriculture trends of the watershed were reviewed and is presented in this section.

Climate Trend: The observed climatic trends from DHM (Department of Hydrology and Meteorology, 1997-2012) were reviewed and extracted for the three watersheds. The data that was available with DHM is at the district level.

However, as the Mugu Karnali and Babai watersheds boundaries do not align with the district boundaries, for the purpose of this study, the climatic trends were analyzed for those districts that lie in the watersheds.

The climate trends in the Mugu Karnali watershed shows an increase in both cold and warm spells. In the case of agricultural areas, temperatures trends exhibit an increase, while monsoon rainfalls present a decreasing trend. The number of rainy days show an increasing trend (Table 3). In Lohare watershed the cold and dry spells are similar to Mugu Karnali watershed but the rate of temperature increase is lower and monsoon rainfall is increasing as compared to Mugu (Table 4). An interesting trend is observed in the lower reaches of the Babai watershed (Bardiya district), where annual and monsoon precipitation trends are increasing at 6 to 8 mm/year. This implies that there will be 60 to 80 mm more rainfall in a decade's time. But upstream districts (Dang and Salyan) have negative trends in monsoon and annual precipitation. The increase in temperature in Babai watershed is lesser as compared to Lohare and Mugu Karnali watersheds.

The trends reflect an increase in many climate parameters which may pose a threat to the watersheds in the future.

Table 4 : Observed Climate Trends in Mugu Karnali and Lohare Watershed (Department of Hydrology & Metrology, Nepal, 2017)

Observed Climate Trend	Mugu Karnali Watershed		Lohare Watershed
	MUGU District	DOLPA District	DAILEKH
Annual precipitation trend	-1.9 to 0 mm/year	+0.1 to 2 mm/day	+0.1 to 2 mm/day
Monsoon precipitation trend	-1.9 to 0 mm/year	+0.1 to 2 mm/day	+2.1 to 4 mm/day
Winter precipitation trend	+1 to +2 mm/year	-1.9 to 0 mm/year	+1 to +2 mm/year
No of Rainy Days	+ o.91 to + 1.2 day/year	+ 0.31 to + 0.6 day/year	+ o.91 to + 1.2 day/year
Maximum Temperature Trend	+0.07 to + 0.09 ^{o}C/year	+0.07 to + 0.9^{o}C/year	+0.04 to + 0.06 ^{o}C/year
Minimum Temperature Trend	-0.02 to 0.0^{o}C/year	-0.02 to 0.0^{o}C/year	-0.02 to 0.0^{o}C/year
Cold spells duration	+0.1 to +1 day/year	+0.1 to +1 day/year	+0.1 to +1 day/year

Table 5: Observed Climate Trend in Babai Watershed (Department of Hydrology & Metrology, Nepal, 2017)

Observed Climate Trend	Babai Watershed		
	BARDIYA	DANG	SALYAN
Annual precipitation trend	+6.1. to 8 mm/day	-3.9 to -2 mm/day	-1.9 to 0 mm/year
Monsoon precipitation trend	+6.1. to 8 mm/day	-1.9 to 0 mm/year	-1.9 to 0 mm/year
Winter precipitation trend	+1 to +2 mm/year	+1 to +2 mm/year	+1 to +2 mm/year
No of Rainy Days	+ o.91 to + 1.2 day/year	+ o.91 to + 1.2 day/year	+ o.91 to + 1.2 day/year
Maximum Temperature Trend	+0.01 to + 0.03 ^{o}C/year	+0.04 to + 0.06 ^{o}C/year	+0.04 to + 0.06 ^{o}C/year
Maximum Temperature Trend	+0.01 to +0.03^{o}C/year	+0.01 to +0.03^{o}C/year	+0.01 to +0.03^{o}C/year
Cold spells duration	+0.1 to +1 day/year	+0.1 to +1 day/year	+0.1 to +1 day/year
Warm spells duration	+0.1 to +1 day/year	+0.1 to +1 day/year	+0.1 to +1 day/year

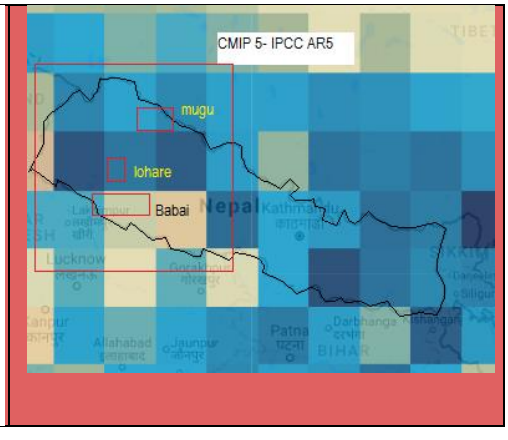
Climate Scenario: NAP proposed two future projection periods: medium and long-term. The medium term (2015–2045) representing 2030, and long-term (2035-–2065) representing 2050. (Synthesis of Stocktaking Report for National Adaptation Plan (NAP) Formulation Process in Nepal, 2017) This study acquired climate change projection parameters based on CMIP5 of 5th Assessment Report of Intergovernmental Panel on Climate Change (IPCC AR5), which was taken from the World Bank Climate Change Knowledge Portal. (Climate Change Knowledge Portal, 2018)

On this portal, future climate information is derived from 35 available global circulation models (GCMs) used by the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report. Data is presented at a 1°x1° global grid spacing, which is produced through bi-linear interpolation. The period available in this portal is 2020-2039 and 2040-2059, 2060-2079 and 2080-2100.

For general climate change study simple three points lying within three watersheds were selected and extracted for monthly temperature changes. It shows the temperature changes will be sharp and it is almost 2 folds between 2020-2039 and 2040-2059 Table 5.

Table 6: General Climate Change Study

	Location 29.01 N , 81.7 E , Mugu		Location 28.97N 81.6 E- Dailekh		Location 28.29 N 81.37 E- Bardiya	
Months	2020-2039	2040-2059	2020-2039	2040-2059	2020-2039	2040-2059
Jan	0.85	2.16	0.9	1.71	0.48	1.49
Feb	1.05	1.67	0.83	1.4	0.38	1.1
Mar	1.39	2.1	1.49	2.05	0.92	1.68
Apr	1.75	2.27	1.27	1.8	0.79	1.58
May	1.89	2.23	1.45	1.62	0.92	0.91
Jun	0.72	1.39	1.06	1.61	0.58	0.99
Jul	0.95	1.5	0.78	1.19	0.48	0.46
Aug	1.1	1.6	0.87	1.19	0.31	0.76
Sep	0.94	1	0.84	1.09	0.26	0.64
Oct	0.71	1.18	0.74	1.35	0.07	0.76
Nov	1.33	1.9	0.96	1.55	0.26	0.85
Dec	0.29	1.68	0.43	1.3	0.13	0.89



Source: IPCC AR5-CMIP5-RCP 4.5-miroc_esm

Watershed Agriculture: The watersheds are situated in different climatic zones. The land cover maps Figure 8 shows Babai and Lohare watersheds as rich in forest and agriculture ecosystem and Mugu Karnali as rich in snow, glacier and rangeland. The district level Agriculture data was collected from agricultural statistics published by CBS 2015. Since only district level detail is published, the agriculture of watershed is presented in terms of districts contributing to watersheds. The crops grown is shown in Table 6. The major crop of Mugu Karnali watershed is potato followed by millet. In the Lohare watershed, paddy is the main crop followed by wheat. In the Babai watershed, the plain areas of Bardiya grow paddy and potato intensively. However, in the upstream area, maize, paddy and wheat are the major crops grown. Beside these major crops, other crops such as barley, pulses are also grown.

The detailed trends of agriculture is presented in Annexure 2. The agriculture production as well as cultivating land in all watersheds are in increasing trend . The livestock is also in increasing trend but birds are in decreasing trend.

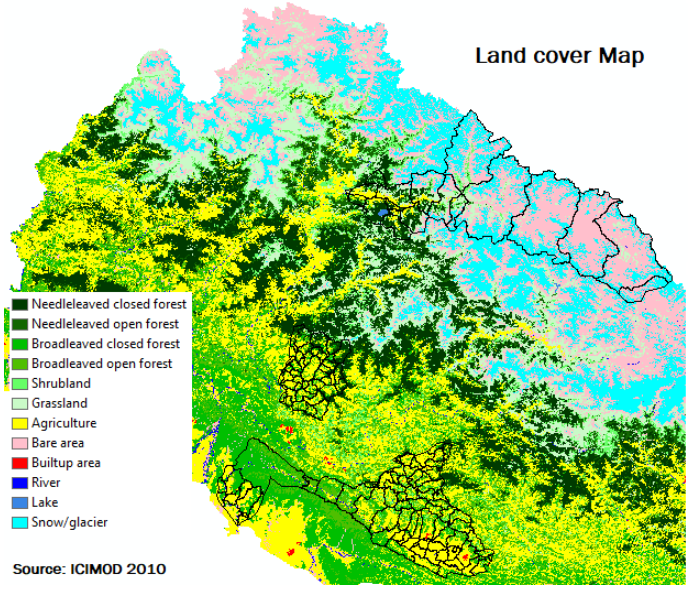


Figure 8: Land cover map of the watersheds

Table 7: Agriculture in the Watersheds (Source: MoAD, 2017)

	MUGU	***DOLPA***	***DAILEKH***	***BARDIYA***	***DANG***	***SALYAN***
	Mugu Karnali Watershed		***Lohare Watershed***	***Babai Watershed***		
Major crops grown	Potato (28.43%), Millet (22.9%), Wheat (20.81%), Paddy (12.03%), Barley (8.83%), Maize (5.08%), Pulses (1.6%), sugarcane (0.16%), oilseed (0.15%)	Potato (58.61%), Wheat (28.53%), Paddy (3.6%), Millet (3%), Pulses (2.03%), Maize (1.9%), Barley (1.9%), Oilseed (0.12%)	Paddy (50.024%), Wheat (18.75%), Potato (16.7%), Pulses (8.17%), Oilseed (3%) Sugarcane (2.08%), Maize (1.4%)	Paddy (33.63%), Potato (28.8%), Maize (14.4%), Pulses (9.53%), Wheat (6.9%), Oilseed (5.7%), Sugarcane (1.06%)	Maize (38.33%), Paddy (24.46%), Wheat (24.11%), Potato (8.66%), Millet (1.59%), Barley (1.23%), Oilseed (1%), Pulses (0.64%)	Wheat (29.725), Maize (29.6%), Paddy (22.24%), Potato (15.17%), Millet (2.05%), Oilseed (0.62%), Pulses (0.4%), Barley (0.2%)

2.2. Delineating Agro-ecological Zones

The methodology adopted for identifying AEZs in the study is based on the methods provided in the Agro-ecological Zoning –Guidelines document published by FAO (Food and Agriculture Organisation, 1996) and the Mapping Philippine Agro-Ecological Zones (AEZs) Technical Notes, published by the Human Development Network (Human Development Network, 2012/2013) documents. As per these methods, temperature, moisture index, topography (elevation and slope) and soil order data are used to identify AEZs. The AEZ mapping was carried out on the ArCGIS platform. The GIS platform was used because it provides flexibility in data manipulation and management and the ability to process multi-dimensional operations.

The Agro-Ecological Zones were worked out using the conceptual framework in figure 9. First, the Climate Class and Moisture regimes data were used to develop Agro-Climatic Zones. Second, the detailed landforms, topography and soil order data were collected from LRMP's digital maps (Project, 1986) and combined to develop Agro-Edaphic Zones.

Subsequently, the Agro-Climatic Zones and Agro Edaphic Zones were combined on the GIS platform to delineate the Agro-Ecological Zones for the three watersheds. The method has been elaborated on in the subsequent sections.

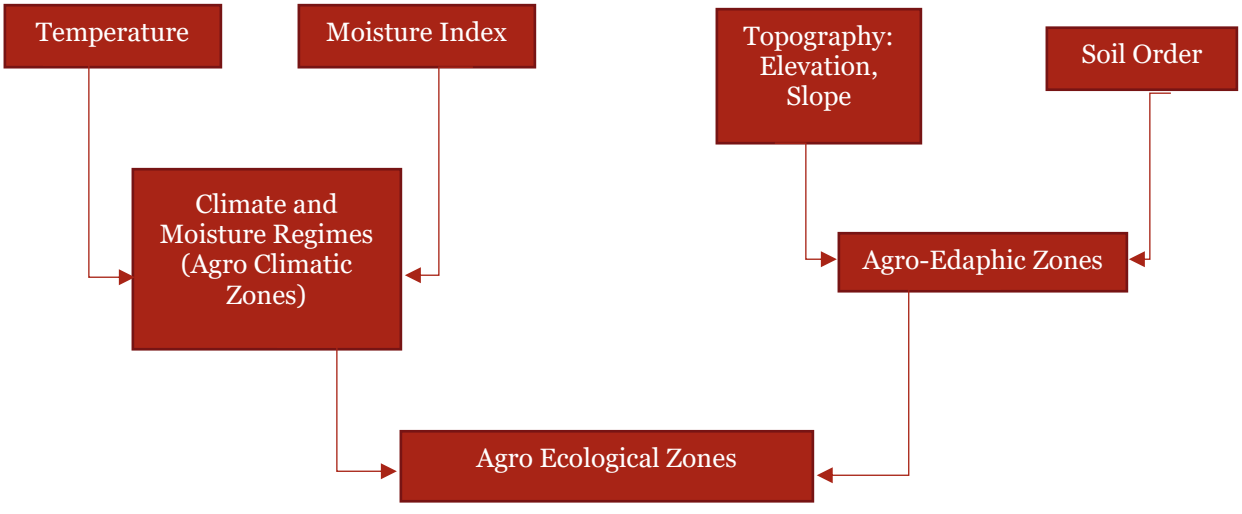


Figure 9: Methodology applied for delineating AEZs for this study (Human Development Network, 2012/2013)

2.2.1. Preparation of AEZ maps on the GIS platform

The 30m SRTM DEM is cropped by watershed area and lapse rate calculated from DHM data is applied to DEM using math algebra tool of GIS. The map of temperature is reclassified to match with Camargo Temperature range to identify climatic Zone. This climate zone is intersected with digital climate moisture zone map to obtained digital agro climate map. The Camargo temperature classification is provided in Table 8.

The digital land form map and digital soil order map from LRMP are intersected and interpreted to obtain digital agro edaphic map. This agro edaphic map is intersected with agro climatic map to obtain agro ecological map. The process under GIS is shown in Figure 10and details of layer processing is described below (Figure 10).

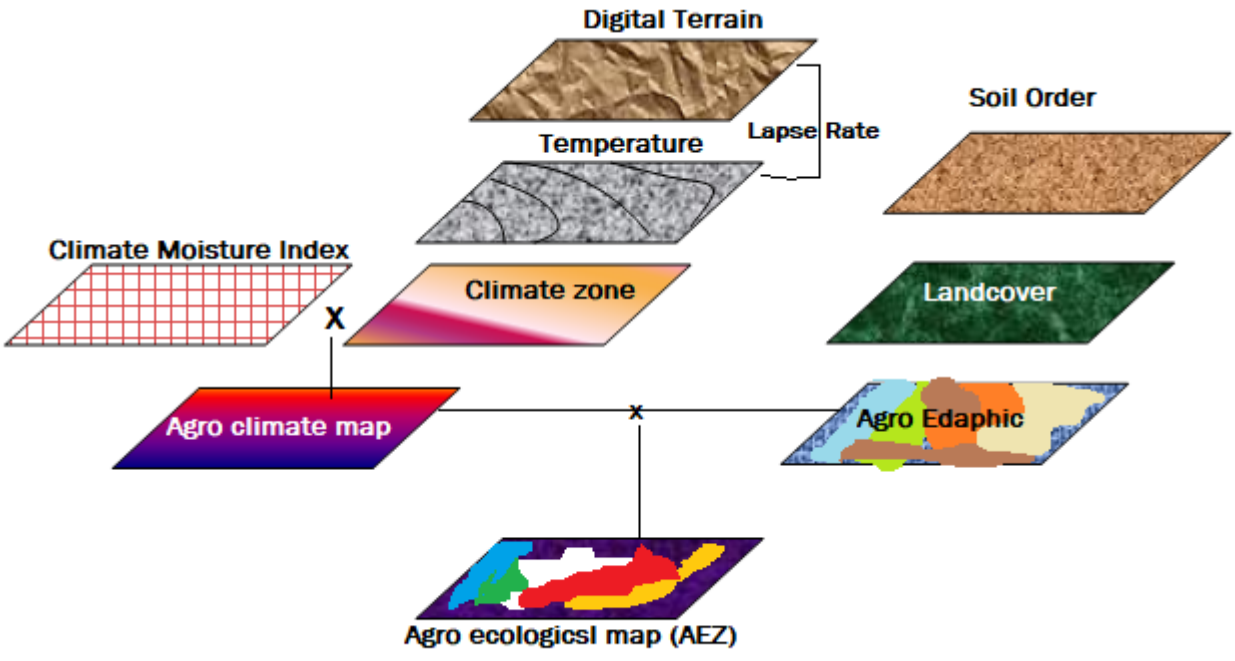


Figure 10: Process AEZ delineation on the GIS Platform

2.2.2. Agro-Climatic Zoning on the GIS Platform:

Table 8: Soil order classification

Climate Type	Land Form/Geomorphology	Landuse	Soil Type (LRMP Land unit)
Cold Temperate	Moderately to steeply sloping mountainous terrain Alluvial fan apron complex 'upper piedmont' (erosional) Alluvial plains and fans (depositional) Steeply to very steeply sloping mountainous terrain	Broadleaved open forest Agriculture 13b/c, 11, 9b, 9c Needle leaved closed forest 12 Broadleaved closed forest 12 Needle leaved open forest 12 Shrub land Grassland River (13a)	• Non-arable temperate steep mountain terrain under forest (LRMP land unit 13a, 12) • arable temperate terraced mountain terrain (LRMP land unit 14a and 11) • arable temperate alluvial fan-apron complexes (LRMP land unit 13b/c/d) • River (13a)
Sub (warm) temperate	Steeply to very steeply sloping hilly and moutainous terrain Moderately to steeply sloping mountainous terrain Fans, aprons and ancient river terraces (tars) Alluvial fan apron complex 'upper piedmont' (erosional) Moderately to steeply sloping hilly and mountainous terrain Steeply to very steeply sloping mountainous terrain Alluvial plains and fans (depositional) Active and recent alluvial plains Depositional basins (duns)	Broadleaved closed forest Broadleaved open forest Agriculture Bare area Shrub land Grassland River	• Non-arable sub-temperate steep mountain terrain under forest (LRMP land unit 8, 12) • arable sub-temperate terraced mountain terrain (LRMP land unit 13b/c/d, 11, 10) • arable sub-temperate alluvial plain, fan and apron complexes (LRMP land unit 9b/c,)

Climate Type	Land Form/Geomorphology	Landuse	Soil Type (LRMP Land unit)
			• Arable sub-temperate ancient depositional basin/ river terrace and recent alluvial plain complexes (LRMP land unit 6a/b/c, 5a/b/c, 4b/c) • Non-arable sub-temperate dissected ancient depositional basin and river terrace under forest (LRMP land unit 6d, 5d) River (LRMP land unit 9a, 4a)
Sub-tropical	Steeply to very steeply sloping hilly and mountainous terrain Fans, aprons and ancient river terraces (tars) Active and recent alluvial plains Past glaciated mountainous terrain below upper altitudinal limit of arable agriculture, Alluvial fan apron complex 'upper piedmont' (erosional) Active Alluvial Plain (depositional) Recent alluvial plain 'lower piedmont' (depositional and erosional) Moderately to steeply sloping hilly and mountainous terrain Steeply to very steeply sloping mountainous terrain Moderately to steeply sloping mountainous terrain Depositional basins (duns)	Broadleaved open forest Agriculture Bare area Broadleaved closed forest River (1a, 4a) shrub land Grassland Built-up area	• non-arable sub-tropical steep mountain terrain under forest (LRMP land unit 7,) • arable sub-tropical ancient depositional basin/ river terrace and recent alluvial plain complex (LRMP land unit 6a/b/c, 5a/b/c, 4b/c) • non-arable sub-tropical dissected ancient depositional basin and river terrace under forest (LRMP land unit 6d, 5d) • non-arable sub-tropical dissected alluvial terrace (LRMP land unit 3d) • diverse crop arable sub-tropical recent alluvial plain (LRMP land unit 1d, 2c/d, 3a/b/c) • paddy arable sub-tropical swales in recent alluvial plain (LRMP land unit 2a/b) non-arable sub-tropical active depositional river terraces (LRMP land unit 1a/b/c, 4a, 9a)

Temperature: The gridded (0.2 km x 0.2 km) annual temperature maps have been prepared using DHM's point temperature data. This has been done by applying lapse rate, which is the temperature change with respect to elevation (Department of Hydrology and Meteorology, 1997-2012), to the digital elevation model. This is shown in Figure 9. In the next step, the annual temperature map is classified as per temperature range of Camargo Climate zone (Lucas Eduardo de Oliveira Aparecido, 2016). This zone is reclassified to temperature based climate type zones[2] (Table 8). The reclassified map with Camargo temperature based climate classes/description is shown in Figure 13 Carmago used temperature range to define climate. It is most suitable for Nepal as the temperature can be mapped more correctly in GIS using digital elevation model.

Table 9: Camargo Climate Zones and symbol defined from Temperature

Yearly mean air temperature (Ty ºC),	Mean Temperature coldest month (T_{COLD},ºC)	Climate	
		Description	Symbol
Ty≤3		Glacial	GL
3< Ty≤7		Frigid	FR
7<Ty≤12		Cold	CO
12<Ty≤18	Or ≤13 T_{COLD}	Temperate	TE
18<Ty≤22	And ≤13 T_{COLD}	Sub temperate	STE
18<Ty≤22	And 13< T_{COLD} ≤20	Subtropical	ST
22<Ty≤25	Or 20< T_{COLD}	Tropical	TR
>25		Equatorial	EQ

Climatic Moisture Index: The global digital annual average climate moisture index (CMI) on a 0.5 X 0.5 degree global grid was downloaded from Data Basin, an organization that provides free and open access to scientifically grounded physical, biological and socio-economic data (DataBasin, 2010). This dataset depicts annual average climate moisture index (CMI, Willmott and Feddema, 1992), which is computed using the ratio of annual precipitation (P) to annual potential evapotranspiration, (PET). PET is dimensionless with arbitrary limits [−100 ≤ Im≤ 100 (∞− 1)]. The CMI illustrates the relationship between plant water demand and available precipitation. The CMI indicator ranges from –1 to +1, with wet climates showing positive CMI, and dry climates negative CMI (DataBasin, 2010). The CMI is an aggregate measure of potential water availability imposed solely by climate. Negative CMI values show potential evapotranspiration in excess of precipitation and thus the potential for climate-based water scarcity. Areas with CMI values exceeding zero generally represent humid or water abundant areas. The classes of CMI are -1to -0.6 (arid), -0.6 to 0 (semiarid), 0-0.25 (sub humid) and 0.25 to 1 (humid) (GWSP , 2005). The CMI value extracted for three watersheds is shown in figure 10.

[2] Note: The Mean Annual Temperature at some of the spots exceed 22^{0}C. But, the cold month temperatures is between 13^{0}C to 20^{0}C. This is why this zone is also placed under the sub-tropical category

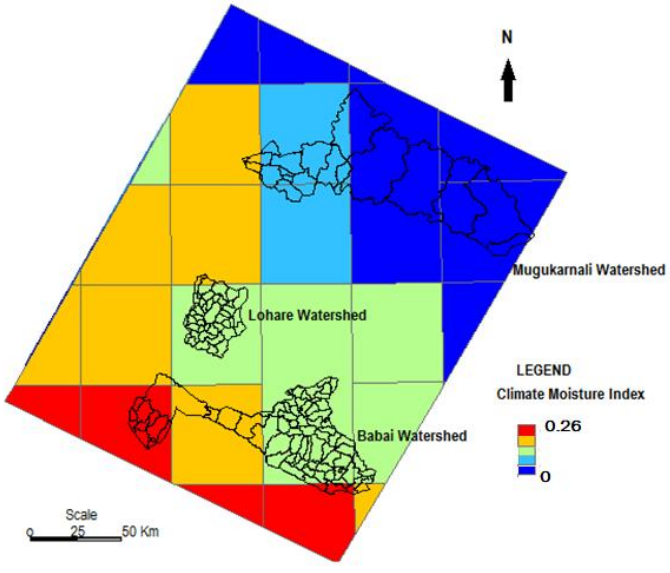


Figure 11: Climate Moisture Index of the watersheds

Agro Climatic Zone: The Climate zoning map derived from the temperature map and the moisture zoning map (described in the earlier paragraphs), derived from the moisture index, and were intersected on the GIS platform to develop agro-climatic zoning maps.

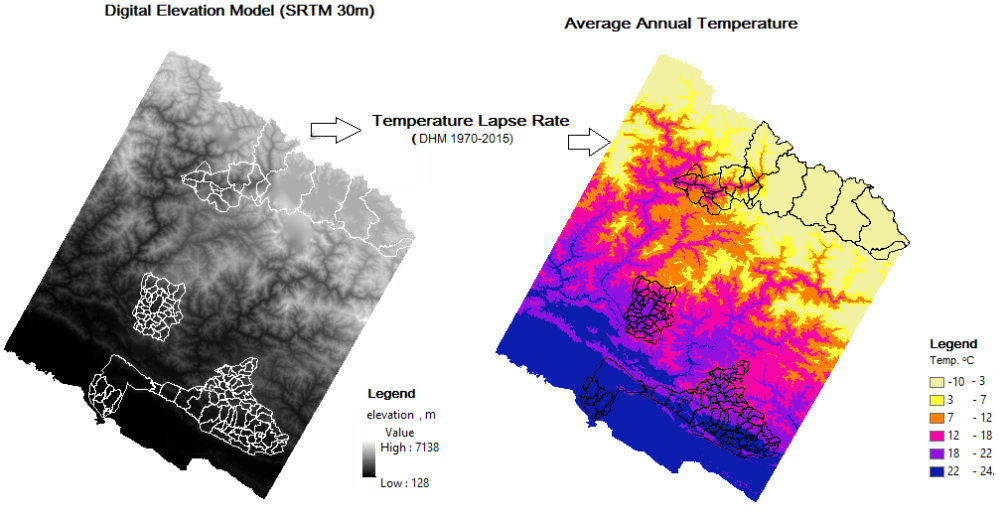


Figure 12: Digital Elevation Model and Average Annual Temperature (Source: SRTM 30m DEM, DHM Temperature data)

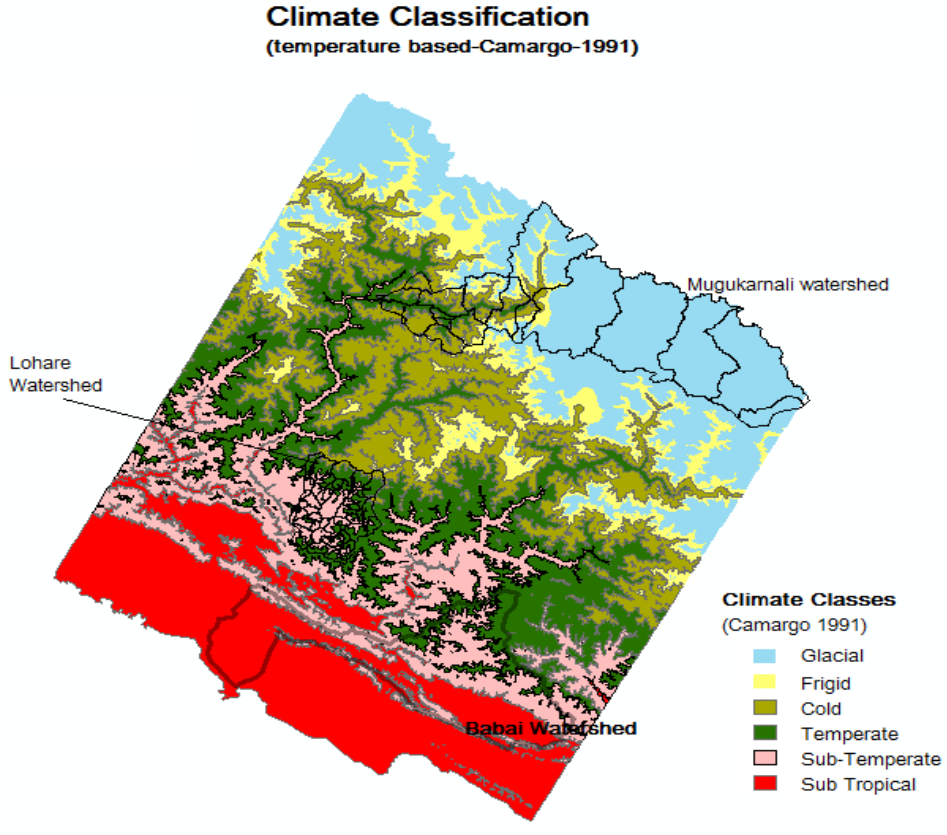


Figure 13: Climate Classes of the Mid-Western Section of Nepal using the Camargo Climate Classification (1991) (Lucas Eduardo de Oliveira Aparecido, 2016)

2.2.3. Agro-edaphic Zone

Agro-edaphic Zone: For developing the Agro-edaphic zones, first, the mapping of land system codes, given by LRMP (Project, 1986), was carried out by aggregating parameters relating to landform and soil order digital information from LRMP. Subsequently, those parameters were generalized to soil suitability and landform to arrive at agro edaphic zones. The available digital maps of these parameters were intersected in GIS and interpreted in terms of soil suitability and land form.

2.2.4. Agro-Ecological Zone

Agro ecological Zoning: Next, the agro-climate classes of the regions within the watershed were imposed on agro edaphic zones derived from LRMP (Project, 1986), Nepal. This combination of agro edaphic and agro climatic zones was carried out to develop the Agro Ecological Zones of the three identified watersheds. The figures that follow show the spatial distribution of the AEZs across the watersheds selected for this study.

2.2.5. AEZs within the watersheds:

Based on the methodology described in the earlier section AEZs were delineated for the Lohare, Mugu Karnali and Babai Watersheds. They are shows in the figures below:

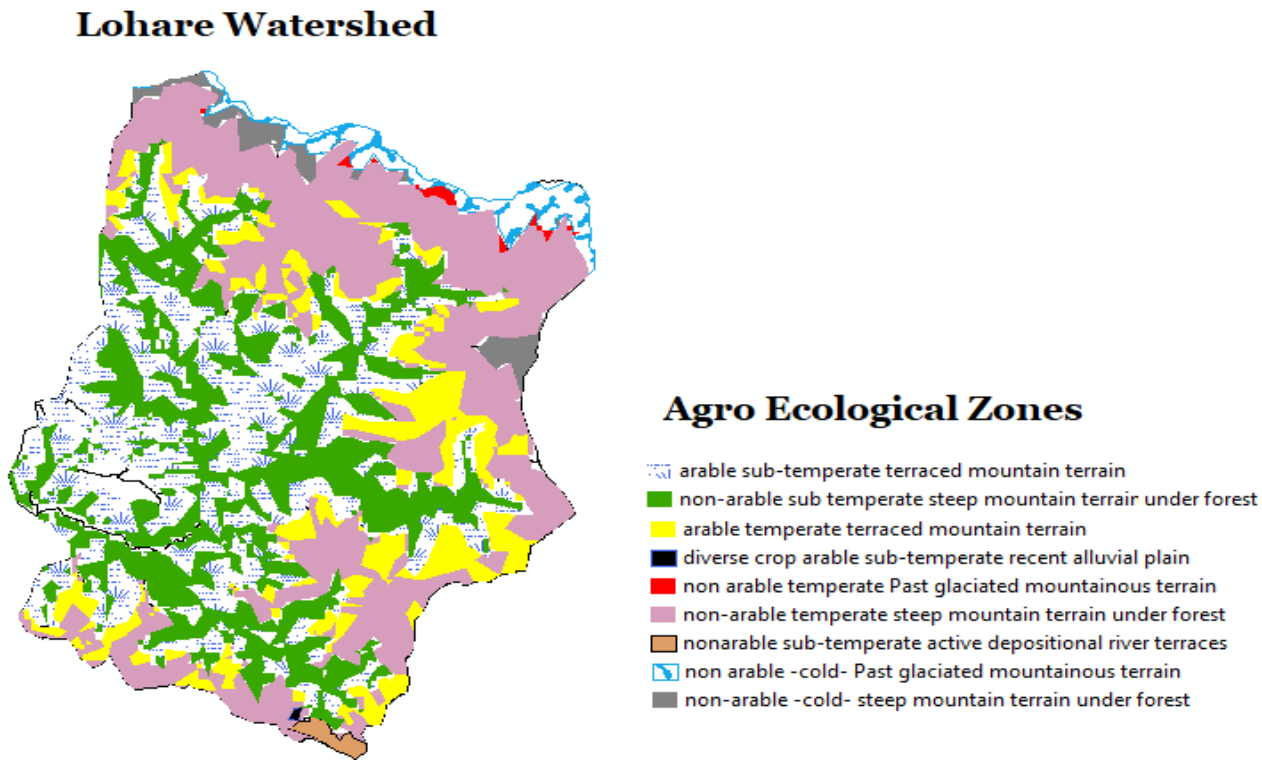


Figure 14: Spatial Distribution of Agro-ecological Zones of the Lohare Watershed (Source: Derived based on information obtained from LRMP, Nepal and methods suggested by Camargo Classification)

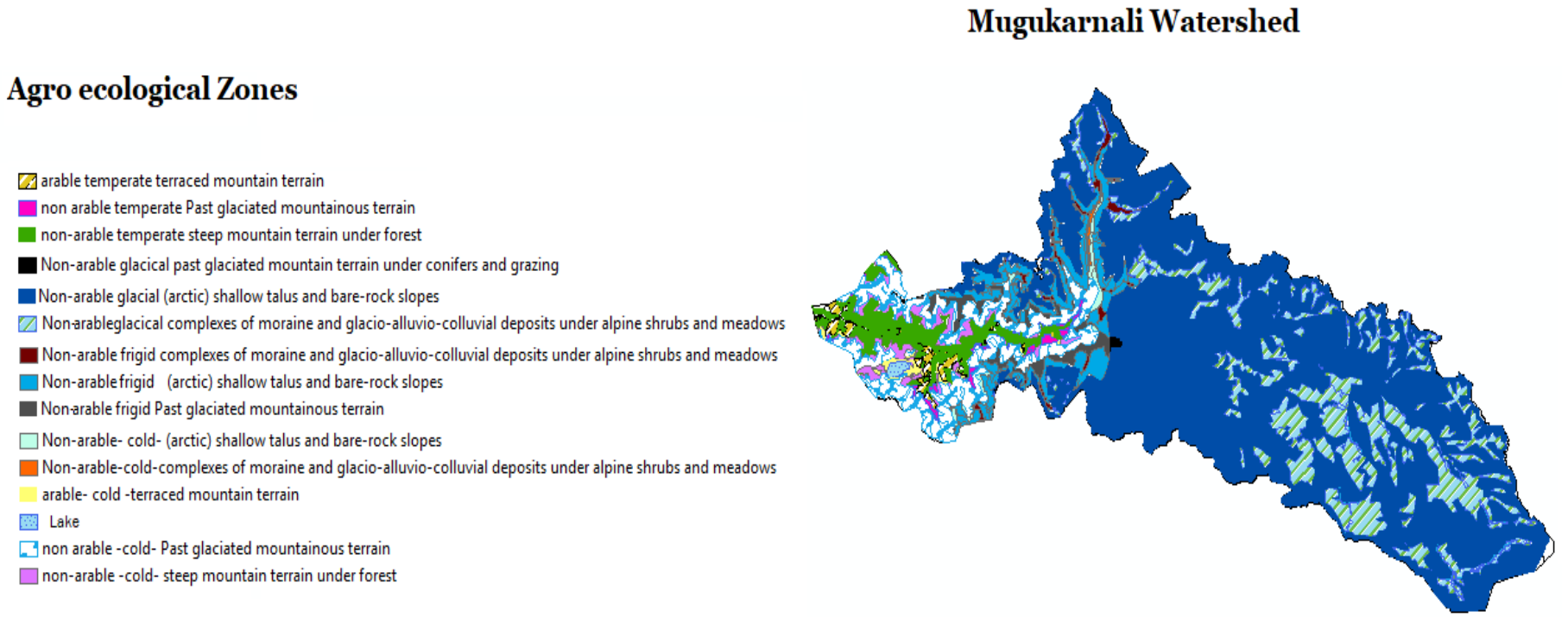


Figure 15: Spatial Distribution of Agro-ecological Zones of the Mugu Karnali Watershed (Source: Derived based on information obtained from LRMP, Nepal and methods suggested by Camargo Classification)

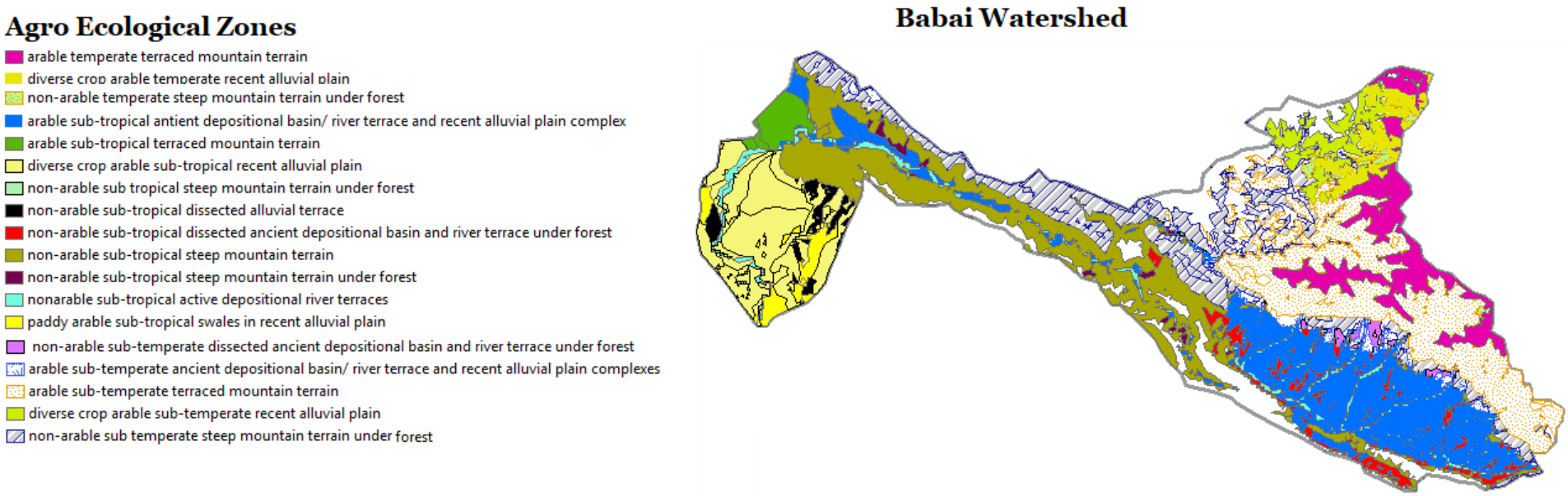


Figure 16: Spatial Distribution of Agro-ecological Zones of the Babai Watershed (Source: Derived based on information obtained from LRMP, Nepal and methods suggested by Camargo Classification)

AEZs represents a combination between similar agriculture (soil), land type and climate. Therefore, common areas were identified as classified as below. For example, AEZ no 4 in Lohare watershed red colour represents soil, blue colour indicates climate and land form in green colour. It temperature changes, climate type changes and agriculture changes. The table below lists the Agro-ecological Zones found in the chosen watersheds.

Table 10: Agro-ecological zones identified within the watersheds

Lohare Watershed	
1	Non arable cold past glaciated mountainous terrain
2	Non arable cold steep mountainous terrain under forest
3	Arable temperate terraced mountain terrain
4	Diverse crop arable sub-temperate recent alluvial plain
5	Non arable steep mountainous terrain under forest
6	Non-arable sub-temperate active depositional river terraces
7	Arable sub-temperate terraced mountain terrain
8	Non-arable sub-temperate terraced mountain terrain under
9	Non-arable temperate past glaciated mountainous terrain
Mugu Karnali Watershed	
1	Non-arable glacial past glaciated mountain terrain under conifers and grazing
2	Non-arable glacial (arctic) shallow talus and bare rock slopes
3	Non-arable glacial complexes of moraine and glacio-alluvial-colluvial deposits under alpine shrubs and meadows
4	Non-arable frigid complexes of moraine and glacio-alluvial-colluvial deposits under alpine shrubs and meadows
5	Non-arable cold past glaciated mountainous terrain
6	Non-arable cold (arctic) shallow talus and bare rock slopes
7	Non-arable cold complexes of moraine and glacio-alluvial-colluvial deposits under alpine shrubs and meadows
8	Arable cold terraced mountain terrain
9	Lake
10	Non arable cold past glaciated mountainous terrain
11	Arable temperate terraced mountain Terrain
12	Non-arable temperate Past mountain glaciated mountain terrain
13	Non- arable cold steep mountainous terrain under forest
14	Non –arable temperate steep mountain terrain
Babai Watershed	
1	Arable temperate terraced mountain terrain
2	Diverse crop arable temperate recent alluvial plane
3	Non arable temperate steep mountainous terrain under forest
4	Non-arable sub-temperate dissected ancient depositional basin and river terrace under forest
5	Arable sub-temperate ancient depositional basin/river terrace and recent alluvial plain complexes
6	Arable sub-temperate terraced mountain terrain
7	Diverse crop arable sub-temperate recent alluvial plain
8	Non arable sub-tropical steep mountainous terrain under forest
9	Non arable sub-tropical dissected ancient depositional basin and river terrace under forest
10	Non arable sub-tropical steep mountain terrain
11	Non arable sub-tropical steep mountain terrain under forest
12	Non-arable subtropical active depositional river terraces
13	Paddy arable subtropical swales in recent alluvial plane
14	Arable sub-tropical ancient depositional basin/river terrace and recent alluvial plain complex
15	Arable sub-tropical terraced mountain terrain
16	Non-arable sub-temperate steep mountain terrain under
17	Non arable sub-tropical dissected alluvial terrace
18	Diverse crop arable sub-tropical recent alluvial plain

2.3. Vulnerability assessment

Vulnerability assessment methodology using IPCC AR5 approach: It is recommended that the vulnerability assessment methodology for Nepal is conceptually aligned to the framework being followed under National Adaptation Plan (NAP). The NAP framework is in line with the IPCC-AR5 and it follows the risk based approach where risk is the function of hazard, exposure and vulnerability.

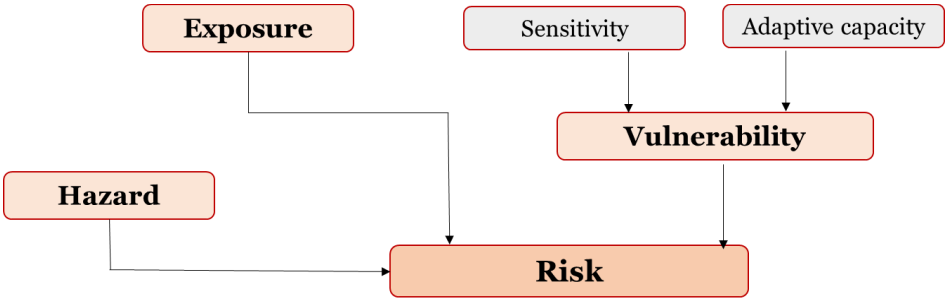


Figure 17: Risk as a function of hazard, exposure and vulnerability

Risk = f (hazard, exposure, vulnerability)

The framework assumes that the risk of climate-related impacts results from the interaction of climate-related hazards with the exposure and vulnerability of human and natural systems. Changes in the climate system (trends and scenarios), biophysical system, and socioeconomic processes (including governance and adaptation and mitigation actions) are drivers of hazards, exposure, and vulnerability.

At this point it is important to note the following IPCC definitions of hazard, exposure, vulnerability and risk in order to understand the framework.

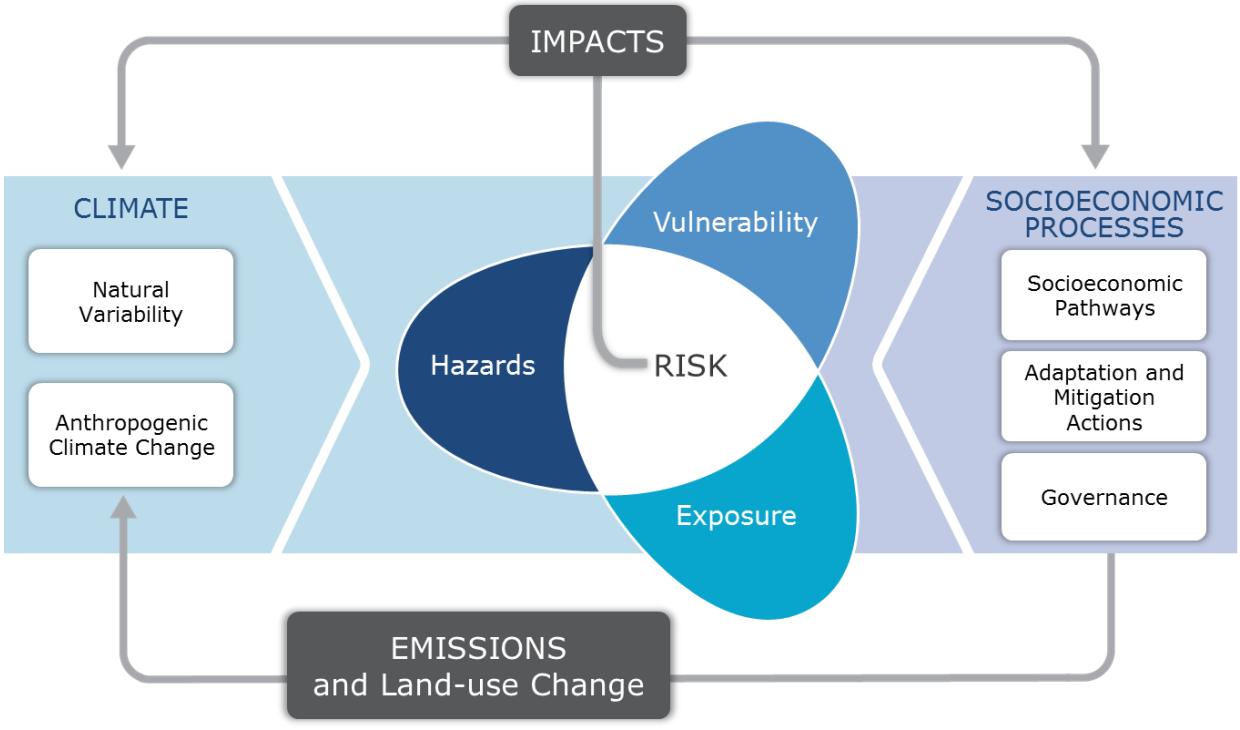


Figure 18: Drivers of hazards, exposure and vulnerability

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods,

service provision, ecosystems, and environmental resources. For the purpose of GCF investment plan, the term hazard may be referred to as climate-related physical events or trends or their physical impacts.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

- **Adaptive capacity (in relation to climate change impacts):** The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences of climate change.
- **Sensitivity:** Predisposition of society and ecosystems to suffer harm as a consequence of intrinsic and context conditions making it plausible that such systems once impacted will collapse or experience major harm and damage due to the influence of a hazard event.

Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.

Assessing vulnerability methods: An effective assessment of ecosystems and human well-being cannot be conducted at a single temporal or spatial scale. Changes in ecosystem that may have little impact on human well-being over days or weeks (drying sources, for instance) may have pronounced impacts over years or decades (declining agricultural productivity). Similarly, changes at a local scale may have little impact on some services at that scale (as in the local impact of forest loss on water availability) but major impacts at large scales (forest loss in a river basin changing the timing and magnitude of downstream flooding). Ecosystem processes and services are typically most strongly expressed, are most easily observed, or have their dominant controls or consequences at particular spatial and temporal scales. They often exhibit a characteristic scale—the typical extent or duration over which processes have their impact.

Ecosystems provide a variety of benefits to people, including provisioning, regulating, cultural, and supporting services. Provisioning services are the products people obtain from ecosystems, such as food, fuel, fiber, fresh water, and genetic resources. Regulating services are the benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, and water purification. Cultural services are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. Supporting services are those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation.

The proposed framework considers ecosystem services (agriculture) and its user as the “System of concern”. The ecosystem services in the pilot watersheds of the agro-ecological zones is mostly derived from agriculture, water and forest with agriculture being the most prominent one. Therefore, the focus of this assessment is based on the provisioning ecosystem services derived from agriculture first, then water and forest and its interaction with people and their livelihood.

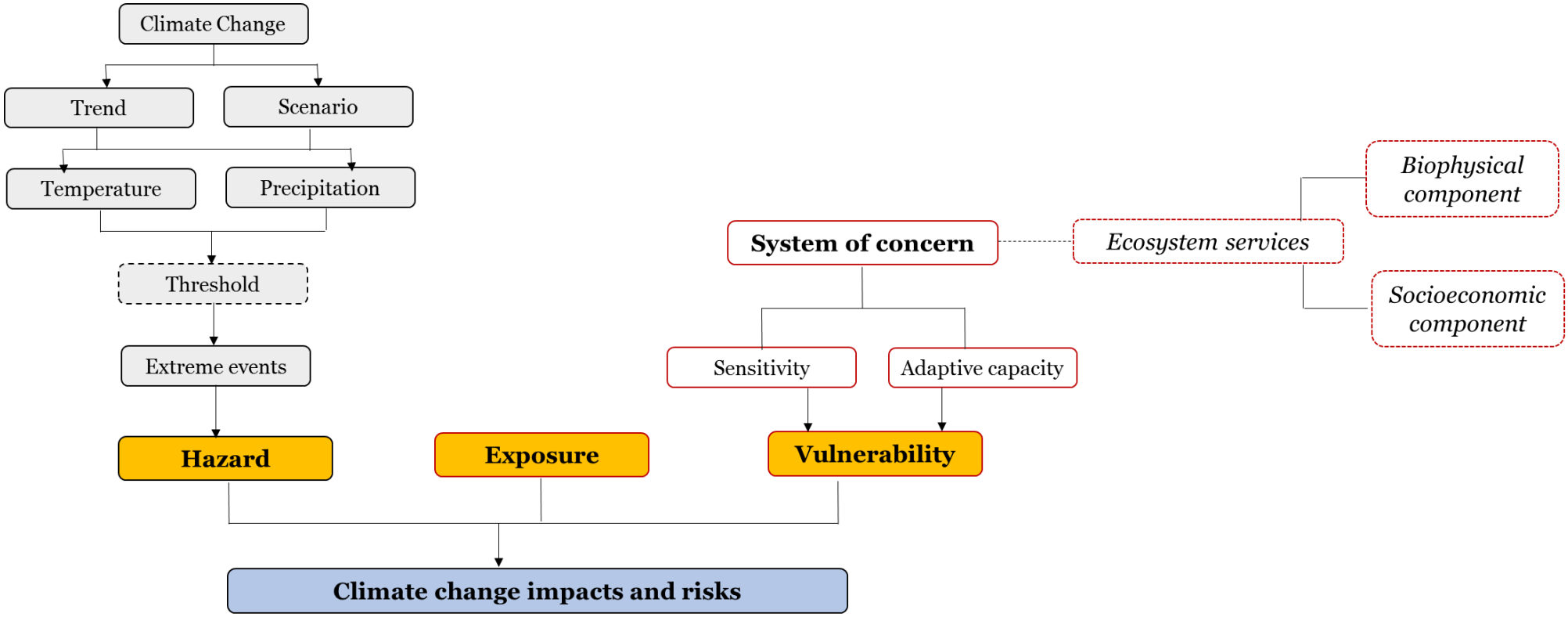


Figure 19: Climate Change Vulnerability Assessment and Risk Assessment Framework

Agriculture and food security indicators identified under NAP for hazard, exposure, sensitivity and adaptive capacity assessment are provided in Annexure I of this report. It is to be noted that vulnerability analysis in the current assignment is carried out in VDC scale. Consequently, only those parameters have been used for which data are available at VDC level or for which data can be interpolated to the VDC level. Certain parameters, although identified as necessary in NAP, have been excluded from the study because the data for those parameters are not available at the VDC level[3] and only available as a single data at district level. The district level data is meaningless for carrying out risk analysis at the watershed level. The sub indicators used for Hazard, Exposure and Vulnerability are detailed in spatial analysis below.

Assessing hazard: This study is aimed at characterizing the disaster patterns by means of relevant metrics (e.g. temperature and precipitation) coming from trend analysis and investigating different scenarios.

Ascertaining the climate trend and climate change scenario: The trend in temperature and rainfall has been assessed in conjunction with future scenario investigation. The annual average rainfall and temperature is considered for trend analysis. The climate change future scenario has been investigated using AR5 RCP scenario of 2040-2059. It is assessed for both annual rainfall and temperature. The biased uncorrected scenario in $1^0 x 1^0$ grid is extracted for the watershed from World Bank Climate Portal. The bias is then corrected using data from the ground stations.

Climate Threshold: The threshold level of both temperature and precipitation that can lead to extreme events was reviewed from published literature and data from DHM. In agriculture sector threshold of climatic variables play an important role as temperature and rainfall beyond a certain threshold not only lead to an extreme event but also lead to a gradual decline in crop yield and/or productivity. Consequently hazard ranking is done with respect to the threshold value identified as part of this study threshold. This threshold value has been selected keeping in consideration that temperature and rainfall values may lead to decline in crop yield/productivity even before a natural disaster strikes.

Keeping the above framework in mind, the indicators are chosen in a manner so that they represent climate change trend and scenarios and help assessing the threshold for occurrence of extreme events and crop failure.

Table 11: Hazard indicators

Indicators	Scenario	Process /source
Number of Hot Days (Tmax > 35°C)	CMIP 5-RCP 4.5-Period 2040-2049	World bank CMIP 5 projection (2017) compared to baseline of study area (projection 1 degree gridded data)
Number of Frost Days (Tmin < 0°C)	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Maximum of Daily Max-Temperature	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Maximum of Daily Min-Temperature	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Monthly Temperature	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Monthly Precipitation	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Maximum Length of Consecutive Dry Spell	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Maximum Length of Consecutive Wet Spell	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Expected Daily Rainfall Maximum in 25 Years (25-yr Return Level)	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Maximum 5-day Rainfall	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)

[3] The same was suggested in the review meeting

Indicators	Scenario	Process /source
Largest Single Day Rainfall	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Annual Severe Drought Likelihood	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)/ baseline DDC rating
Expected Largest Monthly Rainfall Amount in 25 Years (25-yr Return Level)	CMIP 5-RCP 4.5-Period 2040-2049	CMIP 5 (projection 1 degree gridded data)
Trend		
Maximum temperature Trend	DHM Data 1971-2012	DHM 2015-5 km Gridded Data
Minimum Temperature trend	DHM Data 1971-2012	DHM 2015-5 km Gridded Data
Seasonal Precipitation Trend	DHM Data 1971-2012	DHM 2015-5 km Gridded Data
Flood inundation	Available flood maps	Refiefweb/ICIMOD Aug 2017

Assessment of vulnerability: Vulnerability assessment is aimed at evaluating the degree to which ecosystem services and their users (system of concern) could be effected by climate change based on site-specific information. The assessment was carried out in the VDC scale and data for the indicators were selected from available data which were in line with indicators proposed by NAP.

System of Concern: For the purpose of this study, as discussed above, the ecosystem services in the selected watersheds of the agro-ecological zones is mostly derived from agriculture, water and forest with agriculture being most prominent. So the focus of this assessment is the provisioning ecosystem services derived from agriculture first, then water and forest and its interaction with people and livelihood. The vulnerability Assessment framework proposed by NAP, which is in line with AR5 (Ecosystem Services is considered as the System of Concern).

Sensitivity: As per the system of concern defined above, cropping and livestock pattern of the watershed, agricultural production and livelihood dependency on agriculture is the key indicator for assessment. Forest being the other important source of ecosystem services, livelihood dependency on forest is considered significant to assess sensitivity. Since agricultural production is closely related to availability of water resources, it has also been considered for determination of sensitivity. In addition, population density, income disparity, gender inequality are key indicators to assess how sensitive an agro-ecological zone within a watershed may be to climatic variabilities.

Table 12: Sensitivity indicators

Indicators	Data type	Scale	Source
Population /household density	Nos/area HHno/Area	VDC scale	CBS 2011
Income disparity	Per capita/ poverty map/ pop in economic activities/ highly educated population	VDC scale	CBS2011
Livelihood dependency on agriculture	Agriculture land holding	VDC scale	CBS-2001/2011
Livelihood dependency on forest	Fire wood Dependent and housing material depending HH Nos /area	VDC Scale	CBS2011
Gender inequality	Non dimentional ratio-female and male literacy ratio, female and male population ratio	VDC scale	CBS2011
Livestock and cropping pattern	Crop type grown in ha.	landuse map	DOI 2016/ DoS 1995/ Agro climatic atlas DHM/NARC/ICIMOD
Agriculture production	Tonne/ha	District	MoAD/DADO
Water sources system	HH No/Area	VDC Scale	CBS2011

Adaptive Capacity: The key indicators that were used for assessing the adaptive capacity are road network, housing type, age group, literacy rate, female population, irrigated land, economic status of household. The data on area of land under irrigation was taken from 2016 DoI map. All the other indicators were extracted from CBS 2016.

Table 13: Some indicators for vulnerability assessment in Nepal

Elements of risk		Indicators	Source
Vulnerability	Sensitivity	Fire wood consumption	CBS 2011
		Household water use	CBS 2011
		Population density (Agriculture dependent population- high vulnerability if pop density is high)	CBS 2011
		House type (house built from local forest resources)	CBS 2011
		Settlement distributed on slopes (landslide vulnerability)	CBS 2011
		Settlement close to flood plain (flood vulnerability	CBS 2011
		Income disparity	CBS 2011
		Topography	SRTM DEM
	Adaptive capacity	Road density	DDC, DoLIDAR, DoI
		Housing type	CBS 2011
		Availability of electricity	CBS 2011
		Age group with gender	CBS 2011
		Literacy rate	CBS 2011
		Economic activity	CBS 2011

Exposure: Exposure assessment is aimed at identifying the elements at risk. In this step primarily land use (agriculture area, rangeland area) and land cover (forest area) data set has been analyzed for the localization of people, ecosystem resources, and social, economic and cultural assets that could be adversely affected. Since agricultural production is closely related to availability of irrigation structures and water bodies, determination of exposure of these assets becomes significant towards assessment of overall exposure.

Table 14: Exposure indicators

Indicators	Data type	Scale	Source
Population of livestock	No/ VDC	VDC scale	CBS 2011
Irrgation structures	No/ VDC	VDC scale	DoI 2016
Agricultural area	Total area/ VDC area	VDC scale	ICIMOD, 2010/DoI 2016
Rangeland area	Total area/ VDC area	VDC scale	ICIMOD, 2010/DoI 2016
Farming population	HH Nos in VDC	VDC scale	CBS 2011
Forest density	Forest area/vdc area	VDC Scale	ICIMOD 2010DoI, 2016
Water bodies/Ponds	Stream density	VDC Scale	DoS 1995

Overall risk mapping: The analysis will be carried out in VDC scale and the data collected is at VDC level data or converted to VDC scale for the spatial analysis in GIS. The collected data has been analysed to arrive at the climate change risk as per the approach shown in the figure below. Each indicator is normalized in the scale of 0-1. The indicators were averaged with equal weights in a group (Hazard, Exposure, Sensitivity, and Adaptive capacity). The obtained average value is ranked as 1-3 for further analysis as shown below. The details of ranking are given in the normalizing data and scoping sub section in this report.

$$Climate\ Change\ Risk = Hazard^{1-3} \times Exposure^{1-3} \times Vulnerability^{1-3}\left(\frac{Sensitivity}{Adaptive\ capacity}\right)$$

The combination obtained will be re-ranked and mapped as:

Table 15: Risk Scoring Table

High to extremely high Impact 3x3x3 =27 high risk 3x3x2 =18 high risk	**Moderately high Impact** 3x2x2=12 moderately high Risk 3x3x1=9 moderately high Risk	**Moderate Impact** 2x2x2=8 moderate risk 3x2x1=6 moderate risk	**Moderately low impact** 2x2x1=4 moderately low risk 3x1x1=3 moderately low risk	**Low Impact** 2x1x1=2 low risk 1x1x1 =1 low risk

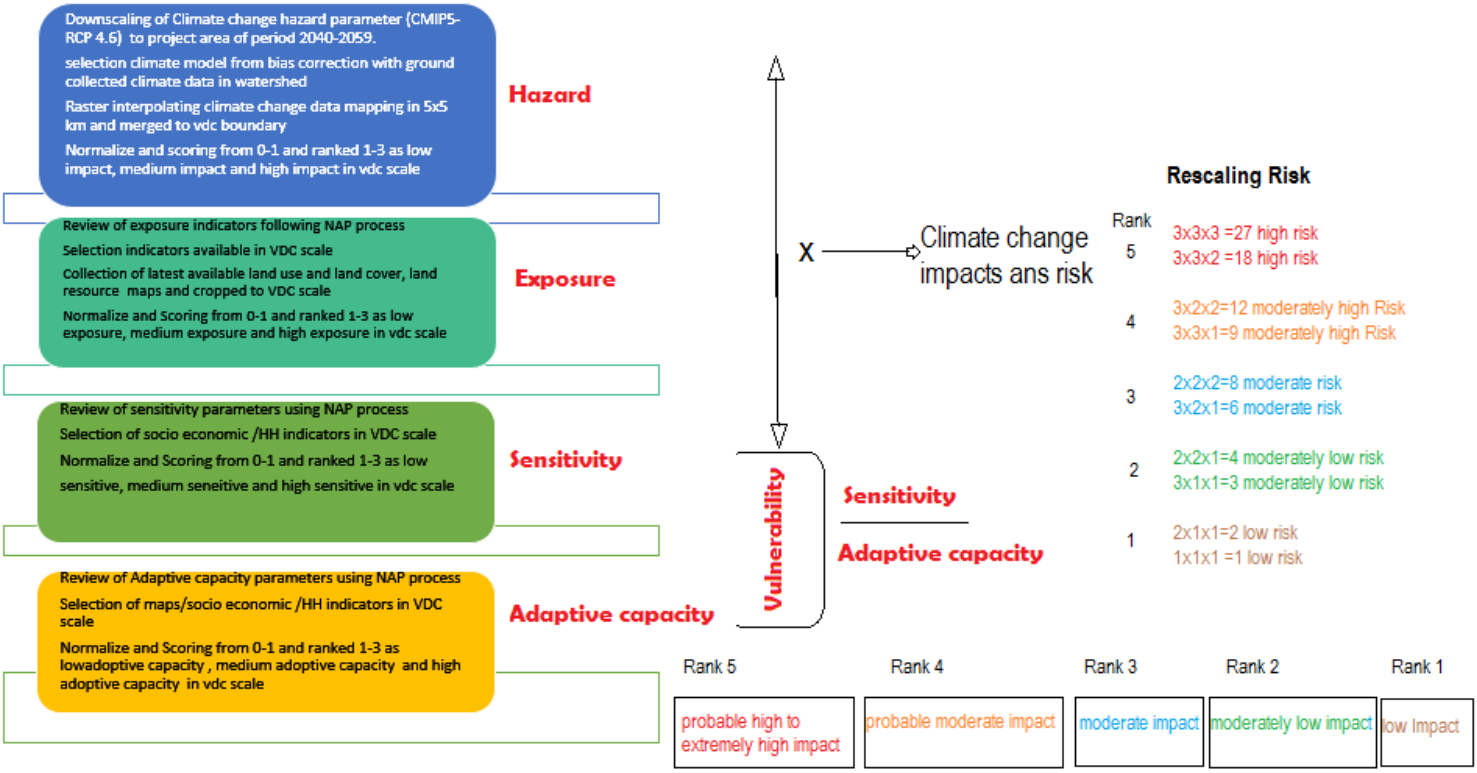


Figure 20: Climate change risk and vulnerability assessment approach

It is to be noted that while the climate change risk, the ultimate output has been ranked in the scale of 1 to 5, the sub-indicators i.e. hazard, exposure, sensitivity and adaptive capacity will be ranked in the scale of 1 to 3. This is to avoid too many permutations and combinations to arrive at risk ranking of 1-5. Below is an illustration of how hazard ranking will be carried out.

- Rank 1 = normal range
- Rank 2 = threshold boundary (upper/lower)
- Rank 3 = exceeded threshold

The rescaling scale in the figure above clearly delineates how values from 1-3 will be permuted and combined to get overall risk ranking from 1-5.

2.4. Climate change risk assessment framework and computation

Nepal's NAP formulation process IPCC – AR5 based framework for vulnerability and risk assessment (VRA), as shown in Figure 20, has been applied for conducting the Spatial Analysis for this assignment. The framework considers risk as a function of hazard, exposure, and vulnerability and assumes that the risk of climate-related impacts results from the interaction of climate-related hazards (including hazardous events and trends) with the exposure and vulnerability of human and natural systems. This study considers agriculture and related Ecosystems as system of concern of framework. The units of available indicators mentioned in NAP process are of different dimensions or dimension less. Therefore, a weighted qualitative scoring method was adopted for the Climate change Risk and Vulnerability analysis.

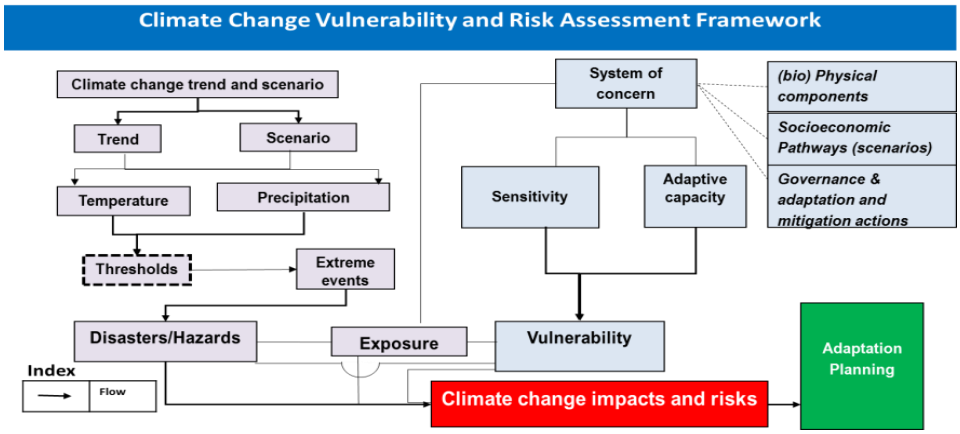


Figure 21: Conceptual Framework of VRA for Nepal's NAP Process

The final outcome of this framework is a combination of indicators of Hazard, Exposure and Vulnerability and then identification of adaptation measures. As the NAP process suggests many dimension and dimension less parameters (indicators) and given that quantitative thresholds are still not available for many parameters in Nepal, this study collected data and performed score based qualitative analysis in watersheds.

2.4.1. Data availability and scale

Here the data refers to those data which are available for climate change risk and vulnerability analysis in agro-ecologies as defined by NAP process (figure 26). The data available and applicable for Hazard, Exposure and Vulnerability analysis have different scales and units. The scale and parameters with their sources are shown in Table 17.

Table 16: Available data and scale for Climate change Risk and Vulnerability analysis

Parameters	Scale	Source
Climate trend (2071-2014)	District	DHM
Climate Change (CC)Projection	1 degree x 1 degree	World Bank Climate Change Portal
CC induced Hazards	VDC	District Disaster Relief Committee, Gov of Nepal

Past Climate Data	Point	DHM
Land Use data (2010)	25m x25m	ICIMOD
Livestock data	VDC	CBS 2011
Demographic Data	VDC	CBS 2011
Socio economic Data ()	VDC	CBS 2011
Food security	VDC	NeKSAP
Gender data	VDC	CBS, Index Mundi

2.4.2. Selection of data and scale

The socioeconomic and demographic data are available both in district and VDC levels. The district data may be useful for conducting general district studies (6 districts in 3 watersheds) but may not be applicable for spatial analysis in GIS platform. Therefore, for conducting this spatial analysis, VDCs have been considered as the working scale. The analysis was carried out for the VDCs lying within the identified watersheds as shown in Figure 29. The data available was at a larger level than the VDC scale and were therefore interpolated and scaled down to the VDC level (only for CC projected data) and those which were available at a scale smaller than the VDC, were scaled up to the VDC level by totaling values inside VDC boundaries .

The data available for the assessment were of different types. The Climate change projection grids available in World Bank Climate Portal is 1 degree x 1 degree data (111.699 km x 111.699 km). This raster data were interpolated to 5 km x 5 grid to arrive at the appropriate value at the VDC level. An example of raster interpolated map of annual drought likelihood is shown in Figure 24.

The land cover data (ICIMOD, 2010) available in 25m x 25m raster grids were cropped within VDC boundaries to estimate different land cover areas within the VDC.

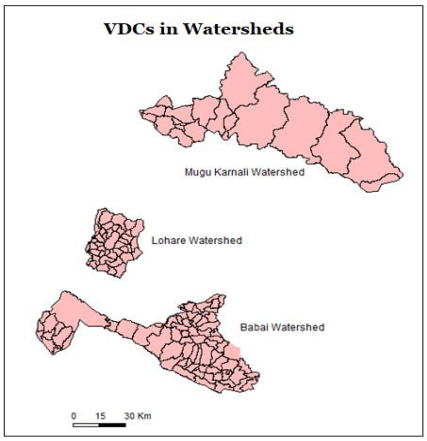


Figure 22: VDC boundary in Watershed

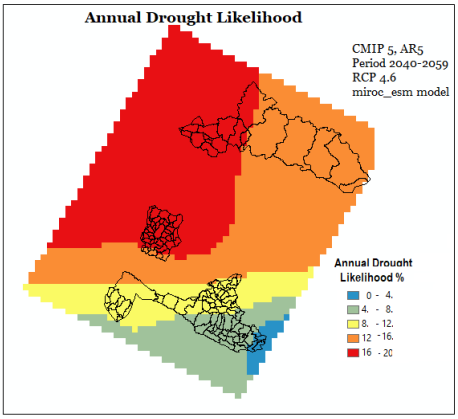


Figure 23: VDC boundary drought likelihood

2.4.3. Normalization of data

The units of all parameters (indicators) are different from each other. They vary from dimensionless units, such as probability, percent, and whole numbers, to dimension based parameters such as rainfall in mm. To fit the data into the above framework (Figure 20), harmonization of all data is required. Therefore, all data were first normalized on to a scale of 0-1 using Min-Max normalization strategy which linearly transforms x to y.

$$y=\frac{(x-min)}{(max-min)}$$

Where, min and max are the minimum and maximum values in X, and where X is the set of observed values of x. The obtained normalized y values were then formatted to a GIS friendly format. The normalization has been done within VDC boundaries shown in Figure 23.

2.4.4. Assessment of climate change risk and vulnerability in GIS

The VDC boundaries' polygons prepared by Department of Survey were filled up with normalized scores of indicators using the Q-GIS platform. To avoid the multiplication by '0' value, all normalized values from 0-1 were rescaled from 1 to 3 in Q-GIS. All indicators within watershed were normalized in the scale of 0-1 and then rescaled to 1, 2 and 3 and interpreted as Low, Medium and High respectively. In NAP process, the weights of sub indicators were not defined for grouping and such research in Nepal has not been carried out in Climate Risk and vulnerability. Therefore, sub indicators were averaged with equal weights in a group (Hazard, Exposure, Sensitivity, and Adaptive capacity). The obtained average value was again in the 1-3 scale for further analysis as shown below.

$$Climate\ Change\ Risk = Hazard^{1\text{-}3} \times Exposure^{1\text{-}3} \times Vulnerability^{1\text{-}3}\left(\frac{Sensitivity}{Adaptive\ capacity}\right)$$

The maximum combined possible products for Risk will be 27 (3x3x3) and minimum is 1 (1x1x1). The Climate change risk obtained from Hazard, Exposure and Vulnerability was again rescaled to 5 classes using combinations shown below.

Table 17: Risk Scoring Table

High to extremely high Impact 3x3x3 =27 high risk 3x3x2 =18 high risk	**Moderately high Impact** 3x2x2=12 moderately high Risk 3x3x1=9 moderately high Risk	**Moderate Impact** 2x2x2=8 moderate risk 3x2x1=6 moderate risk	**Moderately low impact** 2x2x1=4 moderately low risk 3x1x1=3 moderately low risk	**Low Impact** 2x1x1=2 low risk 1x1x1 =1 low risk

All the indicators were converted to raster format. To calculate the risk and vulnerability, raster calculator from map Algebra in Q- GIS was used to develop risk and vulnerability digital maps.

2.4.5. Hazard assessment

As described in framework (Figure 30), the final Hazard assessment should be based on Climate Change derived hazards (scenario and trend). In particular, the climate change indicators derived from temperature and precipitation is suggested in the framework. A hazard assessment flow chart from this framework is shown in Figure 31.

In the flow chart, hazard refers to the final assessment of climate induced hazard which is a combination of trend and scenario of climate change threshold indicators Table 19. Since the risk and vulnerability assessments were carried out qualitatively, the climate change values were normalized and ranked at the VDC level and its aerial impacting distribution was ranked for VDCs. As mentioned above, the working grid is VDC scale and available climate change data is $1^0 \times 1^0$ (111.699 km x 111.699 km) and, therefore, the raster interpolation was carried out in GIS using Kriging interpolation to 5 km x 5 km raster grids. The threshold indicators such as Drought likelihood and change in 5 days cumulative maximum rainfall were used for the Risk analysis. Some other parameters such as threshold temperatures were also worked out for general climate study. The data used for the hazard analysis is shown in Table 17.

The climate trends at the district level are available with DHM (Department of Hydrology & Metrology, Nepal, 2017) but threshold parameters which leads disastrous hazard is not available. The most precise data found for this framework was VDC wise hazard rating data from District disaster relief committee (DDRC) of Nepal Government. This hazard rating was combined with relevant thresholds parameters of Climate change projection available in World Bank Climate portal. The trend from DHM 2017 is used for general climate analysis.

Table 18: Indicators used for Hazard Analysis

Indicators	Source	Data availability
Flood	DDRC	All watersheds
Landslide	DDRC	All watersheds
Drought likelihood	WB –Climate Change Portal	All watersheds
Snow fall	DDRC	Mugu Karnali watershed only
Largest 5 days cumulated Rainfall	WB –Climate Change Portal	All watersheds
No of frost days (T min <0 °C)	WB –Climate Change Portal	Mugu Karnali and Lohare watershed

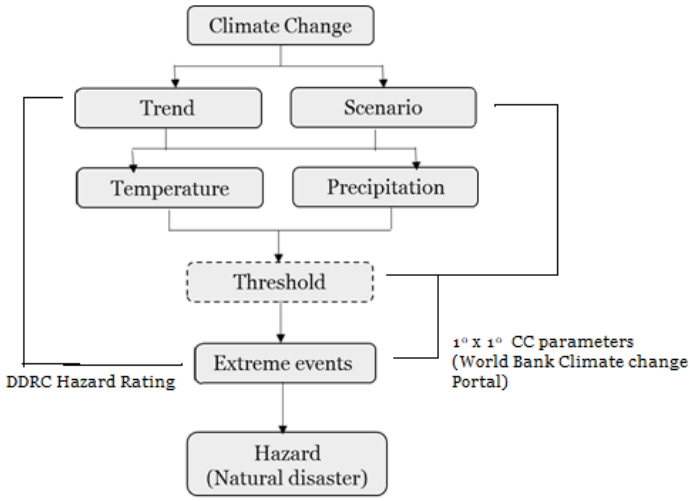


Figure 24: Hazard Assessment flow chart

The projected threshold parameter -largest 5 days cumulative rainfall (period 2040-2059, RCP 4.5 , miroc_esm model) was worked out for the risk analysis of Flood and landslide. The miros esm model was downscaled and successfully tested in Upper Tamakoshi Watershed (Sangam Shrestha, 2016). Since this study is scored based on qualitative analysis, the projection climate change parameter was normalized by maximum and minimum values (0 to 1) and re scaled from 1 to 3 in GIS mapping. The map was then combined with hazard map (scored 1 to 3) developed from VDC 's hazard scoring (DDRC hazard rating) to develop final hazard map.
Flood is generally generated from up stream of watershed and inundates the plain areas downstream. The future change in largest 5 days cumulative was high in south of upstream part of watershed, i.e., Dang Valley. The DDRC rating also shows this area as one of the flood hazard area (Figure 32). Therefore, some VDCs with medium hazard may face high hazard in future.

The combined raster between projection and historical flood indicates medium flood hazard could be turned into high and low could be medium in upstream south of watershed. Since floods in the lower parts of the watershed is mainly due to extreme weather in the upper areas, the lower plain hazard was kept as it is.

A similar assessment was carried out for all watersheds for flood and landslides. Since one of the key hazards (annual drought likelihood) is already available in projection condition, this indicator was directly used as drought hazard for Risk and Vulnerability analysis. The same method was applied to develop frost hazard maps. There is lower flood hazard in the Lohare watershed but landslide, drought and frost are major hazards. In Babai Watershed, flooding is

a major hazard for crops and livestock. In Mugu Karnali, snow fall, droughts, floods and landslides are major hazards. The hazard maps developed for all 3 watersheds are shown in Annex 3.

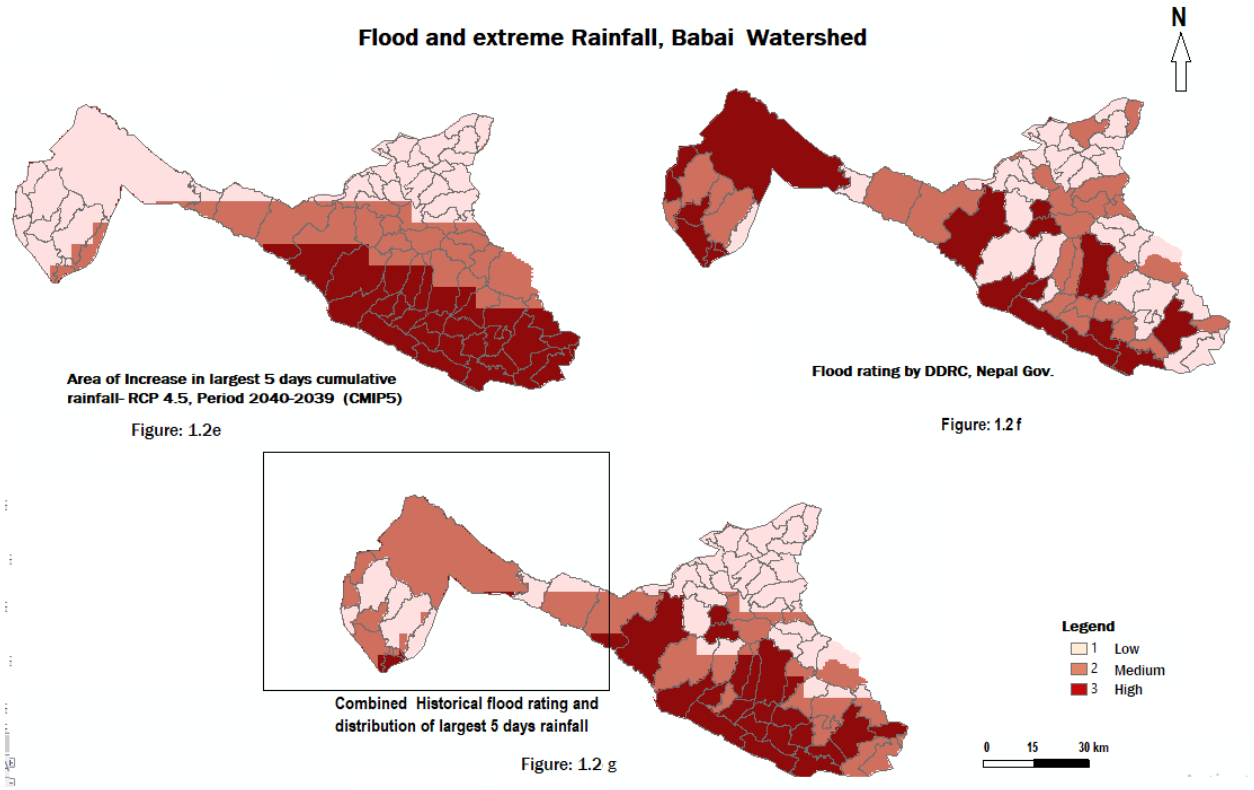


Figure 25: Flood and Extreme Rainfall Babai

2.4.6. Exposure

Exposure assessment is aimed at identifying the elements of human life that are at risk to climate change. The data availability in watershed scale is limited. Since the project focused on climate risk within an agro-ecology, this study treated agriculture area and livestock as exposure elements and forest and range land as supporting elements for agriculture (adaptive capacity of area) in a watershed. The agriculture production at the VDC scale is not available for the identified regions, except for Lohare Watershed of Dailekh District. Therefore, the percent of cultivated lands within VDC (ICIMOD land cover map 2010) was used and rescaled from 1 to 3. Similarly, livestock numbers in VDC, provided by CBS was used as sub indicators of exposure. The final exposure map was prepared by combining both agriculture and livestock. The indicators used for exposure is shown in Table 18 and exposure maps are shown in Annex 1 and combined exposures of three watersheds are shown in Figure 25.

In Mugu Karnali watershed combine exposure is high at the downstream regions and upstream regions of the watershed. In Lohare watershed, majority of the region has medium exposure. The upstream area has low exposure and only couple of VDCs were highly exposed. In Babai Watershed, the southern part of the upstream areas was highly exposed. The majority of area in the watershed had medium exposure.

Table 19: Exposure indicators used for CC risk and vulnerability framework

Indicators	Data type	Scale	Source
Population of livestock	No/ VDC	VDC scale	CBS 2011
Agricultural area	Total area/ VDC area	VDC scale	ICIMOD, 2010/DoI 2016

The weights of livestock and agriculture are complicated in watersheds where altitude variations are significant. Both practices have their equal importance. Therefore, no weights were applied and exposure was calculated using a simple average method.

$$Exposure\ (E) = \frac{Livestock\ Index\ (1-3) + \ Agriculture\ Index\ (1-3)}{2}$$

The value obtained was re scaled again from 1 to 3 for further analysis

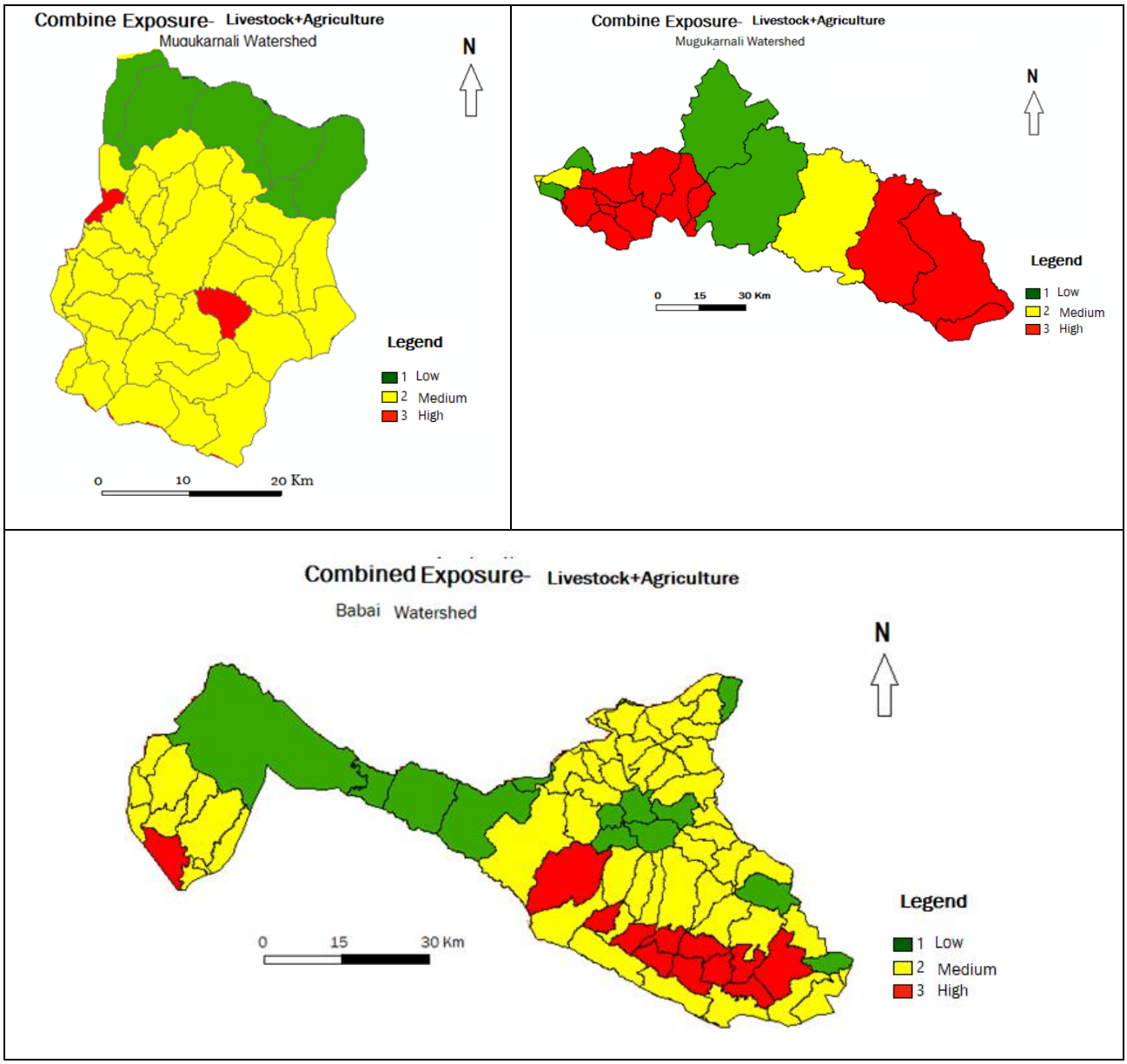


Figure 26: Combines Exposure Maps

2.4.7. Vulnerability

Sensitivity: To access vulnerability from the framework, sensitivity was worked out using demographic and socio economic data from census of 2011 by Central Bureau of Statistics (CBS). The available VDC level data were normalized as mentioned above, mapped and again re scaled from 1 to 3 in GIS. Except Lohare watershed, some VDCs do not lie fully within the watershed boundary. Unless detailed survey is undertaken or data is collected up to the ward levels, it will not be possible to separate VDC level data. Therefore, the data for VDCs were kept as it is for those VDCs which partly contribute to watershed. One VDC in Mugu Karnali watershed and Few VDCs of Salyan District in Babai Watershed were partly inside the watersheds.

This study selected some indicators for Sensitivity in line with NAP recommendation. The data collected and computed are shown in Table 20. High population density means more sensitive area and income disparity, dependency on natural resources; all of which increase sensitivity. Besides this, the gender inequality makes populations more sensitive to Climate. The maps of sub indicators are presented in Annex 3.

Table 20: Sensitivity indicators

Indicators	Data type	Scale	Source
Population density (Pd)	Nos/area HHno/Area	VDC scale	CBS 2011
Income disparity (Id)	HH with or without Facility	VDC scale	CBS2011
Livelihood dependency on forest (Fd)	Fire wood Dependent and housing material depending HH Nos /area	VDC Scale	CBS2011
Gender inequality (Gii)	Non dimentional ratio-female and male literacy ratio, female and male population ratio	VDC scale	Computed-CBS2011, National planning Commition, Dep. Of Healty
Water system supply dependent Population (Wd)	System dependent HH No	VDC scale	CBS2011

Sensitivity was calculated by averaging 5 indicators mentioned in Table 19. Population contributes heavily to sensitivity. The sensitiveness of population to climate depends on their livelihood and indicators such as Gender balance, forest and water dependency and income disparity plays equal roles in sensitizing people. Therefore equal weights was considers for all parameters and sensitivity was carried out using simple mean method:

$$Sensitivity(S) = \frac{(Pd + Ld + Fd + Gii + Wd)}{5}$$

The average value obtained was rescaled from 1-3 for further use.

Adaptive Capacity: Again, going by the system of concern defined, the key indicators that will be used for assessing the **adaptive capacity** are food sufficiency/security, Literacy, economically active age group, forest coverage and range land coverage. The above indicators are availability in VDC scale.

Since this study focused on agro-ecology and forests provide essential services across all scales, from local communities to the whole watershed. Forests contribute to reducing the vulnerability of society to climate change. Forest dependent households are large in the watershed, therefore it is coverage is kept in adaptation sub indicators. Similarly range land coverage is also kept in adaptation's sub indicators as it reduces vulnerability to major livestock.

The increase in all above indicators (table 20) indicates high adaptive capacity. The data available for this study for food sufficiency was food insecurity data, therefore this indicator was inversed while calculating adaptive capacity index. The economic active population (15-59 age) and literacy rate were used directly as increase in index will increase adaptive capacity. The weights of each indicators is not defined for Nepal, therefore equal weights considered and simple average method used to arrive adaptive capacity as

$$Adaptive\ Capacity = \frac{Ep + Lr + Fs + Rl + Fl)}{5}$$

The adaptive capacity obtained from 1-3 then used to calculate Vulnerability. The vulnerability is simply a sensitivity divided to adaptive capacity

$$Vulnerability = \frac{Sensitivity}{Adaptive\ Capacity}$$

*Note: The food condition is minimum insecure throughout Babai watershed. Therefore this layer for Babai Watershed has not been considered.

Table 21: Adaptive capacity indicators

Indicators	Data type	Scale	Source
Economically active population index (Ep)	Population of Age group	VDC Scale	CBS 2011
Literacy rate (Lr)	Percent in VDC	VDC Scale	CBS 2011
Food sufficiency (Fs)	Rating of food security	VDC Scale	NeSKAP, 2015, 2017
Range land (Rl)	Range land coverage	VDC Scale	ICIMOD 2010
Forest land (Fl)	Forest coverage	VDC Scale	ICIMOD 2010

2.4.8. Risk

As per the AR5 based NAP Climate Risk and Vulnerability framework, CC risk is a function of Hazard, Exposure and Vulnerability. The risk assessment as per this framework needs many socio economic, demographic and geographic sub indicators, which represent vulnerability. Some indicators which are directly related to people and their livelihoods, which increase their exposure to climate, are treated as exposure sub-indicators. Therefore, when even Hazard may appear high, the multiple layers of sub indicators of social and geographic condition and their strength could reduce the climate change risk.

The impact of different types of Hazards to a watershed's agro ecosystem is not uniform. In large or regional/country scale, combined hazard to one maybe promising but CC risk assessment in AEZ level within watershed may not be appropriate i.e. Drought hazard area may not be flood hazard area and their likelihood also different largely. Therefore high risk could go down moderate risk of CC assessment. The following method is applied for CC risk mapping

2.5. Climate risks at the AEZ Level

The working boundaries used to identify Climate Change risks and those used for AEZs are not the same due to unavailability of spatial (e.g. climatic data) and non-spatial data (e.g. population). The working boundary of Climate Change risk is at the VDC scale and that of the AEZs has been arrived by cross interpolating climate, land form and soil order data. The Climate Change risk output mapping was attained through the scoring based method outlined in Table 15. The Climate change risk score and its working boundary were overlaid on AEZ boundaries for Climate Change risk assessment at the AEZ level for all the risks. To demonstrate this method, as an example, the drought risk at the AEZ level has been assessed by overlaying climate change risk score for Mugu Karnali AEZs as shown in Figure 36. The risk from different hazards was extracted and presented in Table 23 through Table 25.

2.6. Field validation

The findings from the spatial analysis was corroborated with the field visits. The following methods and tools would be used to generate relevant information:

2.6.1. Transect walk and observation

Transect walk and observations to be carried out in the study sites to identify and locate the major elements of the adaptation options with women and men separately as they can highlight the different issues and constraints/challenges that put them at differential risk and may affect adaptation options. Site specific photographs were taken during transect walk survey and the information collected through observation will be recorded manually.

2.6.2. Focus Group Discussion, Key Informant's Interview and Stakeholder Meetings

The field visits is necessary for carrying out environment & social safeguards ad gender assessment of the identified adaptation measures. Therefore, field assessment was carried out using participatory approaches such as Focused Group Discussions (FGD), Key Informant Interviews (KII) and one to one stakeholder consultations (with local

authorities and institutional experts) to validate the findings of risk assessment and identify mitigation and adaptation options. The FGDs have been split into groups of men and groups of women to ensure perspectives, needs, interest, and constraints are captured and considered.

The general approach followed for each of the methods is depicted below in the form of a flow chart:

A. Focus Group Discussions

Figure 27: Approach - FGD

B. Interview with key informants

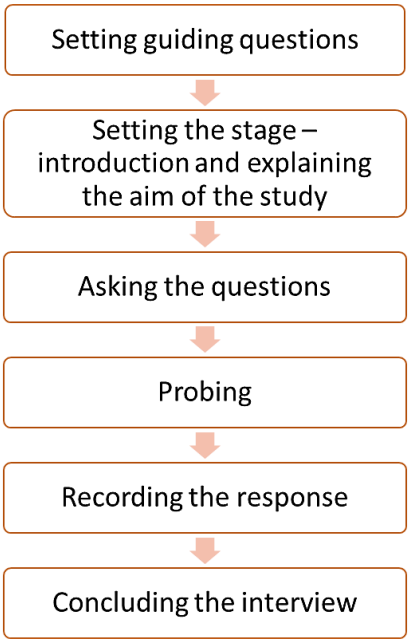


Figure 28: Approach - Interview with key informants

C. Stakeholder meetings

Figure 29: Approach - stakeholder meetings

The ultimate objective of the methodology is to identify, validate (spatial assessment) and prioritize areas and target at risk in the considered region, in order to evaluate the benefits of different adaptation options and to support relevant stakeholders in knowledge-based planning and decision making.

The outcome of the vulnerability analysis in terms of the physical/ environmental risks is further validated through field level consultations. The field level consultations comprise various modes like the Focus Group discussions, Key Informant Interview and stakeholder meetings. The steps undertaken under each mode is presented above in the figure nos. 23, 24 and 25.

Environment & Social Safeguards:

The EbA measures should meet the Environment & Social Safeguards criteria and each identified measure is tested against these criterions. These safeguards typically underpin the fundamental concept of EbAs i.e. the identified measure should not lead to environmental degradation/ contamination & should be culturally aligned to the local practices and should lead to conservation activities.

Gender assessment:

Women are extensively utilized as agricultural labour in Nepal. Women, sometimes, have to complete household work and join their male counterparts in fields as well. Women groups organized into user groups are involved in decision making process and therefore are critical component of identifying the Ecosystem based Adaptation options. During the Focus Group Discussion with local people and district level stakeholder in the study districts, the need assessment from the perspective of gender was carried out to understand the relevance of adaptation measures and whether the recommended options meet the gender assessment criteria or not. The issues that could impact would women/ children and marginalized population from access the intended benefits accruing from the EbAs.

Economic assessment:

Through the E&S safeguards and gender assessment the most viable options of measure were identified. Subsequently, a suitable economic appraisal methodology is identified to ascertain the economic cost and benefits associated with each measure. The economic assessment therefore yields quantitative output to enable policy makers make an informed choice about the EbA measures.

The chart below presents the schematic flow of steps undertaken as part of this study for shortlisting the EbA measures.

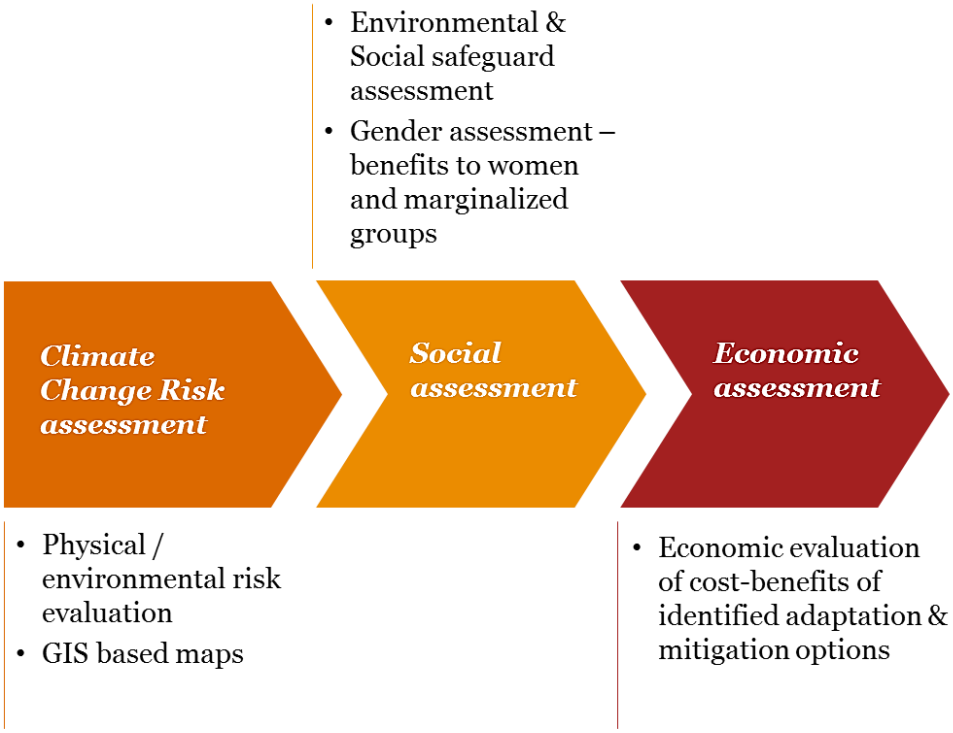


Figure 30: Adaptation planning process

2.7. Cost-Benefit Assessment Methodology

In relation to the economic analysis of projects (or, for that matter, any new project), there exists two distinct approaches to cost-benefit analysis – the financial cost benefit analysis and the economic cost benefit analysis. In the case of Financial CBA (FCBA), the profitability (or return) from the project is of interest. On the other hand, in the case of Extended CBA (ECBA), all externalities, positive and negative, in relation to the economy, society and

environment are considered as benefits and costs respectively. Though both the financial and economic analyses necessarily analyzes "profit" from an investment, there is a distinction between "financial profit" and "economic profit". While the financial profit accrues to the project operating entity, the economic profit is essentially the contribution of the project to the economy as a whole (ADB, 2017), (The World Bank, 2010), (ADB, 1997).

For the projects which are planned with the objective to increase welfare – e.g. adaptation benefits, ECBA is considered to be more robust and desired method (ADB, 2017). ECBA captures costs and benefits accruing to the different stakeholders of the project (over the life-time of the project) and, thus, justifies the efficacy of the investment from the social, economic and the environmental point of view. With the goals of sustainable development becoming the desired outcomes of plans and policies, various development funding institutions like UNDP, The World Bank, the Asian Development Bank, etc. stress on carrying out a comprehensive ECBA as a decision criteria for undertaking an investment which are planned by the government.

A climate project with has effects on the society, environment and economy at large. Therefore, it is not prudent to view any such project in isolation. The Extended Cost Benefit Analysis (ECBA) views the project in relation to the entire economy (local, regional and global) and internalizes all the visible and invisible costs and benefits in the calculation. This is a more robust tool for better resource allocation when competing projects are present. Further, most development funding agencies (The World Bank, Asian Development Bank, Japan International Cooperation Agency, etc.) while appraising a project for investment, puts a lot of stress on this analysis.

A project aimed at water shed management or agriculture, for example, can give rise to a series of costs and benefits to the surrounding geographical space. A few examples of such benefits and costs are presented in the table below. A cost benefit analysis without considering such "external" costs and benefits, and relying solely on the internal (specific) costs and benefits (like the ones considered in the FCBA) tends to provide an incomplete picture of the project as a whole, particularly from the welfare point of view. More important, such external costs (and benefits) are not a one-time affair but continue to accrue over the life of the project. Therefore, a properly done ECBA points to how a project (such as a project for increasing adaptive capacity of beneficiaries) affects the surrounding population over its lifetime.

Table 22: Example of External Costs and Benefits: Adaptation Project

Issue	Economic benefits	Economic costs
Incremental Livelihood	Creates incremental income for the beneficiaries – productivity gains, conservation of resources	Loss of existing occupation due (e.g. loss of land, etc.)
Incremental accessibility to services from infrastructure developed	Beneficiaries can access the infrastructure (physical and social)	Issues concerning development induced displacement
Incremental opportunity to economic activities	Economic agents can engage in trade and commerce	Out-migration, if any, due to loss of opportunities
Incremental abatement of emission/pollution	Incremental value of the carbon sinks created through the project	Any direct/indirect emissions
Incremental bio-diversity	Incremental value of eco-system services	Losses, if any arising due to loss of bio-diversity

The benefits and costs related to the ECBA are, at times, invisible and pertain to measures for adaptation and mitigation and are most commonly, non-traded goods and services – for example, biodiversity preservation, benefits of pollution free environment, social effects from improved infrastructure, etc. In such situations, the method of Willingness to Pay (WTP) may sometimes be deployed to impute a monetary value to such goods and services. ECBA is widely prevalent method in assessing the economic viability of investment projects, particularly, development projects and are mandatory exercises for proposals made to the development funding institutions like UNDP, ADB, The World Bank, etc.

The following table lists steps in carrying out the ECBA. For details, one may please refer to (ADB, 2017), (OECD, 2007), (The World Bank, 1998), (ADB, 1997).

Table 23: Economic Cost Benefit Analysis: Key Steps

Step	Description	Key Activities
1	Defining the objective of the project	• This is the first step in the economic analysis. Clearly defined objective(s) is essential to reduce the number of alternatives considered, and to select the tools of analysis and the performance indicators of success. • Objectives of a project could be narrow to broad.
2	Deciding on the least cost design without compromising on the overall objective	• Examination of alternatives solutions is necessary. The alternative (technically feasible solutions) could be alternative technical specifications policy/institutional reforms (different tax regimes), geographical locations or differences in scale of the project envisaged. • The exercise helps planners and policy makers to come up with a port-folio of alternatives, with associated costs and benefits, so that the most optimal solution is chosen for implementation.
3	Identification of Beneficiaries	• Normally, not everyone benefits from the outcomes of a project and some sections of the society may lose. Moreover, groups that benefit from a project are not necessarily those that incur the costs of the project. Identifying those who will gain, those who will pay, and those who will lose gives an insight into the incentives that various stakeholders have to be guaranteed so that the project is implemented as designed.
4	Assessment of fiscal impacts	• How and to what extent will the costs of the project be recovered from its beneficiaries? • What changes in public expenditures and revenues will be attributable to the project? • What will be the net fiscal effect for the central government and for local governments? • Will the cost recovery arrangements affect the quantities demanded of the services provided by the project? • Are these effects being properly taken into account in designing the project?
5	Assessing the Financial Sustainability	• Is adequate finance available for the project and maintenance of the same throughout its life? • What is the cost of capital? Are their opportunities to minimize the cost of capital? • What are the other costs (other than the cost of capital) for arranging finance for the project through its lifetime?
6	Distribution of Costs and Benefits among stakeholders	• The exercise involves looking at the project from the view-point of the different stakeholders – government, private entities, society at large, etc. and then distributing the costs and benefits among these various stakeholder groups. • A sub national consultation workshop can be conducted to get suggestions from the district and village level institutional officers on the appraised cost and benefits for more precise analysis • Typically, the externalities are distributed between the stakeholders all through the life of the project. Valuation of external costs and benefits is an important issue and there exists different approaches to valuation (The World Bank, 1998). • The exercise also helps to ascertain the incentives to be designed and interventions required so that the project reaches the social optimum.
7	Is the project worthwhile?	• Once the aforesaid activities are completed the "economic benefits" from the project are compared

Step	Description	Key Activities
		with the economic costs. ADB (1997) refers to a measure called EIRR (Economic Internal Rate of Return). A project is considered worthwhile when the economic benefits are far greater than economic costs. • Alternately, a Cost-Benefit-Ratio (CBR) may be calculated and compared to a benchmark
8	Sensitivity Analysis and Risk Mitigation Strategy	• Altering scenarios and observing the impacts on the net economic benefits. • The analysis also points to the sources of risk and thereby helps in formulating appropriate risk mitigation mechanisms

Source: (ADB, 2017), (OECD, 2007), (The World Bank, 1998), (ADB, 1997)

A comprehensive economic analysis is, therefore, not an isolated and independent exercise. It embodies technical specifications, socio-economic and environmental impacts of all the stake holders. For a projects aiming at reducing climate-risks, the analysis must be the FIRST STEP for planning and designing. Decisions (with respect to components, features and technologies) taken on the basis of a robust economic analysis reduces the possibility of selecting inappropriate components, reduces the chance of mal-adaptation and ensures sustainability of the project over a long time horizon.

2.7.1. Climate Change relevance of a project

When projects are intented to be financed through pooling of finances from dedicated climate funds (e.g. GCF, Adaptation Fund, etc.), it is extremely important to highlight the CC relevance of a project. Action of Climate Today (ACT) has developed a framework to find out this relevance. The methodology stems out of ECBA. In this sub-section, a brief description of the method is presented. For a theoretical background of the methods, please refer to figure 27 adopted from(Allan, et al. 2016), (UNDP 2015), (IISD 2012). . The basis of valuation of benefits is at constant prices (ADB, 2017), (GGGI, 2014) and that the units for calculation of benefits does not change remains constant over time (Allan, Resch, Alvarez, & Nicholson, 2016).

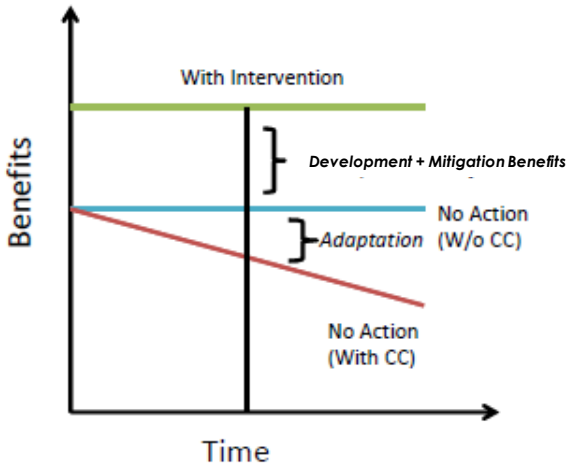


Figure 31: Climate relevance of a project

A project, while having development benefits, may also have benefits in the form of adaptation and/or mitigation (Allan, Resch, Alvarez, & Nicholson, 2016). Conceptually,

- Total Benefits = Economic growth (EG%)+Social development (SO%)+Environmental benefits (EV%)+ Adaptation benefits (AD%)+Mitigation benefits (MI%)
- Climate relevance (CC%) = AD% + MI%

- CC% = (B-A)/B, where B = CBR with climate benefits and A = CBR without climate benefits[4]

Hence, a properly conducted ECBA can also lead to ascertaining the climate relevance of the climate interventions.

[4] Please refer to Annexure for a mathematical deduction of the result.

3. Spatial analysis

Based on the framework discussed in the above section, the spatial analysis was carried out by using the GIS tool. The weighted average tool of ARC GIS was used to map climate change risk areas.

The VDC boundaries polygons prepared by Department of Survey were acquired and filled up all normalized indicators in Q-GIS platform. To avoid the '0' value in multiplication, all normalized values of indicators rescaled to 1-3 from 0 to 1 in Q-GIS. The rescaled score from 1, 2 and 3 was interpreted as Low, Medium and High respectively. In NAP process, the weights of sub indicators were not defined for grouping and such research in Nepal have not been carried out in Climate Risk and vulnerability. Therefore, sub indicators were averaged with equal weights and averaged to arrive Risk indicators (Hazard, Exposure, Sensitivity, and Adaptive capacity). All indicators were converted to raster map and multiplied using raster math tool in Q-GIS to get CC risk map and it is based on formula in Table 14. The Final risk maps with new administrative boundary is presented from figures 26 through 36.

3.1. Climate change risk assessment at watersheds

3.1.1. Babai:

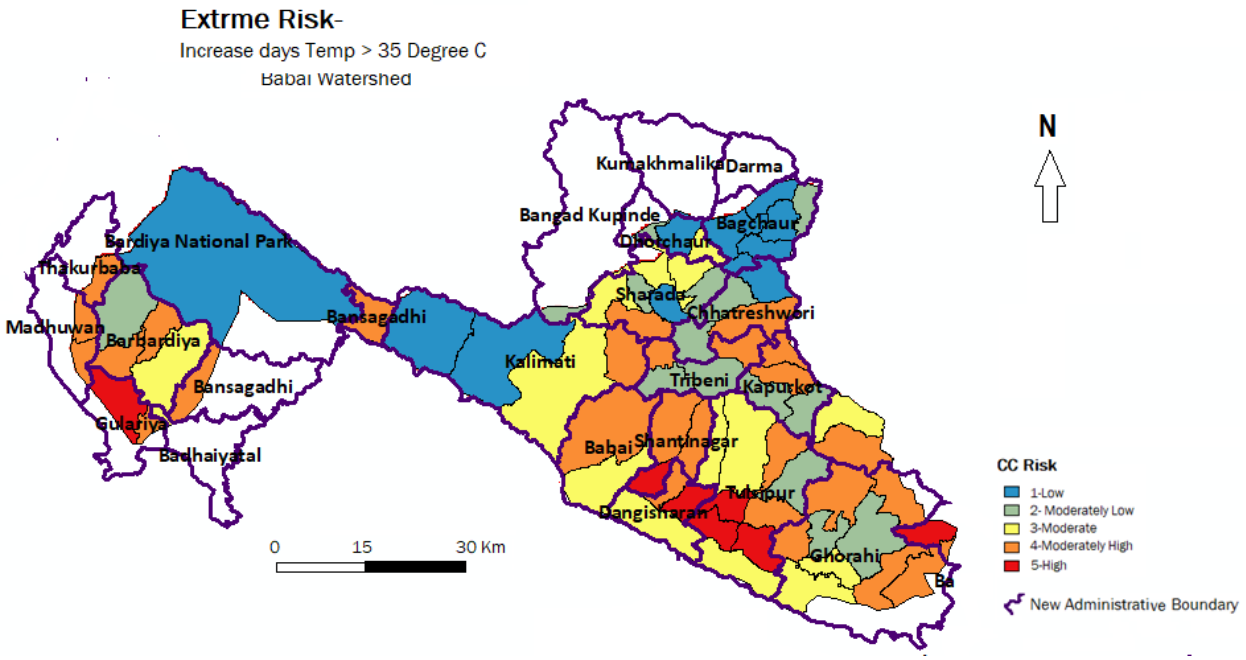


Figure 32: Extreme Temperature Risk

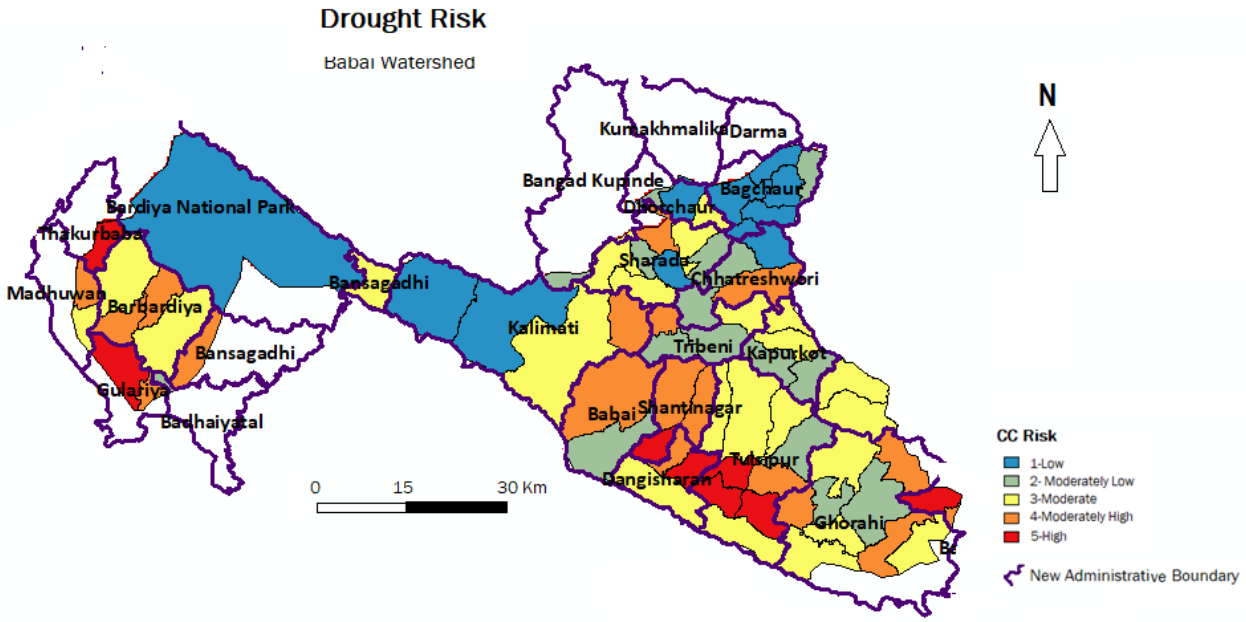


Figure 33: Drought Risk

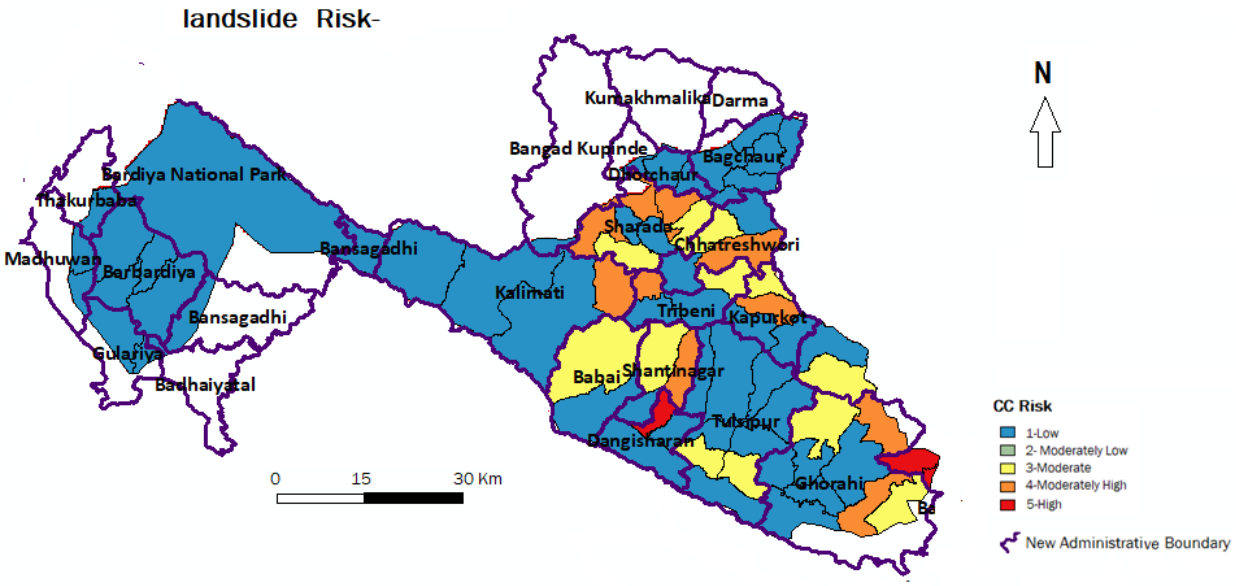


Figure 34: Landslide Risk

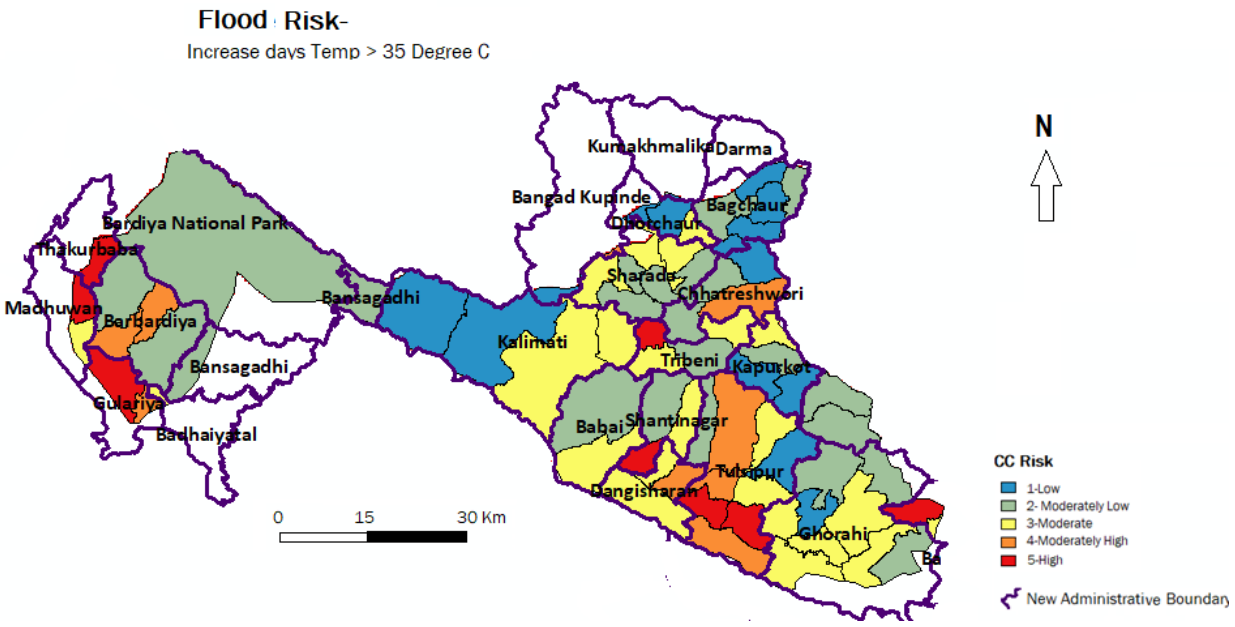


Figure 35: Flood Risk

3.1.2. Lohare Watershed

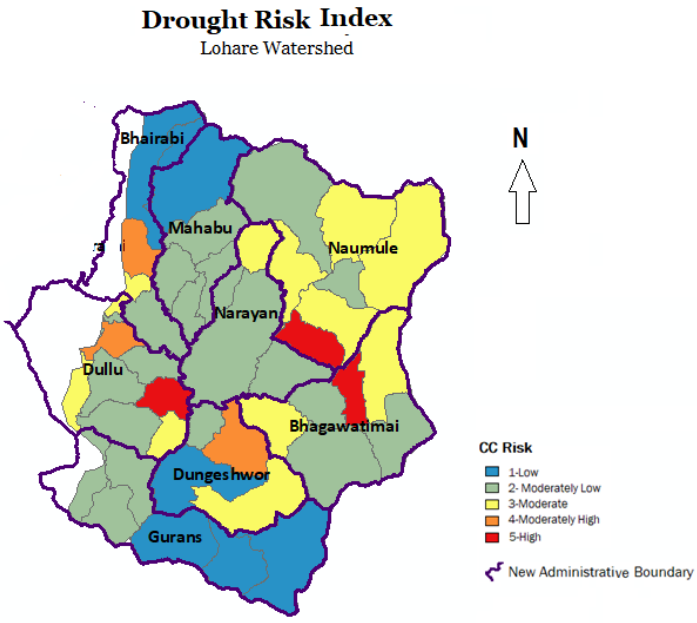


Figure 36: Drought Risk

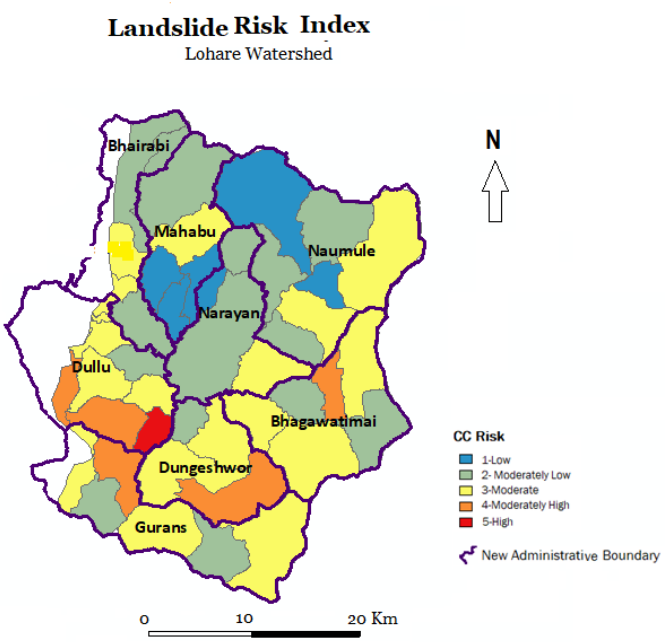


Figure 37: Landslide Risk

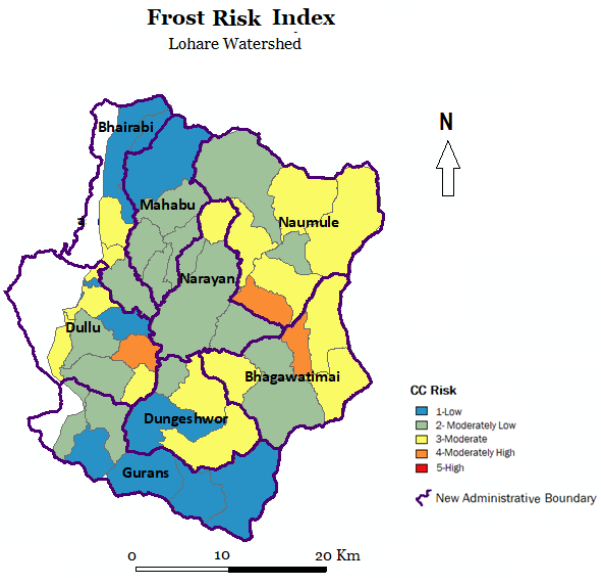


Figure 38: Frost Risk

3.1.3. Mugu Karnali Watershed

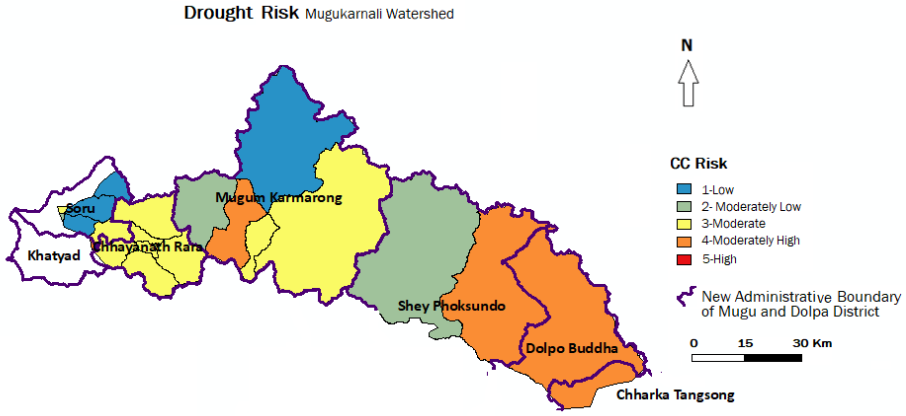


Figure 39: Drought Risk

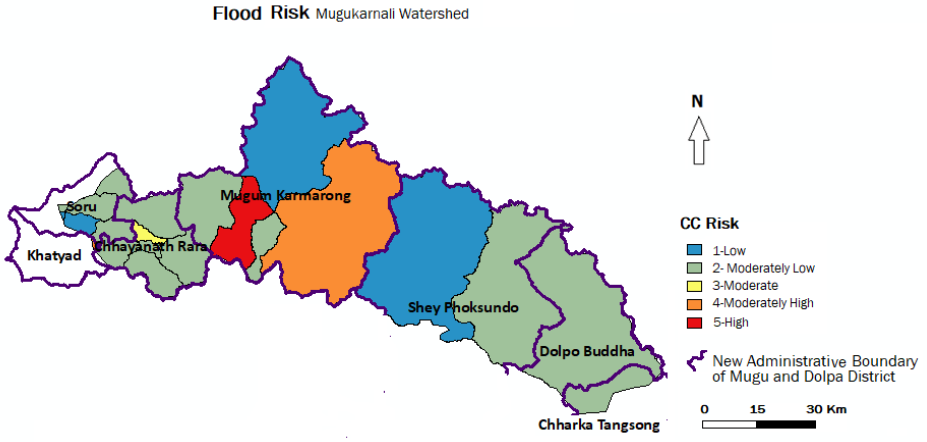


Figure 40: Flood Risk

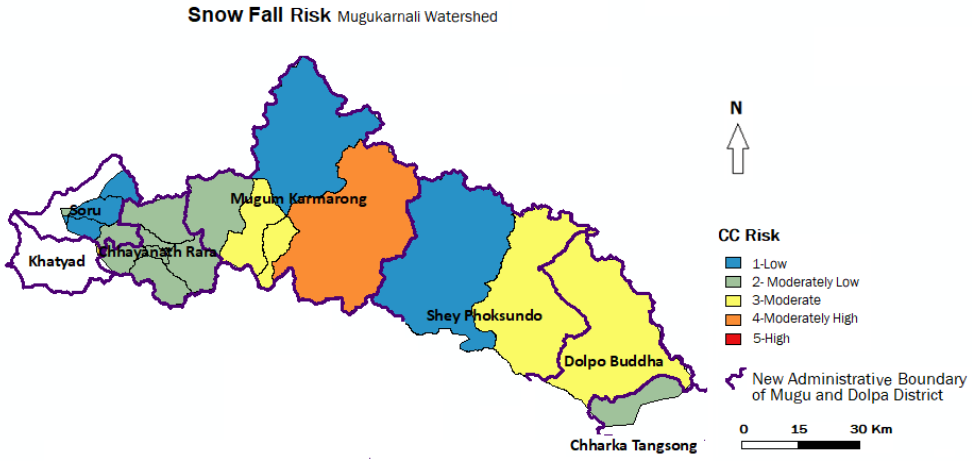


Figure 41: Snow Fall Risk

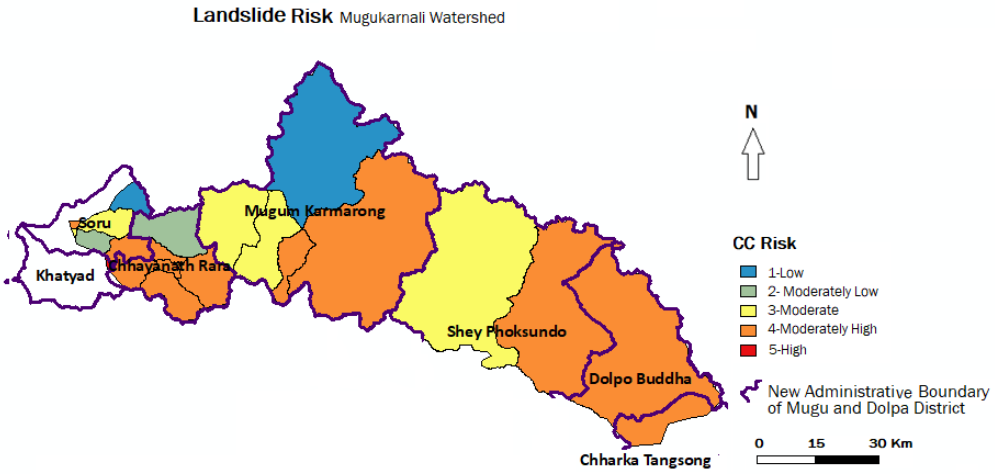


Figure 42: Landslide Risk

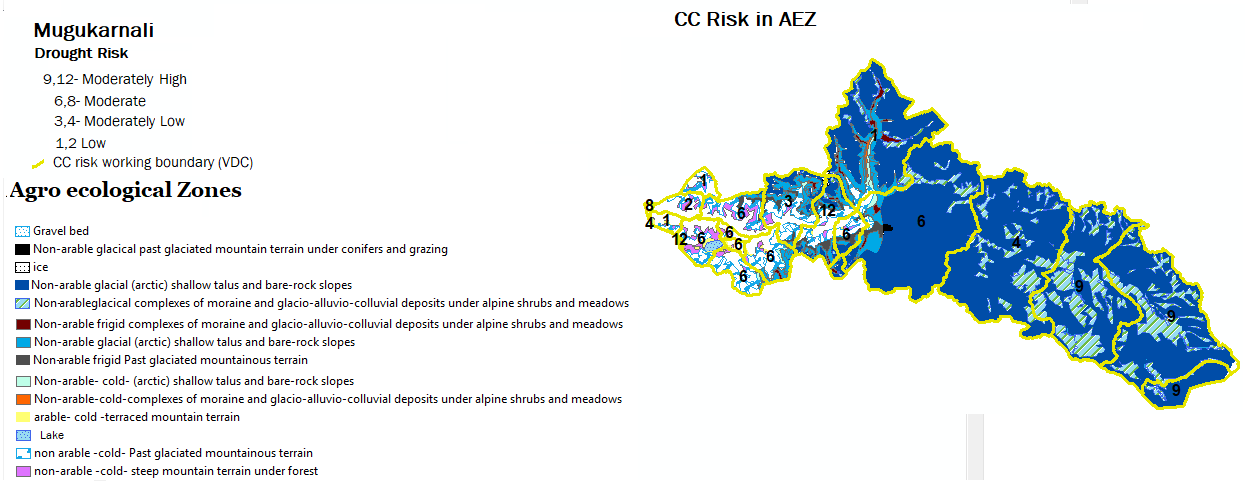


Figure 43: Drought Risk in Mugu Karnali

3.2. Climate Risks at the AEZ Level: Findings

3.2.1. Babai Watershed

Table 24 Climate Risks at the AEZ Level: Babai

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
1	**Arable temperate terraced mountain terrain**	• This AEZ is located in the upstream mountain terrain of the watershed. • While the drought risk in this zone is low to moderate the landslide risk is moderately low to moderately high. • The flood and drought risk is low to moderately low. • The 'extreme temperature hazard' is low to moderately low in this AEZ.	• The high landslide risk in this region may lead to increased sediment deposits in the downstream areas. During high rainfall, landslide risk will increase and could lead to disasters • Landslide and debris flow will increase soil erosion. Likelihood of damage to crops and arable land	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc. • Promote mix cropping. Mixed cropping involves growing two or more crops simultaneously in the same field. Mixed cropping provides additional yield and income per unit area and it serves as an insurance of failure of crops due to adverse climatic condition. Incorporating legumes in mixed cropping increases soil fertility and reduces soil erosion. •
2	**Diverse crop arable temperate recent alluvial plane**	• All risk types in this AEZ are in the low to moderate Low range. It lies in the upstream part of the watershed	• This area is steep area of the watersheds. Moderate risk could damage agriculture	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Promote mix cropping. Mixed cropping involves growing two or more crops simultaneously in the same field. Mixed cropping provides additional yield and income per unit area and it serves as an insurance of failure of crops due to adverse

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
				climatic condition. Incorporating legumes in mixed cropping increases soil fertility and reduces soil erosion.
3	**Non-arable temperate Past glaciated mountain terrain**	*This watershed is not being considered for analysis due to its very small geographic size*	*N.A.*	•
4	**Non arable temperate steep mountainous terrain under forest**	• The landslide risk is moderate to moderately high in this area. • The flood risk and extreme temperature risk are low and the drought risk lies in the moderate to moderately low range.	• Increased landslides risk could erode forest soil and cause losses to forests.	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
5	**Non-arable sub-temperate dissected ancient depositional basin and river terrace under forest**	• The flood risk is moderate to high in this AEZ. Landslide risk and extreme temperature risk are low but drought risk falls under moderately high to high range.	• It is a depositional basin and the river terrace lies under forest. Floods could carry sediment and wood to the downstream regions.	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
6	**Arable sub-temperate ancient depositional basin/river terrace and recent alluvial plain complexes**	• This AEZ predominantly lies in the lower belt and the hills region of the upper watershed part. The drought and flood risk is moderate to high in this AEZ. • The extreme temperature risk is also high but landslide risk is low in this AEZ. • It also extends along the river and in the lower hills. However, all risks are low to moderately low in this stretch of the AEZ	• The extreme temperature drought and flood risk could damage crop.	• Rehabilitation and networking of existing irrigation system and promotion of rain water harvesting technology in order to prevent crop failures caused by drought in drought prone areas thus reduces drought risk and increased planting index. • Promote System of Rice Intensification. SRI is climate smart farming technology that increases the rice yield by 20 to 50 % while the irrigation water is reduced by 30 to 50%.SRI strengthen crop resilience to climate change and variability due to healthy and deep rooted system of rice plants. SRI plants can better resist drought, water logging and rainfall variability. SRI plants reduces

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
				greenhouse gas emission. Methane is reduced by 22 to 64 % as soils are maintained mostly under aerobic condition. • Promote River Bed Farming (RBF) which is an environmentally, ecologically sustainable agriculture technology that generates the HH incomes of marginal and landless farmer and increases rural employment opportunities. In the RBF unused lands of riverbeds are used for the production of watermelon, cucumber, pumpkins, gourds and other summer vegetables. RBF enhances the capacity and capability of marginal and landless farmers to combat the effects of climate change. • Promote Integrated Pest Management (IPM). IPM as a pest management strategy is an ecosystem approach of crop production and pest management that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides. Methods such as cultural practices, use of botanical pesticides, biological control, use of resistant varieties, physical methods are used in integrated way to manage the pests. To promote IPM technology Farmer's Field School (FFS) as a tool should be promoted. • Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc. • Because of increasing incidence of droughts due to climate change, grass for grazing is in short

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
				supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. • As identified during field visits, cattle raising farmers are cut off from markets to sell their produce. They may be provided with facilities of milk collecting and chilling centers for storage of milk and meat. Also, transportation facilities may be provided for transporting the produce to markets. • Promote Vaccination Program-Vaccines can prevent a wide range of diseases that cause reduced production, fertility or death in cattle and economic losses as identified during field visits
7	**Arable sub-temperate terraced mountain terrain**	• It is widely distributed in the mountain and hills of upper water shed area. • The drought risk is moderately low to moderately high but Extreme temperature risk is low in this AEZ. • The flood risk is generally low to moderate but landslide risk goes from moderate to high in this AEZ.	Drought, landslide and flood risk could damage crops. There is potential for heavy soil erosion from the AEZ.	• Rehabilitation and networking of existing irrigation system and promotion of rain water harvesting technology in order to prevent crop failures caused by drought in drought prone areas thus reduces drought risk and increased planting index. • Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. •
8	**Diverse crop arable sub-temperate recent alluvial plain**	• The landslide risk is moderate and drought risk is low in this AEZ.	Drought, landslides	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities.

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
				• Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
9	**Non arable steep mountainous terrain under forest**	• The landslide risk is moderate to moderately high except few patches flood risk is moderately high. • The drought and extreme temperature risk is moderate to moderately high. • Landslide risk is low to moderately low in this AEZ	Floods within the forest area may lead to loss of forest cover area and soil erosion. Large debris could flow from this AEZ to the lower reaches and could cause damage to agriculture.	• Promote ecosystem based approaches such as close-to-nature forestry to increase the adaptive capacity of forests. • Harmonize monitoring systems (using technology or regular research), such as monitoring of invasive pests, to provide information for adaptive forest management.
10	**Non arable sub-tropical dissected ancient depositional basin and river terrace under forest**	• This AEZ lies mostly within the distributaries of the Babai River. The flood risk in this AEZ is moderate to moderately high and drought is moderate	Floods within the forest area may lead to loss of forest cover area and soil erosion. Large debris could flow from this AEZ to the lower reaches and could cause damage to agriculture.	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
11	**Non arable sub-tropical steep mountain terrain**	• This AEZ is located at lower hills. All risks are from low to Moderate in this AEZ	It is located as hills and head walls for Babai river. The landslide risk and debris flow could be high risk. It will bring sediment at arable downstream plain land	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc. •
12	**Non arable sub-tropical steep mountain terrain under forest**	• All risks; flood, landslide, extreme temperature and drought are from low to moderate in this AEZ.	The landslide risk will bring sediment at arable downstream plain land.	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
13	**Non-arable subtropical active depositional river terraces**	• This AEZ is distributed as few small patches at the upstream floor of watershed. • The flood and drought risks goes up to moderately high but landslide risk is low • Temperature risk is moderately low in this AEZ.	Flood risk is major problem which will transport debris downstream	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
14	**Paddy arable subtropical swales in recent alluvial plane**	• The Flood, drought and extreme temperature risks are moderate to high in this AEZ. The landslide risk is low and not applicable in the plain areas of this AEZ.	Flood and extreme temperature risks are major risks in this AEZ. Extreme temperature may increase incidence of hail storms	• Promote System of Rice Intensification (SRI). SRI is climate smart farming technology that increases the rice yield by 20 to 50 % while the irrigation water is reduced by 30 to 50%.SRI strengthen crop resilience to climate change and variability due to healthy and deep rooted system of rice plants. SRI plants can better resist drought, water logging and rainfall variability. SRI plants reduces greenhouse gas emission. Methane is reduced by 22 to 64 % as soils are maintained mostly under aerobic condition. • Construction and improvement of cattle sheds may be put up to protect livestock from cold waves and hailstorms. Dung yard improvement program leads to the improvement of nutrient content of manure which will ultimately lead to the sustainable agriculture productivity. • As identified by the stakeholders during field visits, promote Integrated Pest Management (IPM). IPM as a pest management strategy is an ecosystem approach of crop production and pest management that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides. Methods such as cultural practices, use of botanical pesticides, biological control, use of resistant varieties, physical methods are used in integrated way to manage the pests. To promote

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
				IPM technology Farmer's Field School (FFS) as a tool should be promoted.
15	**Diverse crop arable sub-tropical recent alluvial plane**	• This AEZ is widely distributed across the plains of lower Babai watershed. • The Flood, drought and extreme temperature risks are moderate to high in this AEZ. The landslide risk is low and not applicable in the plain areas of this AEZ.	Flood and extreme temperature is major risk. Extreme temperature may cause more hail storm	• Construction and improvement of cattle sheds may be put up to protect livestock from cold waves and hailstorms. Dung yard improvement program leads to the improvement of nutrient content of manure which will ultimately lead to the sustainable agriculture productivity. • Promote System of Rice Intensification (SRI). SRI is climate smart farming technology that increases the rice yield by 20 to 50 % while the irrigation water is reduced by 30 to 50%.SRI strengthen crop resilience to climate change and variability due to healthy and deep rooted system of rice plants. SRI plants can better resist drought, water logging and rainfall variability. SRI plants reduces greenhouse gas emission. Methane is reduced by 22 to 64 % as soils are maintained mostly under aerobic condition.
16	**Arable subtropical ancient depositional basin , river terrace and recent alluvial plain complex**	• This is a wide Arable land area situated in the upper Babai watershed and elongated along the river till it reaches the Terai plain. • The flood, extreme temperature and drought risks in this zone are moderate to high in this AEZ but landslide risk is low.	It is small area but risk is moderately high in all cases	• Promote System of Rice Intensification (SRI). SRI is climate smart farming technology that increases the rice yield by 20 to 50 % while the irrigation water is reduced by 30 to 50%.SRI strengthen crop resilience to climate change and variability due to healthy and deep rooted system of rice plants. SRI plants can better resist drought, water logging and rainfall variability. SRI plants reduces greenhouse gas emission. Methane is reduced by 22 to 64 % as soils are maintained mostly under aerobic condition. • Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
				provide a steady supply of fodder during droughts and floods. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.

3.2.2. Mugu Karnali

Table 25 Climate Risks at the AEZ Level: Mugu Karnali

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
1	**Non-arable glacial past glaciated mountain terrain under conifers and grazing**	• It is a very small area seen in the lower middle part of the Watershed. The drought risk is Moderate in this AEZ. • The Flood Risk is moderately high in this AEZ. • The landslide risk is moderately high and the snow fall risk is also moderately high in this AEZ.	It is a past glaciated area and snow fall is high in this area. It contributes water in dry season. Climate Risk is low in this area. Drought may impact grazing land and then livestock. The flood may increase soil erosion.	• Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
2	**Non-arable glacial (arctic) shallow talus and bare rock slopes**	• This AEZ dominates the Mugu Karnali Watershed. It extends to both upstream to downstream areas of the watershed and drought risk is moderate to moderately high. • The flood risk in this AEZ is low to moderately low.	The land area covered by this AEZ is small	• Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc. •

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
		• Snow fall risk is moderately high to low in this AEZ. • The landslide risk is moderately high in the AEZ in many parts. Some parts of AEZ fall in moderate landslide risk.		
3	**Non-arable glacial complexes of moraine and glacio-alluvial-colluvial deposits under alpine shrubs and meadows**	• This AEZ extends from the middle part of the watershed to upstream points. Drought risk is moderately high at upstream and moderate to moderately low at middle part. • Flood hazard is low to moderately low in this AEZ. • The landslide risk is moderate to moderately high • Snow fall risk is low to moderate in this AEZ	Wide range of fodder for livestock is available. There the risk posed to livestock is particularly is high in this area.	• Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
4	**Non-arable frigid complexes of moraine and glacio-alluvial-colluvial deposits under alpine shrubs and meadows**	• Drought risk is moderately high in this area. • The flood risk is moderately low to moderate and snow fall risk is moderate in this AEZ. • The Landslide risk is moderate to moderately high.	The flood risk posed to the AEZ is high. It may bring sediment to arable land.	• Construction of check dams, river draining dykes and other measures downstream. • Stabilization of slopes by plantations. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
5	**Non-arable frigid (arctic) shallow talus and bare rock slopes**	• The drought risk is low to moderate in this AEZ. • The flood risk is low but landslide risk is moderately high in this AEZ. • The snow fall risk is moderate in this AEZ	The landslide risk may impact and deposit sediment in the downstream areas.	• Construction of check dams, river draining dykes and other measures downstream. • Stabilization of slopes by plantations. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
6	**Non-arable frigid past glaciated mountainous terrain**	• This AEZ is located below upper ridge of sub watersheds in the lower Mugu Karnali watershed. • The drought risk is low to moderate in this AEZ. • The flood, landslide and snow fall risks are moderately high in this AEZ.	The debris flowing to the downstream areas will impact these regions. There will also be risk to livestock due to landslides	• Construction of check dams, river draining dykes and other measures downstream. • Stabilization of slopes by plantations. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
7	**Non-arable cold (arctic) shallow talus and bare rock slopes**	• This AEZ is extended as strip at lower middle part of Watershed. • The Drought risk is low in this AEZ. • The snow fall risk is moderately low to moderate and flood risk is low in this AEZ. • The landslide risk is moderately high to moderate.	The landslide risk may bring debris to tributaries.	• Construction of check dams, river draining dykes and other measures downstream. • Stabilization of slopes by plantations. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.
8	**Non-arable cold complexes of moraine and glacio-alluvial-colluvial deposits under alpine**	• This AEZ occupies as a tiny strip at lower watershed area near river banks.	May lead to sediment deposit in the downstream region	• Construction of check dams, river draining dykes and other measures downstream. • Stabilization of slopes by plantations. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc.

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
	shrubs and meadows	• The Drought risk is low to moderately low in this AEZ. • The flood risk is high and landslide is moderate in this AEZ. The snow fall risk is moderately low in this AEZ.		
9	**Arable cold terraced mountain terrain**	• Drought -Moderately low to moderate Risk, • Flood and snow fall risks are moderately low but landslide is moderate to moderately high in this AEZ.	There could be increasing incidence of landslide and debris flow in the downstream areas as flood risk may increase soil erosion, cause damage to crops and arable land is likely to increase. Drought may cause soil degradation, lower yields and crop failure.	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Promotion of Slope Agriculture Land Technology (SALT) by plantation of fodder trees and appropriate crops such as apple, pears, etc. on terrace to control erosion and enhance soil fertility. • Rehabilitation and networking of existing irrigation system and promotion of rain water harvesting technology in order to prevent crop failures caused by drought in drought prone areas thus reduces drought risk and increased planting index. • Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. • Introduce soil erosion control measures such as gabion walls, bamboo barriers, etc. •
10	**Lake (Rara Lake)**	• Drought risk is moderate in this AEZ. • The snowfall risk is moderately low in the lake. • The flood and snow fall risks are low to	This is a lake hence no potential impact on ecosystem services is envisaged and analyzed.	N.A.

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
		moderately low in this AEZ but landslide risk is low to moderately high.		
11	**Non arable cold past glaciated mountainous terrain**	• It is distributed in small patches at the lower reaches of the watershed. • Drought Risk is Low to moderate in this AEZ. • The Landslide risk is moderately high but flood risk and snow fall risk is low in this AEZ.	The debris flow as flood could bring sediment. The moderate drought may decline spring source water	• Construction of check dams, river draining dykes and other measures downstream. • Stabilization of slopes by plantations.
12	**Arable temperate terraced mountain terrain**	• Drought risk is moderately low to moderate risk. • The flood risk and snow fall risk is moderate to moderately low in this AEZ.	It is located near main river Mugu Karnali at downstream human habitat area. Flood and snow risk could impact agriculture	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities. • Promotion of Slope Agriculture Land Technology (SALT) by plantation of fodder trees and appropriate crops such as apple, pears, etc. on terrace to control erosion and enhance soil fertility. • Rehabilitation and networking of existing irrigation system and promotion of rain water harvesting technology in order to prevent crop failures caused by drought in drought prone areas thus reduces drought risk and increased planting index. • Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. • Introduce soil erosion control
13	**Non-arable temperate Past mountain**	• This AEZ surrounds arable land and is located in the downstream areas of the watershed.	The drought and landslide risks pose major threats to this AEZ may damage the existing spring water sources. Debris flow may take place	• Construction of check dams, river draining dykes and other measures downstream. • Stabilization of slopes by plantations.

S No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
	glaciated mountain terrain	• The drought risk in this AEZ is low to moderately high. • Only a small portion faces moderately high risk and the rest of the AEZ faces moderate drought Risk. The flood risk is moderately low but landslide risk is moderately low to moderately high.	as flood risk may increase soil erosion, damage of crops and arable land is likely to increase. Drought may cause soil degradation, lower yields and crop failure.	

3.2.3. Lohare Watershed

Table 26: Climate Risks at the AEZ Level: Lohare

S.No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
1	**Non arable cold past glaciated mountainous terrain**	• It is located at the head water area of the watershed. • Drought risk is low to moderate in this area and • Change in frost risk also low to moderate.	It is past glaciated area and snow fall is high in this area. Melting of this snow will contribute to supply of water in the dry season. There will be low climate risk posed to this area.	• Construction of check dams, river draining dykes and other measures downstream. • Stabilization of slopes by plantations.
2	**Non arable cold steep mountainous terrain under forest**	• Drought , landslide and frost risks are moderate to moderately low in this area	The moderate impact of landslide and drought may impact forest and range land which ultimately impact livestock and people of the area. The livelihood of 95% people in this area is dependent on forest for energy.	• Promote ecosystem based approaches such as close-to-nature forestry to increase the adaptive capacity of forests. • Harmonize monitoring systems (using technology or regular research), such as monitoring of invasive pests, to provide information for adaptive forest management.
3	**Arable temperate terraced mountain terrain**	• This AEZ distributed across the northern, southern and eastern parts of the watershed. • The drought risk is moderately low in the northern and southern parts but in the eastern part of the watershed the drought risk ranges from low to high. • Frost and landslide risks are moderate to moderately low.	These climatic conditions can support crops such as paddy, millet, wheat, sugarcane, oilseeds, barley, potatoes etc. The AEZ located in the eastern part of the watershed may face high risk from drought and moderate risk from landslide and frost. Droughts may lead to degradation of soil, lower yields and crop failure. Landslide could cause crop damage, soil nutrient loss and loss of arable land in this AEZ	• Introduce climate-smart agriculture, through adaptation measures including adaptation of sowing dates and crop varieties, improved water management and irrigation systems (drip & sprinkler), adapted plant nutrition, protection and conservation tillage practices. • Facilitate the use of organic and natural fertilizers and decrease the spreading of pesticides and herbicides. • Exploit diversity of climates in mountain to grow high value agricultural products such as medicinal herbs, bee keeping, temperate fruits, etc. • Promotion of Slope Agriculture Land Technology (SALT) by

S.No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
				plantation of fodder trees and appropriate crops such as apple, pears, etc. on terrace to control erosion and enhance soil fertility. • Rehabilitation and networking of existing irrigation system and promotion of rain water harvesting technology in order to prevent crop failures caused by drought in drought prone areas thus reduces drought risk and increased planting index. • Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. •
4	**Diverse crop arable sub-temperate recent alluvial plain**	• This AEZ is small in area and located in the southern part of the watershed. • Drought risk is low and landslide risk is moderate in this AEZ. The frost risk is low in this AEZ	It is just a small area lying in this watershed. Frost risk is low and it may cause less damage to the winter crops such as pulses, potato and wheat. Drought risk is also low, therefore, there will be less loss of soil organic matter, lower yields and crop failure.	• Introduce climate-smart agriculture, through adaptation measures including adaptation of sowing dates and crop varieties, adapted plant nutrition, protection and conservation tillage practices. • Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro-forestry generate income and diversify livelihood opportunities.
5	**Non arable temperate steep mountainous terrain under forest**	• This area dominates the watershed and is spread across the north, south	This zone supports positively to the lower arable zone lying below. The drought risk in this zone (eastern part)	• Promote ecosystem based approaches such as close-to-nature forestry to increase the adaptive capacity of forests.

S.No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
		and east of the watershed. • The drought risk is moderately low in the northern and southern parts but in the eastern part of the watershed the drought risk goes from low to high. • The landslide risk is moderately high in this AEZ in the eastern part of watershed.	may lead to forest fire risk. Landslide risk could do crop damage, soil nutrient loss and loss of arable land in this AEZ.	• Harmonize monitoring systems (using technology or regular research), such as monitoring of invasive pests, to provide information for adaptive forest management.
6	**Non-arable sub-temperate active depositional river terraces**	• It is a small patch of area located in the south of the watershed. • Drought risk is low and landslide risk is moderate in this AEZ. • The frost risk is low in this AEZ	It is small zone located at downstream. The CC risk is low in this area.	Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry generate income and diversify livelihood opportunities.
7	**Arable sub-temperate terraced mountain terrain**	• The Drought risk is moderately low to high in this AEZ and landslide risk is moderately high to low. • Frost risk is low to moderate.	Landslide risk may increase soil erosion, damage crops. Drought may cause soil degradation, lower yields and crop failure. Frost and cold wave in winter may reduce the crop yield considerably of winter crops such as potato, pulses and vegetables. If rainfall is significant Agricultural productivity of certain crops may increase with slight increase in temperature.	• Introduce climate-smart agriculture, through adaptation measures including adaptation of sowing dates and crop varieties, improved water management and irrigation systems, adapted plant nutrition, protection and conservation tillage practices. • Promote plastic tunnel farming for producing off season vegetables. • Promote organic agriculture as it has a great potential to reduce greenhouse gases emission. • Rehabilitation and networking of existing irrigation system and promotion of rain water harvesting technology in order to prevent crop failures caused by

S.No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
				drought in drought prone areas thus reduces drought risk and increased planting index. • Construction and improvement of cattle sheds may be put up to protect livestock from cold waves and hailstorms. Dung yard improvement program leads to the improvement of nutrient content of manure which will ultimately lead to the sustainable agriculture productivity. • Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. • As identified by the local community during the field visits, cattle raising farmers are cut off from markets to sell their produce. They may be provided with facilities of milk collecting and chilling centers for storage of milk and meat. Also, transportation facilities may be provided for transporting the produce to markets. • As identified by the local community during field visits, promote Vaccination Program - Vaccines can prevent a wide range of diseases that cause reduced production, fertility or death in cattle and economic losses.
8	**Non-arable sub-temperate terraced steep mountain**	• It is distributed along with arable sub-temperate	This zone supports positively to Arable sub-temperate terraced mountain	• Promotion of Agro-forestry as it supports ecosystem restoration and soil conservation

S.No.	AEZs	Climate Risks	Potential Impacts	Potential Adaptation Measures
	terrain under forest	terraced mountain terrain AEZ. • The Drought risk is moderately low to high in this AEZ and landslide risk is moderately low to high. • Frost risk is low to moderate	terrain lying below. The drought risk in this zone goes up to high risk may lead to forest fire risk and landslide risk could do crop damage, soil nutrient loss and loss of arable land in this AEZ. Agro forestry could be promoted in this zone.	and reduces land degradation and associated environmental risks. Besides that agro-forestry generate income and diversify livelihood opportunities. • Promote ecosystem based approaches such as close-to-nature forestry to increase the adaptive capacity of forests. • Harmonize monitoring systems (using technology or regular research), such as monitoring of invasive pests, to provide information for adaptive forest management. • Because of increasing incidence of droughts due to climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods.

4. Identifying of EbAs

4.1. Identification of potential adaptation measures based on spatial analysis and field visits findings

There exists a host of technologies and practices that addresses mitigation and/or adaption issues. However, not all are suitable for all regions and all communities. Therefore, selecting the right technology and practices holds the key to the sustainable development of an area. The technology selection is guided by a number of factors:

- Emerging technological pathways: This is guided by the R&D that a nation has invested in to find solutions to climate change impacts on development; and also on the propensity of the State to transfer similar technologies from other external sources.
- Feasibility of technology: This depends on the nature of impacts, spatial/ geographical characteristics of the vulnerable area, cost of the technology, etc.
- Existing technology/ practices: It is not always necessary to create/ adopt new technologies. Existing technologies/ practices can also be employed to increase resilience. This is particularly true for adaptation, where long existing indigenous knowledge have often proved to be extremely effective. The challenge is to identify these practices and revive/ remodel them to address the present issue.
- Economic viability of technology and best practices: The successful deployment of any technology/ practice depends on its economic viability. Investors would hesitate to adopt the same if adequate returns – visible or invisible, are not forthcoming during the tenure of the project.
- Willingness to adopt technologies: There are often psychological, physical, financial and other barriers that deter target communities from accepting a new technology/ practice. Therefore, to increase the adoption rate for a new system it is often important to undertake detailed stakeholder consultations at all levels, spatial analysis, field visits, focus group discussions, etc.
- Prioritization of technologies on the basis of Environment & Social Safeguards/ Gender assessment: The objective of sustainable development is to maximize social, environmental and economic gains. Also, it is well established that the success of any development strategy – sustainable or otherwise, crucially hinges on its acceptance and adoption by the female members of a community – a most vulnerable group. Therefore, among the available technology/ practice set, the right choice must optimize socio-economic and environmental benefits. This can be ensured by carrying out environmental, social and gender assessment studies before the adopting a new technology/ practice.

4.2. Illustration of the process of identification of potential adaptation & mitigation for the three pilot watersheds

The adaptation measures/ coping mechanisms identified during field validation are classified under four categories depending on the ecosystems and its services that are being addressed by the measures. The categories are:

1. Sustainable Agriculture Management
2. Sustainable Livestock Management
3. Sustainable Forest Management
4. Sustainable Water Management

4.2.1. Sustainable Agriculture Management

As per section 3.2., the spatial analysis indicated soil erosion and crop failures due to drought, extreme temperature and landslides in several arable AEZs of Babai, Mugu-Karnali and Lohare watersheds. Consequently interventions such as agro-forestry, cultivation of climate tolerant crop varieties will lead to reduced crop failures and soil erosion and increased agriculture productivity in these regions. Similarly in AEZs where the spatial analysis identified high frost risk, use of plastic tunnel farming leads to increased productivity of several crops by reducing the impact of temperature fluctuation. Below is a description of interventions that may be considered under "Sustainable Agriculture Management".

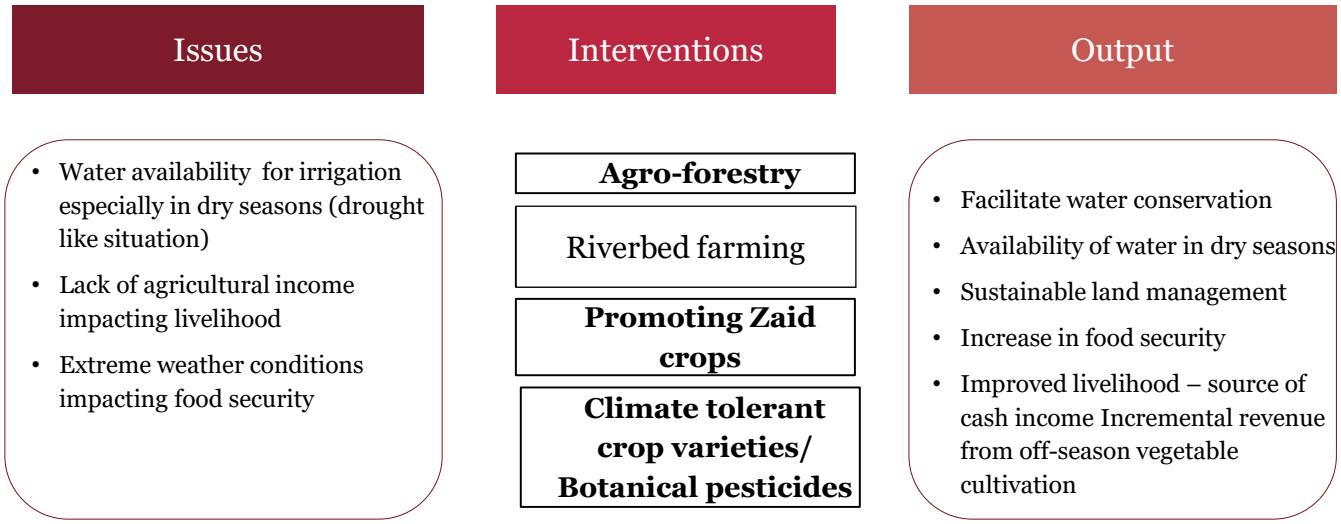


Figure 44: Logical framework for selecting Sustainable Agriculture Management as a strategy

i) Plastic tunnel

Tunnel farming is a simple and low cost practice to control the micro-climate surrounding crops by reducing the impacts of temperature fluctuations. Tunnels also protect crops from unpredictable hailstorm and high intensity rainfall spells. Tunnels are essentially greenhouses-hut-like structures covered with plastic sheets that serve as protection areas, making it possible to grow vegetables off-season and securing the provision of food supplies throughout the year. Crops such as cucumber, capsicum, tomato, pepper, bitter gourds, melons, brinjal and water melon are highly valued vegetables that show significant increase in yield when grown in tunnel farming[5].

ii) Riverbed farming

During heavy floods, river banks and land adjacent to rivers suffer from leaching and denudation, which results in the loss of soil nutrients. Such land, due to loss of fertility, becomes unsuitable for the growth of crops such as paddy, wheat, etc. The silty soil, however, is suitable for growth of crops like watermelon, cucumber, pumpkin and gourds. These crops not only supplement the incomes of those farmers who have suffered due to loss of soil nutrition but also provide essential nutrients and food security to local populations.

iii) Botanical pesticides

With climate change, Nepal will face increased number of droughts and floods as well as higher temperatures and humidity. Under these conditions not only should crops need to be protected from droughts and flooding but also from pest attack. In fact, hot and wet climates are more prone towards proliferation of pests. In order to protect crops from pests, farmers generally use chemical insecticides. However, chemical pesticides lead to the indiscriminate elimination of both harmful pests as well as beneficial micro-organisms and insects. Further, chemical pesticides also cause harm to farmers upon direct physical contact and also enter food chain and disrupt local eco-systems. Given that with changing climate will result in more pest attacks which in turn will lead to higher usage of chemical pesticides, there is a need to move away from the use of chemical insecticides in order to protect the existing balance and the environment.

Botanical pesticides are an effective alternative to synthetic insecticides and enjoy many advantages. Firstly, they are environmentally friendly and do not have negative effects on the health of farmers. Secondly, botanical

[5] Tunnel Farming for off-season vegetable cultivation in Nepal – FAO. http://teca.fao.org/read/7714

pesticides may be toxic to certain insects when applied but they break down into non-toxic compounds when exposed to sunlight. Lastly, most botanical pesticides can be produced using ingredients that could be found locally around the farmer's house/village6.

iv) Introduction and promotion of pests and diseases resistant varieties

As already described above, the incidence of pest attacks is on the increase in districts like Bardiya, Dailekh and Mugu because of increasing temperatures. Increasing temperatures lead to migration of pest and disease species from surrounding regions. In addition to the adaptation measures such as introduction of Botanical Pesticides to counter pest attacks, farmers can also adopt pest and disease resistant varieties of crops.

v) Climate Tolerant Crop Varieties

Rice is the main cereal crop that is grown in Babai watershed. Given that most of the rice grown, and other crops, in this area is dependent on rain fed irrigation for cultivation, climate change poses will increasingly affect crop yields in this region.

vi) Promote mulching

Mulching is essentially covering land with plastic sheets or 'fils' to minimize water from evaporating. This is done by farmers with an aim to conserve soil moisture. This promotes efficient use of water.

In such a scenario farmers have to use water conserving techniques such as mulching to ensure efficient use of water and save crops in the face of unpredictable weather conditions. Further, in Mugu, where there is snowfall in winter, mulching can be used to protect bases of bushes and plants from snow.

vii) Promote agroforestry

Agroforestry is the integration of trees into agricultural systems. It is one of the most promising strategies for agricultural diversification for adaptation to climate change. Agroforestry has been proposed as a strategy not only for adapting to climate change, but also for mitigating and addressing issues of food security and environmental degradation in agricultural systems[7].

4.2.2. Sustainable Water Management

As per section 3.2., the spatial analysis indicated extreme high temperatures and drought as moderate to high risk in several arable AEZs such as Arable sub-temperate ancient depositional basin/river terrace and recent alluvial plain complexes, Arable sub-temperate terraced mountain terrain in Babai watershed, Arable sub-temperate terraced mountain terrain of Lohare watershed, Arable cold terraced mountain terrain of Mugu Karnali watershed etc. In these regions, sustainable water management practices would be imperative to sustain and improve agricultural productivity and retain forest covers.

The FGDs conducted have confirmed that the situation is worsening as the springs and other natural sources of water are drying up. Consequently, the local community – mostly the poor and marginalized groups, face acute water stress, particularly during the dry seasons, as these natural systems are the only available potable water source in the region. To cope with the stress, the community then has to either decrease their water consumption or has to invest time and effort to ferry water from distant sources. Irrigation linked water conservation can be an effective adaptation strategy in such a situation. Below is a description of the interventions that may be considered under Sustainable Water Management.

6 How to buffer impacts of climate variability and dry spells in home gardens by using botanical pesticides and liquid compost, Cambodia – FAO.

[7] ICIMOD – Case Study on tree crop diversity in China, Nepal and Pakistan
http://lib.icimod.org/record/28330/files/WP_13-3.pdf

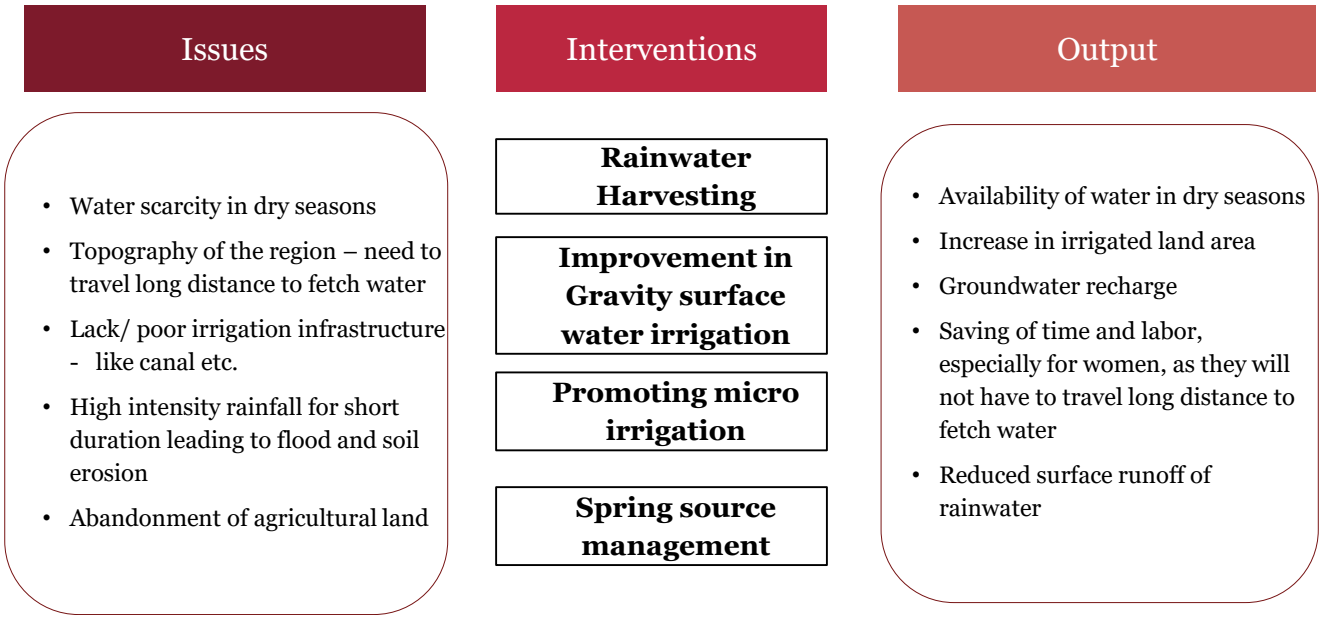


Figure 45: Logical framework for selecting Sustainable Water Management

i) Rain water harvesting

Rain Water Harvesting (RWH) can be used for two primary purposes 1) Storage for future use and 2) Groundwater recharge. RWH involves collecting water that falls on roof of a house during rain storms and conveying it via drain or collector to a nearby covered storage unit or cistern. The roof should be made of an impervious material and the drainage pipe can be made of an aluminum, PVC, wood, plastic or any other local material including bamboo. The size and surface of the catchment area greatly impacts the rainwater yield. More impermeable the roofing material is higher is the quantity collected. A clean and smooth surface is vital to avoid any contamination of the water.

The advantage with rainwater harvesting system is that it is decentralized and independent of topography and geology of the region. Water is delivered directly to the household which reduces the burden of carrying the water, especially for women and children. A sanitation and a rainwater harvesting project are similar in terms of their on-site implementation. In both rainwater harvesting and sanitation, once the system is in place, the ownership lies with household for its operation and maintenance.

Household systems generally catch rain from the rooftops of homes and store it in tanks adjacent to the homes. Water is drawn from the tanks by means of taps at the base of the tanks. In some cases rainwater may be reticulated within a house using a pump/pressure system. Alternatively the tank may be partly buried and a hand pump used to withdraw water. If no suitable catchment surface is available, a separate catchment surface can be built adjacent to, or directly over, the water storage tank. Rainwater harvesting systems can serve households or communities of various sizes.

ii) Promotion of micro-irrigation

Most people who participated in the FGDs were small holder farmers who are dependent on rain fed irrigation for cultivation of their crops. Changes in rainfall patterns and increasing temperatures are increasing the vulnerability of such farmers as availability of water becomes a problem. Through micro irrigation system the water will be supplied to the roots of the crops whereas through sprinkler irrigation the water will be sprinkled to the crop, hence enhancing the optimal use of water without any water loss during irrigation. Micro irrigation as an adaptation measure is most applicable to AEZs where water is in short supply especially for farming communities residing within AEZs in Mugu Karnali such as '*Arable temperate terraced mountain terrain*' and '*Arable sub-temperate terraced mountain terrain'* would benefit from introduction of micro-irrigation.

iii) Improvement of existing gravity irrigation system

This kind of irrigation scheme ensures water is available for irrigation during the period of no rain by using water from the perennial sources. This basically uses gravity led surface water for irrigation. Water is conveyed from the rivers and is distributed across individual fields through a system of permanent and temporary diversions, using

gravity as the driving force. The diversion is created by raising an obstruction on the river stream and diverting water through the artificial channel. Such a system primarily requires two major constructions – head works (obstruction) across the river and water distribution network. The river discharge, if exceeding the capacity of the distribution network, can be stored by creating a reservoir or a storage system. This stored water can then be used as per requirement in a dry season for irrigation.

iv) Management of available spring sources

FGDs conducted, especially in Mugu and Dailekh, showed that water from spring source is the major source of water for drinking and household purposes. During discussions it emerged that the households in the local communities are dependent on this key ecosystem service. Through the FGDs it was observed that the spring sources near the settlements are drying so the local population, especially women, now have to travel longer distance to fetch water from the next nearest spring source. It is therefore vital to revive and maintain drying springs through spring source management.

Spring source management is a feasible adaptation intervention particularly in drought prone areas like Mugu and Dailekh. The basic aim is to reduce the surface runoff of rainwater and allow more water to percolate down to recharge underground aquifers thereby ensuring increased discharge from springs. Some of the potential activities to increase spring discharge include developing springs-sheds, restoring lakes to function as recharge medium, terracing sloping lands and improving water storage infrastructure. The process involves mapping of resources, preparing village spring atlas, identification of recharge areas of various springs and streams based on local geohydrology and finally laying of contour trenches and preparing for rainwater harvesting of various springs and lakes.

The economic evaluation of cost-benefits of the prioritized options is presented in the next chapter for detailed understanding of the economic benefits of the options. This will also serve as an input to building the investment logic framework in the subsequent stage.

4.2.3. Sustainable Livestock Management

As per section 3.2, spatial analysis of several AEZs such as Paddy arable subtropical swales in recent alluvial plane of Babai Watershed, Arable sub-temperate terraced mountain terrain of Lohare Watershed shows hailstorm as a potential impact of extreme temperatures in these regions for which construction of cattle sheds becomes a necessary adaptive measure to protect the livestock. Similarly, as discussed above, drought is found as moderate to high risk in several AEZs such as Arable sub-temperate ancient depositional basin/river terrace and recent alluvial plain complexes, Arable sub-temperate terraced mountain terrain in Babai watershed, Arable sub-temperate terraced mountain terrain of Lohare watershed, Arable cold terraced mountain terrain of Mugu-Karnali watershed etc. In these AEZs, storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder to the livestock during droughts. Below is a description of interventions under Sustainable Livestock Management.

i) Poultry farming (fodder bank)

This adaptation measure is particularly significant from a gender point of view. Women face prevailing socio-economic inequalities including lack of property rights, lack of access to information, employment, unequal access to resources etc. The persistent gender inequality experienced by women is making them more vulnerable to the adverse impacts of climate change and also limits their capacity to cope with them. In this context, it may be noted that, women and their children in Nepal are particularly dependent on small animal rearing for their nutritional and financial security. When the vulnerability of livestock in Nepal increases, the effects are disproportionately felt by the poor, rural women in Nepal. This has been particularly noticed in regions where the population of small backyard animals has fallen because of the focus on cross-bred cow/buffalo farming. Therefore, it is necessary that poultry farming be promoted so that not only farmer incomes are supplemented and nutrition levels are improved, but also because it makes female members of communities more resilient to climate change.

ii) Construction and improvement of cattle shed

Appropriate sheds are an important element of livestock management in the face of climate change. Animal sheds often lack ventilation, sanitation and the conditions necessary for the animals' comfort. Goat sheds should be improved to provide more floor space and separate enclosures for different age groups and use categories of goats.

The roofs of sheds should be raised, to minimize heat stress (applicable specifically to AEZs in Babai watershed) and provide adequate ventilation. Frequent cleaning of sheds, including beneath the floor slats, can improve goats' health and productivity, and the provision of feeding racks and watering places is also important. There should also be manure pits, roof-water collection tanks, and shade trees around the shed to improve hygiene and reduce the impacts of extreme weather conditions.

These measures will not only protect livestock, which are important assets for farmers, but also ensure that milk produce, etc. is not affected due to extreme weather conditions. Due to increasing incidences of drought induced by climate change, grass for grazing is in short supply. Fodder banks and storage of dried fodder such as silage and hay need to be set up which will provide a steady supply of fodder during droughts and floods. This measure will be particularly relevant to 'Paddy arable subtropical swales in recent alluvial plane' AEZ within Babai watershed.

4.2.4. Sustainable Forest Management

As per section 3.2, spatial analysis of several AEZs such as Non arable temperate steep mountainous terrain under forest of Lohare watershed, Non arable steep mountainous terrain under forest of Babai Watershed shows landslides as a potential impact of extreme precipitation in these regions for which promotion of Agro-forestry as it supports ecosystem restoration and soil conservation and reduces land degradation and associated environmental risks. Besides that agro- forestry and allied activities identified within the umbrella of Sustainable Forest Management initiative such as timer logging/ fuel wood cultivation etc. generate additional income and diversify livelihood opportunities. Below is a description of interventions under Sustainable Forest Management.

Forest is a major natural resource of the country as 40 percent of the total land area of Nepal is covered under forest. It provides more than 50 percent of fodder to the livestock. Several industries in the country are based on forest products for their raw materials. Forestry, typically, has a long gestation period – it takes time for the trees to mature and be available for becoming sources of revenue for the communities (Kumar, 2002). Also, in the case of many species, trees live a life of 35 – 40 years and are available for realizing benefits from logging and carbon sequestration (Acharya, 2002). Hence, in the case of sustainable forestry, the life of the project may be considered to be long term i.e. 35 – 40 years. While some of the benefits of Sustainable Forest Management (SFM) start accruing over a short term, some benefits are delayed. But the benefits continue to accrue over a long time horizon.

Sustainable Forest Management has the dual advantage of safeguarding against forest degradation and deforestation while providing direct social & environmental benefits. On the social front, it provides ecosystem services by contributing to livelihoods and sources of revenue of the locals. On the environmental front, it acts as a carbon sink and contributes to biodiversity, water and soil conservation. Forests provide defensive mechanism during extreme weather events by preventing topsoil run-off and protecting people, animals and physical infrastructure.

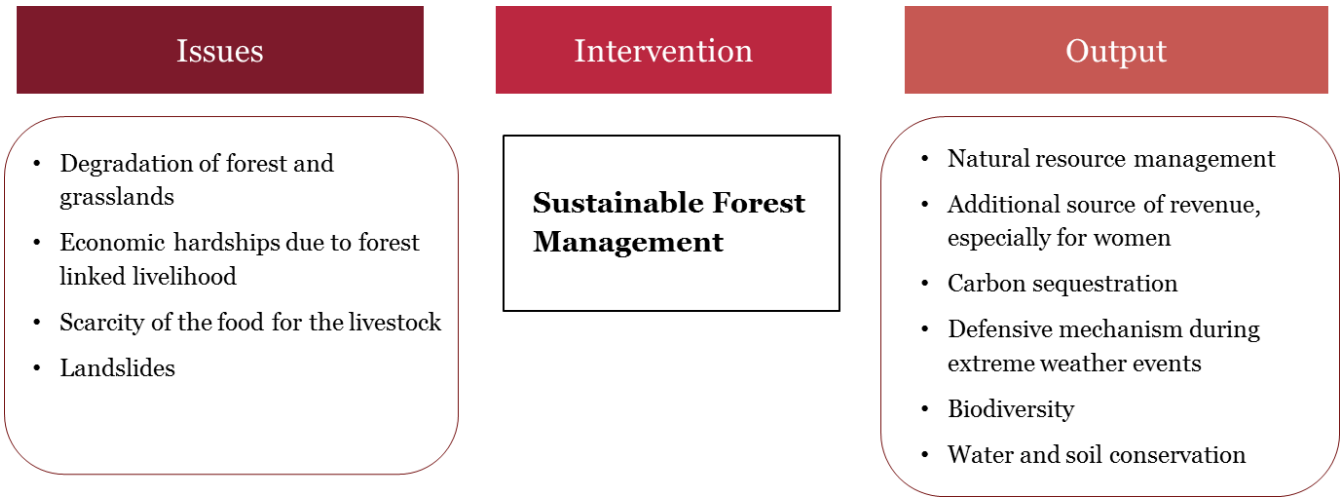


Figure 46: Logical framework for selecting Sustainable Forest Management as a strategy

In the literature, there has been a lot of evidence that Sustainable Forest Management practices in Nepal can generate adequate economic, social and environmental returns. Sustainable forest management (SFM) leverages many benefits of ecosystem services for the local and national economy (Kanel & Niraula, 2017), (GoN, 2015), (Acharya, 2002).

Figure 47: Outcomes of SFM

In view of the above, as a policy action, it is recommended that actions be initiated for:

- Securing forests
- Stopping encroachment and degradation
- Promote SFM to realize mitigation benefits and increase adaptive gains for the population

Direct Benefits from SFM

Literature identifies a host of benefits accruing due to SFM (GoN, 2014), (GoN, 2015), (Kanel & Niraula, 2017). While some of the benefits can be valued easily, some others – particularly social benefits like reduction in morbidity and mortality, community cohesion, psycho-cultural improvements, etc. are difficult to value. Hence for the purpose of this analysis, the incremental economic gains and environmental gains have only been considered. Environmental benefits have been kept limited to mitigation of GHG and adaptation benefits. Due to the paucity of epidemiological statistics on local pollution (air, water, etc.), the same has not been considered for analysis.

Sustainable Forest Management (SFM) can be a strategy to achieve the goals of increasing coping capacity of the population residing by leveraging benefits of eco-system services of forests. Further, the promotion of sustainable forest management practices in the region has potential to generate a host of climate benefits including other developmental benefits.

i) Agroforestry

According to Bardiya District Forest Office, agro-forestry could be an income supplement for farmers in the district in the face of increasing risks posed to crops by flooding and droughts. Local species has to be promoted in the agro-forestry, otherwise encroachment or invasion by alien species might take place on one hand. Furthermore, mono-culture has to be discouraged for plantation to make the forests resilient to diseases.

ii) Measures to reduce forest fires

Forest Management practices may prefer certain species to others. Ethno-botanically or commercially important species will enjoy an advantage over other species, thus resulting in reduction of biodiversity. Therefore local biodiversity should be understood and incorporated.

4.3. Prioritization of the identified measures

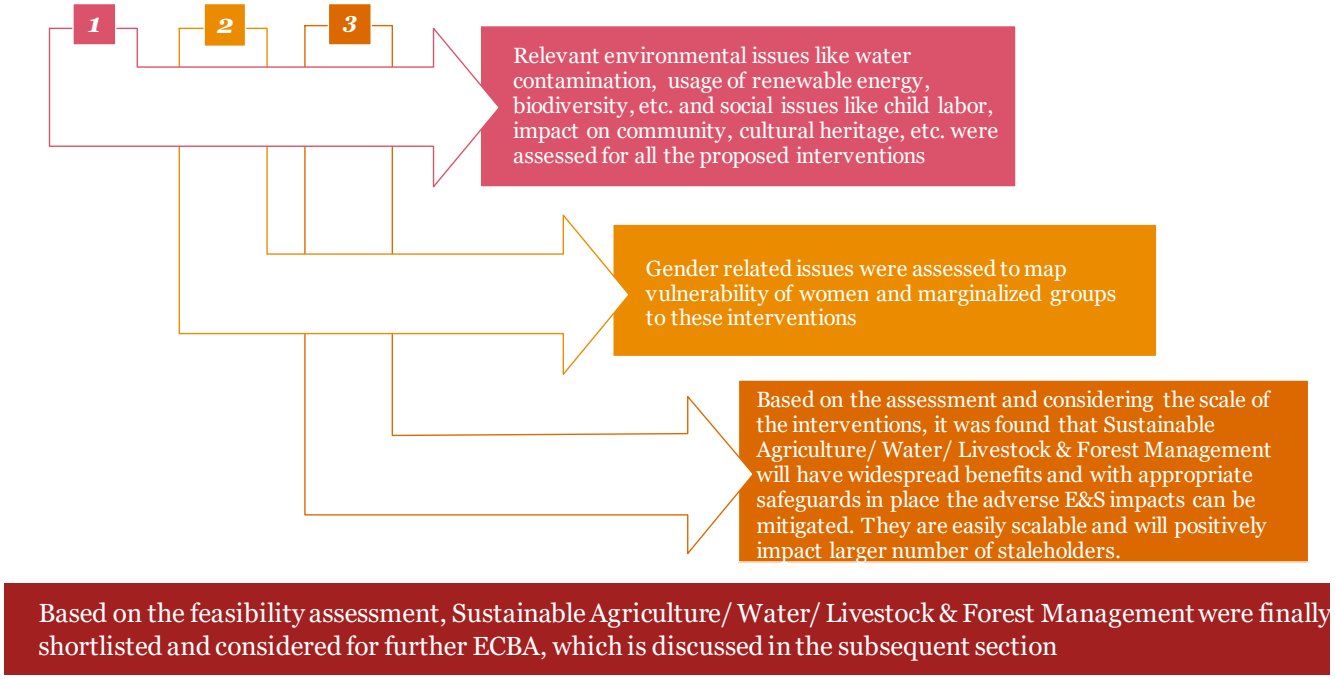


Figure 48: Approach for prioritizing EbA measures

The identified measures were prioritized on the basis of following parameters:

- **E&S and Gender assessment**: E&S and gender related issues were assessed for each of the measures to identify any adverse impacts because of these measures. Relevant environmental issues like water contamination, usage of renewable energy, biodiversity, etc. and social issues like child labor, impact on community, cultural heritage, etc. were assessed for all the proposed interventions. Gender related issues were assessed to map vulnerability of women and marginalized groups to these interventions. Based on the assessment, it was found that the selected measures have no major adverse impacts and with appropriate safeguards in place minor adverse impacts can be easily mitigated.
- **Scalability:** The measures were assessed on their scalability and their reach to stakeholders. The selected adaptation measures will have widespread benefits and are easily scalable. Whereas measure like spring source management for water conservation is location specific. Moreover, the underlining climate driver of drought can be more comprehensively addressed with irrigation linked measures which also has benefits like water conservation.
- **Climate drivers:** The number of climate drivers behind an intervention was a key factor for prioritization. The identified measures were found to have multiple climate drivers like drought, landslides, flood, temperature, rainfall, etc.
- **Sustainability:** Whether a particular intervention can be a long term solution or not was also one of the criteria for prioritization.

4.4. Illustration of prioritization of identified measures through E&S and Gender assessment

E&S and gender assessment was carried out for all the identified measures. The assessment was used to map the vulnerability of women and marginalized groups and prioritize the identified options. The prioritization was also corroborated with the findings of the field assessment.

4.5. Environmental and Social Impacts:

4.5.1. Measure 1 - Sustainable Agriculture Management

- **Plastic Tunnels**: Workers might be more severely exposed to agricultural chemicals while their application in the tunnels than in the open air. Thus limited use of chemicals and use of protective gears by the worker are strictly recommended in the plastic tunnels. Plastics are relatively cost-effective, thus, their usage in agriculture has grown over the time. on the one hand, plastics manufacturing generates pollution, on the other hand, at the end of the lifecycle, plastics y become a pollution source when improperly disposed, leaved on the ground or burned. Therefore, it is recycling of plastic waste is recommended, which will not only control pollution but the collected plastics themselves can become secondary raw material. An adequate management of plastic can prevent economic losses and also environmental damages.

- **Climate Tolerant Crop Varieties:** Introduction of new variety of crops can displace local varieties, and in a long term deteriorate the indigenous gene pool. It is in this context that the idea of 'Gene Banks' have been introduced. Gene Banks preserve the indigenous genotypes that are endemic to a region.

- **Riverbed crops like watermelon, cucumber, pumpkin, gourds to be promoted:** Cultivation of such crops will optimize agricultural productivity of less fertile lands on one hand, whereas on the other hand, farmers can improve their incomes by producing high value crops. However, promotion of this practice, on the hind side, might encourage encroachment of the river banks or flood plains. The encroachment of river banks and flood plains has been observed over the years in Nepal. Therefore, caution should be observed so that these crops are promoted in lands with proper deed documents.

- **'Botanical Pesticides' combined with Integrated Pest Management:** Application of Integrated Pest Management has proved to be cost or labor saving. These methods also reduce application of synthetic chemicals substantially (Fernandez-Corenejo, 1999). This in turn reduces ecological threat posed by the chemicals on one hand and on the other it reduces threat of toxic exposure of farmers to harmful pesticides.

- **Introduction and promotion of pests and diseases resistant varieties:** Introduction of pest and disease resistant varieties will reduce agricultural inputs that can improve the effectiveness. However on the other hand, insects and organisms that are necessary and useful for agriculture might also get eliminated from the agricultural system, reducing agricultural productivity (Fontes, 2002).

- **Promotion of Mulching to cover the land with plastic sheets to minimize water from evaporating:** Plastic mulching involves use of plastic 'fils' or sheets to cover the soil around plant/trees or crops. This is done with an aim to minimize water loss from evaporation. Plastics are relatively cost-effective, thus, their usage in agriculture has grown over time. On the one hand, plastics manufacturing generates pollution, on the other, at the end of the lifecycle, plastics may become a pollution source when improperly disposed or burned. Therefore, recycling of plastic waste is recommended, which will not only control pollution but also collected plastic may be treated as secondary raw material. Therefore, proper management of plastic can prevent economic as well as environmental damages. Further, mulches made of organic material such as wood may also be preferred to plastic mulch.

- **Improvement of existing gravity irrigation system:** Improved irrigation facility is important for development of agriculture. However, it may be noted that extensive diversion of water from rivers might result in degradation of aquatic ecosystems. Thus environmental and natural flow of the rivers must be maintained.

4.5.2. Measure 2 – Sustainable Livestock Management

- **Fodder banks and storage of dried fodder to provide a steady supply of fodder during droughts and floods**: Practices such as storage of agricultural residues are expected to improve the efficiency of agricultural

production. However, if the fodder is collected from the forest for storage, this might create additional pressure. Extensive fodder collection from the forests creates shortage of fodder for resident wild herbivores as well as degrades vegetation diversity in the forest.

- **Transportation facilities may be provided for transporting the produce to markets**: Energy efficiency of the storage facilities is one of the environmental concerns. Therefore, introduction of renewable energy to power the storage facilities must be explored. The location of the storage facilities has to be strategically identified to minimize transportation expenses, which in turn will generate pollution. Accessibility of all members of the community irrespective of caste and creed to the storage and collection facilities must be ensured. It is also essential to promote some of the indigenous practices such as solar drying of the meat, fishes, *etc*. for preserving food meant for transport to remote and distant areas. However, there are some practices that extensively use firewood such as preparation of *Khuwa* from milk, which need to be discouraged.

- **Introduction and promotion of improved breeds (cross breeds) of animals through Artificial Insemination (AI) for higher production of milk and meat**: Intensification of livestock farming with introduction of improved breeds can put pressure on local resources as these foreign breeds require more inputs. There are also the chances that indigenous varieties may be displaced completely from the area by the 'improved' foreign breeds.

- **Cattle-shed management:** The common material for construction of cattle sheds in rural areas of Nepal is wood and agricultural residues such as straw. No significant environmental concern is expected from such construction. However, caution must be observed to ensure that the cumulative pressure on forest for acquisition of wood/timber does not harm the local ecosystem.

- **Promotion of poultry farming**: Commercial poultry farming produces manure in large quantities. If disposed of improperly, this may pose a health hazard to people living in the vicinity of poultry farms. Furthermore, it might also pollute soil and water with nutrients, pathogens and heavy metals (Maheshwari, 2013). However, if properly managed, it can be used as manure in agriculture as well as generate energy through decomposition.

4.5.3. Measure 3 – Sustainable Forest Management

- **Agroforestry:** According to Bardiya District Forest Office, agro-forestry could be an income supplement for farmers in the district in the face of increasing risks posed to crops by flooding and droughts. Local species has to be promoted in the agro-forestry, otherwise encroachment or invasion by alien species might take place on one hand. Furthermore, mono-culture has to be discouraged for plantation to make the forests resilient to diseases.

- **Measures to reduce forest fires: (Water Recharge Zone Creation, Scientific Forest Management**, **Systematic management of sand and gravel):** Forest Management practices may prefer certain species to others. Ethno-botanically or commercially important species will enjoy an advantage over other species, thus resulting in reduction of biodiversity. Therefore local biodiversity should be understood and incorporated into the forest managements.

4.5.4. Measure 4 – Sustainable Water Management

- **Water harvesting structures need to be set up and water channels need to be constructed and improved to increase and ensure better access to water for framers in the district:** Construction of canals in the Terai region has to carefully consider local drainage. During monsoon, these structures might obstruct the drainage creating inundation and water logging

- **River training structures such as gabion wire with boulders, dykes, dams, diversion canals are to be constructed to control floods:** Sanitary condition of water accumulated area has to be maintained to avoid breeding of mosquitoes and water borne diseases, prevalence of which are common in Terai

- **Snow and rain water harvesting in plastic ponds for irrigational and drinking water**: This technology is important in the high altitude settlements, especially in Mugu, to ensure availability of water. However, care must be taken to minimize use of plastics by choosing relatively durable plastic materials.

- **Management of available spring sources for irrigation and improvement of channels**: Improved irrigation facility is important for development of agriculture; however, extensive diversion of water from rivers might result in degradation of aquatic ecosystems. Thus environmental flow shall be maintained in the rivers.

4.6. Gender Responsiveness and inclusiveness of the adaptation measures

In overall assessment, the measures identified are promoting women empowerment and gender equality through:

- Increasing market access and exposure to financial management;
- Increasing food security
- Increased opportunities to additional income sources;
- Time saving in fetching water for women;
- Build social networks at community level through organized groups,

Women through the measures will increase their involvement in market related discussions, making decisions and over resource management, learn new techniques and skills on farm management. However, an adaptation measure itself may not be sufficient to effect the changes in the community, it requires certain gender specific interventions such as engaging men spouses and in laws to create enabling environment for women and marginalized groups at intra household levels and at community level respectively. Below is a detailed discussion.

Table 27: Gender responsiveness and inclusiveness of adaptation options

Measure	Assessment of gender responsiveness and inclusiveness
Sustainable Agriculture Management	**Plastic Technology:** With implementation of plastic tunnels women can access a new and an alternate form of technology which results in: • Improved access to nutritious and diverse food groups and the scope of additional income for women and other marginalized groups. • Overall food security of women and children: use of plastic tunnels will ensure the supply green vegetables during the entire year and as a result children can get fresh and nutritious food. This will reduce incidence of malnutrition in the region. Also with these measures women and marginalized groups will be more involved in decision making processes and execution of the interventions. This is because women are more involved in agriculture practices and hence are the main target of the project. Further Women and other marginalized groups will be involved in planning and making decision over resource management. Further, decision making, planning and execution will be done by women collectively and in a participatory manner. **Poly houses:** Use of poly house for farming would yield production that can be used both for household consumption and for sale, which will contribute to availability and utilization of green vegetables and poultry products for family members and children. Women can use the earnings from the production to fulfill family needs like foods, school expenses, and clothes. Engaging with farmers groups and co-operatives will also train them to make savings and invest on any other productive activities. **Riverbed farming**: The measure of promoting Riverbed crops, will foster women's empowerment, as it will provide them with knowledge and skills in new technology, new seeds and species. This measure has the potential to link women to service providers and markets. This will empower them with negotiation skills, besides enabling them to manage household level food security.

Measure	Assessment of gender responsiveness and inclusiveness
	Pesticides: The chemical pesticides applied in agriculture have a detrimental effect on women, and through them on the health of dependent children and other family members. However, the use of botanical pesticides will have an overall beneficial effect on women's health. While health benefits of using botanical pesticides on women is established, it must be borne that in the developing world in particular, priority is still placed on boys' education rather than girls', and girls are thus likely to be less educated. As a result, girls typically receive fewer years of education than boys. Without education, women are at a disadvantage, as they have less access to crucial information and fewer means to interpret that information. **Pest and Disease resistant varieties:** Pest and disease resistant varieties will help the nutrition levels of entire family improve as a result of enhanced food security. However, in many poor communities, women have limited access to crucial resources such as land. They may have access to land and security to tenure through other male members of a family. Therefore, for women to benefit from such an adaptation measure, it must be ensured that women also have the same degree of control over resources as men. **Mulching:** While, a technology such as mulching has no differential impact for men and women, new technologies may not be as accessible to women as they are to men. New technologies require new sets of skills, which can be challenging for women to master given women's family obligations, households chores, etc. Therefore women receiving support from their families so that they can equally benefit from this project is a precondition for the project. Further, wage discrimination between men and women needs to be addressed and it must be ensured that equal wages are paid to members of both sexes. **Promotion of agro forestry:** Agro-forestry, overall, can play a major role in mitigating climate risks faced by members of the agricultural community in a developing country setting by supplementing incomes and promoting indigenous varieties of fruits and vegetables. While there is substantial potential benefit for women through promotion of agro-forestry, the participation in such enterprises is low for women as it is seen as male domain. Further, women also have limited access to technologies such as technologies improving soil fertility compared to men. Therefore, for ago-forestry to benefit men and women on an equal footing, a level playing field must be provided to women. Steps must be taken to ensure that women have equal access to both resources, such as land and technological knowhow, and decision making.
Sustainable Livestock Management	**Improvement of Cattle sheds:** Improvement of cattle sheds involves setting up of manure pits, roof-water collection tanks, plantation of shade trees around the shed to improve hygiene and reduce the impacts of extreme weather conditions. While these activities will result in both the enhancement and stabilization of farmer incomes, in developing country contexts, the responsibility of implementing such adaptation measures

Measure	Assessment of gender responsiveness and inclusiveness
	will fall disproportionately on women. Therefore, this adaptation measure may result in increased workloads on women, putting more pressure on the spare time available to them and their health. **Artificial Insemination:** Artificial insemination, overall, can play a major role in mitigating climate risks faced by members of the agricultural community in a developing country setting by producing 'sturdier' varieties of cattle and improvement of milk yields. However, in South Asia, women have access to cattle and livestock based income through male members of the family. Hence, women do not enjoy equal access to both resources and decision making when it comes to live-stock and related matters. Therefore, for this adaptation measure to be more equitable from a gender point of view, women must be provided with equal access to resources, technical knowhow and decision making. **Poultry Farming:** As mentioned above, when the vulnerability of livestock in Nepal increases, the effects are disproportionately felt by the poor, rural women in Nepal. This has been particularly noticed in regions where the population of small backyard animals has fallen because of the focus on cross-bred cow/buffalo farming. Therefore, it is necessary that measures like poultry farming be promoted so that not only farmer incomes are supplemented and nutrition levels are improved, but also because it makes female members of communities more resilient to climate change.
Sustainable Water Management	**Water harvesting structures:** First, rainwater harvesting system is decentralized in nature and is independent of topography and geology of the region where water is delivered directly to the household or to agricultural fields which reduces the burden of carrying the water, especially for women and children. Construction of water harvesting structures will provide easy access to water and will lessen the travel time of women who usually walk longer distances in the drought prone areas to fetch drinking water. Second, lack of water due to changing climate affects women adversely. Women have lesser water available for sanitation. So lack of water affects female health and also puts pressure on time that women have at their disposal. However, it must be ensured that women have a say in the construction and location of water harvesting structures and are also members of water user organisations at the local level. The latter will ensure that women have access to decision making at the local level. **Promotion of Micro-irrigation:** Drip irrigation can benefit women in many ways. First, drip irrigation is not as time consuming as conventional irrigation and, therefore, women have more time at their disposal for other activities. Further, studies (The IDE Weekly Review, 2010) have established the following • Drip irrigation promotes joint decision making between men and women. Also, men have more time at their hands to support women in their household chores.

Measure	Assessment of gender responsiveness and inclusiveness
	• Women can use drip irrigation to cultivate in their homesteads and enhance their incomes • Leads to better division of labour between men and women **Improvement of existing gravity irrigation systems:** The gender implications of this measure are similar to those of the sustainable water management measures described in the previous points.
Sustainable Forest Management	Women are primary users of forests and harvesting products such as fodder, fuelwood, medicines and foods. Women are usually also the primary care-givers - they use the products harvested from forests to feed, shelter and heal their families and to earn income that they mostly spend on their families. Through sustainable forest resource management, women can fulfill their practical needs such as saving of time for fuel-wood collection, productive needs such as increased time for child care, leisure and income generation and use of earned income and strategic needs such as women's involvement in decision making process at household and community level. Women can be organized into user groups and involved in decision making to empower them. The income generated through selling of wood and timber can be invested for the welfare of the women members

4.7. Eco-system based Adaptation (EbA):

The selected adaptation measures qualify as EbA measures as they meet the following criteria:

Table 28: EbA criteria check for adaptation options

EbA Criteria	How identified measures meet the criteria?
Promote the resilience of both ecosystems and societies	The adaptation measures identified for the three districts do indeed promote the resilience of both eco-systems and societies. For instance in the case of adoption of botanical pesticides, the measure does not entail adoption of any external technologies or high capital investment, but involves the use of local resources, skills and indigenous knowledge. The measure is not new to the environment and is aligned with local ecosystem services. Further, use of botanical pesticides involves community participation and has significant implications on women's and children's health. The additional income originating from the intervention provides women with freedom and autonomy. Therefore the measures certainly promote the resilience of both ecosystems and societies.
Promote multi-sectoral approaches:	Given that the adaptation measures are aligned with local eco-system services and not foreign interventions, they naturally promote co-operation across sectors. A good example for this would be agro-forestry. Agro-forestry not only adds to the bio-diversity of a region but also is an important source of fodder and non-timber forest produce for local communities. While ensuring conservation of biodiversity and providing for fodder may be at conflict with each other, an intervention such as agro-forestry promotes co-operation across sectors. This intervention is especially important for Bardiya given that fodder is in short supply due droughts and biodiversity loss is significant because of forest fires.
Operate at multiple geographical scales applying landscape-scale approaches and impact assessments to identify cumulative and indirect drivers of vulnerability	The proposed measures are applicable across implementable across the agro-ecological zones to combat the identified climate drivers.
Integrate flexible management structures that enable adaptive management ensuring decentralized management to the lowest appropriate level to foster greater	All measures lead to increased ownership of local community specially women and marginalized groups by way of generating knowledge of new breeds and technology, increased market access, enhanced food security etc.

EbA Criteria	How identified measures meet the criteria?
efficiency, effectiveness, equity and ownership	
Minimize tradeoffs and maximize benefits with development and conservation goals to avoid unintended negative social and environmental impacts ensuring participatory planning, recognizing the needs of the poorest and most vulnerable, taking into account the limits of ecosystem functioning and the varying temporal scales and lag effects of ecosystem processes.	An example of this is the application of micro-irrigation techniques for conservation of water while optimizing crop yields in water scarce regions such as Mugu and Dailekh.
Use best available science and local knowledge and foster knowledge generation and diffusion	All adaptation measures suggested facilitate networks to ensure that information is regularly updated and provided in easily usable forms, and that the media used for knowledge sharing are culturally appropriate and understandable. An appropriate example for this is the use of climate resilient crop varieties in regions such as Bardiya which are frequented by both floods and drought. While variants of Samba Masuli rice are both submergence proof and drought proof they also do not pose any danger to the local ecosystems and are non-invasive genotypes.
Participatory, transparent, accountable, culturally appropriate and actively embracing equity and gender issues	All adaptation measures proposed are based on local/indigenous knowledge, accessible to all, use local resources and provide equal opportunities across gender and social divides. For example, the measure 'promoting the use of Botanical Pesticides' not only makes use of local resources and indigenous knowledge but also promotes gender equity and equity among various social groups. Use of Botanical pesticides will reduce any health risk to farmers especially women farmers and farmers from marginal communities who are directly involved in farming activities. Similarly, women can engage in economic activities if provided with financial literacy and exposure to market environment. Plantation of forage and grasses will definitely contribute to easy availability of feeds for livestock of female farmers that will minimize their long distance travel to unsafe places.

5. Cost Benefit Assessment

5.1. Case study of a subset of Mugu Karnali watershed that includes AEZs like arable cold terraced mountain terrain, Lake, arable temperate terraced mountain terrain within Mugu district

Section to explain on analysis and interpretation.

5.1.1. Sustainable Agriculture Management

Table 29: Adaptation benefits from Sustainable Agriculture Management for Mugu district (Mugu Karnali watershed)

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
1	Incremental revenue from off-season vegetable cultivation	High	Drought, extreme weather conditions	Helps in utilizing the land during dry seasons thereby augmenting income sources. Therefore, this measure is rated as "High".
2	Facilitate water conservation	Low	Drought	Provides for additional irrigation source during dry season in the High mountain region. Therefore this measure is rated as "Low".
3	Increase in food security	High	Drought	Nepal is net importer of food, with impacts of climate change the food security is threatened. Therefore this measure is rated as "High".

Using the social discount rate[8] of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 30: CBA for Sustainable Agriculture for Mugu district (Mugu Karnali watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
ENPV of costs	NPR Million	1,039.02	41,743.85	73,637.14	98,626.38	118,206.10	133,547.32	145,567.57
ENPV of benefits	NPR Million	-	59,692.38	119,384.77	179,077.15	238,769.53	298,461.92	358,154.30
Present Value of cost per hectare	NPR Million/ ha	32.23						

[8] The social discount rate should reflect the social opportunity cost of capital, i.e. the rate of return to capital in its best alternative use. The higher the social discount rate used, the lower is the weight effectively given to future benefits or costs compared to present benefits or costs. The choice of the appropriate social discount rate remains a highly debated issue – refer Willenbockel (2008). The Asian Development Bank (1997/2011) recommends a discount rate of 10 to 12 percent for the appraisal of projects in its member states including Nepal. However, in line with the recommendation of experts and widespread practice in Nepal, a discount rate of 5 percent for the cost-benefit analysis has been considered in this study.

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
Present Value of benefits per ha	NPR Million/ ha	79.29						
Benefit to Cost Ratio	Ratio	2.46						
EIRR over the project lifetime	% p.a.	26%						
Climate Change %	%	17%						
Payback period for initial investment	Years	5						

The main streams of benefits from this intervention is through the additional income generated from sale of agri products. As presented in the table above, the following observations are important to note:

- BCR> 1 and high EIRR% present a suitable investment opportunity over the project lifetime
- Moderate payback period due to the gestation period for increased land productivity
- The adaptation benefits are approximately ~ 17% of the total benefits. This renders the intervention a status of moderate climate relevance.
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5.1.2. Sustainable Water Management

Table 31: Adaptation benefits for Mugu district (Mugu Karnali watershed) from Sustainable Water Management

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
1	Savings in costs incurred for purchasing water.	High	Drought, erratic rainfall	Access to clean drinking water is a growing concern, according to the Government of Nepal's survey data around 84% of the basin's population use improved water sources such as piped, tube well and well water (CBS 2014b). However, due to multiple sources of consumption and the possible impact of climate change, natural springs are drying up. Hence, from the point of adaptation, this benefit has been categorized as "High".
2	Savings in health costs due to water borne diseases.	Low	Drought	In the absence of readily available drinking water, the affected communities collect and store - often in unhygienic conditions, water for future use. This practice leads to the incidence of various water borne diseases (jaundice,

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
				gastro-intestinal disorders, reflux disease, etc.). Approximately 45% of household suffer from such health impacts (ADB, 2012). There have been reports of increase in mosquito infestation, pests and diseases due to increasing temperature. However, there is limited benefit from a RWH structure for avoiding water borne diseases. Therefore, this has been accorded a status of 'Low' benefit from the point of view of adaptation and resilience.
3	Avoided loss of agricultural income due to time spent in collecting water.	High	Drought	Traditionally, the rural population at Mugu have been dependent on agricultural revenue as their main source of income. With climate change and anthropogenic activities (encroachment) leading to increase in time investment in collecting water from far off sources like springs etc. is impacting their productive time. This is expected cause tremendous hardship among the poor rural population. On the other hand SWM-RWH helps to restore and augment this additional source of earnings. Hence, from the point of adaptation, this benefit has been categorized as "High".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 32: CBA for Sustainable Water Management for Mugu district (Mugu Karnali watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
Present Value of costs	NPR Million	7,078.56	14,521.78	20,353.75	24,923.24	25,528.93	26,003.51	26,375.35
Present Value of benefits	NPR Million	2,111.51	4,332.37	6,072.47	7,435.88	7,617.59	7,759.97	7,871.52

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
Cost per capita for RWH system (over project life of 20 years)	NPR Million/ Capita	0.18						
Value of benefits per capita for RWH System (over project life of 20 years)	NPR Million/ Capita	0.40						
Cost per ha. for Gravity irrigation system	NPR Million/ ha	0.07						
Value of benefits per ha. for Gravity irrigation system	NPR Million/ ha	0.33						
Benefit to Cost Ratio	Ratio	4.40						
EIRR over the project lifetime	% p.a.	25						
Climate Change %	%	25						
Payback period of initial investment	Years	3-4						

The main streams of benefits from this intervention is in form of the avoided costs towards securing water, loss of productive time and loss due to water borne diseases. As presented in the table above, the following observations are important to note:

- BCR> 1 and high EIRR% present a suitable investment opportunity over the project lifetime
- Good payback period due to the immediate returns in form of savings towards water expense.
- The adaptation benefits are approximately ~ 25% of the total benefits. This renders the intervention a status of high climate relevance.

5.1.3. Sustainable Livestock Management

Table 33: Adaptation benefits from Sustainable livestock management in Mugu district (Mugu Karnali watershed)

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
1	Avoided loss due to mortality and morbidity of milch cattle	High	Drought, extreme weather conditions	With climate change the instances of heat/ cold spells are expected to increase. Therefore this measure is rated as "High"
2	Incremental income due to increased milk production (due to improvement in lactation rate)	High	Drought	During summer season, it caters to the fodder requirement. Also it acts as a supplemental nutrient through composite feeding. Therefore, this measure it is rated as "High".

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
3	Avoided loss of agricultural income due to time spent in collecting water/fodder for livestock.	Medium	Drought, extreme weather conditions	The incidents of such extreme weather events are limited and therefore, this measure is rated as "Medium".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 34: CBA of Sustainable Livestock Management for Mugu district (Mugu Karnali watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
ENPV of costs	NPR Million	2,096.96	2,489.65	2,797.33	3,038.40	3,227.29	3,375.29	3,491.25
ENPV of benefits	NPR Million	756.92	2,655.52	4,562.36	6,490.35	8,499.28	10,747.37	13,772.65
Present Value of cost of improved cattle shed	NPR Million/ cattle shed	0.04						
Present Value cost of fodder bank	NPR Million/ ha	2.64						
Present Value of benefits of improved cattle shed	NPR Million/ cattle shed	0.22						
Present Value of benefits of fodder bank	NPR Million/ ha	8.78						
Benefit to Cost Ratio	Ratio	3.95						
EIRR over the project lifetime	% p.a.	15						
Climate Change %	%	25						
Payback period for initial investment	Years	3-4						

The main streams of benefits from this intervention is through the additional income generated from sale milk/ livestock and avoided costs due to decrease in mortality/ morbidity of cattle. As presented in the table above, the following observations are important to note:

- BCR> 1 and a moderately high EIRR% present a suitable investment opportunity over the project lifetime
- Good payback period due to the lower initial investment i.e. benefits outweighs the cost from 3rd year onwards only.
- The adaptation benefits are approximately ~ 25% of the total benefits. This renders the intervention a status of high climate relevant.

5.2. Case study of a subset of Lohare watershed that includes AEZs like arable temperate terraced mountain terrain, diverse crop arable sub-temperate recent alluvial plain, arable sub-temperate terraced mountain terrain within Dailekh district

5.2.1. Sustainable Agriculture Management

Table 35: Adaptation benefits from Sustainable Agriculture Management for Dailekh district (Lohare watershed)

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
1	Incremental revenue from off-season vegetable cultivation	High	Drought, intense heat	Helps in utilizing the land during dry seasons thereby augmenting income sources. Therefore, this measure is rated as "High".
2	Facilitate water conservation	Low	Drought	Provides for additional irrigation source during dry season in the Hilly region. Therefore this measure is rated as "Low".
3	Increase in food security	High	Drought	Nepal is net importer of food, with impacts of climate change the food security in threatened. Therefore this measure is rated as "High".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 36: CBA for Sustainable Agriculture Management for Dailekh district (Lohare watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
ENPV of costs	NPR Million	2,153.27	86,510.44	152,606.49	204,394.47	244,971.71	276,765.04	301,675.94
ENPV of benefits	NPR Million	0.00	124,075.00	248,149.99	372,224.99	496,299.98	620,374.98	744,449.98
Present Value of cost per hectare	NPR Million/ ha	32.13						
Present Value of benefits per ha	NPR Million/ ha	79.29						
Benefit to Cost Ratio	Ratio	2.47						
EIRR over the project lifetime	% p.a.	28%						
Climate Change %	%	17%						
Payback period for initial investment	Years	5-6						

The main streams of benefits from this intervention is through the additional income generated from sale of agri products. As presented in the table above, the following observations are important to note:

- BCR> 1 and high EIRR% present a suitable investment opportunity over the project lifetime
- Moderate payback period due to the delayed benefits accrual as agri-produce yield is considered from 5th year onwards only.
- The adaptation benefits are approximately ~ 17% of the total benefits. This renders the intervention a status of moderately climate relevant.

5.2.2. Sustainable Water Management

Table 37: Adaptation benefits for Dailekh district (Lohare watershed) from Sustainable Water Management

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
1	Savings in costs incurred for purchasing water.	High	Drought, erratic rainfall	Access to clean drinking water is a growing concern, according to the Government of Nepal's survey data around 84% of the Basin's population use improved water sources such as piped, tube well and well water (CBS 2014b). However, due to multiple sources of consumption and the possible impact of climate change, natural springs are drying up. Hence, from the point of adaptation, this benefit has been categorized as "High".
2	Savings in health costs due to water borne diseases.	Low	Drought	In the absence of readily available drinking water, the affected communities collect and store - often in unhygienic conditions, water for future use. This practice leads to the incidence of various water borne diseases (jaundice, gastro-intestinal disorders, reflux disease, etc.). Approximately 45% of household suffer from such health impacts (ADB, 2012). There have been reports of increase in mosquito infestation, pests and diseases due to increasing temperature. However, there is limited benefit from a RWH structure for avoiding water borne diseases. Therefore, this has been

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
				accorded a status of 'Low' benefit from the point of view of adaptation and resilience.
3	Avoided loss of agricultural income due to time spent in collecting water.	High	Drought	Traditionally, the rural population at Dailekh have supplemented their earnings from agriculture with revenues from the sale of industrial timber. With climate change and anthropogenic activities (encroachment) leading to increase in time investment in collecting water from far off sources like springs etc. is impacting their productive time. This is expected cause tremendous hardship among the poor rural population. On the other hand SWM-RWH helps to restore and augment this additional source of earnings. Hence, from the point of adaptation, this benefit has been categorized as "High".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 38: CBA for Sustainable Water Management in Dailekh district (Lohare watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
Present Value of costs	NPR Million	49,663.14	50,989.72	52,029.12	52,843.53	52,902.36	52,948.46	52,984.57
Present Value of benefits	NPR Million	29,311.55	58,952.32	82,176.65	100,373.51	100,733.09	101,014.83	101,235.58
Cost per capita for RWH system (over project life of 20 years)	NPR Million/ Capita	0.18						
Value of benefits per capita for RWH System (over project life of 20 years)	NPR Million/ Capita	0.35						
Cost per ha. for Gravity irrigation system	NPR Million/ ha	1.84						
Value of benefits per ha. for Gravity irrigation system	NPR Million/ ha	3.51						
Benefit to Cost Ratio	Ratio	1.91						

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
EIRR over the project lifetime	% p.a.	27						
Climate Change %	%	25						
Payback period of initial investment	Years	4-5						

The main streams of benefits from this intervention is in form of the avoided costs towards securing water, loss of productive time and loss due to water borne diseases. As presented in the table above, the following observations are important to note:

- BCR> 1 and high EIRR% present a suitable investment opportunity over the project lifetime
- Moderate payback period due to high initial investment and lower household coverage
- The adaptation benefits are approximately ~ 25% of the total benefits. This renders the intervention a status of high climate relevance.

5.2.3. Sustainable Livestock Management

Table 39: Adaptation benefits from Sustainable Livestock Management for Dailekh district (Lohare watershed)

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
1	Avoided loss due to mortality and morbidity of milch cattle	High	Drought, hail storm, intense heat/ cold wave	With climate change the instances of heat/ cold spells are expected to increase. Therefore this measure is rated as "High"
2	Incremental income due to increased milk production (due to improvement in lactation rate)	High	Drought	During summer season, it caters to the fodder requirement. Also it acts as a supplemental nutrient through composite feeding. Therefore, this measure it is rated as "High".
3	Avoided loss of agricultural income due to time spent in collecting water/fodder for livestock.	Medium	Drought, extreme weather conditions	The incidents of such extreme weather events are limited and therefore, this measure is rated as "Medium".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 40: CBA for Sustainable Livestock Management in Dailekh district (Lohare watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
ENPV of costs	NPR Million	5,647.77	6,432.27	7,046.95	7,528.57	7,905.93	8,201.60	8,433.27
ENPV of benefits	NPR Million	4,357.75	15,276.61	26,226.96	37,256.43	48,579.84	60,719.89	75,277.10
Present Value of cost of improved cattle shed	NPR Million/ cattle shed	0.04						
Present Value cost of fodder bank	NPR Million/ ha	2.70						
Present Value of benefits of improved cattle shed	NPR Million/ cattle shed	0.60						
Present Value of benefits of fodder bank	NPR Million/ ha	8.41						
Benefit to Cost Ratio	Ratio	8.93						
EIRR over the project lifetime	% p.a.	27						
Climate Change %	%	24						
Payback period for initial investment	Years	3-4						

The main streams of benefits from this intervention is through the additional income generated from sale milk/ livestock and avoided costs due to decrease in mortality/ morbidity of cattle. As presented in the table above, the following observations are important to note:

- BCR> 1 and high EIRR% present a suitable investment opportunity over the project lifetime
- Good payback period due to the lower initial investment i.e. benefits outweighs the cost from 3rd year onwards only.
- The adaptation benefits are approximately ~ 24% of the total benefits. This renders the intervention a status of high climate relevant.

5.2.4. Sustainable Forest Management

Table 41: Adaptation benefits from Sustainable Forest Management in Dailekh district (Lohare watershed)

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate/Anthropogenic Drivers impacting benefit	Explanation
1	Net income from systematic logging of industrial timber	High	Drought, Human Encroachment, landslides	Traditionally, the rural population at Dailekh have supplemented their earnings from agriculture and livestock with revenues from the timber logging. With climate change (leading to damage of forest areas, degradation of the quality of forests) and anthropogenic activities

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate/Anthropogenic Drivers impacting benefit	Explanation
				(encroachment, illegal felling of trees), this additional and important source of revenue is expected to be extinct. This is expected cause tremendous hardship among the poor rural population. On the other hand Sustainable Forest Management helps to restore and augment this additional source of earnings for the locals. Hence, from the point of adaptation, this benefit has been categorized as "High".
2	Net income from fuel wood cultivation	High	Drought, human encroachment, landslides	There is a high correlation between access to energy and development of social capital. In South Asia universal energy access is still a challenge. About 20% of the rural population in Nepal depends on fuel wood, biomass, etc. for meeting their energy needs for lighting, cooking. It has also been found that for the rural population who have access to electricity, the quality of supply is erratic and unreliable. Poor people at Dailekh continue to depend on forests for fuel wood, dried leaves, etc. Degradation of forests would aggravate their woes as this relatively inexpensive source of energy will dry up and additional expenditure needs to be incurred in order to procure, transport fuel wood from other places. Hence, sustainability of availability of fuel wood has been categorized as "High" from the point of view of adaptation.
3	Net income from agro-forestry and step cultivation	High	Erratic rainfall; landslides	In Dailekh, at some places agro-forestry has been promoted on a pilot basis. Cardamoms, turmeric, fodder, multi-purpose trees and crop species are being planted as a part of community based forestry programmes launched by FAO and IFAD. Scaling up such programmes is extremely essential as agro-forestry provides increased income opportunities, together with binding the soil and

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate/Anthropogenic Drivers impacting benefit	Explanation
				preventing landslides and erosion. The benefits from the agro-forestry, being incremental in nature, have been classified as "High"
4	Net income from livestock resources	Medium	Rising temperature; erratic rainfall; degradation of grasslands; forest fire	The community of Dailekh depends heavily on the income from livestock. Due to climate change and anthropogenic activities, grasslands are being encroached upon, proportion of barren lands are increasing. As a result, severe food shortage for livestock has been reported. Consequently, the dependence on income generated from livestock rearing is reducing as the villagers have to incur extra expenses to maintain livestock. Hence the adaptation gains have been considered to be "Medium"
5	Avoided loss due to damage of Properties	High	Landslides, erratic rainfall, degradation of Forests	In Dailekh, the incidences of landslides are increasing – causing both loss to life and property. Considering the magnitude of the loss, the gains are classified as "High".
7	Ground water recharge	Low	Drought, Erratic Rainfall	Dailekh is a drought-prone area. Further most of the population are dependent on agriculture. In the event of less than adequate ground water recharge, the area will continue to reel under water shortage and escalated costs of water harvesting. However, since there are parallel water conservation programmes the incremental gains have been considered as "Low".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 42: CBA for sustainable forestry management in Dailekh district (Lohare watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
ENPV of costs	NPR Million	187,460.86	237,772.14	277,205.31	308,112.38	332,336.83	351,323.55	366,205.03
ENPV of benefits	NPR Million	33.27	1,687,822.95	3,375,771.75	5,064,114.95	6,753,898.91	8,447,556.36	10,152,135.51

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
Present Value of cost per ha	NPR Million/ ha	3.35						
Present Value of benefits per ha	NPR Million/ ha	92.79						
Benefit to Cost Ratio	Ratio	27.72						
EIRR over the project lifetime	% p.a.	54.69						
Climate Change %	Ratio	37.11						
Payback period of initial investment	Years	5-6						

The main streams of benefits from this intervention is through the additional income generated from sale of forest produce like timber logging/ fuel wood cultivation/agro-forestry/ step cultivation/ tourism and in the form of avoided costs due to damage to houses & other structures due to landslides. As presented in the table above, the following observations are important to note:

- BCR> 1 and very high EIRR% present a suitable investment opportunity over the project lifetime
- Moderate payback period due to the delayed benefits accrual since forests take time to develop, all benefits do not accrue in the short term.
- The adaptation benefits are approximately ~ 37% of the total benefits. This renders the intervention a status of high climate relevance.

5.3. Case study of a subset of Babai watershed that includes AEZs like arable sub-temperate ancient depositional basin/river terrace and recent alluvial plain complexes, paddy arable subtropical swales in recent alluvial plane within Bardiya district

5.3.1. Sustainable Agriculture Management

Table 43: Adaptation benefits from Sustainable Agriculture Management in Bardiya district (Babai watershed)

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
1	Incremental revenue from off-season vegetable cultivation	High	Drought, intense heat	Helps in utilizing the land during dry seasons thereby augmenting income sources. Therefore, this measure is rated as "High".
2	Incremental revenue from cultivation of Riverbed crops	Medium	Drought, intense heat	Helps in utilizing the dry areas covered with sediments in the flood plains thereby augmenting income

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
				sources. Therefore, this measure is rated as "Medium".
3	Facilitate water conservation	Low	Drought	Provides for additional irrigation source during dry season in the Terai region however there are parallel water conservation programmes and therefore due to the incremental gain this measure is rated as "Low".
4	Increase in food security	High	Drought	Nepal is net importer of food, with impacts of climate change the food security in threatened. Therefore this measure is rated as "High".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 44: CBA for Sustainable Agriculture for Bardiya district (Babai watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
ENPV of costs	NPR Million	5,086.97	204,375.53	360,523.34	482,869.23	578,730.44	653,840.20	712,690.67
ENPV of benefits	NPR Million	0.00	292,250.57	584,501.14	876,751.70	1,169,002.27	1,461,252.84	1,753,503.41
Present Value of cost per ha	NPR Million/ ha	32.23						
Present Value of benefits per ha	NPR Million/ ha	79.29						
Benefit to Cost Ratio	Ratio	2.46						
EIRR over the project lifetime	% p.a.	26%						
Climate Change %	%	17%						
Payback period of initial investment	Years	5-6						

The main streams of benefits from this intervention is through the additional income generated from sale of agri products. As presented in the table above, the following observations are important to note:

- BCR> 1 and high EIRR% present a suitable investment opportunity over the project lifetime
- Moderate payback period due to the delayed benefits accrual as agri-produce yield is considered from 5th year onwards only.

- The adaptation benefits are approximately ~ 17% of the total benefits. This renders the intervention a status of moderately climate relevant.

5.3.2. Sustainable Water Management

Table 45: Adaptation benefits from Sustainable Water Management in Bardiya district (Babai watershed)

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
1	Savings in costs incurred for purchasing water.	High	Drought, erratic rainfall population growth	Access to clean drinking water is a growing concern, according to the Government of Nepal's survey data around 84% of the Basin's population use improved water sources such as piped, tube well and well water (CBS 2014b). However, due to multiple sources of consumption and the possible impact of climate change, natural springs are drying up. Hence, from the point of adaptation, this benefit has been categorized as "High".
2	Savings in health costs due to water borne diseases.	Medium	Drought, increase in temperature	In the absence of readily available drinking water, the affected communities collect and store - often in unhygienic conditions, water for future use. This practice leads to the incidence of various water borne diseases (jaundice, gastro-intestinal disorders, reflux disease, etc.). Approximately 45% of household suffer from such health impacts (ADB, 2012). There have been reports of increase in mosquito infestation, pests and diseases due to increasing temperature. However, there is limited benefit from a RWH structure for avoiding water borne diseases. Therefore, this has been accorded a status of 'Medium' benefit from the point of view of adaptation and resilience.
3	Avoided loss of agricultural income	High	Drought, excessive extraction	Traditionally, the rural population at Bardiya have supplemented their earnings from agriculture with revenues from the sale of industrial

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
	due to time spent in collecting water.			timber. With climate change and anthropogenic activities (encroachment) leading to increase in time investment in collecting water from far off sources like springs etc. is impacting their productive time. This is expected cause tremendous hardship among the poor rural population. On the other hand SWM-RWH helps to restore and augment this additional source of earnings. Hence, from the point of adaptation, this benefit has been categorized as "High".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 46: CBA for Sustainable Water Management in Bardiya district (Babai watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
Present Value of costs	NPR Million	80,495.22	82,241.57	83,609.89	84,682.00	84,798.96	84,890.60	84,962.40
Present Value of benefits	NPR Million	55,165.72	140,560.85	226,016.82	311,622.16	313,657.59	317,106.55	324,386.45
Cost per capita	NPR Million/ Capita	0.22						
Benefits per capita	NPR Million/ Capita	0.82						
Benefit to Cost Ratio	Ratio	3.82						
EIRR over the project lifetime	% p.a.	22						
Climate Change %	%	24						
Payback period of initial investment	Years	4-5						

The main streams of benefits from this intervention is in form of the avoided costs towards securing water, loss of productive time and loss due to water borne diseases. As presented in the table above, the following observations are important to note:

- BCR> 1 and high EIRR% present a suitable investment opportunity over the project lifetime
- Moderate payback period due to high initial investment and lower household coverage
- The adaptation benefits are approximately ~ 24% of the total benefits. This renders the intervention a status of high climate relevance.

5.3.3. Sustainable Livestock Management

Table 47: Adaptation benefits from Sustainable Livestock Management in Bardiya district (Babai watershed)

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate /Anthropogenic Drivers impacting benefit	Explanation
1	Avoided loss due to mortality and morbidity of milch cattle	High	Drought, extreme weather conditions	With climate change the instances of heat/ cold spells are expected to increase. Therefore this measure is rated as "High"
2	Incremental income due to increased milk production (due to improvement in lactation rate)	High	Drought	During summer season, it caters to the fodder requirement. Also it acts as a supplemental nutrient through composite feeding. Therefore, this measure it is rated as "High".
3	Avoided loss of agricultural income due to time spent in collecting water/fodder for livestock.	Medium	Drought, extreme weather conditions	The incidents of such extreme weather events are limited and therefore, this measure is rated as "Medium".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 48: CBA for Sustainable Livestock Management in Bardiya district (Babai watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
Present Value of costs	NPR Million	8,059.47	8,630.58	9,078.05	9,428.66	9,703.37	9,918.61	10,087.26
Present Value of benefits	NPR Million	7,314.36	25,636.50	44,003.71	62,481.54	81,358.61	101,282.63	124,044.07
Present Value of cost of improved cattle shed	NPR Million/ cattle shed	0.01						
Present Value cost of fodder bank	NPR Million/ ha	1.96						
Present Value of benefits of improved cattle shed	NPR Million/ cattle shed	0.60						
Present Value of benefits of fodder bank	NPR Million/ ha	12.72						
Benefit to Cost Ratio	Ratio	12.30						
EIRR over the project lifetime	% p.a.	32						
Climate Change %	%	24						

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
Payback period for initial investment	Years	3-4						

The main streams of benefits from this intervention is through the additional income generated from sale milk/ livestock and avoided costs due to decrease in mortality/ morbidity of cattle. As presented in the table above, the following observations are important to note:

- BCR> 1 and high EIRR% present a suitable investment opportunity over the project lifetime
- Good payback period due to the lower initial investment i.e. benefits outweighs the cost from 3rd year onwards only.
- The adaptation benefits are approximately ~ 24% of the total benefits. This renders the intervention a status of high climate relevant.

5.3.4. Sustainable Forest Management

Table 49: Adaptation benefits for Bardiya district (Babai watershed) from Sustainable Forest Management

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate/Anthropogenic Drivers impacting benefit	Explanation
1	Net income from systematic logging of industrial timber	High	Drought, human Encroachment, landslides	Traditionally, the rural population at Bardiya have supplemented their earnings from agriculture and livestock with revenues from the sale of industrial timber. With climate change (leading to damage of forest areas, degradation of the quality of forests) and anthropogenic activities (encroachment, illegal felling of trees), this additional and important source of revenue is expected to be extinct. This is expected cause tremendous hardship among the poor rural population. On the other hand SFM helps to restore and augment this additional source of earnings. Hence, from the point of adaptation, this benefit has been categorized as "High".
2	Net income from fuel wood cultivation	High	Drought; Forest Fire; Human Encroachment; landslides	There is a high correlation between access to energy and development of social capital. In South Asia universal energy access is still a challenge. About 20% of the rural population in Nepal depends on fuel wood, biomass, etc. for meeting their

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate/Anthropogenic Drivers impacting benefit	Explanation
				energy needs for lighting, cooking. It has also been found that for the rural population who have access to electricity, the quality of supply is erratic and unreliable. Poor people at Bardiya continue to depend on forests for fuel wood, dried leaves, etc. Degradation of forests would aggravate their woes as this relatively inexpensive source of energy will dry up and additional expenditure needs to be incurred in order to procure, transport fuel wood from other places. Hence, sustainability of availability of fuel wood has been categorized as "High" from the point of view of adaptation.
3	Net income from agro-forestry and step cultivation	Medium	Erratic rainfall; landslides; Rising temperature	In Bardiya, at some places agro-forestry has been promoted on a pilot basis. Cardamoms, turmeric, fodder, multi-purpose trees and crop species are being planted as a part of community based forestry programmes launched by FAO and IFAD. Scaling up such programmes is extremely essential as agro-forestry provides increased income opportunities, together with binding the soil and preventing landslides and erosion. The benefits from the agro-forestry, being incremental in nature, have been classified as "High"
4	Net income from livestock resources	Medium	Rising temperature; erratic rainfall; degradation of grasslands; forest fire	The community of Bardiya depends heavily on the income from livestock. Due to climate change and anthropogenic activities, grasslands are being encroached upon, proportion of barren lands are increasing. As a result, severe food shortage for livestock has been reported. Consequently, not dependence on livestock is reducing but also the villagers have to incur extra expenses to maintain livestock. Hence the adaptation gains have been considered to be "Medium"

S. No.	Type of Benefit	Relative importance from the point of view of adaptation	Climate/Anthropogenic Drivers impacting benefit	Explanation
5	Avoided loss due to damage of Properties	High	Landslides, Erratic Rainfall, Degradation of Forests	In Bardiya, the incidences of landslides are increasing – causing both loss to life and property. Considering the magnitude of the loss, the gains are classified as "High".
7	Ground water recharge	Low	Drought, Erratic Rainfall	Bardiya is a drought-prone area. Further most of the population are dependent on agriculture. In the event of less than adequate ground water recharge, the area will continue to reel under water shortage and escalated costs of water harvesting. However, since there are parallel programmes for water conservation, the incremental gains have been considered as "Low".

Using the social discount rate of 5% p.a., the present values of net benefits have been calculated for 5-10 years (short term), 10-20 years (medium term) and 20-35 years (long term). The results are presented in the table below.

Table 50: CBA for SFM measures in Bardiya district (Babai watershed)

Particulars	UOM	Tenure (in years)						
		5	10	15	20	25	30	35
ENPV of costs	NPR Million	145,224.51	184,290.42	214,910.50	238,910.69	257,722.17	272,466.71	284,023.56
ENPV of benefits	NPR Million	63.67	1,619,616.86	3,239,366.83	4,859,604.54	6,481,624.00	8,108,433.69	9,748,749.95
Present Value of cost per hectare	NPR Million/ ha	2.71						
Present Value of benefits per ha	NPR Million/ ha	93.14						
Benefit to Cost Ratio	Ratio	34.32						
EIRR over the project lifetime	% p.a.	61						
Climate Change %	%	35.01						
Payback period of initial investment	Years	5						

The main streams of benefits from this intervention is through the additional income generated from sale of forest produce like timber logging/ fuel wood cultivation/agro-forestry/ step cultivation/ tourism and in the form of avoided costs due to damage to houses & other structures due to landslides. As presented in the table above, the following observations are important to note:

- BCR> 1 and very high EIRR% present a suitable investment opportunity over the project lifetime

- Moderate payback period due to the delayed benefits accrual since forests take time to develop, all benefits do not accrue in the short term.
- The adaptation benefits are approximately ~ 35% of the total benefits. This renders the intervention a status of high climate relevance.

5.4. Prioritization of EbA measures based on the outcome of CBA

The adaptation options for each of the three pilot districts have been ranked on the basis of the outcome of the Cost-Benefit Analysis. Rank 1 signifies the most favorable option to Rank 4 being the least as per the basis of prioritization consideration i.e. Benefit Cost Ratio/ Climate Change %/ EIRR/ Payback period. For ease of reference, the outcomes for each of the watershed have been presented in the tables below.

Table 51: Mugu Karnali watershed

Suggested Measure	Basis of prioritization			
	Benefit-Cost Ratio	Climate Change %	EIRR	Payback period
Sustainable agriculture management	2	3	1	3
Sustainable water management	3	1	2	1
Sustainable livestock management	1	1	3	1

Table 52: Lohare watershed

Suggested Measure	Basis of prioritization			
	Benefit-Cost Ratio	Climate Change %	EIRR	Payback period
Sustainable agriculture management	3	4	2	3
Sustainable water management	4	2	3	2
Sustainable livestock management	2	3	3	1
Sustainable forest management	1	1	1	3

Table 53: Babai watershed

Suggested Measure	Basis of prioritization			
	Benefit-Cost Ratio	**Climate Change %**	**EIRR**	**Payback period**
Sustainable agriculture management	4	4	3	4
Sustainable water management	3	2	4	2
Sustainable livestock management	2	2	2	1
Sustainable forest management	1	1	1	3

6. Policy memorandum

6.1. Stock taking of existing climate change policy framework in Nepal

The National Adaptation Programme of Action (NAPA) has been formulated in 2010 by the Ministry of Population & Environment, Government of Nepal. Subsequently, the ministry has formulated Climate Change Policy (2011), and National Framework on Local Adaptation Plan for Action (LAPA) during in 2011 as action plan for implementation of the NAPA. In this context, the NAPA framework and action plan are some of the key Government documents, which form the base for other climate relevant guidelines, policies, action plans and frameworks formulated in Nepal. However, some policies that were formulated prior to NAPA, didn't directly refer to climate change and its risks and the relevant adaptation measures.

The list of other related policies and guidelines (Climate Change/agriculture/ecosystem related) by the GoN includes:

- National Adaptation Plan (NAP) 2017
- Agroforestry working paper 2016
- Water induced disaster policy 2015
- Agricultural development strategy, 2013
- Forest Area Protection Plan 2013
- National Agriculture Policy 2004
- Sustainable development goals, status and roadmap: 2016-2030
- Climate resilient planning, 2011
- Priority framework for action for climate change adaptation and disaster risk management in agriculture, 2010
- Irrigation policy, 2060
- Environmental Protection Act 1997
- Water resource Act 1992

The climate change, risk and adaptation related points from different policies and followed by Nepal Government till date is presented in the table below.

Table 54: Climate change policies, programmes and implementation agencies of GoN

Policy and related document	Policy Statement/Goals	Policy-Initiated Programs	Implementing Agencies
Climate Change Policy 2011	Implementing priority actions identified in the National Adaptation Programme of Action (NAPA), and identifying and implementing medium- and long-term adaptation actions in the climate impacted and climate-induced disaster-prone areas, communities, and people	Most of the programs after NAPA formulation	All ministries
	Identifying the people, communities and areas impacted by climate change and Implementing adaptation and impact mitigation measures based on local knowledge, skills and technologies.	Water Resources Project Preparatory Facility (WRPPF) –package 3-: Flood risk assessment	Ministry of Irrigation
	Formulating and implementing integrated programmes taking into consideration the objectives and the provisions of the conventions related to climate change, desertification and biodiversity	Building Climate Resilience of Watersheds in Mountain Eco-Regions (BCRWME)	Ministry of Forest and soil conservation
	Formulating and implementing design standards for climate resilient construction of bridges, dams, river flood control and other infrastructure.	Mainstreaming Climate Change Risk Management in Development	Ministry of Environment
	Formulating and implementing the necessary strategies, guidelines and working Procedures to support a socio-economic development that is climate-friendly and resilient.	Department of Water Induced Disaster Management Policy (now Dept. of Irrigation) 2015	Ministry of Irrigation
	Establishing a Climate Change Fund for mobilizing the financial resources from public and private, internal and external sources to address the issues of climate change.		Ministry of Finance
	Utilizing the financial resources available from national and international sources for climate adaptation, adverse impacts mitigation and low carbon development activities, as well as for food, health and livelihood security of victims of water-induced disasters, such as floods, landslides and droughts		Ministry of Finance
	Allocating at least 80 percent of available funds for field-level climate change activities.		Ministry of Finance

Policy and related document	Policy Statement/Goals	Policy-Initiated Programs	Implementing Agencies
	Managing the fund and making it easily accessible for the climate adaptation, resilience and other climate change-related programs.		Ministry of Finance
	Capacity building, peoples' participation and empowerment	Most of the programs	All
	Conducting climate change-related research to expand the implementation of measures for adapting to adverse impacts and benefiting from positive impacts	Initiation from Green Climate fund (GCF)	Ministry of Finance
Water Induced Disaster Policy 2015	Preparation of National and local master plan to cope with climate induced disaster in watershed	Under process	DWIDM (now Dept. of Irrigation)
	Climate induced disaster adaptation and mitigation will be carried out based on masterplan and prepare short, medium and long term plan.	Under process	DWIDM (now Dept. of Irrigation)
	IWRM principal and basin approach will be followed. The major landslide and mega river control will be planned from national and international sources	River training works from National budget and Indian government support.	DWIDM (now Dept. of Irrigation)
	Flood and landslide zoning and implementing for settlement zoning, park and agriculture planning	WRPPF package 3: Flood risk assessment and CBA analysis	DWIDM (now Dept. of Irrigation)
	Priority will be given to study and development	Regular National Budget program WRPPF package 3	DWIDM (now Dept. of Irrigation)
	Priority will be given to Capacity building of all climate induced disasters	Regular National Budget program All Project programs	DWIDM (now Dept. of Irrigation)

Policy and related document	Policy Statement/Goals	Policy-Initiated Programs	Implementing Agencies
Agriculture Development Strategy 2013	Climate change, input and output market price fluctuations, trans-boundary disease and natural disasters have had major local and regional impacts on agriculture.	Program under National Budget and some projects Such as integrated pest management (IPM)	Ministry of agriculture Development
Sustainable development goals, status and roadmap: 2016-2030	**Take urgent action to combat climate change and its impacts** (i) strengthening resilience and adaptive capacity to climate-related hazards and natural disasters, (ii) integrating climate change measures into national policies, strategies and planning, and (iii) improving education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning, among others. Climate change adaptation plan is proposed for at least 120 Village Municipalities by 2030. In the meantime, climate smart villages are proposed to increase from zero to 170 and climate smart farming to 500 units from zero at present. Almost all schools will be covered by climate change education	Study and implementing is in process	National Planning Commission
	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss This goal targets for (i) ensuring, by 2020, the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements, (ii) promoting the implementation of sustainable management of all types of forests, and halt deforestation. It also aims at ensuring by 2030 the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable		National Planning Commission

Policy and related document	Policy Statement/Goals	Policy-Initiated Programs	Implementing Agencies
	development. In the context of conservation of bio-diversity, 23.2 percent of total land area is declared protected. Similarly, the country also protects 1,727 lakes, wetlands and ponds. More than two-thirds (67.8 percent) of the mountain ecosystem is covered by the conservation areas.		
National Agriculture Policy 2004	Contract agreement for river, pond, reservoir area for farming.	Some practices are seen in river bed by paying some revenue to local government	Ministry of Local development
	Development of small irrigation structure such as pump, drip, sprinkle, water harvesting	Regular program from National budget and from donor	Ministry of Irrigation
	Preparedness for Pest, extreme heavy rainfall weather, drought hazards	Under Regular National program	Ministry of agriculture Development
	Goal of Women participation in agriculture program will be 50%	One of the goals of mostly all national programs and projects	Ministry of agriculture Development
	Promotion of grass land, agro forestry, herbal, silk, cash crop, fruits etc. for poverty reduction.	BCRWME program Other regular work under National agriculture program	Ministry of agriculture Development

Policy and related document	Policy Statement/Goals	Policy-Initiated Programs	Implementing Agencies
Irrigation Policy 2060	Master plan shall be prepared for Trans-basin water transfer and management from water-surplus large river basins to the water deficit area.	WRPPF package 4: Preparation of Irrigation Master Plan Bheri - Babai water diversion program Sunkoshi-Marine River water diversion program Melamchi water diversion program phase I and II	Ministry of Irrigation Ministry of Water supply
	Expanding year round irrigation, water reservoirs, rainwater harvests and ground water resources shall be developed, conserved, promoted and utilized as supplementary sources to the seasonal rainfall.	WRPPF package 6: Mechanized Irrigation System. Ground water irrigation national program and other national program	Ministry of Irrigation
	Available ground water resources shall, be developed and utilized as like the surface water reservoirs, and arrangements shall be made for conservation, promotion and control in quality.	Ground water irrigation national program and other national program BCRWME program Small Irrigation -SIP Project	Ministry of Irrigation Ministry of Forest Ministry of Local Development
	Capability of local bodies and users association shall be strengthened to ensure their effective participation in the planning, construction and management of small and medium irrigation systems. Efforts shall be made to involve non-	Farmer managed irrigation program	Ministry of Irrigation

Policy and related document	Policy Statement/Goals	Policy-Initiated Programs	Implementing Agencies
	governmental organization in the development of new technology in such projects.	BCRWME program Other donor based programs	Ministry of Forest
	The knowledge and skill of the manpower involved in the irrigation sector shall be continued from training and shall enhance the research capability.	All national and project	Ministry of Irrigation Ministry of Local Development Projects
National Framework on LAPA (2011)	Identify the most climate vulnerable Village Development Committee (VDC), Municipality, wards and communities and their adaptation challenges and opportunities, including possible activities; Identify and prioritise adaptation actions in easy ways whereby local communities make the prioritisation decisions about their needs; c. Prepare Local Adaptation Plans for Action and integrate it into local and national plans in accordance with the Local Self-Governance Act; Identify and mobilise appropriate service delivery agents and necessary resources for the implementation of the Local Adaptation Plans for Action; Adopt and/or implement adaptation actions sequentially by the service providers in a timely and resource efficient manner; Conduct monitoring and evaluation by ensuring effective implementation of the plan for action; and Identify cost-effective adaptation alternatives for scaling up into local and national planning.	NCCSP Formulated 14 District 87 Village 8 Municipality EECs. Followed by district agriculture office now *(except Babai watershed's Salyan all districts covered in this study)*	Ministry of Environment

Policy and related document	Policy Statement/Goals	Policy-Initiated Programs	Implementing Agencies
Climate Resilient Planning, 2011	This document is intended to facilitate ministries, departments and development organizations in analyzing sector specific climate issues with a greater understanding of climate variables at the local level and in adopting measures to reduce the emerging and anticipated climate threats which face development plans and programs. This document was prepared to facilitate the preparation of resilient periodic development plans. It is based on a report submitted by a group of experts which, under the technical assistance of the ADB, supported the National Planning Commission in preparing a climate-resilient three-year periodic development plan for the period 2011-2013. UNDP provided support for disaster risk reduction component of the plan.		National Planning Commission
National Biodiversity Strategy and Action plan: 2014-2020	By 2020, climate change adaptation planning adopted by at least 3,000 community based forest user groups.		Ministry of Forest
	The rate of forest loss and degradation reduced by at least 75 percent of the current rate by 2020.		Ministry of Forest
	All the districts, community forests, collaborative forests, and leasehold forests management plans have mandatory inclusion of a biodiversity chapter and the DFOs and user groups implement those provisions by 2020.		Ministry of Forest
	At least 50 percent of the production forests come under sustainable management by 2020.		Ministry of Forest

Policy and related document	Policy Statement/Goals	Policy-Initiated Programs	Implementing Agencies
	Conservation action plans for at least 10 threatened rangeland-dependent plant and animal species developed and implemented by 2020.		Ministry of Forest
	Community based management of agrobiodiversity strengthened and expanded to at least five additional districts by 2020.		Ministry of Forest
	By 2020, at least 10,000 hectares degraded mountain ecosystems restored through implementation of ecosystem based adaptation programmes.		Ministry of Forest
	By 2020, government and all other stakeholders will ensure at least 33 percent meaningful participation of women, dalit, janajatis and marginalized communities at all levels of planning and decision making.		Ministry of Forest
	By 2020, participatory and integrated soil and water conservation initiatives implemented in at least 30 critical sub-watersheds.		Ministry of Forest

The NAPA in 2010 and the LAPA in 2011 are among the major drivers in Nepal for climate change-related activities and adaptation in particular. The climate budget code has identified 124 climate related programmes of which 12 are local programs[9]. Climate Change Policy (2011) is key policy which is considering by government and other agencies. After this, in FY 2013-14, Government of Nepal has institutionalized the budget for addressing climate change impacts, wherein about 5.3 percent of the total budget is said to be directly related and additional 5 percent is indirectly related to climate change activities.

The other climate change related programmes include:

- Nepal Climate Change Support Programme (NCCSP)
- Design of national Strategic Programs for Climate Resilience (SPCR)
- Building Climate Resilience of Watersheds in Mountain Eco-Regions (BCRWME)
- Building Resilience to Climate Related Hazards (BCRH)
- Building Climate Resilient Communities through Private Sector Participation (BCRC)
- Building Climate Resilience in Nepal (BCR)
- National Adaptation Programme of Action (NAPA) to Climate Change, Water Resources Project Preparatory Facility (WRPPF)
- Community Based Flood and Glacial Lake Outburst Risk Reduction Project (CFGORRP)

Some other donor based programs include Hariyo Ban Programme, PANI Programme, KISAN II are other important projects which are being implemented to address the adaptation needs of climate vulnerable population of Nepal.

6.2. Climate Change Adaptation programs in Agriculture Sector

The direct climate change risk study is not available for agriculture sector however adaptation measures works were carried out under different Government projects. The Nepal Climate Change Support Programme (NCCSP) is the first significant intervention on climate change adaptation in Nepal. The programme document was designed in close collaboration with UNDP, Government of Nepal and stakeholders and has been closely aligned with the NAPA. NCCSP will also be guided by the Climate Change Policy (2011) and National Framework on LAPA (2011). NCCSP corresponds to Combined Priority 1 of LAPA – "Promoting Community based Adaptation through Integrated Management of Agriculture, Water, Forest and Biodiversity Sectors".

BCRWME project was designed for spring water conservation and augmenting water supply for agriculture and drinking purposes. The Climate change impact was studied to select the West Seti basin as Pilot area.

The ministry of Irrigation has initiated climate change inclusive flood hazard study of 25 river basins across flood plains in Nepal. It was carried out under ADB grant 229, Water Resources Project Preparatory Facility (WRPPF) package-3 in 2015 and completed on 2016. The main objective of this project was to protect agriculture and settlement from flood damage. As a follow up, the Ministry already contract with service provider for detail design of river protection structure in 6 most vulnerable basins under WRPPF package-7.

PAHAL is working in Promoting Agriculture, Health and Alternative Livelihoods is a five-year USAID climate change adaptation initiative designed to achieve food security among vulnerable populations in 14 districts in the middle and high hills of Mid and Far Western Nepal.

The PANI program is focused on management of critical water resources up till 2020 is another climate change adaptation programme that applies an integrated, whole-of-basin perspective to freshwater biodiversity conservation and sustainable water management in the three critical river basins in Mid-West and Far-West Nepal in response to changing climate conditions.

[9] Source: GWP/JVS 2014

Hariyo Ban Program's work in Nepal focuses on taking an integrated ecosystem and community approach to climate adaptation in Nepal. Major lessons focus on the value of integrating ecosystems in adaptation; the need to work at different scales and the challenges this poses; the importance of taking a multi-disciplinary approach; and the need to consider different time scales.

6.3. How this study integrates with the existing policy framework?

NAPA 2010 is Climate change and variability Hazard and Risk Assessment in District level and the Local Adaptation Plans for Action (LAPA 2011) designed for the effective implementation of NAPA. The National Framework for LAPA has been formulated in order to translate the suggestions into action and to assist identification of local adaptation actions with people's participation as prescribed in NAPA, development and implementation of action plans. However, NAPA assessment is carried out in District Level and therefore, the NAP 2017 guideline is method particularly supports LAPA implementation in small unit.

The LAPA formulated for climate change risk and vulnerability assessment and implementation from country to community level. NAPA 2010 is assessment of climate change risk at district level and does not give any picture in village/ward/community. NAP guideline is method seems to support in implementing LAPA or for other study but suggested indicators are scattered from district to community.

This study has been carried out for 6 districts in agro ecological zones and the method is based on NAP 2017 and it is carried out to Village level. The method could be replicate up to ward level and will be handy tool who follows LAPA for their analysis. The Local and National development planning from LAPA document is shown below

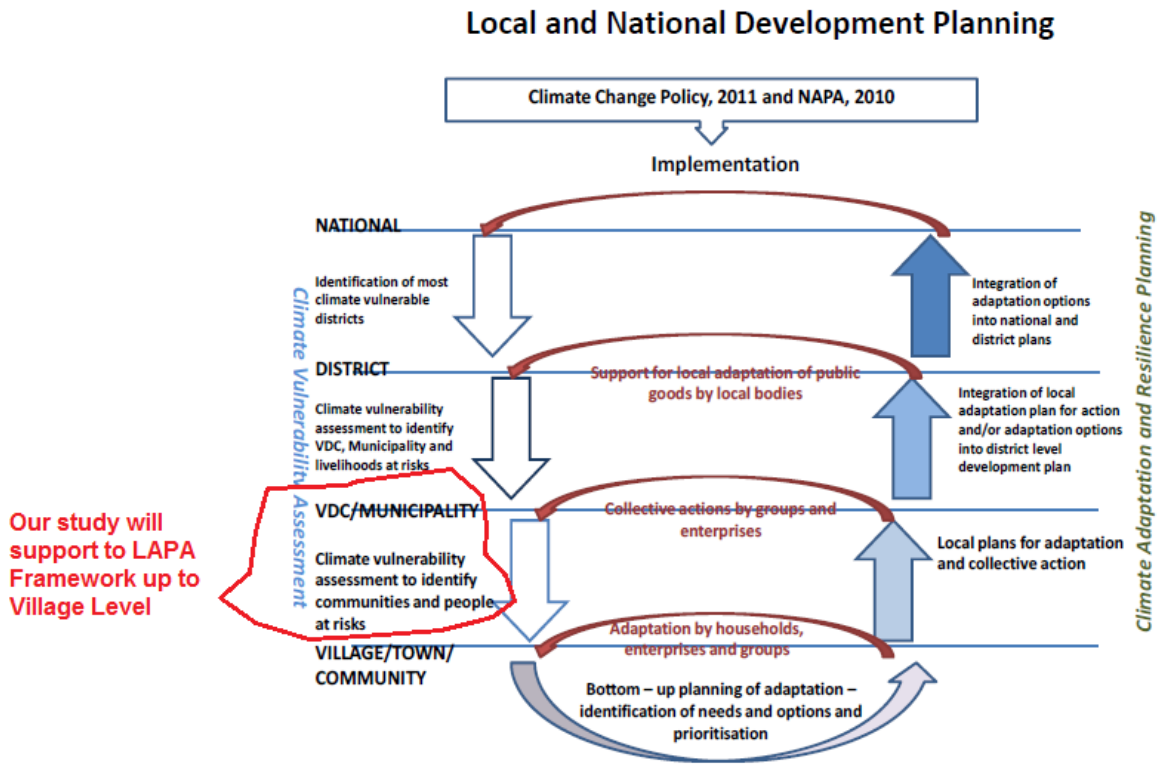

Figure 49: Local and National Development Planning

6.4. Institutional reforms and entry points for MoALMC

From the review of various policies of the GoN, it is apparent that since starting formulating the priority framework for action for climate change adaptation in 2010, the government continuously accorded importance to climate

actions. The actions and plans not only encompass mitigation and adaptation actions, but also plan, programmes and actions for protection and conservation of ecosystems and biodiversity, that are crucial for a country dependent on a fragile eco-system. The strategies suggested in various policies are cross-sectoral in nature – which is also a desired step in the entire process. Hence, it appears that through various policies, planning methods and action plans, the GoN has established (and has institutionalized) a well-defined framework for addressing climate change induced risks. But given the fact that that Nepal is going through a process of transition – particularly in the realm of the governance structure, are there gaps? Are the policies self-sufficient in the light of conditions set out by funds like GCF for financing climate projects? In case some more and immediate actions are required, what are these? This sub-section discusses some important points to be considered by the policy-makers of the GoN in the foreseeable future, if not immediately. The anticipated changes are to be considered as entry-points so as to create a 'climate investment-grade policy regime' attractive to various actors in the landscape of climate finance, including funds like GCF, Adaptation Fund, etc.[10]

6.4.1. Institutionalizing a mechanism for inter-ministerial and cross-sectoral coordination

The review of policies points out that the different tasks associated for implementation of policies are delegated to different line ministries of the national government. This poses a potential obstacle – since plans and actions maybe ideated in silos and are bereft of an integrated approach that requires inter-ministerial coordination. Different line ministries, in pursuit of realizing their immediate targets and political considerations, may lose sight of medium-to-long term objectives that are inherent in climate actions. Further, the plans and actions identified and planned by a particular line ministry may not prove to be 'appealing' or 'convincing' to another line ministry, and hence, implementation may be delayed or even abandoned. Simultaneously, plans and actions by two line ministries may counteract each other, thereby resulting in 'maladaptation' or even reduction of intended overall benefits. For example, a large scale deployment of solar pumps may lead to over extraction of ground water, thereby escalating the long term costs (for water harvesting) for farmers. Hence, it is essential that such policy conflicts are to be resolved ab initio so that the probability of such negative effects is minimized. Thus, there is a distinct requirement for a heightened inter-ministerial (and cross-sectoral) coordination for aligning different plans, policies and actions. The existing policies of the GoN appear to be somewhat silent in regard to this aspect. Thus it is imperative that the GoN takes immediate initiative to promote an apex institution to bring together different line ministries and explore synergies between the plans and policies, particularly in respect of climate actions. The existing Planning Commission (or such similar institution) may be entrusted with this responsibility. The goal is to reduce frictions between policies and leverage maximum gains out of action plans while minimizing resources and effort. This is expected to strengthen the institutional mechanism for ideating, implementing and operating climate actions – particularly, those related to adaptation.

6.4.2. Setting up Institutions for Planning Climate Actions at Local Levels

Most of the climate related policies in Nepal have been formulated during the period 2010 to 2015. During this period there was no existence of a federal governance structure. With the emergence of a three-tier governance framework since 2017, it is absolutely necessary that the philosophies and the contents of the national policies permeate to the sub-national and local policies and programmes. The mechanisms of planning at the sub-national and local level are still emerging.[11] It is important to note that the existing NAPA and LAPA provides a reference for the sub-national and local governments for planning for climate actions. Under the aegis of the Planning Commission, sub-national institutions may be constituted to monitor and guide the process, thereby mainstreaming climate considerations in the sub-national and local plans. This could possibly lead to Action Plans on Climate Change at the Sub-national Levels – aligned with the targets set by the national governments. The sub-national and local plans and programmes thus formulated should essentially have a long-term vision regarding climate-proof development of the provinces and

[10] However, these entry-points are to be considered along with the components of the Strategic Investment Framework.
[11] During this assignment, we had conducted extensive interactions with various Ministries at the National Level and Sub-national levels. We had also consulted the National Planning Commission. Our overall understanding is that the mechanisms are evolving and are still not clear to everybody. However, since April, the sub-national governments have started announcing their budgets.

regions. This action needs to be started immediately. At least some key sectors – agriculture, forests, irrigation, etc. may be brought under the ambit of such a coordinated regional planning process. Other sectors may be added subsequently, as the 'exact' mechanism evolves. It is also important to consider the conditions laid down by GCF and other financing partners while designing such plans. Else, there may be conflicts of interests (between the country and financing partners) which may lead to delay in execution of plans at the sub-national and local levels.

6.4.3. Sub-national Climate Funds and 'Ring-fencing' Principles

The set of climate policies in Nepal entrusts the Ministry of Finance with the responsibility of creating and managing a National-level Climate Change Fund for financing climate actions. It is also mandated that at least 80% of the resources from such a Fund are to be spent on in financing climate related activities at the local/ community level. Essentially, such a concept promotes a top-down approach for financing climate actions.[12] In the wake of a multi-level governance structure and a possible fiscal federalism in Nepal (in the years to come), the sub-national and local budgets must also imbibe in themselves such a philosophy. Hence, while the financial guidelines are being prepared for preparing budgets for sub-national and local governments, this principle needs to be mainstreamed into the system at the earliest. In doing so, the Ministry of Finance may have to assume the leadership while garnering support from other line ministries and related institutions for this work. It is important that sub-national and local governments are equipped with just not only capacities but also with suggestions about instruments (fiscal and non-fiscal) to mobilize resources and mechanisms to ring-fence the funds for climate related interventions. Additionally, guidelines are required to be spelt out for effective managing of such dedicated funds – institutions, rules for investments, priorities, etc. The issue of blending finances has to be adequately and comprehensively addressed. While creation of such funds at the levels of local governments may be difficult in the short run, adequate care needs to be accorded to institutionalize climate change funds at the sub-national level. This has to be done immediately so that provincial budgets are aligned to the national targets.

6.4.4. Institutionalizing mechanisms to screen projects for investment

This study adequately emphasizes that while there may be dedicated climate projects, many development projects may also have inherent climate relevance – particularly in the form of adaptation benefits. However, the climate benefits accrues provided the project is carefully designed and implemented after taking into account the possible loss and damages due to climate change. This is particularly true for the sectors like agriculture, forests, irrigation, water supply, etc. A scientific basis – like the spatial analysis needs to be embarked upon before deciding on a project. Such a philosophy is also apparent in various strategies of the climate related policies in Nepal. However, it is not clear how this will be integrated within the sub-national and local plans and actions. This would require the GoN to design and institutionalize a set of project development and project screening guidelines for the sub-national and local governments so that the latter can use the tools and techniques to screen alternative projects and select those that maximize both development and climate benefits. Else, there may be problems of investing in development projects with less climate benefits and rejecting similar projects with considerable climate benefits. This would also empower sub-national and local governments to prioritize across alternative projects and development plans conceived at these levels.

In this context the role of the four nominated Direct Access Entities (DAEs) for GCF project development in Nepal is important to note. The four entities include, 1) Alternative Energy Promotion Centre (AEPC), 2) National Trust for Nature Conservation (NTNC), 3) Town Development Fund (TDF) and 4) Nepal Investment Bank Limited (NIBL).

It is to be noted here that these entities present a spectrum of actors in climate finance landscape of Nepal. The expertise pooled in here by engaging a full scale financial institutions like NIBL leverages on its expertise of appraising large projects by being the lead banker for some of the major hydro-power projects in Nepal. It is well complemented through financial intermediary agency like TDF that has a focus on development financing and prior

[12] The review suggests that accessing finance from various sources and blending of finances are inherent in the national policies. To this extent, the national financing policy for climate actions is compatible to some of the conditions as proposed by GCF.

experience of working with DFIs. The range of projects in terms of ticket size of the projects jointly presented by these two institutions should cover a good spectrum of GCF proposals.

These two financial entities along with NTNC which brings it technical expertise of conservation/ adaption related projects and AEPC being the nodal agency for promoting renewable energy/ technology in Nepal is quite suited arrangement for providing the required guidance and technical support in developing GCF grade projects from Nepal.

6.4.5. Introducing Codes for monitoring and reporting Sub-national expenditures for achieving SDGs

Post the Paris Agreement of 2015, it is becoming imperative for all countries to report their expenditures on climate actions and sustainable development goals. The GoN has already finished institutionalizing codes for their national budget to this effect.
However, in the multi-level governance set up the mechanism needs to be replicated for both sub-national and local governments' budgets. Standardized norms are required so that comparison becomes rational and meaningful. Therefore, the codes are to be extended (with modifications, as necessary) at the levels of sub-national and local budgets. Detailed policy guidelines are to be framed to enable these lower tiers of governance to monitor and report their budgetary allocations for climate related expenditures and the SDGs.

6.4.6. Policies for ensuring Private Sector Participation

The review of existing policies does not clearly show the roles and responsibilities of the private sector in addressing climate issues. However, the actors in the landscape of climate finance are increasingly stressing on mobilizing resources and efforts from private sector in both mitigation and adaptation. GCF, in particular, lays down the participation of private sector as a precondition for their assistance. GoN has to immediately embark upon formulating policies and programmes to attract investments and involvement of the actors from the private sector – corporates, co-operatives and civil societies. As we shall see in the later chapters this involves initiating a broad spectrum of reforms. The policy is expected to act as an entry point towards this goal.

Evidently, Nepal has a set of policies in place to promote climate actions. But since the country is in the state of a transition, in terms of governance, there are some missing links. The immediate goal of GoN should be address these gaps so that policies are aligned across sectors and various tiers of governance. This would, expectedly, render the climate policy space in Nepal holistic and adequately attractive to the different actors of the landscape of climate finance, including GCF, to invest in Nepal. The GoN needs to prioritize across sectors (and also, regions), given the fact that it has to embark upon urgent actions within a constrained timeframe. The process of transition to a federal state provides Nepal and opportunity which it should leverage. The aforementioned points are some of the pressing issues that GoN needs to address immediately. Particularly, for agriculture, which is a complex yet important sector, Nepal has to attract finance from various sectors in short term to promote the concept of EbA. This action has long-term development benefits – which, as a welfare state, the country cannot ignore. Climate change may cause a serious loss and damage in this sector. The country has to adequately prepare for it. And it calls for attracting investments form various actors of climate finance. The entry-points in the policy-space, as discussed, are expected to make Nepal achieve this crucial goal.

6.5. Recommendations

Nepal has accessed climate finance for adaptation, mitigation, capacity building and awareness. National public finance (government revenue), carbon finance and international public finance (multilateral and bilateral funds) are the major sources of climate finance in Nepal (GWP Nepal 2014). Many donor agencies as development partners are working in Nepal and UK being the largest bilateral donor and the World Bank being the largest multilateral donor. The achievement in climate funds are LDC Fund, Strategic Climate fund of Climate Investment Fund (PPCR and SREP), Global Climate Change Alliance, Forest Carbon Partnership Facility, UK's International Climate Fund, Japan's Fast

Start Finance and Germany's International Climate Initiative for adaptation and mitigation activities. Adaptation fund (AF), Green Climate Fund (GCF) and Special Climate Change Fund (SCCF) are among other potential funds that Nepal can have access to. Grants (used by all Funds), concessional resources (PPCR, Japan), budgetary support and private financing (Japan) are the current modes of financing. Most climate adaptation projects in Nepal are funded through grants except for PPCR which has a loan component too. The funding arrangement by source for Nepal is shown in figure below.

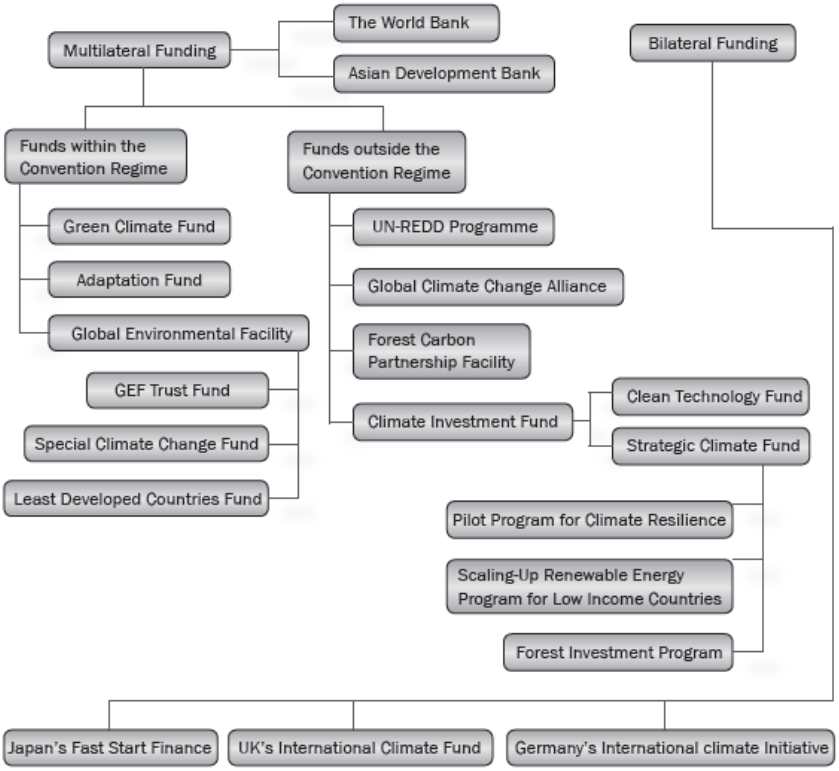

Figure 50: Climate Funding Agreement in Nepal (source: GWP/JVS 2014)

The NAPA in 2010 and the LAPA in 2011 are some of the major momentums in Nepal for climate change-related activities, adaptation in particular. The NCCSP, PPCR), and Hariyo Ban Programme are other important projects being implemented that address the adaptation needs of the vulnerable people of Nepal. Nepal started benefitting from the provisions of UNFCCC after it became a Party in 1994. Finance for both adaptation and mitigation activities from multilateral and bilateral sources are flown mostly in between 2009 and 2011. It is observed that climate finance for adaptation actions has been increased after 2010 suggesting how NAPA has been instrumental in securing funds for adaptation activities. The fund flow, however, has been reduced from 2012 onwards, especially for adaptation actions. The projects solely for building capacity and raising awareness are very few in numbers although these components are somewhat reflected in adaptation and mitigation projects and Nepal intends to integrate capacity building as an integral part of the projects.

Climate financing is emerging as a complex challenge in Nepal due to the lack of definition, use of various terms in climate expenses and the availability of different sources of climate finance. It is difficult to track consolidated spending on climate change activities. There are a lot of projects related to climate change and are facing difficulty to separate the same from normal developmental activities. The Government of Nepal introduced a climate change budget code from the fiscal year 2013-14 to track the public finance flowing into the country and is expected to differentiate the funding received between climate change work and normal development assistance. However, tracking private finance would still be a challenge. Developed countries have provided more funds in mechanisms operating outside the Convention regime. Most of the climate change projects are either funded directly by the donor institutions or implemented through UN agencies and INGOs. These agencies are largely interested in channeling the funds through the traditional channel or institutions that make their conditions easier. The project preparation and

supervision services given by those agencies require service charge which could have been provided to recipient countries. Nepal's capacity building of its institutions and development practitioners seems very crucial for enabling it to have direct access to the dedicated climate funds like the Adaptation Fund. Recently, the Minsitry of Federal Affairs and Local Development has brought out a climate change budget allocation document for the Government of Nepal. This is could serve as a starting point for the GCF projects.

It is recommended that such funding mechanism should ease the accreditation process so that national institutions could have that facility efficiently and in time. Countries like Nepal should be exempted from the obligation of proving additionality for adaptation activities taking into consideration the data shortage, poor data management practices, and less research studies. Accessing the funds under the Convention is a complex process requiring significant time for project endorsement and fund disbursement. GEF IAs and MIEs should provide 'fast track' services for financing the adaptation actions in the LDCs as a matter of high priority.

7. Preparing an investment plan

7.1. Sections of investment proposal

GCF funding proposal development process is based on their extant guidelines. It requires the project proponent to address the following points in their funding proposal.

Table 55: Sections of a GCF funding proposal

Section	Particulars	Detailed description
A	Project/ programme summary	• Project/ programme title • Basic information like executive summary, contact point, project focus (adaptation/ mitigation/ cross cutting) project size & lifespan
B	Financing cost/ information	• Description of financial elements of the Project / Programme - project financing information like co-finance, loans, GCF financing etc.
C	Detailed project/ programme description	• Political/ institutional information • Policy & institutional set-up • Objectives w.r.t baselines • Impact on climate change • Barriers address by the project/ programme • Project/ programme management structure
D	Rationale for GCF involvement	• Value added by GCF involvement • Exit strategy
E	Expected performance against investment criteria	• Impact potential - Potential of the project/programme to contribute to the achievement of the Fund's objectives and result areas • Paradigm Shift Potential - degree to which the proposed activity can catalyze impact beyond a one-off project/programme investment • Potential for knowledge and learning • Environmental, social and economic co-benefits, including gender-sensitive development impact • Country Ownership - beneficiary country (ies) ownership of, and capacity to implement, a funded project or programme
F	Appraisal summary	• Economic and Financial Analysis • Technical evaluation

Section	Particulars	Detailed description
		• Environmental, Social Assessment, including Gender Considerations • Financial management and procurement
G	Risk assessment and management	• Risk Assessment Summary • Risk Factors and Mitigation Measures
H	Results monitoring and reporting	• Paradigm Shift Objectives and Impacts at the Fund level • Outcomes, Outputs, Activities and Inputs at Project/Programme level • Arrangements for Monitoring, Reporting and Evaluation
I	Annexes	Supporting Documents for Funding Proposal, such as Feasibility Study, Environmental and Social Impact Assessment & Management Plan, Gender Analysis and Action Plan, Timetable of project/programme implementation, Economic analysis etc.

7.2. Dimensions and strategies of an effective Strategic Investment Framework for promoting Ecosystem based Adaptation financing

Table 56: Key dimensions of an effective Strategic Investment Framework

S. No.	Dimensions	Reasoning
1	Bridging finance gaps	• Using funds from GCF to leverage other climate funds, the Strategic Investment Framework must layout a mechanism so that a part of finances from Government of Nepal's budget is channeled in to climate investments as grants or subsidies as per the requirement of the GCF and other DFIs. This is one of the ways for co-financing of projects through Government's own sources and upholding the issue of Country ownership. • Blending of finances and instruments so that the investments are de-risked and adequate leverage is ensured. • Ensuring certainty regarding investment requirements hence, strategies must be in place to mainstream climate actions in the national, sub-national and local plans and programmes. Detailed analysis concerning the investment requirement for various climate actions is required to be incorporated in such plans and budgets.

S. No.	Dimensions	Reasoning
		• Capacity to access funds - trickle-down effect: Internationally and Nationally new funds are emerging for financing adaptation and mitigation. Also, the existing funds are evolving with new modalities of access. Although at the national scale the expertise for meeting eligibility criteria and accessing these funds exists, the same is, at best, trickling down to the sub-national and local levels.
2	Making interventions sustainable	• Encouraging revenue generation from interventions • Mainstreaming climate investments in local budgets and plans • Removing bottlenecks (of supply chain) and ensuring last mile delivery
3	Ensuring private sector participation	• GCF stresses heavily on the inclusion of the private sector in the climate actions. Not only GCF emphasizes on the fact that the finances from GCF should not substitute or deter investments from the private sector but also stipulates that the deployment of finances from GCF should be used so prudently so as to stimulate private sector participation. This principle has been advocated by GCF given the need for unlocking private sector finances for financing adaptation-mitigation actions
4	Promoting an integrated approach	An integrated approach to project ideation, planning, implementation, monitoring and evaluation is a mandatory aspect that the Strategic Investment Framework (SIF) must embrace. The SIF is required to promote integrated and inter-disciplinary thinking among ministries and layers of Government. The strategies it may consider for adoption are: • Integrated project planning • Integrated project financing • Integrated approach to monitoring & evaluation • Foster an integrated and investment grade policy regime

8. Limitations of the study

8.1. Limitations to the Cost-Benefit Analysis

- Some of the assumptions deployed in constructing the financial models for CBA are generic – i.e. applicable to the whole of Nepal and not specific to a particular watershed. Specific assumptions may change the results marginally.
- Some of the data used in the models are a little dated – as available from the Census published by the Central Bureau of Statistics and other Government Agencies. Needless to state, there may be changes in the data if the present situation is considered. However, given the paucity of latest data, the study has used data that have been published by the GoN, although a little dated. Using current data may change the results of the models, marginally.
- Some of the prices have been collected through a stake-holder consultation in the selected watersheds. There may have been a 'recall-bias' in such data. Although, efforts have been made to use the appropriate measures of central tendencies to smooth out the biases, this issue may be recognized as a limitation.
- On the whole, the models for CBA provide a framework for conducting CBA of the alternative and, sometimes, mutually exclusive projects. The results are indicative and may be used only as decision criteria for prioritization between projects. This has been stressed upon while discussing the screening matrix with alternative parameters concerning the interventions.
- The cost of the interventions – both CAPEX and Operation and Maintenance Costs have been 'estimated' based on the secondary literature review and various assumptions. The costs are not strictly engineers' estimates. While designing a project for implementation, it is absolutely important that the implementing agencies embark upon deriving a proper engineers' estimate.
- The costs of projects have been assumed to be free of impacts of climate change. Needless to say, there may be changes in costs of projects if climate change influences the implementation schedule of the projects. These are expected to be in the form of cost and time overruns. In our analysis, this possibility has been ruled out – as more detailed technical analysis is required to ascertain the impacts of CC on the costs. This is outside the scope and duration of this assignment.
- In case of most of the interventions, it has been assumed that the CAPEX is spread over a certain period – 3 to 5 years, on an average. This is purely a matter of assumption. Limitation of time did not permit us to consult the technical personnel regarding ascertaining the exact time required for implementation of a particular intervention – given the physical nature of terrain and various other related constraints.
- In the models, the gestation period has been a matter of assumptions based on similar experiences in other parts of the world. Actually, the gestation period may be more or less. An increase in the gestation period will adversely affect the decision criteria like EIRR, BCR, CC%, etc. On the other hand, shortening of gestation period will have a positive impact on these parameters.

8.2. Limitations to the Strategic Investment Framework:

- While carrying out this assignment, as stated in various parts of the report, Nepal was going through a phase of transition in terms of the Governance Structure. While policies are being framed to facilitate an era of fiscal federalism, none of the policies have been finalized. We have tried to make conjectures, based on our discussions with Ministries and other stakeholders and have tried to capture the same in suggesting the investment framework. However, the conjectures are based on our understanding and may vary when the policies are actually published. To this extent, the reforms suggested in the strategic investment framework are generic.
- It has also been noted, particularly during consultation of stakeholders at the local levels, there is an absence of clarity regarding the policies related to issues like devolution of fiscal powers, quantum of assistance from the Central Government, independence in planning and financing for local actions, etc. These are issues which may have tremendous impact on deployment of local actions for addressing climate risks. Since this assignment has

been carried out during the phase of transition, there is an absence of clarity. The team carrying out this assignment have tried to use their best judgement where there has been absence of clarity.

While we recognize these limitations, the study has attempted to address it through rational judgements/ proxy data and to this extent most of the limitations have been addressed to the maximum extent possible.

9. Conclusion

The objective of this assignment is to build the capacities of the functionaries with the Agriculture department and other related stakeholder for GCF project development. The need for establishing a scientific basis for the intervention i.e. in this case demonstrated through vulnerability assessment through spatial analysis in the pilot watersheds of Mugu Karnali, Lohare and Babai. In a study of this nature, a pertinent question is the unit of analysis for vulnerability assessment of agro-ecological zones. The most logical approach is opt for watershed level analysis however, this also depends on the time and resources available for the assignment. Data availability is a key concern and therefore usually the political/ administrative boundaries are considered for the analysis. The distinguishing aspect of this study is developing the concept of agro-ecological zones specific to the case of Nepal. This study can serve as a starting point for future work and investigations on agro-ecological zones.

The Ecosystem based Adaptation (EbAs) measures identified through vulnerability assessment and then validated by field survey were further prioritized by taking into consideration the gender assessment and environmental & social safeguards. This studies also tests the measures identified against in the criteria for qualification as an Ecosystem based Adaptation measure.

Subsequently, the investments for the EbAs have been identified and a cost-benefit analysis has been carried out for the interventions identified for the three districts (Mugu, Dailekh and Bardiya) as a case study across the three pilot watersheds. While deciding on the projects for adaptation, the stakeholders are faced with a portfolio of options. Each option has its costs and benefits – such costs and benefits are not only internal but are also external in the way these options affect the society, economy and environment. Therefore it is necessary to carry out a comprehensive economic analysis of the envisioned projects by incorporating different options and evaluating the "overall" cost-benefit ratio. The conventional financial cost benefit analysis may prove to be inadequate as all the external costs and benefits are ignored in such analysis. A correct and comprehensive economic cost benefit analysis aids decision related to proper selection of options among alternative choices and increases the sustainability of the project. In that sense, the economic cost benefit analysis if the first step after the portfolio of the feasible options and strategies has been identified. A key point note over here is that the methodology adopted for the cost benefit analysis depends on the objective of fund and should be accordingly selected. However, given the investment requirement, an important question for the policy-makers is how to generate sufficient funds – not just for meeting the CAPEX requirements but also for revenue expenditures during the entire life of interventions? The challenge increases as the GoN plans to avail assistance from the GCF – since GCF has certain investment criteria and GoN must conform to the same. This calls for a Strategic Investment Framework for investments in climate actions – using GCF and other funds. Further for ensuring sustainability of these projects through generations, an economic plan, incorporating policy instruments based on the principles of command-and-control and market based tools have to be devised to ensure the continuance of the adaptation projects in way as envisioned. This also directs one towards institutional reforms.

From the strategies recommended as focus areas of the investment framework a number of key points emerge. These are of interest to the policymakers and the salient observations are as follows:

- A sound financing plan needs to be in place – for each project and all projects. The plan must uphold the principle of co-financing and country-ownership. The measure requires intense coordination among funds, their nature of disbursement and devising an effective way of blending finances from various sources.

- Private sector can no longer be a fringe entity. The policies and strategies must ensure that there is sufficient private sector participation. As a matter of fact, all efforts must be directed, in the medium to long run, to unlock the private capital for financing climate actions.

- There is need exploring mechanisms to identify the most efficient ways in which finances can flow from various sectors. The mechanism ought to include all actors in the financial space. With each actor having competing interests and priorities, the framework need to make all economic entities happy with their rational interests satisfied.

- There is a need for policy reforms at various levels of governance and regulation. The reforms should be inclusive – in a way that takes on board all the stakeholders. The framework, if properly designed, can bring forth an investment grade policy regime in Nepal, not just in the context of climate change but in different spheres of development actions.

- Certain institutional reforms are also warranted to facilitate the financing objectives. While old institutions need to be strengthened in terms of capacity and capabilities, some new institutions may be required to ensure a seamless functioning of the climate and development financing system

These systemic transformations are easier said than realized. It is an iterative process and a time consuming process. Therefore, GoN needs to start the process immediately – carrying out a proper understanding of the AS-IS situation; envisioning a TO-BE situation and then finding out the steps and processes required to bridge the gap. The task is arduous, though not difficult.

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Annexure I: NAP-process identified V/RA indicators for Agriculture and Food Security (Nutrition)

Elements of hazard	Data source	Parameters Used	Comments
Climate extreme events: - Extreme heat - Consecutive dry days - Consecutive cold days - Heat waves - Cold waves (fog) - Extreme weather variability - Warm, cold, dry and wet spell	DHM	- Extreme heat - Consecutive dry days - Consecutive cold days - Heat waves - Extreme weather variability - Warm, cold, dry and wet spell	Certain parameters, although identified as necessary in NAP, have been excluded from the study because the data for those parameters are not available at the VDC level and only available as a single data at district level. The district level data is meaningless for carrying out risk analysis at the watershed level.
Climate-induced hazards: - Flood - Drought - Landslides - Hailstorm	DHM, ICIMOD, MoHA	- Flood - Drought - Landslides	
Sector specific hazards: - Crop inundation - Seasonal shift/temporal variability - Shifting of temperature isolines - Irrigation sediment - Pests and diseases outbreak	MoAD, DHM, MoIR, MoAD		

Elements of Exposure	Unit	Data source	Parameters used	Comments
Farming population (agriculture, horticulture, apiculture, livestock)	HH	CBS, Agri. stat.		Certain parameters, although identified as necessary in NAP, have been excluded from the study because the data for those parameters are not available at the VDC level and only available as a single data at
Irrigation schemes	No./Km	MoI DoI, ICIMOD		
Fish farms and ponds: - Number - Area	 No. Ha	MoAD, Agi Stat.		
Agricultural land area	Ha	CBS, Agri. stat.	- Agricultural - land area	
Population of livestock	No.	CBS, Agri. stat.	- Population of livestock	
Poultry farms	No.	CBS, Agri. stat.		
Horticulture area	Ha	CBS, Agri. stat.		

Rangeland area	Ha	MoLD, RIC	- Rangeland area	district level. The district level data is meaningless for carrying out risk analysis at the watershed level
Agriculture road and market network: - Road length - Markets	Km No.	DoLIDAR		
Agriculture labour population	No.	CBS		
Agro-ecosystems: - Types - Area	No. Ha	NARC		

Sub-system	Elements of Sensitivity	Unit	Data source	Parameters Used	
Agriculture, apiculture and horticulture	Income disparity	HH, %	CBS, UNDP	- Income disparity	Certain parameters, although identified as necessary in NAP, have been excluded from the study because the data for those parameters are not available at the VDC level and only available as a single data at district level. The district level data is meaningless for carrying out risk analysis at the watershed level.
	Land holding, land ownership and tenure	HH %	CBS, Agri.Stat.		
	Livelihood dependency on agriculture	HH %	CBS, MoAD	- Livelihood dependency on agriculture	
	Geography and access	Index	CBS		
	Gender inequality	Index	CBS, District Profile	- Gender inequality	
	Seasonal and out migration	No.	CBS, DoS, MoAD		
	Population structure	No. %		- Population structure	
	Geomorphology (edaphic factor, aspects, altitude, terrain)	Index	ICIMOD, NARC	- Used for AEZ	
	Farming system (rain-fed, single)	Ha/Type	NARC		
	Cropping pattern	Ha	NARC		
	Land cover and land use change	Ha	CBS, MoFSC		
	Species composition	Index	MoAD, NARC		
	Phenological characteristic changes	Index	MoAD, NARC		
Livestock and poultry	Cattle shed structure: - Type - Number	Type No.	MoLD, RIC		
	Livestock rearing practices	Type	MoLD		

	Pressure on rangeland	Ratio	MoLD, MoFSC		
Fisheries	Productivity and distribution	Mt/ha	MoAD, Agri. Stat.		
Food security and nutrition	Living standard	Index	NLSS		
	Age factor	Index		- Food security	
	Food stability	Index			

Sub-system	Elements of adaptive capacity	Unit	Data source	Parameters Used	
Agriculture, apiculture and horticulture	Availability of irrigation: - Source - Coverage - Type - Functional structure	No. Ha, Km	MoI, MoAD, Agri. Stat., Agri. Census	- cover age	Certain parameters, although identified as necessary in NAP, have been excluded from the study because the data for those parameters are not available at the VDC level and only available as a single data at district level. The district level data is meaningless for carrying out risk analysis at the watershed level.
	Agro-biodiversity pocket	No. Ha	MoAD, NARC, LI-BIRD		
	Use of efficient agro-tools and implements (modern, indigenous)	No.	MoAD, Agri. Stat., CBS		
	Use of environment-friendly technology and practices	No.	MoAD, NARC, Agri. Stat.	- Type of energ y used	
	Transportation facilities, market structures, collection centres, storage centres, warehouse and network	Km No.	MoAD, Agri. Stat., CBS	- Trans port netwo rk	
	Service (decentralized extension) centres, technology (early warning system) and human resource (including agriculture advisory system)	No.	MoAD	- Eco active pop/li terate pop	
	Availability of stress/flood tolerant genotypes, community seed banks and gene banks (indigenous and underutilized)	No.	MoAD, NARC, LI-BIRD		
	Government budget/investment in agriculture including human resources available	NRs/No.	MoAD, MoF		

Sub-system	Elements of adaptive capacity	Unit	Data source	Parameters Used	
	Insurance and financial services*	No.	NRB, Insurance companies		
	Farmers groups, cooperatives and networks	No.	MoAD, MoCPA		
	State investment and GDP contribution*	NRs	MoF, NPC, MOAD, MoLD		
	Policy, program and project support*	No. HH	NPC		
	Income poverty*	HH, %	UNDP		
	Agro-based industries, enterprises and employment*	No.	MoAD, FNCCI, Doln., CBS		
Livestock and poultry	Availability of water facilities	No.	MoLD, Agri. Stat., CBS, MoI	- Availability of water facilities	
	Housing system	Type	MoLD, CBS		
	Use of improved breed	No.	MoLS		
	Use of improved technologies	No. HH	MoLD		
	Service centres (resources and infrastructure)	No.	MoLD		
	Availability of stress tolerant genotypes of fodder	No.	MoLD, NARC		
	Availability of fodder and forage area	Ha	MoLD		
	Rangeland carrying capacity	LSU/ha	MoLD, RIC	- Rangeland carrying capacity	
Fisheries	Pond structure	No.			
	Water sources	Ha, km			
	Insurance	No			
	Market networks	No			
	Hatchery	No			
	Road access	Km			
	Adaptive breeds	No			
Food security and nutrition	Food sufficiency	No/Ha/ months	MoH, WFP, FAO, MoAD, NPC, MoF	- Food sufficiency	

Sub-system	Elements of adaptive capacity	Unit	Data source	Parameters Used	
	Nutrition status				
	Storage				
	Distribution channel				
	Food diversity				
	Food accessibility			- Food accessibility	
	Health				
	Food utilization				

** Used for other sub-sectors*

Annexure II: Observed Agricultural Trends

ANNEX 2						
Observed Agricultural Trend	***MUGU***	***DOLPA***	***DAILEKH***	***BARDIYA***	***DANG***	***SALYAN***
	MuguKarnali Watershed		*Lohare Watershed*	*Babai Watershed*		
Major crops grown	Potato (28.43%), Millet (22.9%), Wheat (20.81%), Paddy (12.03%), Barley (8.83%), Maize (5.08%), Pulses (1.6%), sugarcane (0.16%), oilseed (0.15%)	Potato (58.61%), Wheat (28.53%), Paddy (3.6%), Millet (3%), Pulses (2.03%), Maize (1.9%), Barley (1.9%), Oilseed (0.12%)	Paddy (50.024%), Wheat (18.75%), Potato (16.7%), Pulses (817%), Oilseed (3%) Sugarcane (2.08%), Maize (1.4%)	Paddy (33.63%), Potato (28.8%), Maize (14.4%), Pulses (9.53%), Wheat (6.9%), Oilseed (5.7%), Sugarcane (1.06%)	Maize (38.33%), Paddy (24.46%), Wheat (24.11%), Potato (8.66%), Millet (1.59%), Barley (1.23%), Oilseed (1%), Pulses (0.64%)	Wheat (29.725), Maize (29.6%), Paddy (22.24%), Potato (15.17%), Millet (2.05%), Oilseed (0.62%), Pulses (0.4%), Barley (0.2%)
Paddy Trend (2002-2015)	The cultivation area is increasing by 6.23 ha/year. The production is decreasing by 40.72mt/year. The yield is decreasing by 23.9 kg/year.	The cultivation area is increasing by 5.9 ha/ year The production is increasing by 24.52mt/year The yield is increasing by 61.96kg/year.	The cultivation area is 1298 ha/year. The production is increasing by 7989mt/year. The yield is increasing by 81.53kg/year.	The cultivation area is increasing by 336.7 ha/year. The production is increasing by 5017mt/year. The yield is increasing by 108.6kg/year	The cultivation area is increasing by 12.42 ha/year. The production is increasing by 915.3mt/year. The yield is increasing by 127.6(mt/ha)/year.	The cultivation area is decreasing by 20.62 ha/year. The production is increasing by 738mt/year. The yield is increasing by 93.85kg/year
Wheat Trend (2002-2015)	The cultivation area is increasing by 131 ha/year. The production is increasing by 264.7mt/year. The yield is increasing by 20.8kg/year.	The cultivation area is increasing by increasing by 182.7 ha/year. The production is increasing by 404mt/year. The yield is increasing by 39.29 kg/year.	The cultivation area is increasing by 288.8ha/year. The production is increasing by 2986mt/year. The yield is increasing by 114.7kg/year	The cultivation area is increasing by 1.428ha/year. The production is decreasing by 60.23mt/year. The yield is decreasing by 4.954 kg/year.	The cultivation area is increasing by 288.6 ha/year. The production is increasing by 1100 mt/year. The yield is increasing by 41.14 kg/year.	The cultivation area is increasing by 1.428ha/year. The production is decreasing by 60.23mt/year. The yield is decreasing by 4.954kg/year.

Millet Trend (2002-2015)	The cultivation area is increasing by 309.8ha/year. The production is increasing by 336.4 mt/year. The yield is increasing by 1.170kg/year.	The cultivation area is increasing by 5.769 Ha /year. The production is increasing by 10.72mt/year. The yield is increasing by 18.79kg/year.	No cultivation.	The cultivation area is decreasing by 13.26 ha /year. The production is decreasing by 11.45kg/year. The yield is increasing by 11.27kg/year.	The cultivation area is decreasing by 16.97 ha /year. The production is decreasing by 24.63mt/year. The yield is increasing by 4.976kg/year.	The cultivation area is decreasing by 4.928 ha /year. The production is decreasing by 56.42 mt /year. The yield is decreasing by 20.87kg/year.
Maize Trend (2002-2015)	The cultivation area is increasing by 6.489 ha /year. The production is increasing by 5.951mt/year. The yield is increasing by 1.170kg/year.	The cultivation area is decreasing by 151.0 ha /year The production is decreasing by 234.2mt/year. The yield is decreasing by 23.49kg/year.	The cultivation area is by 646.4 ha /year The production is decreasing by 1247mt/year. The yield is increasing by 63.04kg/year.	The cultivation area is increasing by 20.33ha/year. The production is decreasing by 438.0mt/year. The yield is decreasing by 9.559kg/year.	The cultivation is decreasing by 543.5ha/year. The production is decreasing by 692.6mt/year. The yield is increasing by 30.70kg/year.	The cultivation area is increasing by 916.1ha/year. The production is increasing by 1632mt/year. The yield is increasing by 4.941kg/year.
Barley Trend (2011-2015)	The cultivation area is increasing by 51.34ha/year The production is increasing by 72.16 mt/year. The yield is increasing by 10.29kg/year.	The cultivation area is increasing by 7.631ha/year. The production is increasing by 25.31mt/year. The yield is increasing by 15.33kg/year.	The cultivation area is constant. The production is decreasing by 0.033mt/year. The yield is decreasing by 3.296kg/year.	The cultivation area is decreasing by 0.950ha/year. The production is decreasing by 1.362mt/year. The yield is decreasing by 4.568kg/year.	The cultivation area is increasing by 12.24ha/year. The production is increasing by 20.58mt/year. The yield is increasing by 4.455kg/year.	The cultivation area is decreasing by 2.318ha/year. The production is increasing by 1.104mt/year. The yield is increasing by 19.94kg/year.

Potato Trend (2011-2015)	The cultivation area is increasing by 5.8ha/year. The production is decreasing by 186.8mt/year. The yield is increasing by 2313kg/year.	The cultivation area is increasing by 6.4ha/year. The production is decreasing by 293.5mt/year. The yield is decreasing by 371.6kg/year.	The cultivation area is increasing by 80ha/year. The production is increasing by 320mt/year. The yield is decreasing by 190kg/year.	The cultivation area is increasing by 21.5ha/year. The production is increasing by 1454mt/year. The yield is increasing by 527.8kg/year.	The cultivation is decreasing by 10.9ha/year. The production is decreasing by 156.9mt/year. The yield is decreasing by 61.6kg/year.	The cultivation is increasing by 17.5ha/year. The production is decreasing by 637.6mt/year. The yield is decreasing by 517.2kg/year.
Pulses Trend (2011-2015)	The cultivation area is increasing by 69.4ha/year. The production is increasing by 65.5mt/year. The yield is increasing by 683.7kg/year.	The cultivation area is increasing by 28.7ha/year. The production is increasing by 27.3mt/year. The yield is increasing by 601.2kg/year.	The cultivation area is increasing by 698.1ha/year. The production is increasing by 1570mt/year. The yield is increasing by 1115kg/year.	The cultivation area is decreasing by 268.7ha/year. The production is increasing by 1240mt/year. The yield is increasing by 681.6kg/year.	The cultivation area is increasing by 144ha/year. The production is increasing by 160.1mt/year. The yield is increasing by 1056kg/year.	The cultivation area is decreasing by 28.8ha/year. The production is increasing by 27.6mt/year. The yield is increasing by 756.9kg/year.
Sugarcane Trend (2003-2015)			The cultivation area is decreasing by 245.1ha/year. The production is decreasing by 8293mt/year. The yield is decreasing by 617.2kg/year.	The cultivation area is increasing by 76.07ha/year. The production is decreasing by 187.6mt/year. The yield is decreasing by 2320kg/year.		
Oilseed Trend (2003-2015)	The cultivation area is increasing by 1.576ha/year.	The cultivation area is increasing by 1.011ha/year.	The cultivation area is increasing by 126.6ha/year.	The cultivation area is decreasing by 111.9ha/year.	The cultivation area is increasing by 56.47ha/year.	The cultivation area is increasing by 11.75ha/year.

	The production is increasing by 1.807mt/year. The yield is increasing by 24.53kg/year.	The production is increasing by 1.181mt/year. The yield is increasing by 134.6kg/year.	The production is increasing by 243.2mt/year. The yield is increasing by 12.88kg/year.	The production is increasing by 535.0mt/year. The yield is increasing by 37.77kg/year.	The production is increasing by 54.46mt/year. The yield is increasing by 2.160kg/year.	The production is increasing by 16.56mt/year. The yield is increasing by 8.067kg/year.
Fruits Trend (2011-2015)						
Citrus Fruit (2011-2015)	The cultivation is decreasing by 9.15ha/year. The production is decreasing by 86.5mt/year. The yield is decreasing by 1164kg/year.	The cultivation area is increasing by 1.6ha/year. The production is increasing by 16.85mt/year. The yield is increasing by 970.8kg/year.	No citrus fruit.	The cultivation area is decreasing by 28.6ha/year. The production is decreasing by 49.5mt/year. The yield is decreasing by 1408kg/year.	The cultivation area is decreasing by 158.9ha/year. The production is decreasing by 2767mt/year. The yield is decreasing by 1145kg/year.	The cultivation area is decreasing by 109ha/year. The production is decreasing by 1254mt/year. The yield is decreasing by 198.7kg/year.
Winter Fruit (2011-2015)	The cultivation area is increasing by 4.22ha/year. The production is decreasing by 124.8mt/year. The yield is decreasing by 292.3kg/year.	The cultivation area is increasing by 51.8ha/year. The production is increasing by 3108mt/year. The yield is increasing by 4855k/year.	No cultivation.	No cultivation.	The cultivation area is increasing by 2ha/year. The production is decreasing by 44.17mt/year. The yield is decreasing by 279.7kg/year.	The cultivation area is increasing by 2.35ha/year. The production is increasing by 18.54mt/year. The yield is increasing by 12.96kg/year.
Summer Fruit (2011-2015)	The cultivation area is decreasing by 2.4ha/year.	No cultivation.	The cultivation area is increasing by 171.5ha/year.	The cultivation area is increasing by 322.4ha/year.	The cultivation area is increasing by 11.9ha/year.	The cultivation area is decreasing by 7.25ha/year.

	The production is decreasing by 43.2mt/year. The yield is decreasing by 5400kg/year.		The production is increasing by 506mt/year. The yield is decreasing by 688kg/year.	The production is decreasing by 788.8mt/year. The yield is decreasing by 1141/year.	The production is increasing by 26.2mt/year. The yield is increasing by 220.9kg/year.	The production is decreasing by 2045mt/year. The yield is decreasing by 8336kg/year.
Vegetable Trend (2011-2015)	The cultivation area is increasing by 88 ha/year. The production is decreasing by 598.9mt/year. The yield is decreasing by 10.24 kg/year.	The cultivation area is decreasing by 34.4 ha/year. The production is increasing by 253.1mt/year. The yield is decreasing by kg/year.	The cultivation area is decreasing by 410.4ha/year. The production is decreasing by 8167mt/year. The yield is decreasing by 321.9 kg/year.	The cultivation area is decreasing by 98.4ha/year. The production is increasing by 999.7kg/year. The yield is increasing by 744.8kg/year.	The cultivation area is decreasing by 140 ha/year. The production is decreasing by 634mt/year. The yield is decreasing by 23.26 kg/year.	The cultivation area is increasing by 176.3ha/year. The production is increasing by 1582mt/year. The yield is decreasing by 177.1kg/year.
Major Livestock	Goat(34.14%),Sheep (32.12%), Cattle (26.74%), Buffalo (6.92%)	Goat(53%), Sheep(27.67%), Cattle (16.9%), Buffalo (2.39%)			Goat(38.43%), Cattle (36.16%), Buffalo (17.58%),Sheep(4. 21%),	
Livestock trend Cattle						

Cattle Trend	The population of cattle is increasing by the number of 596/year.	The population of cattle is increasing by the number of 3557/year.	The population of cattle is decreasing by the number of 1389/year.	The population of cattle is increasing by the number of 126.8/year.	The population of cattle is increasing by the number of 1983/year.	The population of cattle is decreasing by the number of 1101/year.
Buffalo Trend	The population of buffalos is increasing by the number of 428/year.	The population of buffalos is decreasing by the number of 39.8/year.	The population of buffalos is decreasing by the number of 370.4/year.	The population of buffalos is increasing by the number of3336/year.	The population of buffalos is decreasing by the number of 526.4/year.	The population of buffalos is increasing by the number of 6150/year.
Sheep Trend	The population of sheep is increasing by the number of 158/year.	The population of sheep is increasing by the number of 6407/year.	The population of sheep is increasing by the number of 20.7/year.	The population of sheep is increasing by the number of 1150/year.	The population of sheep is increasing by the number of 667.3/year.	The population of sheep is decreasing by the number of 322.1/year.
Goat Trend	The population of goat is increasing by the number of 2937/year.	The population of goat is increasing by the number of 12085/year.	The population of goat is increasing by the number of 5331/year.	The population of goat is increasing by the number of 5237/year.	The population of goat is increasing by the number of 5070/year.	The population of goat is increasing by the number of 8993/year.
Pig	The population of pig is increasing by the number of 4.6/year.	The population of pig is increasing by the number of 2.9/year.	The population of pig is increasing by the number of 2753/year.	The population of pig is increasing by the number of 1963/year.	The population of pig is decreasing by the number of 301.6/year.	The population of pig is increasing by the number of 377.1/year.
Birds Trend (2011-2015)						
Fowl Trend	The population of fowl is decreasing by the number of 3339/year.	The population of fowl is increasing by the number of 1756/year.	The population of fowl is increasing by the number of 6950/year.	The population of fowl is increasing by the number of 18993/year.	The population of fowl is decreasing by the number of 44726/year.	The population of fowl is decreasing by the number of 1387/year.
Duck Trend	The population of Duck is decreasing by the number of 0.4/year.	The population of Duck is increasing by the number of 7/year.	The population of Duck is increasing by the number of 109.9/year.	The population of Duck is increasing by the number of 259.7/year.	The population of Duck is increasing by the number of 55.6/year.	The population of Duck is decreasing by the number of 163.5/year.
Meat Production (2011-2015)						
Buff Trend	The production is increasing by 23.7mt/year.	The production is increasing by 0.7mt/year.	The production is increasing by 174.7mt/year.	The production is increasing by 109.5mt/year.	The production is increasing by 58.3mt/year.	The production is increasing by 71.5mt/year.
Mutton Trend	The production is increasing by 2.4mt/year.	The production is decreasing by 11.4mt/year.	The production is decreasing by 0.7mt/year.	The production is increasing by 3.9/year.	The production is increasing by 5.7mt/year.	The production is decreasing by 1.2mt/year.
Goat Trend	The production is decreasing by 6.4mt/year.	The production is increasing by 34.4mt/year.	The production is decreasing by 185.4mt/year.	The production is decreasing by 4.2mt/year.	The production is increasing by 74.1mt/year.	The production is increasing by 35.9mt/year.

Pig Trend	The production is increasing by 0.1mt/year.	The production is increasing by 0.4mt/year.	The production is increasing by 30.5mt/year.	The production is increasing by 67.3mt/year.	The production is increasing by 9mt/year.	The production is decreasing by 1mt/year.
Chicken Trend	The production is decreasing by 3.6mt/year.	The production is decreasing by 4.4mt/year.	The production is increasing by 36.4mt/year.	The production is increasing by 75mt/year.	The production is decreasing by 7.8mt/year.	The production is increasing by 3.9mt/year.
Duck Trend	No production.	No production.	The production is decreasing by 0.2mt/year.	The production is increasing by 0.2mt/year.	The production is increasing by 0.1mt/year.	No production.
Milk Production (2011-2015)						
Milking Cows Trend (no.)	The population is increasing by the number of 703/year.	The population is increasing by the number of 20.4/year.	The population is increasing by the number of 121.6/year.	The population is increasing by the number of 608.9/year.	The population is increasing by the number of 238.6/year.	The population is decreasing by the number of 999.1/year.
Milking Buffalos Trend(no.)	The population is increasing by the number of 121.1/year.	The population is increasing by the number of 43.8/year.	The population is increasing by the number of 81/year.	The population is increasing by the number of 1966/year.	The population is increasing by the number of 1291/year.	The population is increasing by the number of 2183/year.
Cow Milk Trend (mt)	The production is increasing by 143.5mt/year.	The production is increasing by 126.9mt/year.	The production is increasing by 657.6mt/year.	The production is increasing by 514.7mt/year.	The production is increasing by 308.9mt/year.	The production is increasing by 338.9mt/year.
Buffalo Milk Trend (mt)	The production is increasing by 101.4mt/year.	The production is increasing by 35.7mt/year.	The production is increasing by 897.7mt/year.	The production is decreasing by 1181mt/year.	The production is increasing by 747.1mt/year.	The production is increasing by 733.6mt/year.
Egg Trend (2011-2015)						
Laying Hens (no.) Trend	The population is decreasing by the number of 615.4/year.	The population is decreasing by the number of 858.2/year		The population is increasing by the number of 33045/year.	The population is decreasing by the number of 7489/year.	The population is increasing by the number of 6481/year.
Laying Ducks (no.) Trend	The population is increasing by the number of 4.6/year.	The population is increasing by the number of 5.6/year.		The population is decreasing by the number of 87.4/year.	The population is decreasing by the number of 71.3/year.	The population is decreasing by the number of 33.6/year.
Hen Egg (*1000)Trend	The production is decreasing by the number of 93.8/year.	The production is decreasing by the number of 79342/year.		The production is increasing by the number of 126.8/year.	The production is increasing by the number of 246.3/year.	The production is increasing by the number of 883.4/year.
Duck Egg (*1000)Trend	The production is increasing by the number of 0.4/year.	The production is increasing by the number of 0.4/year		The production is increasing by the number of 3336/year.	The production is increasing by the number of 2.4/year.	The production is decreasing by the number of 0.5/year.
Fish Trend (2011-2015)						
Ponds no. Trend			The ponds number is increasing by 27.6/year.	The ponds number is increasing by 28.3/year.	The ponds number is increasing by 21.2/year.	The ponds number is increasing by 24/year.
Water Surface Trend			The water surface is increasing by 7.664ha/year.	The water surface is increasing by 12.29ha/year.	The water surface is increasing by 1.015ha/year.	The water surface is increasing by 12ha/year.
Fish Production Trend			The production is increasing by 99089kg/year.	The production is increasing by 74218kg/year.	The production is increasing by 3912kg/year.	The production is increasing by 1800kg/year.
Yield Trend				The yield is increasing by 210.2(kg/ha)/year.	The yield is increasing by 48.6(kg/ha)/year.	The yield is increasing by 450(kg/ha)/year..

*Annexure III: Hazard/Exposure/ Adaptive Capacity Maps***

**The Maps are provided in a separate Attachment.

Annexure IV: Local prices

Seeds	Prices (in NPR)
Sava Masuli 1 seeds	350/kg
Sava Masuli 2 seeds	350/kg
Sava Masuli 3 seeds	350/kg
Sava Masuli 4 seeds	350/kg
pumpkin seeds	1500/kg(local seed), 18000/kg
gourds seeds	Bottle-gourd(hybrid)- 10000/kg Bitter-gourd(hybrid)-20000/kg Sponge-gourd(hybrid)-18000/kg 25-30 gm seeds needed for (508 sq.m^2=1 ropani=5476 sq.ft) land
cucumber seeds	25000/kg (hybrid)
Alfa-alfa grass seeds	500/kg 1 kg is needed for 508 m^2 land
Crofton weed (Banmara Tree)	1500 plant per 508 m^2 land
asuro (malabara tree)	500 plants
neem	20/ plant 500 trees for 508 m^2
Titepati (Mugwort)	132.27736 $/ Kg (https://www.vermontwildflowerfarm.com/wildflower-seed.html)
Timur (Nepali Pepper)	50/sapling 500 trees for 508 m^2
Persian Lilac (Bakaino)	4000/kg 500 trees for 508 m^2
Field Mint (Patina)	5/ plant 1000 sapling for 508 m^2
plastic mulch	5000 for (400*1.2)m 25 micron plastic
pump unit	8000 to 22000 which can cover 1.016-1.27 ha land
Control head (valves)	1450 /valve with double union 1 valve can cover 508 m^2 land
Main pipes	130/m
lateral pipe	17-30/m
emitters or drippers	7-10/piece 1 piece for small plants and 3-4 piece for big trees (depends on the tree size)
fuelwood	1500/40 kg
bamboo	150-250/ piece depending on the bamboo type/species