

# Chapter 7

## Climate-Resilient Forest Management in Nepal



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### 7.1 Introduction

#### 7.1.1 *Ecosystem Degradation in the Hindu Kush Himalaya Region*

Forests are important components of livelihood system for a large percentage of the population in the Himalayan region, and they also offer an important basis for creating as well as safeguarding more climate-resilient communities. The HKH region hosts diverse vegetation systems, which could be attributed to the climate variability within the region. However, the region is fragile in terms of land-cover diversity and its association with variable terrain, climate, and socio-demographic interactions. The region is also rich in biodiversity; nonetheless, it is one of the most understudied regions of the world in this regard (Kumar et al. 2019). In addition, in the last few decades, the HKH region has experienced rapid economic, social, and environmental changes owing to unsustainable and haphazard development (Sharma et al. 2019). The Millennium Ecosystem Assessment of the United Nations (MEA 2005) shows that more than 60% of the world's ecosystem services are either degraded or used unsustainably. Stern et al. (2006) have highlighted the detrimental effect of deforestation on climatic conditions, which demands the urgent need for improved management and governance of forest resources to avoid further chronic disturbances leading to degradation. As a matter of fact, higher forest degradation is

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**Fig. 7.1** Forests are major sources of timber and fuelwood in Nepal. Photo by Jitendra Bajracharya

occurring in the lower and middle slopes because of heavy anthropogenic activities (Fig. 7.1) (Nandy et al. 2011). In such a scenario, the natural ecosystems are experiencing changes that are adversely affecting the services provided by these pristine ecosystems. Increase in the frequency, duration, and/or severity of drought and heat stress, changes in phenology, increasing pest and fire outbreaks, and changing nutrient dynamics under climate change scenarios are altering the composition, productivity, and biogeography of forests and also affecting the potential and promising ecosystem services as well as forest-based livelihoods. Additionally, vegetation shifts and decline in vegetation productivity have been observed due to the impact of climate change on the HKH region (Wester et al. 2019).

Nepal covers 6.61 million hectares of forest land, representing 44.74% of the total area of the country (FAO 2018; DFRS 2015) and 0.17% of the global forest area (FAO 2018; Keenan et al. 2015). Almost 35% of Nepal's population is dependent on forest resources for their livelihood (FAO 2018), which means that forest degradation and deforestation are major environmental issues for Nepal (Chaudhary et al. 2016). Deforestation is the conversion of forest into another land-cover type while degradation results when forests remain forests but their capacity to produce all ecosystem services is reduced (Lei et al. 2017; MEA 2005; Acharya et al. 2011). In the case of deforestation, the conversion of subtropical broadleaf and lowland sal forests into other land types has been rapidly increasing, while these forests are vulnerable to climate change as well (Thapa et al. 2016).

Degradation can be measured by various approaches, viz. decrease in the canopy density or decrease in biodiversity or increase in the occurrence of invasive plants or a decline in the ecosystem services provided by the forests. Nepal's forest statistics reflects that forest degradation is more critical than deforestation (Acharya et al. 2011) and a major catalyst in promoting forest fragmentation (Panta et al. 2008). Between 1947 and 1980, the annual rate of deforestation in Nepal was 2.7% (Chaudhary et al. 2016), whereas the degradation trend was at 5.57% for the period 1978/79–1994 (Acharya et al. 2011). Studies also show that Nepal's forests are considered to be one of the most vulnerable to the effects of climate change in the HKH region (Lamsal et al. 2017), thereby placing in peril the communities that are dependent on the forests in so many ways (Ma et al. 2012).

### ***7.1.2 Forest Policies and Management in Nepal***

In response to the need for a forest management regime, some key policies and legal instruments have been introduced in Nepal: Private Forest Nationalization Act, 1957; National Forest Plan, 1976; Master Plan for the Forestry Sector, 1989; Forest Act, 1993; Forest Rules, 1995; Revised Forestry Sector Policy, 2000; Leasehold Forestry Policy, 2002; Herbs and Non-Timber Forest Product (NTFP) Development Policy, 2004; Forest Policy, 2015; and the Forestry Sector Strategy (2016–25). These policies have been supported by several strategies and action plans such as the Terai Arc Landscape Strategy, 2004–2014; Gender and Social Inclusion Strategy in the Forestry Sector, 2004–19; Sacred Himalayan Landscape Strategy, 2006–16; and the National Biodiversity Strategy (NBS 2002) and Action Plan, 2014. As of 2020, Nepal has 22 protected areas (PAs) distributed across different altitudinal gradients, which have been designed mainly with a focus on wildlife habitat and corridors. Although the earlier policies did not explicitly address the issue of vulnerability of forest and its dependent communities to the repercussions of climate change, the latest policies and strategies have specific provisions related to reducing this vulnerability and promoting/ensuring climate-resilient forest management practices. For example, climate change mitigation and resilience is one of the eight pillars and responding to climate change as a core strategy of the Forestry Sector Strategy (2016–25). Nepal's National Adaptation Plan also has a sector on “forests and biodiversity” to specifically look at the climate change vulnerability under predicted scenarios and identify suitable adaptation options (MoPE 2017). Then there's the model of community forestry which has been in existence in Nepal for four decades and more after the enactment of the National Forestry Plan in 1976. Currently, the number of community forests in Nepal exceeds 22,000, which managing a total area of about 22.37 million hectares involving almost 2.9 million households (Dahal et al. 2017; DoF 2018). These community forests follow the Community Forest Development Guidelines (2014) which empowers the forest user groups to develop their own constitution and management plans, and directs them in implementing activities as per the plans

(GoN 2014). This guideline also includes a mandatory provision on how the revenue that is generated ought to be used—at least 35% of a community forestry group’s income should be invested in pro-poor activities and 40% toward the welfare of the forest community (GoN 2014). So far, community forests have been successful in achieving their “dual goal” of ecosystem restoration and livelihood improvement; however, better efforts have to be made to ensure at least 50% participation of women and members of the marginalized communities in decision-making roles; this would tick the boxes of gender and social equality that is part of the UN’s Sustainable Development Goals (SDGs).

### ***7.1.3 Importance of Gender and Social Inclusion in Community Forest Management***

Community-based forest management (CFM) is considered one of the successful models of community-based forest governance; however, its success depends on several factors—socioeconomic heterogeneity, institutional setting, leadership, property rights regimes, degree of decentralization, community characteristics, technology, and market influence (Cox et al. 2010; Pagdee et al. 2006). Moreover, as things stand currently, while Nepal has taken some important steps in securing gender and social equality, its National Adaptation Plan of Action (NAPA), the Local Adaptation Plan of Action (LAPA), and REDD + (Reducing emissions from deforestation and forest degradation) initiative are not gender and socially inclusive (Gurung et al. 2011).

The United Nations Framework Convention on Climate Change (UNFCCC) first introduced gender to global climate change discussions in 2001, specifying gender equality as a guiding principle in the preparation of adaptation plans for the “urgent and immediate needs” of the least developed countries. It also highlights the importance of women participating in climate change negotiations in a meaningful way. Of all the South Asian countries in the Women’s Resilience Index—a tool that assesses the extent to which a country has been able to integrate women into resilience-building efforts—Nepal is the only country where gender has been “mainstreamed” into its climate change decision-making setup, which acknowledges women as a vulnerable group (Agarwal 2010). However, there is an absence of targets for women’s involvement within the NAPA, and of the nine specified projects, none is gender-specific (Economic Intelligence Unit 2014; GoN 2010). In our study, we provide more insights into how gender and social inclusion play a role in community-based forest management in Nepal; for this, we have relied on data from three priority districts. We also point out how it is important that the community forest user’s groups (CFUGs) have an equal representation of households from all ethnicities and different income categories. The premise of CFUGs asserts that communities or groups of forest users should collectively be engaged in the management of forests (Negi et al. 2018).

### ***7.1.4 Climate Change Adaptation and Forest Ecosystems***

Understanding the vulnerability of forests and the degradation of ecosystems is the first step toward effectively identifying adaptation and management strategies. The two fundamental response options to the predicted climate change scenarios are mitigation and adaptation. Traditionally, mitigation has been the main focus of those studying climate change, from both scientific and policy perspectives. However, researchers have been underlining the importance of considering adaptation options as a response measure to climate change, along with mitigation mechanisms; the reasons being: Climate change is inevitable; adaptation measures produce more instant benefits; and adaptive actions can be carried out at both local and regional levels (Millar et al. 2007). Hence, the assessment of the vulnerability of forest ecosystems to climate change and the development of a database to identify and support relevant adaptation strategies have been identified as urgent needs.

At present, there is a gap in terms of availability of accurate information on forest degradation and about the impacts of climate change on forest ecosystems; the bridging of this gap could prove crucial in assisting the decision-makers to make more effective plans for managing forest ecosystems. Effective adaptation to climate change depends on the availability of two important prerequisites: information on what to adapt, where to, and how to; and resources to implement the adaptation measures. Ground-based information about the vulnerable systems and the stressors that they are exposed to and the transfer of resources to vulnerable societies to help them prepare to cope with the inevitable impacts of climate change are thus necessary elements of a comprehensive climate policy (Saxon et al. 2005; Parmesan et al. 2013). In this context, in the present study, we introduce the concept of a multi-tier approach that can support effective identification and implementation of adaptation measures.

## **7.2 Context of Services**

### **A Climate-Resilient Forest Management System (CRFMS) to support decision-making processes at different geographic scales**

The district/divisional forest offices of Nepal follow a five-year Divisional Forest Operation and Management Plan (DFOMP), which is used to prioritize the activities of the various divisions. This plan currently lacks a scientific approach to effectively address deforestation and forest degradation as well as the vulnerability of the forests to climate change impacts. To introduce a scientific approach to DFOMP, the Department of Forests and Soil Conservation (DoFSC) is attempting to prepare a vulnerability profile at the district/division level. It would use this profile as a guiding document to identify the hotspots of degradation and

vulnerability, and then decide the priorities for that particular district or division. There is also the Hariyo Ban program undertaken by a consortium of four agencies: Cooperative for Assistance and Relief Everywhere (CARE); World Wide Fund For Nature (WWF); the Federation of Community Forestry Users Nepal (FECOFUN); and the National Trust for Nature Conservation (NTNC). The information developed under the CRFMS at the district level could provide important data and information on climate change vulnerability and the degradation of forest ecosystems at the community forest level. This information can add scientific evidence to community-level forest management plans and enhance the decision-making process at the community forest level.

### Scope of the service

**Theory of change:** It is important to define the scope of a service by jointly agreeing with the co-developer and user agencies. It is also important to understand and monitor the impact of the service, which is often done by developing a theory of change (ToC) and identifying impact pathways—and all along adopting the monitoring, evaluation, and learning approach. In the case of the CRFMS service, we and our partners both developed and revised the ToC (Fig. 7.2). Our definition of the ToC revolved around the following elements: zone of project control; zone of project influence; zone of partners’ influence; the context; outputs and outcomes; and risks and impacts.

**Zone of project control:** While developing a service, it is crucial to identify and understand the gap areas through a needs assessment process and to design and develop the service so that the products of the service help in supporting the

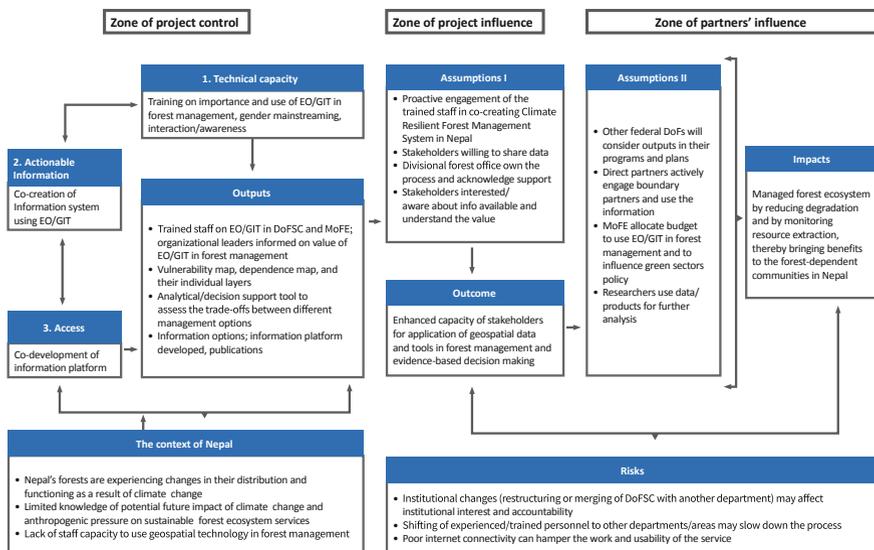


Fig. 7.2 Theory of change for a climate-resilient forest management system

decisions at various scales. Alongside, there's a need to enhance the technical capacity of the implementing partners/co-developing agencies. Co-development of services can be helpful for all the organizations that are involved in the collaborative process, where some stakeholders benefit by getting access to data and information that can help in decision making; while some organizations benefit by getting the thrust to engage with decision-makers for policy-level changes and suchlike. In order to enhance the use of the products that have been developed, packaging them as “actionable information” plays an important role that can help decision-makers to improve their planning and management with precise information, in this case, on the vulnerability of forest ecosystems to climate change.

**Zone of project influence:** This zone mainly focuses on working together with the partners and involves data collection, data sharing, co-design, and co-development as well as co-implementation of the service. This can be of mutual benefit to both the agencies and adds value to the different products being developed under the service. A proper validation of the products and the information that is generated under the service by the partners is important to assess the accuracy of the products through the decision-makers' lens, which helps in increasing the acceptability of the service to a wider audience. It is also useful to understand the different dimensions, such as gender and social inclusion, in order to explore the socioeconomic linkages and in this case the impacts of forest-related work under the service; this provides an idea about the users of the forest resources and how to bring in sustainable forest management. This also improves the sense of ownership of the service among the partner agencies, which can then enhance the usability of the products by adding to the decision-making capacity of the users.

**Zone of partners' influence:** This zone focuses on up-scaling and out-scaling of the service to take it to other relevant user agencies—in this case, institutions like the Ministry of Forests and Soil Conservation (MoFSC) and the Department of National Parks and Wildlife Conservation (DNPWC), as well as projects working on the relevant thematic area. Through this scaling approach, we aim to bring a regional dimension to the service so as to get the decision-makers of the HKH region to work on reducing forest degradation and climate change vulnerability in the region.

## **7.3 Service Implementation**

### ***7.3.1 Service Design and Development***

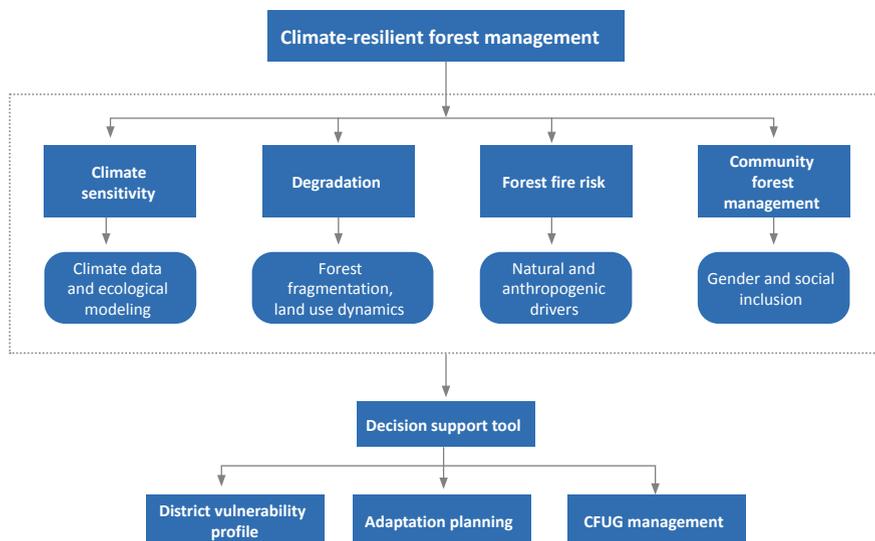
To ensure accurate incorporation of user needs, the service was co-designed through a series of user consultations and engagements at different levels. The service-planning process broadly involved three steps: needs assessment, service design, and service delivery. These steps also involved defining the objective and

scope of the service, identifying the data and analysis requirement, and defining the features of the application and the design of the system (for more details, see Chap. 2). We conducted a needs assessment workshop with different stakeholders in order to understand their needs in terms of the use of EO and GIT to enhance the decision-making process in natural resource management in Nepal; here, we found gaps in district-/divisional-level forest management, which could be addressed by adding scientific evidence and more useful information on climate change impacts.

This study broadly analyzed four components: climate sensitivity, forest degradation, forest-fire risk, and community forest management (Fig. 7.3). In the climate-sensitivity component, we quantified the impact of observed and predicted climate change on the functioning of the forest ecosystems. We assessed forest degradation by taking into account forest fragmentation and the spread of invasive plants. The forest-fire risk was assessed using more than six different variables responsible for the occurrence of forest fires. In the community forest management component, we explored the role of gender and social inclusion in the management practices of Nepal's CFUGs.

### 7.3.2 Climate Sensitivity and Degradation Analysis

To analyze climate sensitivity and forest degradation, we used satellite data from MODIS, Landsat Thematic Mapper/Enhanced Thematic Mapper, and the Shuttle



**Fig. 7.3** Framework of the CRFMS

Radar Topography Mission (SRTM). In this context, biophysical, climatic, ecological, and socioeconomic data were reviewed and analyzed. For biophysical analysis, we used MODIS-based products like Net Primary Productivity (NPP), Leaf Area Index (LAI), Evapotranspiration (ET), and Forest Fire (FF). As for climatic data, the annual mean temperature and the annual precipitation figures of both current and future periods (RCP 4.5 and RCP 8.5 for the year 2030) were gathered from bioclim datasets. Tree density and species richness were considered as ecological data. And to analyze forest degradation, the following elements were studied: forest fragmentation; distribution of invasive plants; and the demand–supply dynamics of fodder, fuelwood, NTFPs, and timber. The study was carried out in three districts of Nepal located at different altitudinal gradients: Rasuwa in the high-altitude; Lamjung in the mid-hills; and Kapilvastu in the plains.

### 7.3.2.1 Trend Analysis and Calculation of Climate Sensitivity

The biophysical and climatic data were initially masked by the classified forest cover of the year 2010, and the annual and seasonal linear trend analysis of each biophysical index (ET, LAI, and NPP) was carried out in the R software. Four seasons, namely pre-monsoon (March–May), monsoon (June–September), post-monsoon (October–November), and winter (December–February), were categorized, and the indices' trend was analyzed. Each index (NPP, ET, and LAI) was categorized into five classes using Jenks Natural Breaks in the ArcMap software and reclassified (one to five) at the pixel level. The Jenks Natural Breaks Classification (or Optimization) system is a data classification method designed to optimize the arrangement of a set of values into “natural” classes. A “natural class” is the most optimal class range found “naturally” in a dataset (Chen et al. 2013). The spatial layers of the reclassified indices were then overlaid, and composite values were calculated, through which climate-sensitivity layers were generated. For predicting future climate sensitivity, a model was developed using the R platform for each of the indices, and the spatial raster layers of LAI, ET, and NPP were generated for two climate change scenarios (RCP 4.5 and RCP 8.5) for the year 2030. Future climate sensitivity was calculated from the predicted biophysical indices produced from the developed model. The model was validated by predicting the LAI, ET, and NPP data for the years 2010, 2014, 2015, and 2018, and cross-checked with the MODIS product data for the years 2010, 2014, 2015, and 2018. Furthermore, based on the composite value, the climate-sensitivity classes were categorized into five levels—very low, low, moderate, high, and very high—using the Jenks Natural Breaks Classification system.

### **7.3.2.2 Assessment of Forest Degradation**

The spatial layer of forest degradation was generated based on the demand–supply dynamics of deforestation, fodder, NTFPs, fuelwood, forest fragmentation, and invasive plants distribution.

Ground- and satellite-based data were then used to generate geospatial layers on these parameters, and these were integrated to develop a forest-dependence layer depicting low-, medium-, and high-dependence classes.

The spatial layer for fuelwood supply was generated based on the above-ground biomass map of the landscape, whereas the fuelwood demand map was generated based on the actual fuelwood demand noted in the district forest management plans of the three districts. The data on the demand–supply of NTFPs were generated using the data obtained from the forest management plans of all the districts falling in the study area. The fodder demand map was generated based on the district-wise livestock information and the annual fodder demand for each livestock type; while the grazing supply map was generated based on a grassland map that was created using RS datasets. The spatial layer of deforestation was generated based on the forest dynamics from the years 2000–2010. The forest fragmentation layer was generated based on the land-use and land-cover map of 2010. The invasive plant distribution pattern was developed using the ground locations of 21 dominant invasive plants; this was done via Maxent modeling for the current scenario and for the future scenario of year 2030. All the layers from this climate sensitivity and degradation analysis were aggregated to generate the final layer of climate sensitivity and degradation, which was then divided into five classes to generate the overall layer of forest vulnerability using a classification matrix based on the Jenks Natural Breaks Classification system.

### **7.3.2.3 Assessing Forest-Fire Risk**

We assessed the forest-fire risk using various datasets involving natural and anthropogenic drivers, which was based on a study by Matin et al. (2017). The datasets included: forest type; the average land-surface temperature during the summer season; distance to roads and distance to settlements; altitude; and slope (More details on this can be found in Chap. 8).

### **7.3.2.4 Integrating Gender Analysis for Enhancing Forest Management at the Community Level**

As almost 35% of Nepal's population depend on forest resources for their livelihoods, our study attempted to understand and address the important issues related to gender and social inclusion. The study on gender and social inclusion was mainly focused on CFUGs in western Nepal; it was jointly conducted with a team from Hariyo Ban, a consortium of four agencies working in Nepal, viz. WWF, CARE,

FECOFUN, and NTNC. The study aimed to analyze how gender and social inclusion in community forest management vary across the geographical zones in Nepal. We thus hoped to gain important insights into the policy environment and the state of policy–practice interface regarding gender equality and social inclusion in the community forestry sector. Specifically, the study aimed to address the following two major domains by analyzing the secondary data/information at the national level; it also conducted a survey in three districts representing three different geographical terrains (mountain, mid-hill, and plains).

- (i) Understanding women’s voice and agency in CFUGs
- (ii) Allocation of community forest funds for rural development

We utilized the data from the Hariyo Ban I program, which was implemented in the Chitwan Annapurna Landscape and the Terai Arc Landscape during 2010–2015. Due to limited availability of data, only three districts were chosen for the gender analysis: Rasuwa (high altitude); Makwanpur (mid-hills), and Bara (plains). The data were collected in 2017–18 through a questionnaire survey—with 85 parameters—of all CFUGs in these three districts. However, as the data were missing in terms of a lot of parameters, our study focused on only those attributes that had relevance with the gender and social inclusion aspect.

### **7.3.3 Service Delivery**

#### **7.3.3.1 Enhancing the Decision-Making Capacity of Forest Managers in Nepal**

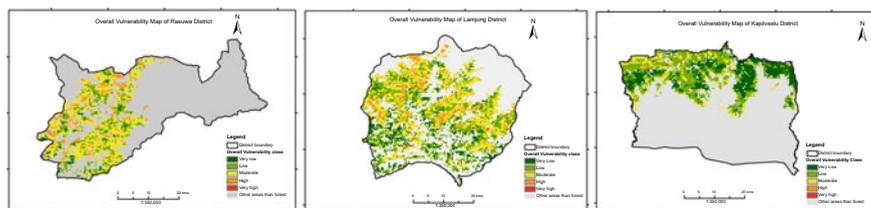
We jointly conducted the work in collaboration with the DoFSC with the aim of using science to improve the decision-making process. Regular user engagement was maintained with the DoFSC through frequent meetings and feedback sessions in order to keep the decision-makers updated on the progress of the work as well as on the results obtained during the analysis. The methodology was designed considering the applicability, usability, and scalability of the framework for other countries in the HKH region. The three priority districts were selected considering the differences in their climate, ecology, and socioeconomic conditions; this, we believed, would give us a fair idea about the varying impacts of climate change and about the anthropogenic drivers that trigger this change. The selection of these districts was made after discussions at a consultation workshop in Kathmandu with officers from the various forest divisions of Nepal. Keeping the aspect of usability in mind, we used publicly available datasets for most of the analyses, which comprised of MODIS and other satellite datasets.

The methodology framework of the study was presented to the decision-makers at multi-stakeholder platforms in order to take their feedback and revise the framework wherever needed. This multi-stakeholder forum involved officials from

the DoFSC, members of the NAPA team, those involved in the Adaptation for Smallholders in Hilly Areas (ASHA) project, and representatives from WWF, CARE, and FECOFUN. The initial rounds of presentation at this forum focused on finalizing the methodology and data, while later on, the results of the study were presented for validation by the stakeholders. The results highlight the overall vulnerability of the forest ecosystems to observed and predicted climate change and degradation due to the anthropogenic drivers in these three districts.

### Climate sensitivity, forest degradation, and forest-fire risk analysis

The feature of climate sensitivity was found to be the highest in Lamjung district, with more than 42% of the forest area falling under the high and very high climate-sensitivity indices. This sensitivity trend is predicted to intensify in the future, where 48% of the current forest area may fall under high and very high sensitivity indices (Fig. 7.4). Moreover, high-altitude ecosystems are predicted to experience more warming than the hills and the plains (Wester et al. 2019). In a 2015 study, Bhatta et al. had observed similar impacts on the forests in Dolakha district, situated in northern Nepal. Our results are in line with results from earlier studies where the forest ecosystems in the high-altitude areas of Nepal have been observed to depict a higher degree of climate change impacts than other physiographic regions in the country (Ebi et al. 2007; Chaudhary and Bawa 2011; Zomer et al. 2014; Chitale et al. 2014; Baral et al. 2018). In the study, out of the three districts, we found Rasuwa facing the highest forest degradation rate, with more than 32% of its forest area depicting high and very high degradation; this could be attributed to the remoteness of its landscape which hinders accessibility to traditional energy sources such as LPG. This might be putting pressure on the forest ecosystems, leading to the extraction of fuelwood. A similar trend was observed in Dolakha in a 2016 study by Kandel et al., while Reddy et al. in (2018) also observed similar trends in forest degradation. In our study, the district of Lamjung depicted 26% high and very high forest degradation areas. In the case of forest-fire risk, it was found to be the highest in Kapilvastu district, with above 52% of it in the categories of high and very high risk. This could be attributed to the plain terrain, dominant broadleaved vegetation, the proximity of agriculture lands, and the easier access to forest areas compared to the mid-hills and the high-altitude areas. So, the possibility is higher of anthropogenic drivers triggering forest fire.



**Fig. 7.4** Climate sensitivity of the forest ecosystems in the pilot districts (left to right) of Rasuwa, Lamjung, and Kapilvastu

### Gender and social inclusion analysis in the CFUGs

The CFUGs across Nepal may differ in their capacities, interests, and perceptions regarding community forestry (Pandit and Bevilacqua 2011), which might eventually affect the social and environmental outcomes of collective action. Therefore, we attempted to explore the contextual factors that motivate the resource users to participate in collective action. This information could then provide new and important insights into the working of the practitioners who are aiming to improve forest governance by mobilizing cooperation and participation in the management of forests. As per the guidelines for CFUGs, the representation of both women and men in the executive committees should be 50%, i.e., equal. However, our results from the three districts show varied trends of representation of women.

The representation of women in the executive committees of CFUGs in Bara (plains) and Makwanpur (mid-hills) was 47.64% and 46.30%, respectively (Fig. 7.5). This demonstrates that there is still a gap in terms of equal gender representation in the decision-making processes in these districts. However, in the case of Rasuwa (mountain), the percentage of women in CFUGs was 52.89%. The reasons for this could be attributed to higher rates of outmigration of men searching for better opportunity abroad or in the big towns of Nepal; secondly, Rasuwa district is mostly dominated by a homogenous ethnic group called Tamang, in which women have a greater voice in decision making (Acharya and Gentle 2006). As to how this disparity in the gender composition of CFUGs affects forest management practices is a matter for further studies.

### Representation of different ethnic groups

Income inequality and ethnic diversity are the two most widely studied heterogeneities that play a significant role in explaining the socioeconomic outcomes of

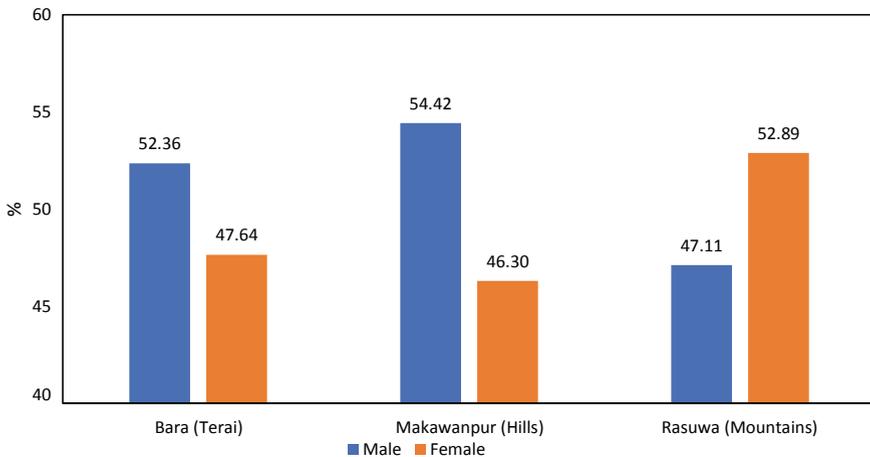
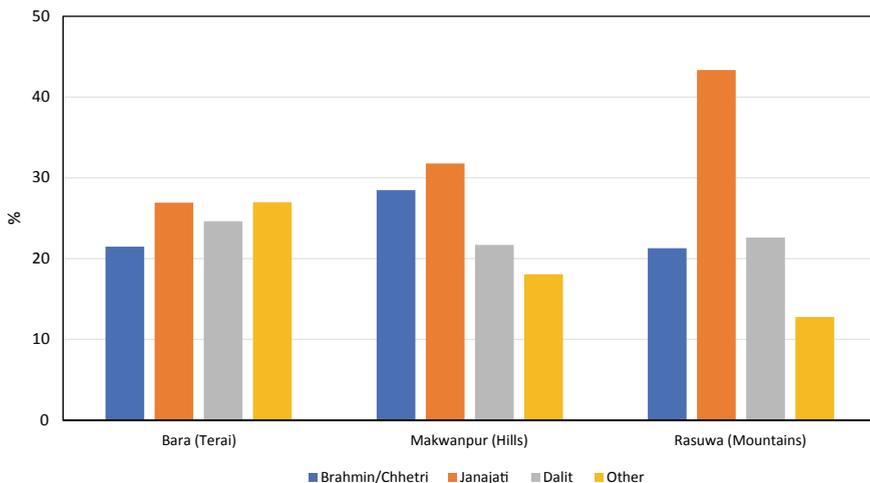


Fig. 7.5 Comparison of community forestry executive committees in terms of gender

collective action (Negi et al. 2018). These and other heterogeneities can shape differences across the users of CFUGs in terms of trust, social capital, and views on the usage and importance of forest, which compel differentiated needs in terms of sustainable collective management.

Since the ethnic composition in Nepal changes along the lines of physiography and accessibility, we expected different variations in composition in the three districts that lie in three different physiographic zones. While in the plains district of Bara, we found almost equal representation (Fig. 7.6)—20% each of Brahmins/Chhetris, Janajatis, Dalits, and Others—as we moved up from the Terai to high altitude, i.e., from Bara to Makwanpur to Rasuwa, we found an increasing representation of Janajatis and a decreasing number of Others.

However, we found a peculiar trend in increasing representation of Janajati and decreasing trend of representation of Other category as we move from Terai to high altitude, i.e., from Bara to Makwanpur to Rasuwa (Fig. 7.6). This highlights differences in the ethnic composition of CFUGs due to reasons linked to physiography. Here, it has to be mentioned that the success of a CFUG lies in being inclusive and accommodating a sufficient number of members from all ethnicities, all income groups, and all genders—such a CFUG is a good and transparent model of governance that provides voice to all different categories (Adhikari and Lovett 2006). Another study has highlighted the fact that generally, rich households prefer more valuable forest products such as timber, whereas the poor households prefer subsistence and commercial forest products as they have limited source of income (Paudel and Sah 2003). However, this is an area that needs further study, and so, through our collaboration with the Hariyo Ban II program, we hope to collect more data on the gender and social inclusion dimension as well as data on the forest management and forestry preferences of CFUGs.



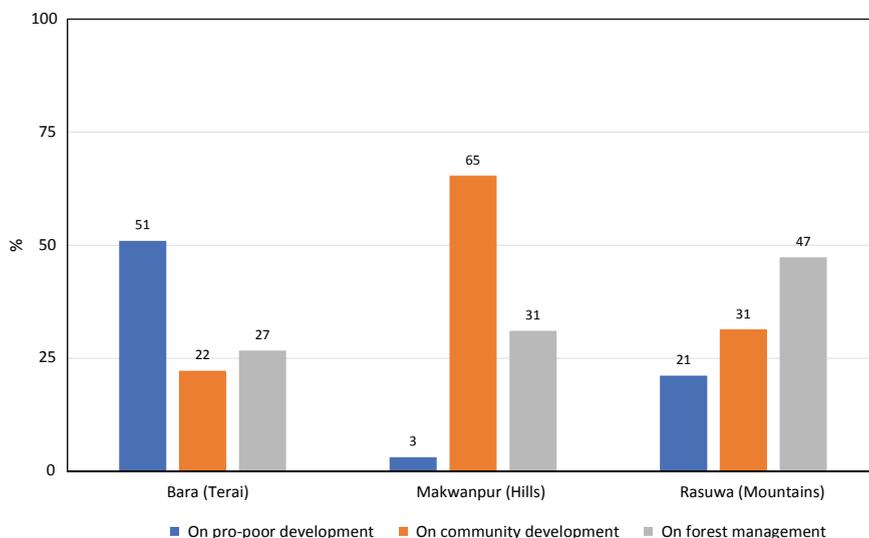
**Fig. 7.6** Comparison of community forestry executive committees in terms of ethnicity

### Allocation of community forest funds for rural development

Apart from protecting the forest, CFUGs have been mandated to collect revenue from the forest resources and invest in development activities (Angelsen et al. 2005). The sources of revenue for CFUGs are: trade in forest products; membership fee; penalty; and grants and donations from governmental and non-governmental organizations. It is estimated that the annual income of CFUGs in Nepal is more than USD 10 million, with most of it coming from the sale of forest produce, especially high-value items like timber and NTFPs (Pokharel 2010).

Figure 7.7 presents the allocation of funds among CFUGs in the three study districts and how they are spent in areas such as community and forest development, and in welfare measures for the poor.

Forest development activities include silvicultural operations, plantation, and NTFP promotion; community development funds are used for community development, road/foot trail construction, paying the salary of school teachers, building schools, providing drinking water, and securing health/sanitation. The pro-poor welfare measures mainly include income-generating activities. Figure 7.7 shows variation among the three districts in the allocation of funds for these activities. In the case of Rasuwa, more funds—as much as 48% of it—go into forest development activities, while the area of community development receives 31%. Makwanpur, on the other hand, accords high priority to community development, with the expenditure share of this sphere being 65%, followed by funds for forest development at 31%. In contrast, Bara CFUGs allocate more funds—51% of it—for welfare measures that address the needs of the poor; their second priority is forest development activities for which they spend around 27% of funds. All of this



**Fig. 7.7** Comparison of community forest fund allocation and expenditure

indicates that the revenue generated at CFUGs is mostly used for collective benefits rather than individual ones. The results presented in this chapter will be further explored in detail in our future work in the area of gender and social inclusion.

### **Integrated approach for enhancing the resilience of ecosystems**

Our results provide important information about the current trends in climate sensitivity and degradation as well as about the predicted impacts on the functioning of forest ecosystems; the results also shed light on the aspect of gender and social inclusion in CFUGs, which needs to be integrated into the planning and management contours of the forest ecosystems in Nepal.

Every five years, Nepal's divisional forest offices prepare and revise forest management and operational plans, which also have a section on climate change adaptation. The findings from our study will be included in this section wherein we will describe the current and predicted climate-sensitivity indices and the observed trends in forest degradation, along with the some six suitable adaptation measures that can be adopted. The framework of the International Union of Forest Research Organizations (IUFRO) on climate change adaptation suggests a list of 144 adaptation options for forest ecosystems across the world. Out of that, we have short-listed six adaptation options through consultations held in the three study districts; these could be suitable for building the resilience of forest ecosystems not only in these districts, but also for Nepal as a whole. The six options are: forest-fire regulation; grazing regulation; improving stock levels; introducing/enhancing agro-forestry; utilizing solar energy; and maintaining forest cover.

The results from our study have been compiled in a web-based decision-support tool (<http://geoapps.icimod.org/CRFMS/>) that provides user-friendly access to all information on climate sensitivity, degradation, and forest-fire risk from all 77 districts in Nepal. It is also compatible with Nepal's new federal structure, where the districts fall under seven provinces. The tool is open access and includes options to compare any two parameters for the same study area side by side, which should be useful for the decision-makers. The adaptation planning toolbox provides a list of suitable adaptation options that can be implemented to enhance the resilience of forest ecosystems. The decision-support tool also comprises of a module on forest management at the community forest level, which can support decision-makers at CFUGs to understand the trends and predicted scenarios of climate sensitivity, degradation, and forest-fire risk. It can also show them the current patterns of gender and social inclusion in the decision-making processes in the CFUGs. All such tools should further strengthen the capability of CFUGs in the planning and management of forest ecosystems.

## 7.4 Way Forward

Considering the observed trends and predicted climate change impacts and forest degradation in the countries of the HKH region, it is crucial to incorporate scientific analysis into the planning and management aspects of forest ecosystems. The CRFMS framework follows a “Science into Use” approach that can play an important role in enhancing forest management in these countries. The CRFMS framework is less data intensive, which makes it also suitable for extending its operations to countries outside the HKH region. Building the institutional capacity of user agencies, such as governmental ministries and departments and CFUGs, has been one of our priorities; we believe that partnerships and the active involvement of co-development and user agencies since the conceptual phase of the service is important to ensure a sense of ownership on the products by these agencies. We aim to scale out this framework to the whole of the HKH region, but do not want it to be restricted to this region alone—this framework can be easily implemented in any part of the world. With the advent of freely available satellite data and platforms like GEE, we can apply CRFMS to reduce both time and resources. Ultimately and looking into the future, it is the geospatial tools that are going to be the prime players in decision making, not only in the HKH but also globally.

## References

- Acharya KP, Dangi RB, Acharya M (2011) Understanding forest degradation in Nepal. *Unasylva* 62(2):238
- Acharya K, Gentle P (2006) Improving the effectiveness of collective action: sharing experiences from community forestry in Nepal. CAPRI Working Paper No. 54
- Adhikari B, Lovett JC (2006) Transaction costs and community-based natural resource management in Nepal. *J Environ Manage* 78(1):5–15
- Agarwal B (2010) The impact of women in Nepal’s community forestry management. *Sustain Mt Dev* 57:26–29
- Angelsen A, Berguers P, Belcher B, Nasi R (2005) Livelihoods, forests, and conservation in developing countries: an overview. *World Dev* 33(9):1383–1402
- Baral P, Wen Y, Urriola N (2018) Forest cover changes and trajectories in a typical middle mountain watershed of western Nepal. *Land* 7(2):72
- Chaudhary P, Bawa KS (2011) Local perceptions of climate change validated by scientific evidence in the Himalayas. *Biol Let* 7(5):767–770
- Chaudhary RP, Uprety Y, Rimal SK (2016) Deforestation in Nepal: causes, consequences, and responses. In: Shroder JF, Sivanpillai R (eds) *Biological and environmental hazards, risks, and disasters*, pp 335–372. Elsevier
- Chen J, Yang S, Li H, Zhang B, Lv J (2013) Research on geographical environment unit division based on the method of natural breaks (Jenks). *Int Arch Photogramm Remote Sens Spat Inf Sci* 3:47–50
- Chitale VS, Shrestha HL, Agrawal NK, Choudhury D, Gilani H, Dhonju HK, Murthy MSR (2014) Forest climate change vulnerability and adaptation assessment in Himalayas. *Int Arch Photogrammetry, Remote Sens Spatial Inf Sci* 8

- Cox M, Arnold G, Tomás SV (2010) A review of design principles for community-based natural resource management. *Ecol Soc* 15(4)
- DFRS (2015) State of Nepal's forests. Forest Resource Assessment (FRA) Nepal, Department of Forest Research and Survey (DFRS). Kathmandu, Nepal
- Dahal GR, Pokharel BK, Pokhrel PR (2017) Why does tenure security Matter in community forestry? A critical reflection from Nepal. *J For Livelihood* 15(1):15–26
- DoF (2018) Database on community forests in Nepal. Department of Forests, Ministry of Forests and Soil Conservation, Kathmandu, Nepal
- Ebi KL, Woodruff R, von Hildebrand A, Corvalan C (2007) Climate change-related health impacts in the Hindu Kush-Himalayas. *Eco Health* 4(3):264–270
- FAO (2018) The state of the world's forests 2018—forest pathways to sustainable development. Rome, Licence: CC BY-NC-SA 3.0 IGO
- GoN (2014) Community forestry program development guideline (Third Revision) 2014. Available online: [http://d2ouvy59p0dg6k.cloudfront.net/downloads/community\\_forest\\_development\\_directive\\_2.pdf](http://d2ouvy59p0dg6k.cloudfront.net/downloads/community_forest_development_directive_2.pdf)
- Government of Nepal (GoN) (2010) National adaptation programme of action (NAPA) to climate change. Overmment of Nepal, Ministry of Environment, Singa Durbar, Kathmandu, Nepal
- Gurung J, Giri K, Setyowati AB, Lebow E (2011) Getting REDD right for women: an analysis of the barriers and opportunities for women's participation in the REDD + sector in Asia. USAID (United States Agency for International Development). [http://www.gender-climate.org/Content/Docs/Publications/Gender\\_REDD\\_Asia\\_Regional\\_Analysis.pdf](http://www.gender-climate.org/Content/Docs/Publications/Gender_REDD_Asia_Regional_Analysis.pdf). Accessed on 7 April 2020
- Keenan RJ, Reams GA, Achard F, de Freitas JV, Grainger A, Lindquist E (2015) Dynamics of global forest area: results from the FAO global forest resources assessment 2015. *For Ecol Manage* 352:9–20
- Khadka M, Karki S, Karky SK, Kotru R, Dargee BK (2014) Gender equality challenges to the REDD initiative in Nepal. *Mt Res Dev* 34(3):197–207. International Mountain Society: <https://doi.org/10.1659/MRD-JOURNAL-D-13-00081.1>. Accessed on 1 April 2020
- Kumar M, Singh H, Pandey R, Singh MP, Ravindranath NH, Kalra N (2019) Assessing vulnerability of forest ecosystem in the Indian Western Himalayan region using trends of net primary productivity. *Biodivers Conserv* 28(8–9):2163–2182
- Lamsal P, Kumar L, Atreya K, Pant KP (2017) Vulnerability and impacts of climate change on forest and freshwater wetland ecosystems in Nepal: a review. *Ambio* 46(8):915–930
- Lei G, Li A, Cao X, Zhao W, Bian J, Deng W, Koirala HL (2017) Land cover mapping and its spatial pattern analysis in Nepal. In: Land cover change and its eco-environmental responses in Nepal, pp 17–39. Springer, Singapore
- MEA (2005) Millennium ecosystem assessment. Ecosystems and human well-being: synthesis. Island Press, Washington, DC
- Ma M, Singh RB, Hietala R (2012) Human driving forces for ecosystem services in the Himalayan region. *Environ Econ* 3:53–57
- Matin MA, Chitale VS, Murthy MS, Uddin K, Bajracharya B, Pradhan S (2017) Understanding forest fire patterns and risk in Nepal using remote sensing, geographic information system and historical fire data. *Int J Wildland Fire* 26(4):276–286
- Millar CI, Stephenson NL, Stephens SL (2007) Climate change and forests of the future: managing in the face of uncertainty. *Ecol Appl* 17(8):2145–2151
- MoPE (2017) Vulnerability and risk assessment framework and indicators for national adaptation plan (NAP) formulation process in Nepal. Ministry of Population and Environment (MoPE), Kathmandu
- NBS (2002) Nepal biodiversity strategy. Ministry of Forests and Soil Conservation, Government of Nepal, Kathmandu, p 132
- Nandy S, Kushwaha SPS, Dadhwal VK (2011) Forest degradation assessment in the upper catchment of the river Tons using remote sensing and GIS. *Ecol Ind* 11(2):509–513
- Negi S, Pham TT, Karky B, Garcia C (2018) Role of community and user attributes in collective action: case study of community-based forest management in Nepal. *Forests* 9(3):136

- Pagdee A, Kim YS, Daugherty PJ (2006) What makes community forest management successful: a meta-study from community forests throughout the world. *Soc Nat Res* 19(1):33–52
- Pandit R, Bevilacqua E (2011) Forest users and environmental impacts of community forestry in the hills of Nepal. *Forest Policy Econ* 13(5):345–352
- Panta M, Kim K, Joshi C (2008) Temporal mapping of deforestation and forest degradation in Nepal: applications to forest conservation. *For Ecol Manage* 256(9):1587–1595
- Parnesan C, Burrows MT, Duarte CM, Poloczanska ES, Richardson AJ, Schoeman DS, Singer MC (2013) Beyond climate change attribution in conservation and ecological research. *Ecol Lett* 16:58–71
- Paudel S, Sah JP (2003) Physiochemical characteristics of soil in tropical sal (*Shorea robusta* Gaertn.) forests in eastern Nepal. *Himalayan J Sci* 1(2):107–110
- Pokharel RK (2010) Generating income from Nepal's community forestry: does timber matter? *J Forest Livelihood* 9(1)
- Reddy CS, Pasha SV, Satish KV, Saranya KR, Jha CS, Murthy YK. (2018) Quantifying nationwide land cover and historical changes in forests of Nepal (1930–2014): Implications on forest fragmentation. *Biodivers Conserv* 1;27(1):91–107
- Saxon E, Baker B, Hargrove W, Hoffman F, Zganjar C (2005) Mapping environments at risk under different global climate change scenarios. *Ecol Lett* 8:53–60
- Sharma E, Molden D, Rahman A, Khatiwada YR, Zhang L, Singh SP, ... Wester P (2019) Introduction to the hindu kush himalaya assessment. In: *The Hindu Kush Himalaya assessment*, pp 1–16. Springer, Cham
- Stern NH, Siobhan P, Vicki B, Alex B, Catherine C, Sebastian C, Diane C et al (2006) *Review: the economics of climate change*, vol 30. Cambridge University Press, Cambridge
- Thapa GJ, Wikramanayake E, Jnawali SR, Oglethorpe J, Adhikari R (2016) Assessing climate change impacts on forest ecosystems for landscape-scale spatial planning in Nepal. *Curr Sci* 345–352
- The Economic Intelligence Unit Limited, ActionAid and Australia Aid (2014) *The South Asia women's resilience index: examining the role of women in preparing for and recovering from disasters*. <https://www.gdonline.org/resources/The%20South%20Asia%20Women%27s%20Resilience%20Index%20Dec8.pdf>. Accessed on 1 April 2020
- Wester P, Mishra A, Mukherji A, Shrestha AB (2019) *The Hindu Kush Himalaya assessment: mountains, climate change, sustainability and people*, p 627. Springer Nature
- Zomer RJ, Trabucco A, Metzger MJ, Wang M, Oli KP, Xu J (2014) Projected climate change impacts on spatial distribution of bioclimatic zones and ecoregions within the Kailash Sacred Landscape of China, India, Nepal. *Climatic Change* 125(3–4):445–460

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