Compendium of Research

2076-2079

Gandaki Province Government
Ministry of Industry, Tourism, Forest and Environment
Forest Research and Training Centre
Pokhara, Nepal

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Foreword

Forest Research and Training Centre (FRTC), Pokhara, Gandaki Province, is a government organization under the Ministry of Industry, Tourism, Forest and Environment, responsible for conducting research in diverse aspects of forestry sector in the province. A research plays a pivotal role in enhancing our understanding of forest ecosystems, promoting sustainable forest management practices and maximizing the socio-economic benefits derived from the forest. The number of studies carried out till date placed in one platform, provide a comprehensive and invaluable resources for researchers, practitioners, policymakers, and stakeholders in the field of forestry. A research compendium helps in sharing valuable research findings with various audiences at large.

It is my great pleasure to introduce this research compendium featuring with synthesized and summarized content of various research endeavors made by FRTC. The compendium encompasses a diverse range of topics spanning from forest research need assessment, biodiversity conservation to mapping and modeling the highly valuable areas. Each research study included in this compendium reflects the expertise and dedication of the researchers, who have tirelessly pursued excellence in their respective fields. Their dedication to producing high-quality research outcomes is commendable, and their contributions have enriched our understanding of forest dynamics including forest-related industries, climate change impact, biodiversity and the socioeconomic dynamics inter wined with forestry sector.

I would like to extend my heartfelt appreciation to all the researchers, consultants, and support staffs who have contributed to the production of this compendium. Your dedication and hard work are invaluable.

I would also like to take this opportunity to express my sincere gratitude to the Gandaki Province Government, Ministry of Industry, Tourism, Forest and Environment, Forest Directorate, Divison Forest Offices (DFOs), Soil and Watershed Management Offices and all the concerned stakeholders for their valuable feedbacks and support at the field level to ensure the successful completion of the research studies.

I believe that this research compendium will serve as a valuable resource for policymakers, researchers, practitioners, and students alike. It may inspire further exploration, collaboration, and innovation in the field of forestry research.

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Acronyms and Abbreviation

ACAP	Annapurna Conservation Area Project
AFOLU	Agriculture, Forestry, and Other Land Use
AUC	Area Under Curve
CBS	Central Bureau of Statistics
CCSP	Concentric Circular Sample Plot
CFUGs	Community Forest User Groups
CHAL	Chitwan Annapurna Landscape
CO2	Carbondioxide
DBH	Diameter at Breast Height
DFO	District Forest Office
DHR	Dhorpatan Hunting Reserve
DNPWC	Department of National Parks and Wildlife Conservation
FGD	Focus Group Discussion
FINNIDA	Finnish International Development Agency
FRA	Forest Resource Assessment
FRTC	Forest Research and Training Centre
FY	Fiscal Year
GDP	Gross Domestic Product
GEE	Google Earth Engine
GESI	Gender Equality and Social Inclusion
GIS	Geographical Information System
GoN	Government of Nepal
GPS	Global Positioning System
GS	Growing Stock
GVA	Gross Value Added
HWC	Human Wildlife Conflict
IAPS	Invasive Alien Plant Species
ICS	Improved Cooking Stoves
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IVI	Importance Value Index

LCPV	Lake Cluster of Pokhara Valley
LULC	Land Use and Land Cover
MAPs	Medicinal and Aromatic Plants
MaxEnt	Maximum Entropy Modelling
MaxSSS	Maximum Sum of Sensitivity and Specificity
MCA	Manaslu Conservation Area
MFSC	Ministry of Forest and Soil Conservation
MoFE	Ministry of Forest and Environment
NFI	National level Forest Inventory
NGO	National Government Organization
NTFP	Non Timber Forest Products
PAPA	Provincial Adaptation Program of Action
PF	Protection Forest
PFPA	Panchase Forest Protection Area
PSPs	Permanent Sample Plots
PZP	Pachbhaiya Zoological Park
Q GIS	Quantum Global Information System
RBA	Relative Basal Area
RCP	Representatives Concentration Pathways
RD	Relative Density
RF	Relative Frequency
SNC	Second National Communication
SWOT	Strength Weakness Opportunity Threats
TNC	Third National Communication
USAID	United States Agency for International Development

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Preparation of Forest Resource Assessment design and model in Gandaki Province

Introduction

A number of Forest Resource Assessments (FRAs) have been conducted at national, regional, and community levels, each differing in purpose, scale, scope, design, and technology. The initial national-level Forest Inventory (NFI) took place in the 1960s (1963-1967) with support from the United States Agency for International Development (USAID). Subsequently, the second NFI occurred in the 1990s (1994-1998) with technical and financial assistance from the Finnish International Development Agency (FINNIDA). The third and most recent NFI was conducted in the 2000s (2010-2014), serving as a foundation for forthcoming national-level FRAs. However, the national-level FRA carried out by the FRA Nepal project during 2010-2014 does not provide the detailed information required by individual provinces with high accuracy. Therefore, it is essential to conduct province-level FRAs to obtain precise data on forest area, growing stock, biomass, carbon, and other variables within each province, enabling the development of sustainable forest management plans.

Despite the abundant forest resources in Gandaki Province, no forest resource assessment has been recently carried out on the available growing stock (GS) in the Province. To address this gap, it is crucial to establish an appropriate inventory technique, including sampling design and plot design, that ensures accurate and cost-effective province-level FRAs. This study aims to develop a forest resource inventory design and model specifically tailored for province-level FRAs in Gandaki Province. By doing so, it will contribute to improved understanding and management of the province's forest resources in a sustainable manner.

Objectives

- To discuss with the concerned stakeholders about the FRA and its importance in forestry sector management and further development
- To develop forest inventory sampling and plot design appropriate for province- level FRA
- To determine variables needed for province-level FRA

Methodology

The FRA design and model for Gandaki Province were developed based on the previous model used for the National-Level FRA. To collect the necessary data, a comprehensive approach was adopted, including literature review, stakeholder consultations, land cover mapping, and forest

resource inventory. For the sampling design, a two-phased method was employed to focus field measurements on forested clusters and minimize the need for extensive travel to non-forested areas. To ensure accuracy in assessing various biophysical forest parameters, a 10% margin of error at a 95% confidence level was set for stem volume estimation.

Regarding the sample plot design, the number of sample plots to be measured in the field was determined based on second phase sampling, accessibility, and reachability of the plots. The concentric circular sample plots utilized by the FRA Nepal Project were recommended for field measurements. In the field, general information about each plot, such as physiographic zone, district name, cluster code, plot longitude, plot latitude, plot number, and fixed point details, was recorded after establishing the plot center.

Results

Land Cover Map: The land cover map of the Gandaki Province was developed on the Google Earth Engine Platform. That map represents six land cover classes of Gandaki Province as shown in figure below.

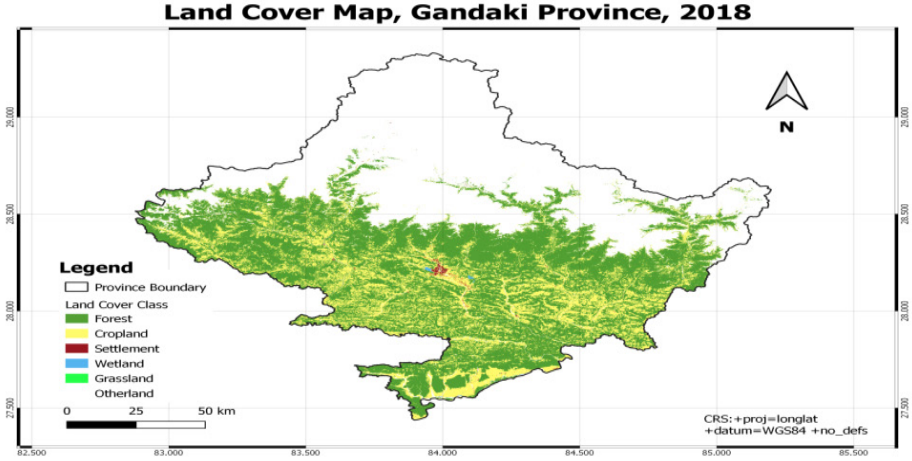

Figure: *Land Cover Map of Gandaki Province*

Land Cover Class: After the classification, the land cover map was extracted from the Google Earth Engine platform, and the area for each class was calculated. The areas occupied by the six land cover classes are presented in Table. The total area covered by all the six land uses was found to be approximately 9.000 sq. km. The forest land accounted for 39.28 % (8,62,717 ha) followed by crop land at 18.28% (4,01,319.90 ha), settlements at approximately 0.2% (4055.89 ha), and wetland 0.1% (2,107.50 ha). The grassland covered almost 0.00013% (3.06 ha), with the remaining area occupied by the other land at 42.15% (9,25,676.65 ha).

Forest Resource Assessment Sampling Design and Model:

Altogether, 5,429 clusters were identified in the Imagery. Each cluster

consisted of four sub-plots, resulting in a total of 21,716 plots were identified by cluster ID, longitude, latitude and plot number within the Gandaki Province.

Table: *Forest plot information within clusters*

S.N.	No. of plots within a cluster	No. of clusters
1.	At least one forest plot	3,340
2.	At least two forest plot	2,712
3.	At least three forest plot	1,755

In the national-level FRA, 4 ×4 km grid sampling captured all the forest diversities in national level, which is not suitable for province-level. So, in the first phase, we developed a 2 × 2 km grid for sampling to capture the forest diversities within Gandaki province, which includes forest area from Terai to High Mountain. For the second phase sampling, the number of clusters for field measurement would be selected based on the available resources of Gandaki province to maintain required accuracy level.

Conclusion

Province level FRA design and model are useful for other provinces as well and will become a part of National-level FRA in future. The two phased stratified systematic cluster sampling design has proven to be more effective for FRA sample design, where the first phase sampling is derived from 2 x 2 km grid, and second phase sampling is derived by fixing the forest strata from first phase sampling. CCSPs is the most suitable method for field measurements within the selected second-phase sampling plots.

Recommendation

- FRA needs to be carried out at least every five to ten years, depending on the availability of financial resource, human resource and time,
- A two-phase systematic sampling approach with forest clusters spaced at 2 km × 2 km, and 4 plots at a spacing of 300m is recommended for province-level FRA in the future.
- FRA field measurement need to be based on the selection of clusters and the percent of standard error must be maintained at 95% confidence level.

Forest Research Need Assessment in Gandaki Province

Introduction

Forest area covers about 37.1% of the total land area in Gandaki Province making it an integral component of the local livelihoods and a potential contributor to the sustainable development at both the provincial and local levels. Effective management of forestry resources requires careful consideration from economic and environmental perspectives. Even a minor misstep in decision-making regarding forest management can result in irreversible and widespread environmental loss and degradation. Therefore, research in forestry sector is essential to strengthen the decision making system in forest resource management at both the national and local levels. The outcomes of forest research benefit a wide range of stakeholders and provide valuable guidance for planning various facets of development, including environmental protection and socio-economic progress. However, due to the recent administrative restructuring in the country, there is a lack of province-level disaggregated data. Therefore this project aims to conduct forest research need assessment of Gandaki Province outlining the future forestry research priorities in this province. The research need assessment is vital to identify and comprehend the diverse data needs of key forestry organizations/stakeholders for planning and implementing effective forest management activities in the province.

Objectives

- To identify the gaps and map the research need assessment in forestry related thematic areas for planning and implementing forestry projects at Gandaki province
- To share the gaps in forest research and recommend appropriate mechanism for planning and effective implementation

Methodology

This report identifies the institutions working in forestry sector and categorized them into three different groups based on their work i.e. Advocacy group, Forest technicians and policy makers and Forest user committee and their respective working area. Field observation, focus group discussion, key informant interview, expert interview and informal discussion were conducted for exploring the perception of resource management. A checklist was developed for key informant interview and informal discussion with local people in the study area. SWOT analysis, district level data need assessment and district level workshop is done to identify the research need assessment in four key thematic working areas of research these stakeholder. The relevant published and unpublished documents, books and journal were also reviewed as a secondary source of information for this report.

Results

This report highlights the key thematic areas of biodiversity and wildlife conservation, forest governance, eco-tourism, and scientific forest management as the main focus for stakeholders. While satisfactory work has been carried out by each stakeholder in their respective fields, there are still overlooked opportunities for socio-economic development in Gandaki Province. Despite the identification of high-value non-timber forest products (NTFPs) such as Seabuckthorn (Hippophae rhamnoides), Jatamansi (Nardostachys grandiflora), Allo (Girardinia diversifolia), Lokta (Daphne papyracea), Satuwa (Paris pariphylla), Dalchini (Cinnamomum tamala), Lichens , and Dhupi (Juniperus indica) in various regions of Gandaki Province, there is insufficient research on the feasibility of NTFP farming, commercialization through promotion, processing, value addition, and market strategy specific to Gandaki Province.

Furthermore, this study reveals a focus on mega wildlife species in wildlife research, neglecting important small wildlife species. Additionally, the long-term impact of climate change on biodiversity, water resources, and human health has not been adequately studied. Gender and social inclusion issues in forestry have also received limited attention from stakeholders. Consequently, future research efforts should emphasize the potential of NTFPs, integrated research on climate change, and small wildlife species in Gandaki Province. It is recommended to develop a specialized Gender Equality and Social Inclusion (GESI) strategy at the provincial level, which can also serve as a model for national-level implementation.

Conclusion

Gandaki Province has a diverse range of natural resources. The study emphasized the importance of implementing management plans in four key thematic areas for effective resource management and utilization: Biodiversity and Wildlife Conservation, Forest Governance, Eco-tourism, and Scientific Forest Management. Future research efforts should primarily focus on developing management plans for specific species. Despite the considerable potential of non-timber forest products (NTFPs) to enhance livelihoods and foster economic growth in Gandaki Province, their significance is often overlooked. Therefore, it is crucial to establish enterprises based on NTFPs to promote their marketing. Providing training to local farmers on value addition techniques and commercial farming is essential in this regard.

Preparation of Model and design of land use and land cover change assessment in Gandaki Pradesh

Introduction

Land cover is commonly known as coverage on the ground surface like forests, agriculture, settlements, urban infrastructures, water, grass, bare soils, rocks, snow or other. Land use and land cover (LULC) change assessment is an essential task for informing decision making in major sectors such as land use allocation, forest area management, food production, hydrological modeling and other natural resource management for a particular country. LULC change assessment documents provide information on the existing LULC condition along with its past situations. It also provides the trend of conversion from one LULC class to another class that help support the management team in shaping the conversion of LULC in a planned way. Gandaki province is one of the seven provinces and it does not have document related to land use and land cover change assessment yet. Therefore, this study aims to fill this gap by preparing a comprehensive document that presents the current situation of LULC and its situation a decade ago. It will be a milestone in coming year for further planning on proper use of such LULC. The result of this project can be a huge asset for the future endeavors carried out within the Province.

Objectives

- To conduct a robust discussion with the concerned ministries and relevant stakeholders about the need of land use and land cover analysis and its importance in overall development.
- To develop a concept for undertaking integrated spatial land use and land cover map for sustainable development of Gandaki Province.
- To help decision makers for adopting appropriate land use policy.

Methodology

All the relevant literatures such as National Land Use Policy (2015), previous forest resource assessment reports, Land Act etc, published and unpublished government reports were consulted. Consultation with all the relevant stakeholders such as Division Forest Offices, NGOs and other relevant were done. Appropriate scripts were developed in GEE for preparing LULC map, analyzing and classifying the image. Accuracy assessment were performed to ensure the data quality keeping in mind the limitation of the input data.

Results

1. Visual interpretation

Upon conducting visual interpretation, the analysis revealed that out of the sample points examined, 3,765 were identified as cropland, 8,761 as forest, 235 as grassland, 8,643 as other land, 190 as settlement, and only 122 as wetland. The distribution of these categories is presented in Table 1.

Table 1: *Categories of Visually Interpreted points of 2018*

S. N.	IPCC Classes	No of VI Points
1	Cropland	3,765
2	Forest	8,761
3	Grassland	235
4	Other Land	8,643
5	Settlement	190
6	Wet Land	122
	Grand Total	**21,716**

2. Land Cover Map

The classification was done in GEE platform using the Random Forest classifier employing systematic training sample collected through visual interpretation. Land Cover map of 2018 from Landsat 8 and 2008 from Landsat 7 were prepared. Both maps were classified into the same as defined by IPC; namely, Forest, Cropland, Settlement, Wetland, Grassland and Other land. The calculated areas for each land cover class in 2018 and 2008 are presented in Table 2 and Table 3, respectively.

Table 2: *Land Cover wise area in 2018*

S. N.	Land Cover	Area (ha)	Percentage
1.	Cropland	401319.90	18.28
2.	Forest	862717.00	39.29
3.	Grassland	3.06	0.00013
4.	Other Land	925676.65	42.15
5.	Settlement	4055.89	0.18
6.	Wet Land	2107.50	0.096
	Total	**21,95,880.00**	**100%**

Table 3: *Land Cover wise area in 2008*

S. N.	Land Cover	Area (ha)	Percentage
1.	Cropland	431617.97	19.66
2.	Forest	840839.22	38.29
3.	Grassland	2413.09	0.11
4.	Other Land	916834.62	41.75
5.	Settlement	1282.96	0.06
6.	Wet Land	2892.14	0.13
	Total	**21,95,880.00**	**100%**

3. Accuracy assessment

Table 4: *Accuracy Assessment of Classification for 2018*

	Forest Land	Crop Land	Settlement	Wetland	Grassland	Other Land	Total	User's Accuracy	Error of Commission
Forest land	2268	156	2	0	0	197	2623	86.47 %	13.53 %
Crop land	84	929	5	1	0	105	1124	82.65 %	17.35 %
Settlement	1	46	4	0	0	6	57	7.02 %	92.98 %
Wet land	3	11	1	3	0	18	36	16.67 %	83.33 %
Grassland	16	9	0	0	0	44	69	0 %	100 %
Other Land	115	129	0	1	0	2206	2451	90.00 %	10 %
Total	2487	1280	12	5	0	2576	6360		
Producer's Accuracy	91.19 %	72.58 %	33.33 %	60.0%	0.0 %	85.64%			
Error of Omission	8.81 %	27.42 %	66.67 %	40.0 %	100 %	14.36%			
Overall Accuracy	**85.06%**								

Table 5: *Accuracy Assessment of Classification for 2008*

	Forest Land	Crop Land	Settlement	Wetland	Grass and	Other Land	Total	User's Accuracy	Error of Commission
Forest land	2178	257	0	1	1	186	2623	83.03%	16.97%
Crop land	200	815	1	2	1	105	1124	72.51%	27.49%
Settlement	3	27	24	0	0	3	57	42.11%	57.89%
Wet land	2	11	0	4	0	19	36	21.05 %	78.95 %
Grassland	15	13	0	0	0	41	69	0.00 %	100 %
Other Land	114	149	0	1	3	2184	2451	89.11 %	10.89 %
Total	2512	1272	25	8	5	2538	6360		
Producer's Accuracy	86.70%	64.07%	96.00%	50.00%	0.00%	86.05%			
Error of Omission	13.30%	35.93%	4.00%	50.00%	100 %	13.95%			
Overall Accuracy	1.83 **%**								

4. Land Cover Change

Table 6: *Change in Land Cover area.*

S. N.	Land Cover class	Area (ha) in 2008	Area (ha) in 20018	Change in Area
1.	Cropland	431617.97	401319.90	(-)30298.07
2.	Forest	840839.22	862717.00	(+)21877.78
3.	Grassland	2413.09	3.06	(-)2410.03
4.	Other Land	916834.62	925676.65	(+)8842.03
5.	Settlement	1282.96	4055.89	(+)2772.93
6.	Wet Land	2892.14	2107.50	(-)784.64

Conclusion

Land cover assessment informs land characteristics, aids policy decisions, and identifies suitable afforestation/plantation areas. With technology evolution, periodic updates are crucial for robust and comprehensive assessment. Higher resolution satellite imageries must be used for accuracy, conduct extensive field visits for higher training sample collection.

An Assessment of the Contribution of Forest Sector to the GDP of Gandaki Province, Nepal for FY 2017/18

Introduction

Over the past millennia, forests have played a significant role in local and national economies, as well as global development. The importance of properly recognizing the role of forests in sustainable development, green economy, and poverty eradication could not be overstated. However, the prevailing perspective on forests, influenced by colonial-era ideologies, often views them solely as resources to exploit for immediate financial gain. This was more evident in the Himalayan mountains during the 60s and 70s, where poverty, underdevelopment, and political unrest led to rapid exploitation of common pool resources and land degradation, resulting in devastating floods in nearby plains. Private and Farm Forestry were also promoted for improved agriculture production, food security, local environment conservation and to meet the raw material demand of local industries locally. While it is widely reported that forest cover in Nepal, especially in the middle mountains, has increased since the 1990s nationwide forest inventory, its contribution to the national economy remains a subject of debate. Institutional studies indicate that the forest sector's contribution to GDP has grown alongside improved forest conditions, but official government estimates suggest a declining contribution of the primary sector (agriculture, forestry, and fishery) to the national economy, with the secondary (manufacturing) and tertiary (services) sectors expanding. With recently established federal structure in the country, no attempt has been made to quantify the GVA in the forest sector in the newly established Provinces, assess its contribution to the Provincial GDP and validate the findings against recent national-level estimates.

Objectives

- To quantify the economic contribution of the forest sector to the GDP of Gandaki Province in terms of the total GVA in forestry and logging sector in the Province in the FY 2017/18.

Methodology

Field level data on type and quantity of timber and NTFP products traded were collected for the study. The field data were supplemented with secondary data gathered from various sources including DFO reports, DoF records and various periodic publications from MoFE, CBS, and other government agencies. The private sector (collectors, local traders, processors, exporters) was consulted to get the market price of various timber (Roundwood) and NTFP (wood fuel, MAPs, fodder, etc.) products for the base year 2017/18. The data was then sieved, sorted and analyzed in MS Excel to get revenue from timber and NTFP sub-sectors by each District/Protected Area, which were then added together to get the GVA in forestry and logging sector in each District/Protected Area. The data from individual District/Protected Area was then totaled to get the total GVA in forestry and logging in Gandaki Province. Unfortunately, due to limited data availability, the GVA calculation

could not include the wood manufacturing and pulp and paper sectors in Gandaki Province.

Results

In the fiscal year 2017/18, Roundwood emerged as the primary traded timber product in Gandaki Province. It was sourced from various entities such as the Divisional Forest Office, the District Forest Product Supply Committee, Private and Farm Forests, and Community Forest User Groups. The quantity of Roundwood removal varied significantly, ranging from 0 cubic feet in Mustang District to over 900,000 cubic feet in Nawalpur District. With a revenue exceeding NPR 4.15 billion or 78% of the total, Roundwood made the most substantial contribution to the provincial GDP. Within the non-timber forest products (NTFP) category, Medicinal and Aromatic Plants (MAPs) played a dominant role in the forestry and logging sector of Gandaki Province. During the FY 2017/18, MAPs generated revenue of NPR 921 million. Notably, Baglung District and the Annapurna Conservation Area were responsible for more than 94% of the total revenue generated by the NTFP subsector in Gandaki Province. Fuelwood extraction and sale in the province reached 3.95 million cubic feet, generating over NPR 20 million and contributing approximately 4% to the provincial GDP. Fodder and leaf litter collectively contributed around 0.5% to the GVA in forestry and logging in the province, owing to their extensive use in the agriculture and livestock sectors. The revenue obtained by Community Forest User Groups from the sale of oleoresin (khoto) amounted to nearly one million NPR, corresponding to approximately 0.02% of the Provincial GDP.

Conclusion

It is estimated that the GVA in forestry and logging in Gandaki Province accounts for about 1.95% of the GDP of Gandaki Province (0.21% of the national GDP). The sectoral share in the Provincial GDP is below the national estimates made in the past year. Previous estimates in the national context have reported that the forestry sector contributes as much as 9.45% to the national GDP. However, recent statistics indicates a decline in the primary sector's contribution to the national GDP, suggesting the forestry sector's contribution in this study could align with the national estimates. The current GDP estimate undervalues the forestry sector's contribution due to the exclusion of wood processing, manufacturing, and pulp and paper components. If all cash and environmental benefits from the forest were considered, the forest sector GDP would be much higher. Although the forestry sector in Gandaki Province has untapped potential, it is not the sole determinant of long-term economic development. Further investments and research are needed to maximize its output and income. The study emphasized the importance of quantifying both direct economic benefits and non-cash benefits generated by forests, such as non-wood forest products, biodiversity conservation, and ecosystem services. More data collection and collaboration across agencies are necessary to improve research and inform forestry policies. The NTFP sub-sector, in particular, requires attention and research to enhance its contribution to local livelihoods and the overall economy.

Assessment of Impact of Climate Change on Biodiversity of Gandaki Province, Nepal

Introduction

Climate change is a challenging issue for biodiversity conservation. The habitats of wildlife will likely to be reduced and shifted due to climate change and land use change in the future. Forest and freshwater wetland ecosystems of Nepal are vulnerable to climate change. Majority of Nepalese people are experiencing drought due to climate change. Conservationists need to know the impact of climate change on biodiversity to prepare strategies to conserve it effectively. Conservation of mountain biodiversity in the Himalayas is becoming more challenging due to its vulnerability to climate change. Conservationists do not know how future climate change will affect the distribution of threatened wildlife, high-value NTFP, and major timber and fuelwood species. This knowledge gaps hinder their capacity to preserve biodiversity within the region.

Objectives

- To predict the potential impacts of future climate change on threatened wildlife of the Gandaki Province
- To predict the potential impacts of future climate change on high-value NTFP of the Gandaki Province
- To predict the potential impacts of future climate change on major timber and fuel wood species of the Gandaki Province

Methodology

The study collected secondary occurrence data of nine species from published and unpublished reports, as well as government reports from 2010 to 2019, using GPS receivers. Primary occurrence data was collected through field surveys conducted between February and June 2019 in all 11 districts of the province by recording direct and indirect signs of species, such as droppings, using GPS. A total of 724 presence points were collected and used for the study. Environmental variables were downloaded from freely available sources, such as the WorldClim database, and processed in ArcGIS to create appropriate formats, same spatial resolution (1 km), and equal geographical extent. Nineteen bio-climatic variables and topographical variables, such as elevation, slope, and aspect, were used for the habitat modeling of the species. The study carefully collected data using different assumptions for different species, such as collecting points only if groups of trees (n>100) were recorded for Schima wallichi and only if patches of A. nepalensis trees (n>500) were found for Alnus nepalensis.

The Maxent model was used to project the future distribution of species under climate change based on current species-environment relationships.

Topographical variables and current bio-climatic variables were used, while vegetation-related and other anthropogenic variables were avoided due to the unavailability of future projections for them. RCP 4.5 of 2070 and MIROC5 GCM were used for future predictions. One occurrence point was used from each pixel of environmental variables to reduce spatial autocorrelation. The MaxSSS threshold was used to produce the distribution map of the nine species in Gandaki Province. Species distribution models, such as BIOCLIM, BRT, DOMAIN, GARP, GLM, and MaxEnt, have been developed and used to predict the distribution of plants and animals, the risk of landslides, fires, accidents, and diseases. Similarly, accuracy assessment was carried out to assure the quality of data where 50% of species occurrence points were allocated for the training dataset, and the remaining 50% were used as a testing/validation dataset for all models.

Results

S.N	Species	Current Distributed Area (km2)	Change in distributed Area in 2070 (km2)	Result	Thresold use to convert continuous map to a binary map	AUC	TSS
Threatened Wildlife							
1	P. pardus	782.5	350.2	-	.331	.899	.673
2	M. chrysogaster	1205.92	518.57	-	.136	.984	.915
3	P. uncial	2591.66	622.43	-	.244	.909	.723
NTFP							
1	A.wallichii	4679.47	1003.81	-	.465	.861	.786
2	S. Chiraita	3848.71	2554.20	-	.477	.679	.531
3	D. bholua	5601.85	2207.87	-	.363	.772	.650
Major timber and Fuel wood							
1	S. wallichi	5663.26	327.42	-	.216	.885	.689
2	S. robusta	4208.83	212.12	-	.203	.902	.774
3	A, nepalensis	2951.93	284.18	-	.199	.934	.807

By 2070, climate change is expected to cause a significant reduction in the distribution of all nine species. Except for S. robusta and S. wallichi, distribution of all species will be shifted towards northern sides.

Conclusion

The study finds that climate change will have a significant impact on the distribution of threatened wildlife, valuable non-timber forest products (NTFP), as well as important timber and fuel wood species in this province

by 2070. Threatened fauna and high value NTFP are found to be less resilient to climate change compared to timber and fuel wood species. The study predicts a shift in species distribution towards the northern and southern areas of the province, leading to habitat reduction for certain species due to climate change. The study recommends modeling the current distribution of species to identify biodiversity hotspots throughout the province, identifying factors affecting the distribution of species, conserving the identified habitat of species, and preparing and implementing Provincial Adaptation Program of Action (PAPA) to mitigate the impact of climate change on biodiversity. Additionally, the study proposes further research on species resilience to climate change to incorporate ecosystem-based adaptation and landscape-level conservation into provincial planning. It emphasizes the importance of coordination among government agencies, local communities, academic institutions, and private sectors to effectively implement programs for climate change mitigation and adaptation.

Identification and Mapping the Pocket Areas of Medicinal Plants in Gandaki Province

Introduction

Gandaki Province is overwhelmed with the richness of medicinal plants due to the unique geographic position with altitudinal and climatic variations. Medicinal Plants are listed as an economic sector of five year periodic plans of Gandaki Province (PPPC Gandaki Province, 2020). The growing demand and acceptance of the utility of plant derived drugs globally has amplified the use of the medicinal plants with time. Despite their importance, medicinal plants sector are facing severe threats. The increasing human destructive exploitation activities and economic development have placed the rich medicinal flora under considerable conversion pressure. To conserve the medicinal plants, identification and mapping of pocket areas are crucial for monitoring and strategic management. Conservation strategies based on the geographic patterns of medicinal plant species richness, including recognition of meaningful floristic regions and priority areas for conservation could improve the effectiveness of policy and management of medicinal flora in this province.

Objectivess

- To identify the medicinal plants that are abundantly available and highly traded from the Gandaki Province.
- To identify the potential pocket areas of these medicinal plants in the study area.
- To analyze the current distribution and coverage of these medicinal plants in the study area.
- To map the pocket areas of these medicinal plants.

Methodology

This study was conducted in eleven district of the Gandaki Province. The potential habit and pocket areas of different species of Medicinal plants were identified in consultation with District Forest Offices, Forest Directorate and community forest user groups. Based on the information collected, field survey was carried out to assess the occurrence points of the Medicinal plants while other occurrence points were also compiled from secondary sources. A systematic sampling method was adopted where the vegetated area (forests, shrub lands and grasslands) were identified using land cover map. A grid of 10km×10km was prepared throughout the province and only grids with vegetation cover was identified through visual interpretation and expert consultation. A transect of 100 m length and 10m wide was employed for data collection in the identified grids.

In this study, two types of data were collected for modeling: one were the geographical location of the medicinal plant species to describe the distribution of the species and other was the climatic data of distribution

areas. The species, for mapping the pocket area were chosen based on their value, traditional use, trade amount, the possibility of farming and domestication as well as ease of cultivation. The Maximum Entropy (MaxEnt) model was used to predict the distribution of the species by using the occurrence points and environmental variables.

Results

- A total of 54 species were traded from this province in the last ten years. Among them, Tejapat *(Cinnamomum tamala)* was highly traded and Bhutkes *(Jurinea dolomiea Bioss.)* was least traded by volume.
- From this study, pocket areas of 15 species: Ban Lasun *(Allium wallichii)*, Bish *(Aconitum spicatum)*, Chiraito *(Swertia chiraita)*, Jatamasi *(Nardostachys grandiflora)*, Kurilo *(Asparagus officinalis)*, Kutki (*Neopicrorrhiza scrophulariflora)*, Lauth Salla *(Taxus wallichiana)*, Nirmansi *(Aconitum heterophylloides)*, Panchaule *(Dactylorhiza hatageria)*, Satuwa *(Paris pariphylla)*, Setakchini *(Moringa Oleifera)*, Siltimur *(Lindera neesiana)*, Tejpat *(Cinnamomum tamala)*, Timur *(Zanthoxylum piperitum)*, Yarshagumba *(Ophiocordyceps sinensis)* were identified and mapped.
- The largest suitable area (1057 km^2) was found for Kutki *(Neopicrorhiza scrophulariiflora)* while the smallest was found for Siltimur *(Lindera neesiana)*.
- Four Himali districts *(Myagdi, Mustang, Manang and Gorkha)* and one middle mountain district *(Baglung*) have maximum pocket areas of more than 300 km^2 .
- The largest area of species coverage was found in Gorkha district (1520 km^2).
- Jatamansi *(Nardostachys jatamansi),* Kutki *(Neopicrorhiza scrophulariiflora)*, Banlasun *(Allium wallichii)* and Panchaule *(Dactylorhiza hatagirea)* have maximum coverage areas with respect to species coverage.
- Among these species, pocket areas of the majority of the species were identified around the High Mountain regions of the Province.
- This study also identified the pocket areas of the most of the medicinal plants inside the Dhorpatan Hunting Reserve though almost half of the reserve falls in the province.

Conclusion

Important medicinal plants are present in the High mountain region of the Gandaki Province. The region can be considered as suitable habitats of medicinal plants and also serves as pocket areas. Based on the findings, this study recommends conserving and planting of these medicinal plants and their identified suitable habitats. It also suggests to create awareness to the collectors for sustainable harvesting, to establish the processing plants and to conduct researches to identify potential plantation sites for important medicinal plants.

Diet Analysis of the Wild Animals of Pachbhaiya Zoological Park

Introduction

The knowledge of diet and nutrition to captive animals can be used to refine captivemanagement techniques and may make a substantial influence on the survivorship of animals. The importance of captive animal dietary knowledge for their long-term conservation is highlighted by the fact that interpreting information received in the outdoors can be challenging and can benefit from reasoning with captive feeding studies. It has the ability to be refined and quantified by simplifying the identification of fragments or feeding remains and quantifying differential proportions of fragments as a result of digestion. Most herbivores in a zoo can be fed rather successfully on dry diets formulated for livestock, comprising agricultural grains and supplemental fresh or dried forages. But wildlife and zoo nutrition are naturally linked; therefore, the physiological and biochemical components must be considered as critical as ecological and behavioral considerations of the animals which are under our care. This research is not just vital for Pachbhaiya Zoological Park but it is also of national significance and plays a crucial role in park management, particularly for captive species.

Objectives

- To identify the preferred diet for captive wild animals
- To examine the optimal nutrient composition, quantity, and frequency (feeding interval) of food required for wild animals based on sex, age (infant/young/adult), and seasons
- To recommend the best alternative considering cost and diet analysis for the management of captive animal

Methodology

In this study both the diet provided to captive animals and excreta (fecal) after computation of the given diet was recorded for 41 days in three phases. Therefore, all the diets (composition and weight) provided for respective animals were recorded. The leftover from the given diet was recorded and the weight of excreta produce from the given food was recorded. Diet composition was recorded by ocular observation and confirming with park staff and the weight of food provided and excreta was recorded with the help of digital balance. Diurnal behavior of all available animals was recorded using focal scan sampling at an interval of 5 minutes. The behaviors were recorded in three shifts: morning, day, and evening. Feeding and related behaviors including as resting, sleeping, sitting, standing, walking, grooming, calling, and excretion were recorded. The study also carried a three-day community forest inventory. During the survey, 20m*20m quadrate was

plotted for tree species assessment, 5m*5m quadrate for shrubs analysis. A total of 20 random quadrates was plotted in park forest during for inventory. A sample of 50 gm food provided to respective animals was collected for 10 days in a plastic jar which was later covered by silica crystals and sealed for dehydration. Fodder provided was carefully observed for volume, weight, and species diversity, and 500gm (wet weight) of each were collected and kept for oven dry. The fecal samples depending on food provided were collected respectively. They were collected for 12 -41 days depending upon the weight of defecation by animals since a minimum of 300gm of wet weight is necessary for nutritional analysis. All fecal samples were collected in a plastic jar which was sealed using cotton and silica crystal to remove moisture. In this study, the collected samples were dried in a hot air oven at 36°C, then grinded and sieved through 1mm sieve size. Nutrients: crude protein, Crude fiber, Cellulose, Hemicellulose, Acid Detergent Lignin, Acid detergent fiber, Neutral Detergent Fiber, and Total energy from all collected samples were further analyzed in the laboratory of Nepal Agriculture Research Council.

Results

Animals in PZP are healthy; they have absorbed enough energy from their meals and are quite active in their behavior. Food is available seven days a week. Except for the Eurasian Eagle and the civet, the amount of meat supplied to carnivores is more than national/international standards. The amount of protein excreted by birds such as Barn Owls, black kites, and Egyptian Vultures is excessive. Except for Egyptian eagles, black kites, and leopard cats, carnivores prefer to feed at night or in the evening. The amount of choker is higher to herbivores than national and international practice, and fodder is insufficient, despite the fact that they leave a large amount of fodder every day. Pacing behavior is prevalent in felid species, indicating that space is insufficient and that they are still not accustomed to living in a cage.

Recommendation

i. The study suggests adjusting the schedule of food distribution.
ii. The study recommends reducing the amount of meat supplied to all carnivores except the civet.
iii. The study recommends providing food to carnivores only six days per week.
iv. A cage size is so small that it is impossible for animals to move freely within it, so we recommend to develop suitable size of the cage. It is also recommended that captive animals be vaccinated and get frequent medication in accordance with national and international standards.

Assessing the Status of Forest Regeneration under Silviculture System Based Forest Management" (A case study from Nawalpur district, Gandaki Province)

Introduction

Silviculture, the part of forest management that deals with the biology of tree growth, is the art and science of producing, tending, and manipulating forest stands. Silvicultural practices include regenerating the forest, maintaining tree growth, and harvesting trees to satisfy the landowner's objectives (Web and Gautam, 2001). The silvicultural system provides a framework for carrying out different silvicultural operations. The Government of Nepal began promoting Scientific Forest Management defining it as an application of appropriate silviculture system and forest management principles through design of systematic compartment of fixed rotation age. This follows primarily the shelter wood silviculture system with very high intensity logging , leaving only 15 to 30 mature mother tree per hectare. This system integrates specific harvesting, regeneration, and stand tending methods to achieve a predictable yield of benefits from the stand over time. From fiscal year 2073/74, Government of Nepal has started to manage the Dumkibash-Arunkhola block forest of Nawalpur District under Irregular Shelterwood System with the aim of conservation and sustainable production of forest product, better regeneration, and to achieve higher growth of forest through its proper management. Therefore, it is important to conduct detailed documentation, and analysis of vegetation of the area which will serve as temporal important source information to the forest department, researcher, and other concerned stakeholders.

Objectives

- To analyze the plant community structure and distribution pattern
- To assess the species diversity and density of regeneration.

Methodology

Shape and size of sample plot

Systematic random sampling methods was used to determine the placement of plots. A grid with points at the center of each cell over the entire study area was created using the Fishnet tool available in (ArcGIS 10.6, Esri). Rectangular plots with 500 m^2 were laid for the tree and vegetation study and several sub plots were established within each plot for specific purposes: 100 m^2 for pole, 25 m^2 for sapling and 1 m^2 was established for counting regeneration. After uploading the plot coordinates into the Global Positioning System (GPS) device, sample plots were navigated in the field using GPS devices.

Measurement of seedlings

Seedling consist of those plants that have the height less than 1.3 m. Data of seedling were collected from four plots of size 1m^2 laid on four cardinal directions of 100 m^2 plots (Plot size for pole). All seedling within that plots were counted and recorded on data collection sheet.

Measurement of the sapling

Saplings are considered those with a height greater than 1.3 meter and DBH less than 10 cm. They were counted in the plot within 5.64 m radius, and the heights and DBH of saplings were measured using Abney's Level and or Vernier caliper. The first sapling was measured to the North from the center of plot and gradually other saplings were recorded in clockwise direction. The diameter of each saplings were measured precisely at 1.3 m (at breast height) from ground level and recorded in the field data sheet.

Measurement of trees and Poles

All the trees having the diameter at breast height equal or greater than 30 cm are considered as trees. The trees were counted and measured within the plot of 500 square meters with radius of 12.62 meters. The heights and DBH of saplings were measured using Abney's Level and Diameter Tape. Additionally, Poles, categorized as a young tree, with DBH between 10-29.9 cm, were also measured.

In both managed and control area, the plant community structure were studied. For each species, the basal area, density and frequency were calculated to determine the Importance Value Index (IVI).

Basal area: Basal area refers to the ground penetrated by the stems. It is one of the characters that determine the dominance. Basal area of a species in each sampling plot was obtained by the summation of Basal area of all individuals of a species.

Basal Area (m^2) = $\frac{\pi(DBH)^2}{4}$

Likewise, species in all the sampled plots were ranked according to the importance value index (IVI) which is a statistical quantity that gives the overall picture of the importance of the species in the vegetative community. It was obtained by the summation of relative density (RD), relative frequency (RF) and relative basal area (RBA).

$$Relative\ Density = \frac{Density\ of\ the\ species}{Total\ density\ of\ all\ speceis} \times 100$$

$$Relative\ Frequency = \frac{Frequency\ of\ occurence\ of\ the\ species}{Total\ frequency\ of\ all\ species} \times 100$$

$$Relative\ Basal\ Area = \frac{Sum\ of\ basal\ area\ of\ all\ individuals\ of\ a\ spps\ in\ the\ sample}{Total\ basal\ area\ of\ all\ the\ spps\ in\ the\ sample} \times 100$$

To measure the species diversity in different plots, the Shannon Wiener function of species (Shannon and Weiner 1963) diversity was calculated:

$$H = -\sum pi \log pi$$

Where,

pi is the proportion of total number of individuals that occur in the species i. i.e. (ni /N).

ni is the number of the individuals of a species i and i = 1 to k.

k is the total number of the species.

N is the total number of individuals of all species in the sample.

Results

- ***Plant species composition and distribution pattern***

The total number of species recorded in managed and control area were 11 and 18 respectively. The IVI of Sal was 150.52 for managed area and 140.58 for control area. In both the managed and control area, Sal had a higher IVI, indicating its dominance as the primary species, Sal was significantly more prevalent in the managed area compared to control area. Additionally, Asna (*Terminalia tomentosa)* was found to be co-dominant species in both the managed and control area.

Regeneration Status

The study found higher seedling and sapling density in the managed area as compared to the control area which is due to the regeneration felling and the different silvicultural treatments like weeding, cleaning were performed in the managed area. In managed area, mean density (number of seedling per hectare) were estimated to be 31,670 and whereas in control area, mean density per ha of seedling were estimated to be 19,462. However, tree and pole density were found greater in the control area as compared to the managed area.

- ***Comparison of regeneration between managed and control area***

Statistical analysis with the application of T-test showed that there was significance difference in number of seedling and sapling between managed and control area at 5% level of significance (Table 1).

Table 1 : *Statistical comparison of regeneration between managed and control area*

Description	Control		Managed		T-test (P-value)
	mean (stem/ha)	SE	mean (stem/ha)	SE	
Sapling	3133	0.4	4300	0.4	2.20E-16
Seedling	19462	0.34	31670	0.21	3.50E-09

- ***Per hectare seedling distribution of* Shorea robusta *with different height classes***

The distribution of Shorea robusta seedlings in both managed and control

area were constructed based on the height measurement. Height was classified into 25 cm interval. It was found that the *Shorea robusta* seedling was densely distributed in the managed area than in control area with the height of 50-<75 cm. Similarly, in the control area seedlings with the height of 50-<75 cm were found densely distributed. At each height class, the seedling was found to be the densely distributed in managed area as compared to the control area indicating effects of canopy opening and the different treatments applied in the managed area.

- ***Comparison of regeneration of* Shorea robusta *with other species***

In case of managed area, the density of *Shorea robusta* seedling was found higher i.e. 21,345/ha while the density of other species was found low i.e. 10,325/ha. Similarly, in control area the density of *Shorea robusta* was found 11,236/ha while the seedling of other species was found low with 8,226/ha. Also in case of sapling density, *Shorea robusta* was found higher in both (managed and control) area as compared to other species. Hence, the regeneration of *Shorea robusta* was found higher in both managed and control area.

Statistical analysis with the application of Mann-Whitney test showed that, in case of sapling and seedling the diversity index was varied significantly between managed and control area, but in case of tree and pole there was not significance difference in diversity index between managed and control block.

Table 2: *Shannon Weiner's Diversity Index in control and managed area*

Description	Variables	Control		Managed		Mann-Whitney U test
		Mean/plot	**SE**	**Mean/plot**	**SE**	
Shannon wiener Index (H)	Tree	0.46	0.07	0.31	0.07	0.57
	Pole	0.96	0.08	0.72	0.07	0.087
	Sapling	0.85	0.07	0.42	0.05	8.34E-06
	Seedling	0.98	0.05	0.73	0.06	0.0054

Conclusion

Among the different silvicultural systems, the irregular shelterwood system applied in lower region of Nepal can be a good model for promoting the sustainable regeneration and regulation of Shorea robusta as it is economically importance tree species for achieving economic prosperity from forestry sectors.

An Assessment of Human-Wildlife Conflict in Gandaki Province (Case study of Tanahun and Gorkha)

Introduction

Despite Nepal's remarkable effort to increase the forest cover of the country (44.74%), the increased forest landscape does not guarantee the larger forest patches. Disconnected forest patches reduce habitat suitability and hinder the migration and communication processes of the animals. Furthermore, the distant resources and diminished habitat suitability due to the changes in environmental factors compels animals to seek resources near human settlement. This will in return causes economic loss, human casualties and reduces food security and livelihood opportunities leading to Human-Wildlife Conflict. Habitat loss, pressure to natural resources, agricultural expansion and unscientific and unmanaged developmental projects generally causes HWC. The extent of HWC varies based on the species, season and availability of the natural resources and damages are site-specific. In Nepal, sixty-nine districts have specific incidences of wildlife conflicts caused by 26 identified species (DNPWC 2017), but the studies on drivers of HWC are scarce and are often too general, vague, and have less scientific merit.

Objectives

- To assess the nature, intensity and quantify the loss caused by HWC
- To evaluate the methods and techniques adopted to reduce human wildlife conflict
- To explore the spatial and temporal patterns of wild animal attacks on people and identify conflict hotspots in the study area

Methodology

Social surveys, including structured questionnaire household survey, consultation meetings and focus group discussion were performed in the settlements that experienced highest human-wildlife conflict in Suklagandaki, Vyas and Bhanu municipalities of Tanahun district and Gorkha, Palungtar Municipalities and Barpak Sulikot Rural Municipality of Gorkha district. Twenty-four Community Forests were (four each from six municipalities) selected randomly in coordination with Division Forest Offices in district level consultation meetings. Key Informant Interviews were conducted with professional and knowledgeable authorities and personalities of Tanahun and Gorkha. Focus group discussions were

conducted in 17 CFUGs and household survey was conducted in 240 households of 24 CFUGs. Secondary information was collected from Division Forest Offices, Annapurna Conservation Area and Manaslu Conservation Area Liaison offices of Pokhara and Gorkha, NGOs, media and other stakeholders.

Results

Wildlife damage occurs across all rural and municipal areas and is in increasing order. The scale and nature of conflicts vary between municipalities. In Gorkha, Palungtar, and Barpak Sulikot Rural/Municipalities of Gorkha, and Vyas of Tanahun, there is a higher incidence of livestock depredation, while Bhanu municipality experiences more human casualties. The major damages caused by wildlife include crop damage, livestock depredation, and human injuries or casualties. Crops such as maize, paddy, millet, and potato are damaged by animals such as monkeys, porcupines, parrots, wild rabbits, and deer. Livestock such as goats, buffaloes, cows, and chickens are killed by common leopards, jackals, jungle cats, and foxes. More than half of the livestock depredation occurs in farm lands. Property damage, particularly to livestock sheds, is relatively minimal.

The annual economic loss due to wildlife damages is estimated at NRs 3,132 per household, and NRs 10,063 per victim household. On average, each household experiences a crop loss of 1.71 muri (137 kg), equivalent to NRs 5,217, and the average affected crop damage area per household is 4 ropani. There is an average of 9 cases of injury and casualties per year. The common leopard is responsible for both injuries and casualties, with 59% of the 121 individuals found in a dead condition. Children (below 11 years old) are more vulnerable to wildlife attacks, with a higher frequency reported in spring (35%) followed by autumn (30%). The documentation of wildlife damages is aided by information on the HWC relief fund. A higher number of households receiving relief funds indicate a higher frequency of wildlife damages. Various general and specific measures have been adopted to minimize damages. A predator-proof corral is effective in controlling livestock depredation at home, while making noise, fencing, and using scarecrows are moderately effective in reducing crop losses. Wildlife movement in settlement areas varies depending on the species and time. Wildlife attacks on humans are more common in the evening. Crop damage is more prevalent during the ripening time, specifically in the months of Jestha/Ashad and Kartik/Mangsir. Livestock depredation and human injuries or casualties occur throughout the year.Top of FormBottom of Form

Conclusion

The human wildlife conflict exists and is increasing in many regions where people and wildlife coexist and share limited resources. The spatial and temporal factors influence the patterns of wildlife attacks on humans. It is crucial to develop the conflict resolution strategies and effective conservation measures for the long term survival and coexistence of both humans and wildlife. HWC can be minimized through knowledge dissemination and awareness, improvement of livestock shed, promoting stall feeding, habitat management (waterhole construction, increasing prey base in forest), management of abandoned agricultural lands, management of Rapid Response Team (RRT) at municipal level, formulating HWC management strategy and action plan in provincial/municipal level, establishing insurance scheme at local level, Promoting alternative and wildlife friendly crops, Creating coordination forum of stakeholders to facilitate and simplify process of HWC relief fund, Capacitating and equipping forest offices together with local governments in wildlife handling. Altogether, addressing HWC requires a multi-faceted approach that includes knowledge dissemination, infrastructure improvement, habitat management, stakeholder coordination, and policy development at various levels of governance. By implementing these measures, we can strive towards the coexistence of humans and wildlife while ensuring the long-term survival of both.

An Assessment of Carbon Sequestration and Emission in Gandaki Province

Introduction

Nepal, a scenic mountainous country in South Asia, is grappling with increasing greenhouse gas emissions. This has induced multifaceted effects of Climate Change in the globe and in Nepal as well. The increasing greenhouse concentration in the atmosphere accounts for approximately two thirds of the overall energy imbalance that is raising earth's temperature. In Nepal, millions of Nepalese are estimated to be at risk from the impacts of climate change including reductions in agricultural production, food insecurity, strained water resources, loss of forests and biodiversity, as well as damaged infrastructure. To combat climate change, Nepal actively participates in global efforts. Carbon sequestration, the process of removing and storing CO2, has gained significant attention. Forests, agriculture, and oceans play pivotal roles in carbon sequestration. In Gandaki Province, the Energy, IPPU, AFOLU, and Waste sectors contribute to carbon emissions. Evaluating these sectors is crucial for understanding the province's carbon balance and its potential to achieve carbon neutrality

Objectives

- To determine the total carbon emission of Gandaki Province,
- To determine the total carbon sequestration of Gandaki Province.

Methodology

This study was carried out in eleven districts of Gandaki Province. The methodology adopted for this study were based on the approaches as determined by Top Down Approach (Reference Approach) and Bottom Up Approach (Sectorial Approach) using the IPCC Tier 1 and Tier 2 framework. Due to a lack of detailed disaggregated data for many activities in the sectors, this analysis relied heavily on the Tier 1 methodology of the 2006 IPCC guidelines. Tier 2 and Tier 3 were also considered based on data availability. This report presents a detail status of carbon Sequestration and carbon emission (CO2) in Gandaki Province from four sectors; Energy, Industrial processes and product use (IPPU); Agriculture, Forestry, and other Land Use (AFOLU); and Waste. IPCC guidelines 2006, Initial National Communication (INC), Second National Communication (SNC) and Third National Communication (TNC) were considered as the guiding documents. To collect relevant data and information, field visits, direct observation, key informant interviews were done in several areas of Gandaki Province.

Results

- According to this study, the total carbon emissions in Gandaki Province were 4253.42Gg CO2-eq, whereas total carbon sequestration was 2330.79Gg CO2-eq, indicating that emissions outweighed sequestration by 1923Gg.
- Among the emitted carbon, Energy sector contributed 2142.42Gg/yr (51% of total carbon emitted from Gandaki Province). The total estimated carbon emission from transportation, residential, agriculture, manufacturing industries and commercial sectors were 705.06 Gg, 1,183.75Gg, 32.88Gg, 101.9 Gg and 118.8Gg, respectively.
- The total estimated CO2 emission from IPPU sector was estimated to be 771.16Gg (approximately 18% contribution from cement production).
- The total estimated amount of CO2 emission (including fire) from this AFOLU was 1339.8Gg (32% of the total emission) of CO2-eq and the total amount of CO2 sequestration was 2330.7 Gg of CO2-eq.
- The total estimated CO2 emission from the waste sector is 0.07 Gg (0.002%) of the total emission).
- Energy sector contributes the most for carbon deposition and waste sector the least.

Conclusion

At present, carbon sequestration is less than carbon emission, but adoption of ways to increase carbon sequestration would definitely help Gandaki Province to be a Carbon-Neutral Province in the near future.

Recommendations

- Developing policies to promote solar, wind, micro-hydro, improved cooking stoves (ICS) and biogas as alternatives
- Sound Management of the Public Transportation system and if possible adopt Bus Rapid Transit System
- Encourage the use of electric vehicles
- Adopt technologies that reduce pollution level immediately
- Prepare plans and policies that bind industrialists to use alternative sources of energy
- Promotion of green enterprises
- Replace fossil fuel-based energy sources by alternative sources of energy (hydro, wind, solar etc.)
- Promote tree plantation in denuded or degraded lands, urban open spaces and on both sides of roads

Distribution and Impacts of Major Invasive Alien Plant Species in Gandaki Province

Introduction

Biological invasion is one the major environmental problems at all levels of spatial, geographic and political (jurisdictional) scales with range of impacts on biodiversity, agriculture production, livelihood, health and economy. The problem of biological invasions is ever increasing with rising and diversified global trade and travel. Other components of global environmental changes such as land use changes, climate change, and pollution have further augmented the invasion process. In recent decades, Nepal has experienced an increase in the number of invasive alien plant species (IAPS), their spread into new areas, and the subsequent negative impacts on biodiversity, ecosystem services, wildlife habitats, agricultural production, and human well-being. These changes and impacts have been also anticipated and observed in Gandaki Province, located in central Nepal, the Province is rich in floral and faunal diversity, including many endemic and threatened species. . Previous studies have indicated the adverse effects of IAPS on biodiversity and local livelihoods, and a significant portion of Gandaki Province is suitable habitat for noxious invasive weeds. However, these data are not adequate to inform decisions for the management of IAPS in the Province. In specific, there is lack of district level data on diversity, distribution and impacts of IAPS in province, hindering the formulation of effective management strategies at both the district and provincial levels

Objectives

- To document diversity of IAPS in the Gandaki Province and prioritize six major IAPS.
- To analyze current and future potential distribution of the selected six IAPS.
- To document environmental and socio-economic impacts of the IAPS.
- To identify the methods of community practices of IAPS management.
- To suggest preventive and control measures for major IAPS.

Methodology

Primary data were collected through Focused group discussions (FGD) among users of the Community forests (N = 18) and distribution mapping of IAPS in selected grids (25 km^2 , N = 56). The information collected during

the FGDs were focused on the level of awareness on plant invasions, occurrence of IAPS in habitats managed by local communities, list of five most problematic IAPS, and management and utilization of IAPS by local communities. During the distribution mapping, 268 plots (25 m^2) were sampled in 56 grids to record the occurrence of IAPS, their cover, impacts, habitat type, and geographic coordinates of the plots. Six priority species were identified by scoring method that combined community perceptions, species status context, and experts' opinions. Distribution maps of all IAPS were prepared by combining primary data collected during the present study with secondary data available from previous studies and publicly available database. Climatically suitable areas of six priority species were predicted under current and future climate scenario using occurrence data and bioclimatic variables (obtained from WorldClim) in MaxEnt modelling platform. Management options were identified based on the results of present study and review of literature including various management strategies.

Results

- Twenty five IAPS were known to have invaded various habitats in Gandaki Province that account for more than 80% of the IAPS reported in Nepal including the presence of five of the six globally noxious IAPS present in Nepal
- The six prioritized species identified for Gandaki Province included Ageratum houstonianum, Ageratina adenophora, Chromolaena odorata, Mikania micrantha, Parthenium hysterophorus and Lantana camara.
- Among them, Ageratina adenophora, Ageratum houstonianum, Chromolaena odorata and Parthenium hysterophorus were currently widespread whereas other two species Lantana camara and Mikania micrantha had limited distribution.
- The number of species in each district ranged from 3 (Mustang) to 23 (Kaski) and the districts having the high number of the IAPS (>15 species) included Kaski, Nawalpur, Tanahun and Gorkha.
- Species like Ageratina adenophora, Bidens pilosa and Galinsoga quadriradiata were found in all districts whereas species like Argemone mexicana was found in a single district (Nawalpur).
- In the future (2050), climatically suitable areas of all species were predicted to increase and it varied from 3% for Chromolaena odorata to 65% for

Mikania micrantha.

- Consultation with local communities and direct observations revealed that the IAPS had increased weed problems in farmlands, suppressed other useful species and reduced tree regeneration. Some of the IAPS were utilized by local communities as composting materials, livestock feed, herbal medicine and vegetable.
- Common methods of IAPS management practiced by local communities included uprooting and buring, utilization of biomass for composting, burying and herbicide uses.

Conclusion

The problem of plant invasion is likely to increase further in future due to, among others, the high probability of introduction of additional IAPS, expansion of currently established IAPS to new locations and increase in climatically suitable areas as a result of climate change. There are data gaps but the current knowledge is adequate for the national and province level governments to initiate prevention and control programs targeting priority species identified in this research. Untimely actions will results in loss of opportunities for prevention, eradication and containment of some IAPS in Gandaki Province.

Demand and Supply of Forest Products in Gandaki Province

Introduction

Forest is an integral part of the Nepalese livelihoods. Forest provides multiple services along with the fulfillment of their demand for basic commodities like timber, fuelwood, fodder. Globally, forest products play an important role in international trade. Timber is one of the commodities to be traded internationally between different countries. In Nepal, timber and fuelwood are an important source of cash earning and means to improve livelihood of local people. Maintaining a sustained supply of forest products- timber and fuelwood- is one of the key Objectivess of forest management. Despite having potential to meet the demand of the country as well as potential to trade timber, timbers are still imported from other countries. Gandaki Province is also not an exception to this situation. Most of the forest area in this Province lies in the mid-hill region managed by community as community based forest management or are under private forests. Majority of the timber and fuelwood production through CFs are consumed domestically. Only the timber produced from certain districts are exported to other parts of the country. The large quantities of the forest stocks are not properly utilized and they are decaying. Despite having abundant forest resources, country is not able to fully utilize the resources and collect the benefits. The country is still importing from other countries while our resources are mass decaying due to improper management. Despite demand for forest products, insufficient supply remains the challenge for effective contribution in national (and provincial) economy. This may also leads to unsustainable harvesting of forest products in the long run. Therefore, it is necessary to utilize our forests efficiently and effectively through analysis of current/future demand and supply scenario and identification of hurdles with their probable solutions.

Objectives

- To estimate the current and future potential demand of forest products
- To estimate the current and future potential supply of forest products
- To analyze the trend in the production and consumption of forest products
- To estimate the annual production of timber and fuelwood from the forest of Gandaki Province
- To explore the problems in demand and supply of forest products

Methodology

This study was carried out in the eleven districts of Gandaki Province. For data collection, the desk review of published as well as unpublished reports of the government of Nepal was carried out. Importantly, provincial reports of Gandaki Province were consulted for data collection. Then the field survey

and discussions were conducted in all Division Forest Offices (DFOs) of the Province. The timber and fuelwood demand/supply data were collected for the last three fiscal years (FY) namely FY 2075/76, 2076/77, and 2077/78. The study relied primarily on the demand and supply data recorded and documented by the DFOs in all the districts. While the quantitative data was entered into spreadsheet for the quantitative analysis in the R-software, qualitative data was entered in the document file listing the key problems and probable solutions. The quantitative data was analyzed with descriptive statistics such as mean, standard deviation, and correlation and presented through bar diagrams and plots. For the future projections on the demand and supply, the team used simple simulation model in R-software

Results

- For timber, average quantity was 158,383±86,897.5 cft in FY 2075/76 that decreased to 122,049.5 IN FY 2077/7.
- the average demand of fuelwood was [2] 176.6±296.9chatta that decreased to 125.3±164.6 chatta in FY 2077/78. BS
- Districtswise, Nawalpur had the highest demand of timber (283,333±76,376.3 cft) and Manang had the lowest demand (371.67±108.67 cft) of timber. Fuelwood demand was also highest for Nawalpur (733.33±251.66 chatta) and lowest for Manang (3.98±3.61 chatta).
- Similarly, the study revealed that in the next 5, 10, and 20 years, the demand will decline to 557,700.43 cft, 290,372.26 cft, and 78,716.07 cft respectively. However, this demand will exceed one million cft if demand increases by either 5% or 10% of the current amount every year. Likewise, fuelwood demand will also decrease to 452.52 chatta, 193.60 chatta, and 35.44 chatta in the coming 5,10, and 20 years respectively. In average, CFs supplied 95.24±218.70 chatta and 61.15±113.06 chatta of fuelw
- In average, CFs supplied 95.24±218.70 chatta and 61.15±113.06 chatta of fuelwood in FY 2075/76 BS and FY 2076/77 BS respectively whereas PFs supplied the highest quantity of fuelwood (58.95±84.79 chatta) in FY 2077/78 BS. Overall, FY 2075/76 observed the highest quantity of fuelwood supply (183.98±297.80 chatta) from CFs, PFs, and other types of forests.
- District wise, Nawalpur supplied the highest quantity of timber (249,719±88,376 cft) from CFs, PFs, and others combined whereas Manang supplied the lowest quantity (227±110 cft) of timber during last three fiscal years. For fuelwood, the results were similar – Nawalpur as the largest supplier (673.65±295.97 chatta) and Manang as the smallest supplier (6.18±3.08 chatta).
- The timber supply will be 478,897 cft, 282,368.94 cft, and 98,167.13 cft in the next 5, 10, and 20 years if the constant rate of supply remains extant. Likewise, fuelwood supply will also decrease to 306.95 chatta, 99.52 chatta, and 10.46 chatta in 5, 10, and 20 years.

Conclusion

In general, both the demand and supply status and pattern of timber and fuelwood is found decreasing in the Province in last three fiscal years. The current regulatory procedure for timber harvesting for forest user groups is tedious and demands multiple approvals from DFO. Similarly, the regulatory barriers including prohibition to harvest Sal species from private forest is one of the major cause of problems in the supply of forest products. This has created multifaceted effects on timber supply. It has decreased the availability of Sal timber in the market while increasing the timber price. In case of fuelwood, the expensive harvesting costs in the mid-hills forest and illegal collection and sale in Terai region has raised as a key problem including the less value given to fuelwood management and use by community and forest managers has limited the potential harvesting.

Recommendation

- Consistence and supportive policies formulation is pivotal to enhance sustainable flow of forest resources and ensure consistency in decision making and supply of forest products.
- Province and District level annual forest products harvesting and distribution plan should be developed and implemented.
- Forest resource management plans and objectives need to be developed based on the forest resource availability, forest types, timber and fuelwood potentiality, and forest condition. It may vary between forest management regimes, within and between districts and between the geographic settings.
- The current regulatory procedure for timber harvesting from forests (community-based forests) is complicated and tedious. It needs to be revised in order to ease the harvesting and distribution of timber within appropriate time and revitalize the resource ownership of community forest user groups.
- Use of modern tools and technology and development of local forest-based enterprise to process and supply timber and fuelwood based on market demand

Tusa Cultivation and Promotion in Machhapuchchhre Rural Municipality, Kaski district, Gandaki Province, Nepal

Introduction

The global human population is benefited from the forests and forest products to sustain their livelihood. The people who live near to forest mostly depends on the forest resources and forest products. Therefore, the dependency on the forest and forest products is determined by proximity to the forest. The forest products extracted from the forest especially Non-Timber Forest Products can be used for nutritional and health needs. Bamboos are one of the major non-timber forest products and are widely distributed in Nepal from lowland to high mountain regions. The diversity and distribution of bamboo species varied according to altitude and other climatic and physiographic factors. The increasing human population, unplanned resource utilization, forest encroachment through agricultural land expansion and infrastructure development, knowledge gap on the cultivation, harvesting time, and preservation has led to the limited availability of the bamboo (and bamboo shoots). Due to its contribution to a sustainable livelihood, and one of the major income-generating resources in the mountain region, the Government of Nepal has initiated programs to promote its production with people's active participation. However, the baseline data for site-and species specific is little known.

Objectives

- To identify the factors affecting the Tusa production (regeneration from the clump) in the study area.
- To assess the people's attitude and activities towards Tusa collection and promotion in the study area.

Methodology

This study was carried out at Sardikhola (ward 2) and Ghalel (ward 9) of the Machhapuchchhre Rural Municipality of Kaski district after consultation with ACAP officials, local people. Both primary and secondary data were collected during this study period. Primary data such as Tusa number, production, and factors acting on the Tusa production were collected from the field survey. Altogether, 1.92,000 plots were designed within the study area. Among which, a total of 269 plots were used for sampling which were randomly chosen under 6% margin of error at a 95% confidence level. A sampling plot of 1m*1m size was used for data collection in the field. In addition, the demographic data and people's attitudes and activities on the Tusa cultivation and collection were collected during the questionnaire survey. Secondary information was collected from the relevant journal, published and unpublished reports, ACAP annual report.

Results

All together four species of Nigalo including Tite (Drepanostachyum intermedium), Malingo (Himalayacalamus cupreus), Ghode (Himalayacalamus asper), and Jarbute (Thalmocalamus spathiflorus) are recorded from the study area. Among these species, the Malingo is widely distributed and highly abundantly available species, followed by Tite and Ghode Nigalo in the study area. The distribution of these Nigalo is mainly within the average elevation of 2451 m (range: 1496-2952 m) above the sea level within the average slope of 29° (range: 5°-60°). The production of Tusa for these species in these areas is supported by elevation, soil type, available public land, and more people's willingness to cultivate. The Nigalo suitable habitat in the study area is under the threats from forest fire, Tusa damages from wildlife, livestock, and wildlife grazing, illegal Tusa collection. For that local people should be made aware about the conservation and management of Tusa/Nigalo, illegal collection and impacts of early and late harvesting of Tusa, local people should be encouraged to cultivate bamboos on the noncultivated barren/abandoned/sloppy lands. Local people in the study area are supportive and has involved in Tusa cultivation and collection. However, more training and awareness programs on Tusa cultivation and promotion, harvesting and their value chain mechanism are needed to local people and farmer.

Conclusion

Bamboo shoots are consumed as vegetable by local people can be promoted for cultivation. The production of Tusa for these species in these areas is supported by elevation, soil type, available public land, and more people's willingness to cultivate. However, a strong management plan is pre-requisite for sustainable management of Tusa cultivation and production. The information on prescribed month and time for Tusa collection and cultivation need to be monitored and followed strictly. More research is needed to identify the probability of overexploitation on bamboos and other vegetation in the area at temporal and spatial scales. Based on the findings, as local people are willing to cultivate, we recommend providing incentives for Tusa production for increasing income sources and sustainable livelihood of local people.

Identification of Biological Corridor within Gandaki Province

Introduction

Gandaki Province is home to diverse range of flora and fauna. However, growing human settlement and economic development activities stipulates fragmentation isolating habitats and reducing connectivity for wildlife movement resulting in decreased genetic diversity. Land use changes impact habitat selection, movement patterns, and home range of wild animals hindering migration and dispersal process. The province contains significant protected areas, with high altitudinal gradient creating mosaic of different vegetation type and habitat. Thus, ensuring the interconnectivity between lowland and upland protected areas is crucial for the survival of the wildlife species amidst changing environmental conditions.

Objectives

- To document wildlife species migrating in Gandaki province
- To prepare GIS based habitat corridor maps of the Gandaki Province considering fragility risks factors which can be visualized in any web-based open-source platform
- To prepare land management layer in potential corridor area such as land use patterns Land ownership (Agriculture land, waste land, grassland, nearest settlements area, and other public land for infrastructure etc.)
- To identify potential biological corridors in Gandaki Province

Methodology

This study was carried out within the Gandaki Province. This study was conducted with GIS-based approaches for the identification of potential biological corridors through field assessment and focus group discussion. The migratory species within Gandaki Province were compiled from literature, and three umbrella species Himalayan black bear *(Ursus thibetanus laniger)*, Common leopard *(Panthera pardus)* and Musk deer *(Moschus leucogaster)* were selected for further analysis. Four protected areas were used as sources or cores to develop connectivity through least-cost modeling based on assigned resistance value of landscape variables. The suitability of each land use and the degree of its resemblance to the optimal habitat of three umbrella species provided the context for assigning landscape resistance values to the determined resistance surface model. Then, two GIS layers (source and resistance surface layers) were used for least-cost modeling to determine landscape connectivity. These points were verified using patch sampling techniques with field verification, and habitat patches larger than 500 ha were used as potential biological corridors.

Results

Gandaki Province inhabits significant diversity of migratory wildlife. These species include both mammals and birds, move to different habitats on a seasonal basis depending on conditions like food availability, sunlight, and temperature. The Kali Gandaki valley and CHAL serve as an essential corridor for trans-himalayan mammals and bird species during their migration. These migratory species are particularly vulnerable to alterations in the environment and patterns of land use. Consequently, it is crucial for the preservation of these species to identify and protect biological corridors and suitable habitats. A crucial step in preserving and safeguarding biodiversity is the establishment of a biological corridor. In order to permit species movement, genetic exchange, and the preservation of ecological processes, it involves reuniting habitats that have been fragmented. The study concluded five possible biological corridors: ACA-Chitwan, MCA-Chitwan, ACA-DHR, ACA-MCA and ACA-Tanahu in Gandaki province that connect south and north as also connect different protected areas. These corridors help permit spaces movement, genetic exchange and the preservation of ecological processes by reuniting fragmented habitats. ACA-DHR and ACA-MCA corridor can be priorities for conservation and restoration program based on biological corridor in accordance with NPWC act.

Recommendations

- Strong partnerships and engagement with local communities, government agencies, NGOs and other stakeholders needs to be done for the management of biological corridor.
- Provincial government needs some legal obligation for biological corridor. To establish legal protection for the corridor may involve creating new protected areas, developing conservation agreements, or incorporating the corridor into existing protected area networks. It is important to implement effective governance mechanisms to ensure compliance, enforcement, and long-term management of the corridor.
- Identification of degraded areas within the proposed corridor and prioritize restoration efforts should be carried out. Habitat restoration, reforestation, invasive species removal, and the promotion of sustainable land use practices should be done supportive to biological corridor.
- Implementation of conservation actions such as anti-poaching measures, wildlife monitoring, and public awareness campaigns needs to be done to foster stewardship and support for the corridor

Biodiversity Monitoring Permanent Plot Establishment in Panchase Forest Protection Area

Introduction

Biological diversity is defined as the variability among living organisms from all sources including, among others, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part (GoN, 2014). Biodiversity provides ecosystem services essential for human well being and is also interrelated with overall socio economic development. However, various direct and indirect human activities affect the ecosystem functions by altering biodiversity, thereby endangering the species reliant upon intact forest landscapes and welfare of the humankind. Considering the changes and alteration of the biodiversity and ecosystem due to natural and anthropogenic interferences, permanent monitoring plots need to be established for the long run assessment and monitoring purposes. Monitoring of the biodiversity changes over time can be systematically carried out through Permanent Sample Plots as it provides us a series of direct observations on forest condition, dynamics and change over time. Panchase is an important ecological zone for its biodiversity values and biological corridor linkage of lowland (Chitwan–Nawalparasi) and Annapurna Himalaya range (Chitwan–Annapurna Conservation Landscape) and there exist limited information on the faunal-floral diversity and habitat conditions (Bhandari et. al.,2022). Hence, PSPs can be effective for long term monitoring of the biodiversity and to create a baseline data that can be used to assess the environmental chage, identify threats and developing strategies for their effective management.

Objectives

The main objectives of this study was to establish permanent monitoring plot of biodiversity in Panchase forest. With the establishment of the permanent plots, the objectives in the following years are as:

- To assess current status of biodiversity in PFPA
- To monitor changes in biodiversity over time
- To monitor changes in growing stock and carbon of the forests
- To identify threats to biodiversity and develop strategies for their mitigation
- To develop management strategies for the conservation of biodiversity in the forest.

Methodology

This study was carried out in Panchase forest protection area which lies in Kaski, Syangja and Parbat districts. Methodology to establish permanent plots for biodiversity monitoring include literature review and field works. Stratified random sampling method, based on altitude and slope, was used

to select sample points in the study area. Altitudinal range of the study area was reclassified and both slope and elevation maps were overlayed to generate sample plots. The sample points that have been generated with the help of Q GIS software were accordingly established in the field with their GPS coordinate location. Two metal pegs were used in the establishment of the sample plots. First metal peg with twelve inch in length, with round ring /loop at the top was inserted at the center of the plot and second peg, with ten inch long with small screw attached at the top, was inserted into the ground at five meter distance from the first peg towards magnetic north direction. Natural landmarks were determined and located nearby the plot centre to detect the pegs at the time of re/measurement.

Results

- Out of total sample plots, about forty two percent plots are located each in Kaski and Parbat districts.
- Thirty percent plots are located in South East aspect and 3/4th of the total plots are located above 20° slope.
- Among the total plots, about seventeen percent plots are inaccessible due to steepness.
- While considering elevation, more than two third plots were established in 1,500- 2,000 m and more than half plots are in forest areas.
- Major benchmarks, reference points are trees, villages, river and those reference points for more than 3/4th plots are trees.
- These permanent sample plots will be a basis for monitoring the change in biodiversity including growing stock, carbon in the forest of Panchase region.

Conclusion

Biodiversity encompasses vast arrays of ecological attributes and the assessment of such takes long period of time. Likewise, there exists limited information on biodiversity including faunal diversity and habitat conditions in protection forests (PF) of Nepal. Monitoring of the biodiversity changes through Permanent Sample Plots can provides us a series of direct observations on forest condition, dynamics and change over time which can be the useful for further conservation and management interventions. However, due to rugged terrain and size of the monitoring plot (20m. radius), there exist a significant challenge in re/measurement of the plots.

Establishing learning sites for monitoring climate-forest-water relation

Introduction

Forests play important role in producing and regulating worlds temperature and freshwater flow, are stores of carbon, and source of many more benefits both tangible and intangible (Ellison *et al.*, 2017). Approximately 75 per cent of the world's accessible freshwater resources is supplied by forested watershed on which half of the global population relies for their basic needs. Over the past centuries, forest cover and structures have been impacted globally by anthropogenic activities and climate change; whose combined impact together seriously threaten water sources and resilience of watersheds in most places (Furniss *et al.* 2010). Despite the strong interlinkages between forests and water, the forest-water relationship is often overlooked in policy making and planning. Therefore, long-term monitoring-based study at watershed level covering all aspects of forest management, and water resources have been planned and initiated. This research project is a multiyear project which has generated baseline data in the first year. Regular monitoring and remeasurement of established sample plots, instrumentations for monitoring climate-forest relation, and student's engagement in research activities are the future targeted activities of the research project.

Objectives

- To study the impact of forest management interventions on floral and faunal diversity, and hydrological functions at watershed level
- To analyze the role of forests on climate induced disasters
- To identify possible adaptation strategies against climate change impacts

In order to achieve these long term objectives, this year the study aimed to

- To establish forest sample plots to generate baseline data on forest conditions, watershed characterization and house hold dependency on forest products
- To analyze climatic data and prepare forest interventions/watershed monitoring plan

Methodology

In order to understand ongoing forest management activities and its impact on biodiversity, forest product supply and hydrological functions with due consideration to climate change, this project was implemented in two micro-watersheds (Pudi and Hadi) of Kaski district in Gandaki Province of Nepal. Pudi Khola is a small tributary of seti river extended within ward no 33 of Pokhara metropolitan city, dominated by hill Sal forest with limited

water flow. Hadi Khola, a tributary of Harpan originating from Panchase Protected forest features mixed forest with higher water flow lies in ward no 23 of Pokhara metropolitan city.Preliminary field visits and consultation meetings, watershed delineation and characterization, spring and stream water resource mapping, permanent forest sample plot establishment and its measurement, household survey and climatic data analysis from 1971 to 2022 were employed for the research project.

Results

- Pudi and Hadi micro watershed have respectively 26 and 33 spring water sources.
- However, the study indicates that the spring water sources are drying up.
- A total of 66 permanent forest sample plots were established; 38 in Pudi and 28 in Hadi.
- Measurement of dbh and height were carried out for a total of 1805 trees. The result showed the higher density of trees/poles and sapling in Hadi whereas regeneration density of trees was higher in Pudi.
- Pudi and Hadi micro-watershed has the potential to sequester 196.94 ton/ha and 213.72 ton/ha carbon respectively.
- The analysis of forest product supply shows people of Pudi and Hadi are more dependent on privately owned land than community forest for fuelwood, fodder.
- The analysis of the temperature data from 1971 to 2022 shows the increasing trend of the temperature over the past 51 years.
- Anthropogenic pressures are prominent within the micro watersheds.

Conclusion

The study have delineated Pudi and Hadi micro watershed of Kaski districts which covers different aspect of forest, water and climate that provided baseline data for monitoring forest-water-climate relation. The generated data in the first year of this long termed research project will be very useful to the policy makers and students to understand and build up on the baseline data for further research. With the changing socio-economic context of rural areas of Nepal, the long-termed generation of both socio-economic and biophysical data at microwatershed level is expected to support both province and central government to update the existing policy on forest and water resource management.

Status, Impact and Mitigation Measures of Invasive Alien Plant Species of Ramsar site, Lake Cluster of Pokhara Valley, Pokhara

Introduction

Wetlands are the most productive ecosystem in the earth, providing resources and benefits to people worldwide. However, as they are used extensively globally, they are always at the risk of being invaded by the non-native species. The new species whether brought intentionally or accidentally, can bring significant changes to the ecosystem either through competition, predation, hybridization, disease spread and altering the environment. The increasing volumes of the global trade and land use changes enhances the opportunity for the global spreading of the invasive species and are likely to become more severe in the future. Most of the wetlands of Nepal, particularly of tropical and subtropical regions, are witnessing a rapid invasion by aquatic invasive species with noticeable negative effects on biodiversity and livelihood of indigenous communities (MFSC, 2014). The nutrient loading from the agricultural runoff, solid wastes, industrial effluents etc. facilitates the wetland invasion which is further augmented by global environmental changes. Previous studies have reported the significant presence of invasive alien plant species (IAPS) in Gandaki Province, as over 80% of the IAPS found in Nepal are reported to occur there. Additionally, five out of the six globally harmful IAPS that exist in Nepal are also spreading across different ecosystems within Gandaki Province. The limited studies carried out in IAPS were mostly focused to forest and protected areas or large wetlands like Phewa, Begnas, Rupa in Gandaki Province. All the nine lakes of the Lake Cluster of Pokhara Valley (LCPV) were scarcely studied for the impact of the IAPS. Hence, this study was carried out to assess the current status, impact and mitigation measures of the invasive plant species of Ramsar site, Lake cluster of Pokhara Valley.

Objectives

- To prepare a checklist of IAPS in Pokhara lake cluster
- To identify the drivers and dispersal pathways of IAPS in study sites
- To assess the environmental and socio-economic impacts of IAPS
- To recommend the mitigation measures for the management of IAPS

Methodology

This study was carried out in lake cluster of Pokhara Valley (Phewa, Begnas, Rupa, Dipang, Khaste, Neureni, Maidi, Gude, Kamalpokhari) which is listed as Ramsar site for its biological significance. The primary data were collected through focus group discussions among the member of Lake conservation

committee and local people on the presence of the invasive species in and around the wetlands, drivers and dispersal pathways of IAPS, problem caused, management and utilization of IAPS by local communities. The cover of IAPS was estimated visually, potential dispersal pathways were identified by scoring method. Secondary data were collected from the previous studies.

Results

- The most frequently occurring and problematic invasive species that were recorded from these wetlands were Jalkumbhi *(Eichhornia crassipes)*, Besaram *(Ipomoea carnea)*, Kumbika *(Pistia stratiotes)*, Jaljambo *(Alternanthera philoxeroides)* and Karautee ghans (Leersia hexandra).
- Among these, L. hexandra was found in all nine lakes, while E. crassipes and A. philoxeroides, and I. carnea are aggressively advancing.
- Agricultural runoff, flooding, Eutrophication, intentional introduction for ornamental purpose were found to be the major pathways of dispersal.
- The variable such as proximity to road and settlement, location such as nearby city, disturbances such as grazing, road construction facilitates the plant invasion in wetlands.
- The wetlands near road, settlement, city area are at the high risk of the invasion from these species.
- The IAPS are altering the ecosystem services provided by the LCPV, affect the aquatic biodiversity, demands high budget for their eradication, reduces the scenic and recreational values of the wetland.
- Public participation is a must for the effective management of the IAPS. However, local people (specially fisherman) should be educated properly and timely about the risk associated with invasive plant, fish species; applying conservation measures to reduce agricultural runoff, soil erosion, landslides etc, season round removal of the IAPS should be practiced to limit their proliferation within the wetlands.
- Regular monitoring and proper management strategies can reduce and prevent their spread to the non- invaded wetlands.

Conclusion

The lake clusters of Pokhara valley play an important role in people's livelihood for their ecological, cultural and economic significances. Five harmful IAPS are reported which have caused negative impacts on the overall health of the wetlands. The problem of plant invasion is likely to increase further in the future due to global environmental changes. Therefore, effective early detection and rapid response program are essential for proper management of IAPS. Similarly, timely implementation of the management strategies and regular monitoring can benefit to local communities and broader objectives of biodiversity conservation and sustainable management.

Gandaki Province Government

Ministry of Industry, Tourism, Forest and Environment

Forest Research and Training Centre

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