Understanding local perception on NTFP availability in the Himalayan landscape of Nepal

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Abstract

Non-timber forest products (NTFPs) are integral to the livelihoods and socio-cultural practices of forest-dependent communities in Khare village, Dolakha district, located within Nepal's Gaurishankar Conservation Area. However, their availability is increasingly threatened by climate change and human-induced pressures. This study, conducted in 2023, applied a convergent parallel mixed-methods approach to assess both the status of NTFP availability and local perceptions of climate-related changes. A total of 95 randomly selected households were surveyed using a pre-tested semi-structured questionnaire (Cronbach's alpha = 0.82), supplemented by key informant interviews, focus group discussions, and field observations. Results show that 95.8 per cent of respondents observed noticeable changes in NTFP occurrence. While fodder (100%) and fuelwood (99%) were most commonly used, medicinal plants (42%) and honey (21%) had lower usage, largely due to ecological degradation and overharvesting. Significant altitudinal variation was observed ($p < 0.05$ for most categories), with decreased availability reported below 1600 m and increases above. Key stressors identified included overexploitation (75%), climate change (52%), forest fires (36%), invasive species (*Ageratina adenophora*), and pest outbreaks (*Gazalina chrysolopha*). Respondents emphasised reduced grazing and growing conservation awareness as contributors to localised recovery. The study calls for stronger regulatory mechanisms, sustainable harvesting guidelines, and community-led restoration efforts to safeguard NTFPs and strengthen rural resilience in Himalayan landscapes.

Keywords: NTFP, Climate change, Community perceptions, Local ecological knowledge, Likert scale, Altitudinal gradient

INTRODUCTION

Non-timber forest products (NTFPs) are products derived from forests other than timber (Ahenkan and Boon 2011). Recently, NTFPs have gained recognition as significant forest resources, especially for rural communities. These products have long been a vital part of livelihoods (Chandrashekharan 1998). Common NTFPs include medicinal and aromatic plants, wild vegetables, wooden utensils, edible fruits, bamboo, fodder, and fuelwood (Shackleton and Shackleton 2004). Among these, medicinal and aromatic plants (MAPs) are the largest and most important component, contributing more to the rural economy and healthcare than other NTFP sub-sectors (Ghimire *et al.* 2008). NTFPs are especially crucial for mountain communities, where 12 per cent of the world's population resides, and about 10 per cent rely on NTFPs and mountain resources for their livelihoods (ICIMOD 2008). In Nepal, NTFP-based activities can account for up to 90 per

cent of rural household income (Bista and Webb 2006). Approximately one-third of rural Nepali people collect and trade forest products, which generated USD 7.66 million in 2010 and benefited 78,828 participants (Chitale *et al.* 2018).

Climate change refers to long-term shifts in weather patterns over decades to millions of years (Forner and Robledo 2005; Parmesan and Yohe 2003). Globally, increase in temperature, atmospheric carbon dioxide, and variations in rainfall, along with the frequency and severity of extreme weather events, have been observed (FAO 2008). These changes have significant impacts on forest ecosystems worldwide, including species extinctions (plants and animals), prolonged or shifted growing seasons, and increased forest fires. Human-induced climate change has intensified since the latter half of the 20th century (Cook *et al.* 2013; Reusswig 2013). Extreme weather and climate conditions affect forestry and agriculture, leading to reduction in productivity and food shortages. The impacts on species populations and ecosystems alter the availability and supply of ecosystem services; provisioning, regulating, supporting, and cultural (Malhi *et al.* 2020). Changes in optimal temperature ranges threaten the survival of multiple species, accelerating the loss of NTFPs by gradually changing forest structures (Leal *et al.* 2021).

In Nepal, forests cover about 46.08 per cent of the total land area (FRTC 2024), contributing 0.92 billion NPR to the national GDP in fiscal year 2072/73 (NPC 2016). Nepal's rich biodiversity makes NTFPs a vital part of its economy, providing for people's needs without causing deforestation. Despite significant potential, NTFPs are often undervalued within the forestry legal framework in many developing countries (Wynberg and Laird 2007). Most national forest policies categorise NTFPs as minor products, prioritising timber over other forest resources (Gautam and Devoe 2006). Local communities and forest dwellers often rely heavily on timber for income, and the contribution of NTFPs is frequently overlooked. Policy efforts have emphasised timber value, and recently, some countries have initiated plans for NTFP management and utilisation, yet many still focus primarily on timber. While development efforts have concentrated on timber promotion, the ecological and livelihood benefits of NTFPs are often neglected, despite their potentially greater conservation and socio-economic importance. The inhabitants of the Himalayan region possess extensive traditional knowledge regarding the sustainable management and use of natural resources (Chauhan *et al.* 2021). Nevertheless, understanding local perceptions related to NTFP availability and management within the Himalayan region remains limited (Azhar *et al.* 2021). Gaining insights into these perceptions is vital for developing effective conservation and sustainable resource management strategies (Masoodi and Sundriyal 2020). Investigating local viewpoints is essential for creating strategies that promote the sustainable use of these resources (Baral and Katzensteiner 2009).

This study focuses on the Gaurishankar Conservation Area, specifically Khare village in Dolakha district, Nepal, renowned for its biodiversity and dependence on NTFPs. Despite their key role in supporting livelihoods and ecosystem services, the effects of climate change on NTFP availability and community perceptions in this area are poorly documented. The research aims to assess the current state of NTFPs in Khare, examine how climate change and other factors impact these resources, and understand local perceptions regarding changes in rainfall and temperature. By integrating local knowledge with altitude- and village-specific conservation strategies, this study aims to inform forest management and restoration efforts. The results will help shape evidence-based policies to sustain NTFPs and improve the livelihoods of forest-dependent communities in the Gaurishankar Conservation Area.

METHODOLOGY

Study sites

The study was conducted in Khare (27°49'N, 86°18'E), located in the Gaurishankar Rural Municipality within Dolakha District, Bagmati Province, northeastern Nepal, as shown in Figure 1. This region falls under the Gaurishankar Conservation Area (GCA 2022) and spans a tropical to sub-alpine elevation gradient, ranging from 1,010 meters to 5,522 meters above sea level. The area comprises diverse forest types, including subtropical forests (1,000–2,000 m), temperate forests (2,000–3,000 m), and sub-alpine forests (3,000–4,000 m) (DNPWC 2022). Covering an area of 104.43 square kilometers, the region is home to a population of 1,718 individuals belonging to various ethnic groups such as Chhetri, Brahmin, Tamang, Sherpa, B.K, Nepali, Newar, Gurung, Magar, Thami, Surel, and Jirel (GON and NSO 2021). Agriculture is the predominant livelihood, with more than 90 per cent of residents engaged in harvesting NTFPs for either subsistence or income generation. Dependence on NTFPs is particularly pronounced among households with limited alternative income sources (Maharjan and Dangal 2020). Key NTFPs collected in the area include *Swertia chiraita, Curculigo orchioides, Bergenia ciliata, Rheum australe, Ophiocordyceps sinensis, Rhododendron anthopogon, Eulaliopsis binata, Paris polyphylla, and Astilbe rivularis* (DNPWC 2022).

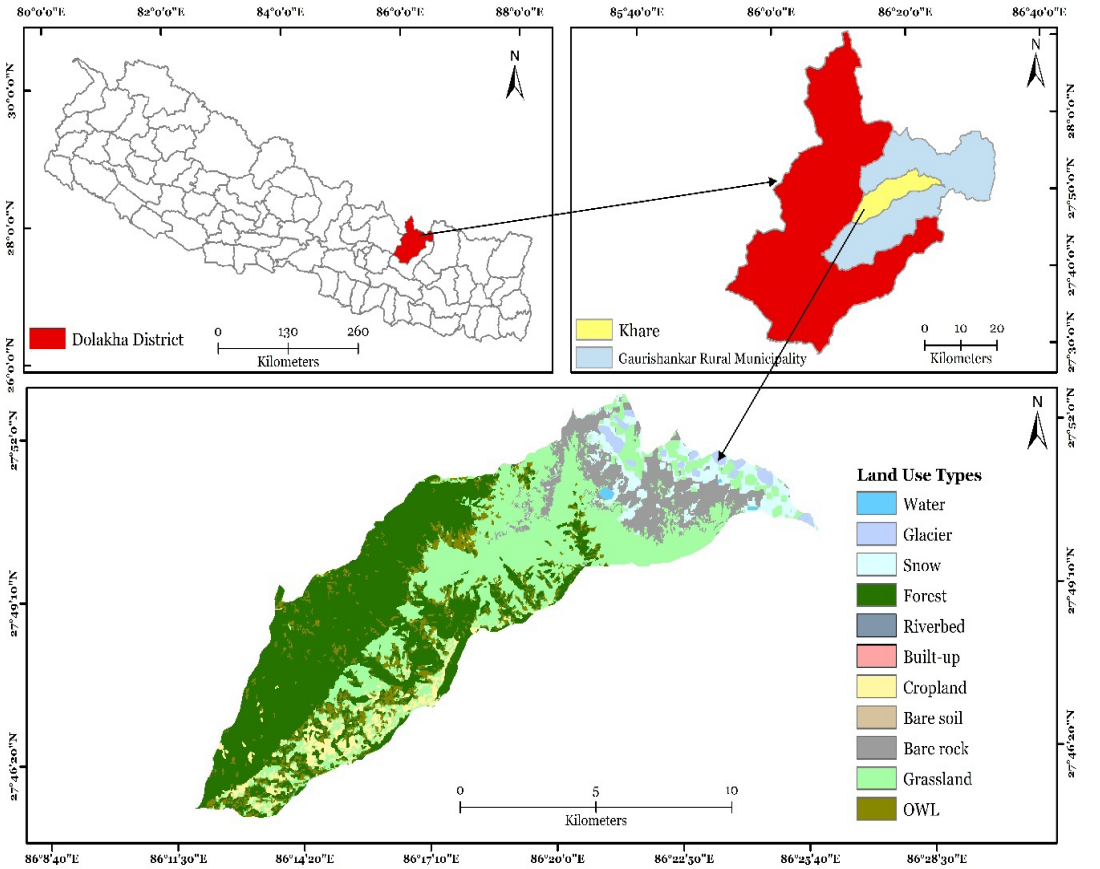

Figure 1: Study area map

Sampling strategies and data collection

A random sampling method was employed to assess the local community's perceptions of the availability of NTFPs and the impact of climate change. A total of 95 respondents from the Khare area were selected randomly. To ensure the integrity of the sample, we avoided including multiple respondents from the same household and aimed to represent various types of residents within the community. The sample size was determined using the online Survey Monkey platform, based on the formula presented in Equation 1.

$$Sample\ size = \frac{\frac{z^2 \times \rho(1-\rho)}{e^2}}{1+\frac{[z^2\rho(1-\rho)]}{e^2 \times N}} \quad \text{.. equation 1.}$$

Where z is the z score $=$ 1.96 (for a confidence level of 0.95). e is the margin of error (calculated as 10%). N is the population size (the total population of Khare according to the 2021 census is 1718). ρ is the population proportion (kept as 50%).

The survey focused on Khare villages, namely Tunitar, Suri Dobhan, Besi, Tallo Kaseri, Lamakali, Manedada and Sothali. The data were collected during January, February, and March of 2023 by using household surveys and key informant interview questionnaires. Key informant interviews were qualitative, in-depth interviews with selected people. The participants were asked to provide all the information they perceived, mainly to identify changes in climate and the impacts of such changes, particularly on NTFPs availability. The questionnaires were semi-structured. A typical five-level Likert item (Table 1) was used (Poggie 1972) as an effective and systematic means of studying human attitudes and the factors that influence them.

Table 1: Likert scale value

Response Category	Value	Range
Strongly Disagree	1	1.00-1.80
Disagree	2	1.81-2.60
Neither/Nor Agree	3	2.61-3.40
Agree	4	3.41-4.20
Strongly Agree	5	4.21-5.00

The questions were pre-tested through a pilot survey conducted with selected households and were modified before the actual field survey. A systematic and evidence-based approach, as outlined by Yusoff (2019), was employed to ensure proper validation. The Item-level Content Validity Index (I-CVI), the Scale-level Content Validity Index based on the average method (S-CVI/Ave), and the Scale-level Content Validity Index based on the universal agreement method (S-CVI/UA) were calculated to be 0.869, 0.8452, and 0.8095, respectively. We consulted two experts for content validation, and the calculated values of the Content Validity Index (CVI) exceeded the accepted CVI threshold of 0.8 recommended by Davis (1992).

For content reliability, we measured Cronbach's alpha, which assesses the internal consistency of a test or scale and is expressed as a number between 0 and 1 (Tavakol and Dennick 2011). Acceptable values of alpha range from 0.70 to 0.95 (Bland and Altman 1997; Nunnally 1975). In this study, Cronbach's alpha for the Likert scale was calculated to be 0.82, which falls within the accepted range. Therefore, the questionnaire scale has achieved a satisfactory level of content validity and reliability.

Data analysis

Both qualitative and quantitative methods were employed to analyze the data collected from KIIs and household surveys. The household survey data were visualized graphically and analyzed quantitatively using R version 4.3.2 (R Core Team2023) and ArcMap 10.8. The qualitative data obtained from the KIIs were analysed using thematic coding analysis.

To examine the association between perceived trends in NTFP availability (e.g., increasing, decreasing, or no change) and the altitudinal gradient (categorised into two elevation bands: above 1600 meters above sea level (masl) and below 1600 masl), Fisher's exact test was applied. This non-parametric statistical test was selected due to the categorical nature of the variables and the relatively small sample sizes within elevation categories. Fisher's exact test is particularly suitable for contingency tables where the assumptions of the chi-square test may not be met (Kim 2017). The test was performed in R using fisher.test() function to determine whether the distribution of perceived NTFP availability was statistically independent of the altitudinal gradient.

RESULT

Demographic overview

A total of 95 per cent of the targeted households responded to the survey. Among the respondents, 51.6 per cent were male and 48.4per cent were female. The majority of participants (53.6%) were between 30 and 60 years of age, followed by those over 60 years (33.7%) and those below 30 years (12.6%). In terms of educational attainment, a significant portion of respondents (48.4%) reported having no formal education. Meanwhile, 18.9 per cent had completed primary education, 24.2 per cent had attained secondary-level education, and only 8.4 per cent had education beyond the secondary level. Occupationally, the majority of respondents (77.9%) were engaged in farming. Other occupational categories included the service sector (11.6%), trade (6.3%), daily wage labor (3.2%), and remittance-based livelihoods (1.1%). With regard to household income, more than half of the respondents (54.7%) reported an average monthly income of less than NPR 15,000. Approximately 28.4 per cent earned between NPR 15,000 and NPR 25,000, while only 16.8per cent reported a household income exceeding NPR 25,000 per month.

Categorisation of NTFPs from KII

The communities in the study area possess rich traditional ecological knowledge, particularly in the use of NTFPs. Nine major categories were identified: fodder, fuelwood, medicinal plants, wild vegetables, agricultural tools, bamboo, wild fruits, weaving grass, and honey. While all were used to some extent, their level of utilisation varied considerably (Figure 2), reflecting differences in daily necessity, accessibility, and cultural significance.

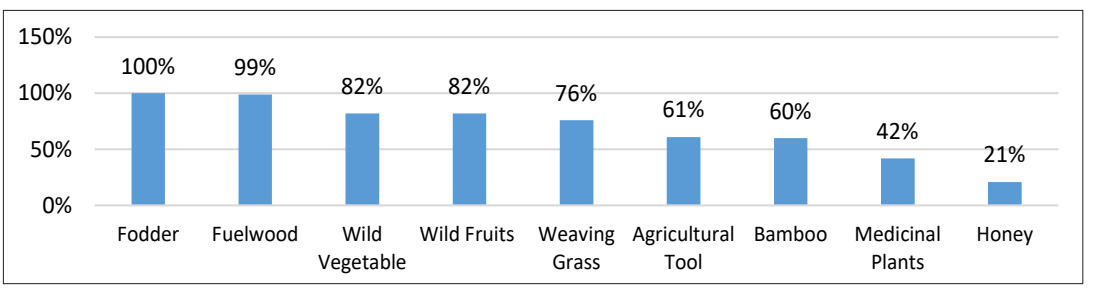

Figure 2: People's involvement in the collection of different categories of NTFP

The survey confirmed the critical role of forest products like fodder and fuelwood in daily subsistence, while highlighting varying degrees of reliance on wild edibles, materials, and medicinal resources. Lower usage of items such as medicinal plants and honey may reflect limited access or waning traditional practices. Although key informants provided an extensive inventory, actual usage proved more nuanced and context-dependent, offering deeper insight into local perceptions and utilisation of forest ecosystem services.

Perceived trend of NTFP availability

Community perceptions of NTFP availability offer valuable insights into both social and ecological dimensions. The following sections present findings across four key areas: overall trends in availability, variations by altitude, and perceived factors driving both increases and decreases.

Overall NTFP availability trend

The respondent perceived the availability of the fuelwood and weaving grass to be more increased in the study area than agricultural tools, fodder, wild fruits, wild vegetables, honey, medicine and bamboo (Figure 3). The mean score of fuelwoods (3.29%), weaving grass (3.21%), agricultural tools (3%), fodder, wild fruits (2.94%), wild vegetables (2.92%), honey (2.83%) and medicines (2.71%) were within the neutral scoring range of Likert scale i.e. 2.61-3.4 while that of bamboo (2.56%) lied within the decreased scoring range of Likert scale i.e. 1.81-2.6. Hence, overall bamboo was perceived to be decreased among the major NTFPs in the study area.

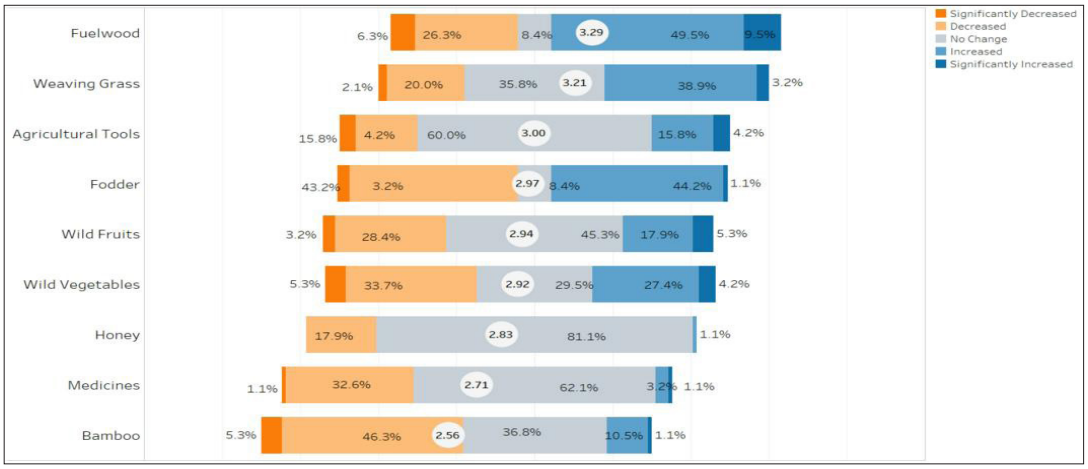

Figure 3: Overall changes on availability NTFPs in the study area (where 1-Significantly decreased, 2-Decreased, 3-No change, 4-Increased, 5-Significantly increased)

NTFP change with altitude

The availability of NTFP has changed over the past few decades. 95.8 per cent of the respondents agreed that NTFPs have changed in occurrence. Below 1600 masl, 74 per cent of the respondents agreed that the increase in NTFPs while above 1600 masl, 69 per cent of the respondents reported the overall increase in the NTFPs. The fisher's test result showed that the availability of medicine, fuelwood, fodder, agricultural tools, weaving grass, bamboo, wild vegetables were significantly different with altitude (Table 2). In the higher altitudes; fuelwood, weaving grass, agricultural tools, fodder, wild vegetables and

wild fruits were reported to have increased, whereas bamboo, honey and medicines were reported to have decreased (Figure 4). Overall, the NTFPs were perceived to be increasing with increase in altitude. However, the accessibility of medicinal plants was found to decrease along the altitude gradient.

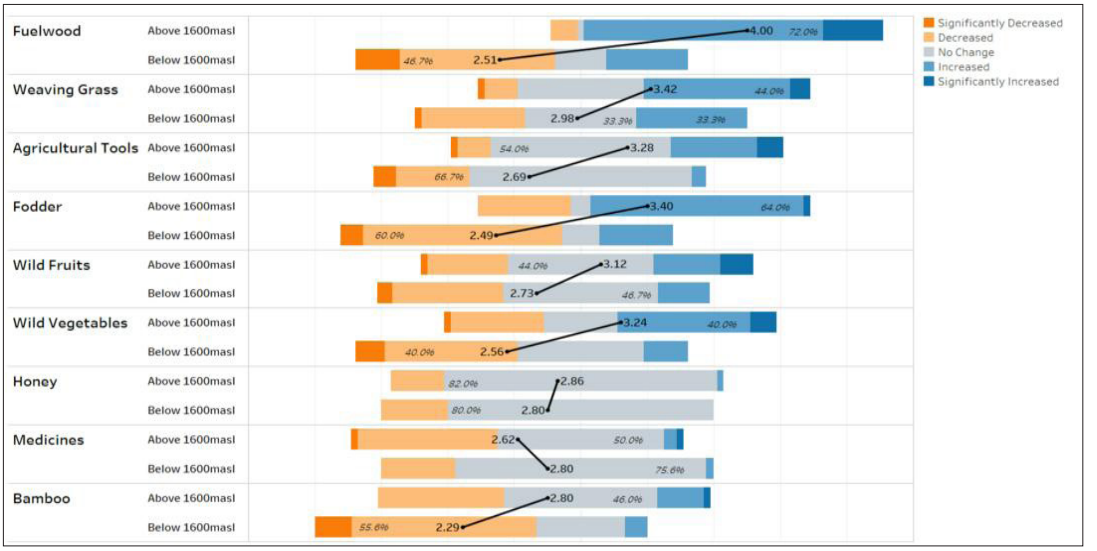

Figure 4: Perceived trends in the availability of major NTFPs above and below 1600 masl in the study area

Table 2: NTFPs trend against altitudinal gradient

NTFP Category against altitude	Fisher's test
Medicine and Altitude	0.04459 *
Fuelwood and Altitude	1.78E-10 ***
Fodder and Altitude	8.81E-05 ***
Agriculture Tools and Altitude	0.002555**
Weaving grass and Altitude	0.04305 *
Bamboo and Altitude	0.01126 *
Wild Vegetable and Altitude	0.003043 **
Wild Fruits and Altitude	0.1926
Honey and Altitude	0.8893

Cause of increase in NTFP availability

The major perceived reasons for the increase in NTFP above 1600 masl was decreasing livestock and harvest (69%) followed by decreasing population and family size (54%), increased awareness (40%) and reduced cultivation area (31%). Some respondents believed increment as a result of forest conservation policy (25%).On the contrary, decreasing livestock and harvest (20%) along with increased awareness, reduced cultivation area and forest conservation policy were perceived as the major contributors to the increase below 1600 masl (Figure 5).

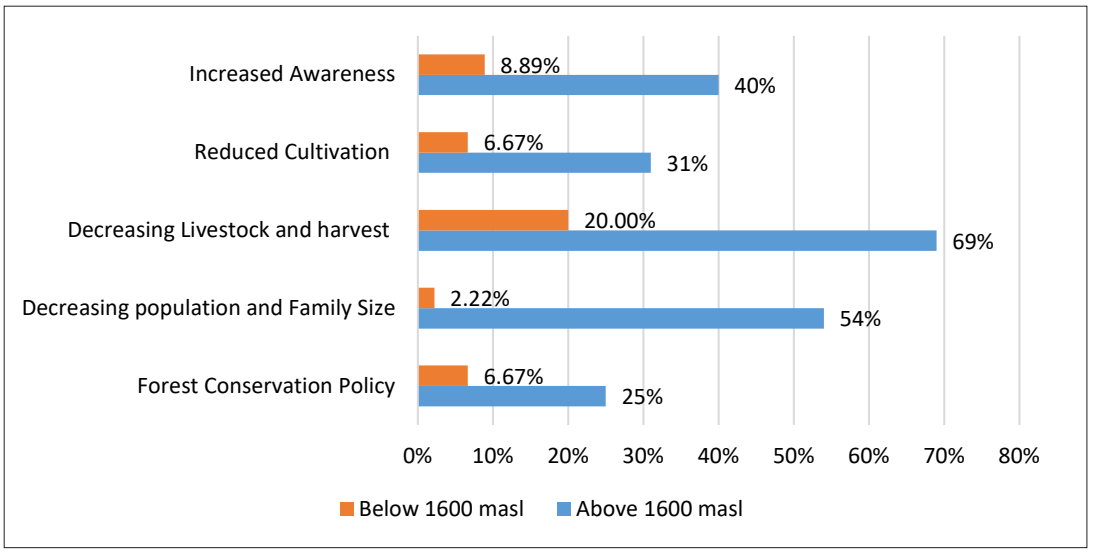

Figure 5: Comparison between perceived reasons for the increment in the NTFPs above and below 1600 masl

Cause of decrease in NTFP availability

The major perceived reasons for the decrease in NTFP above 1600 masl was over-exploitation (75%) followed by climate change (52%) and forest fire (36%). Some respondents believed decrement as a result of earthquakes (11%) and God's Action (16%). On the contrary, forest fire and over exploitation were perceived as the major contributors to the increase below 1600 masl (Figure 6).

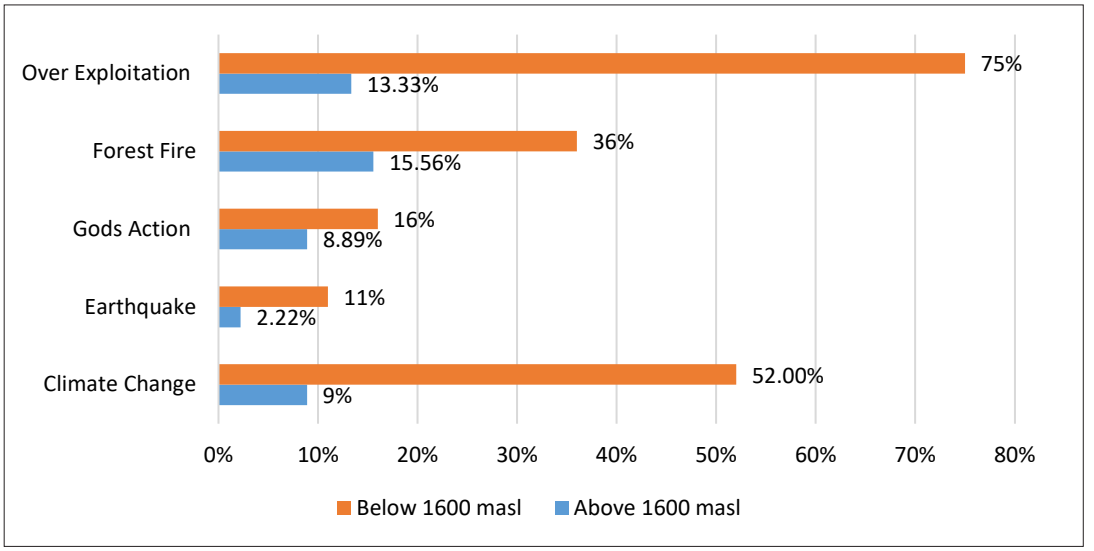

Figure 6: The comparison between perceived reasons for the decrement in the NTFPs above and below 1600 masl

Over exploitation impacts on NTFPs

Respondents agreed that fuelwood, followed by fodder, wild fruits, were the major NTFPs decreased as a consequence of the over-exploitation (Table 3). While weaving grass and bamboo were least affected by over exploitation, harvesting details of GCA in the fiscal year 2077/2078 BS showed that medicinal plants like black musli (*Curculigo orchioides*), pakhanbhed (*Bergenia ciliate*), sunpati (*Rhododendron antopogon*) and wild honey were found to be more than the permitted amount.

Table 3: Ranking of the availability of NTFPs due to over-exploitation impacts on the basis of local perception

Particulars	Mean SD	Rank
Fuelwood	2.39 ± 1.07	I
Fodder	2.46 ± 0.84	II
Wild Fruit	2.57 ± 0.63	III
Wild Vegetable	2.64 ± 0.78	IV
Honey	2.64 ± 0.49	V
Agricultural Tools	2.71 ± 0.854	VI
Medicines	2.86 ± 0.36	VII
Bamboo	2.86 ± 0.59	VIII
Weaving Grass	2.96 ± 0.74	IX

Note: Particulars indicate resources whose availability has decreased due to over-exploitation

Impacts of climate change and extreme events

Respondents identified an increase in forest fire, an increase in pest and insect attack, expansion of invasive plant species, strong wind events, changes in rainfall and temperature patterns, landslides and floods, and more frequent and severe winter drought as the major drivers reducing the availability of NTFPs. Most participants perceived that forest fire has impacted the provision of most NTFPs (Figure 7). A high proportion of respondents agreed that its impacts on fruit, vegetables, fodder, fuelwood, bamboo, honey and medicines had increased. Most participants also reported that an increase in landslide incidences had also impacted the provision of most NTFP including fuelwood, fodder, bamboo products, medicines, and fruit. The increased invasion and upward shift of alien species like banmara (*Ageratina adenophora*) was also reported. Increased insects and pest were also the reasons behind the decrease in NTFPs. Similar research reported the moth caterpillar locally called Ghyosipiti (*Gazalina chrysolopha* Kollar) as the major pest consuming leaves of trees especially *Alnus nepalensis, Rhododendron arboreum* and other fodder plants around regions. Bamboo was responded to decline heavily under- going the flowering process. Reduced hailstone and snowfall incidences were also reported.

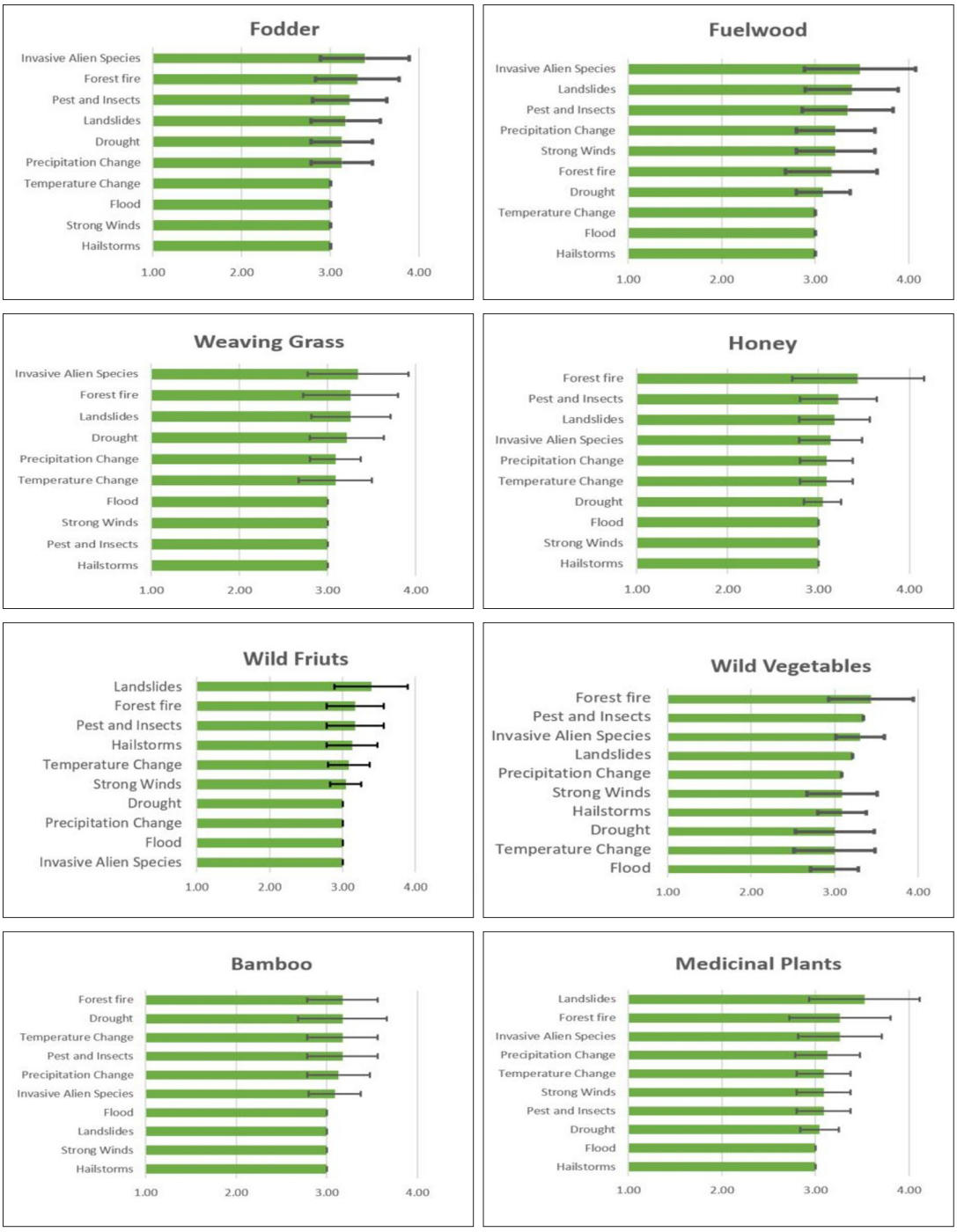

Figure 7: Perceived impacts of climate change on NTFPs (where 1-No impacts, 2-Low impacts, 3- Moderate impacts, 4-High impacts, 5-Very High impacts, and the error bars represent ± 1 standard deviation)

DISCUSSION

Our findings demonstrate a high subsistence dependence on NTFPs, with 100 per cent of households using forest-derived fodder and 99 per cent relying on fuelwood. This underscores a deeply rooted livelihood-forest linkage that is consistent with previous research across Nepal (Uprety *et al.* 2016; Sherpa 2025; Paneru 2024). For instance, Sherpa (2025) reported comparable fuelwood reliance in the Annapurna region, while Paneru (2024) highlighted a similar dependence on fodder in the mid-hills. Together, these patterns reaffirm the continued centrality of NTFPs to rural economies.

In contrast, lower usage rates of medicinal plants (42%) and wild honey (21%) may signal a decline in traditional ecological knowledge and reduced availability, likely driven by overharvesting and climate-induced ecological changes (Kunwar *et al.* 2013). Notably, some respondents reported increased availability of weaving grasses and wild vegetables, especially at higher elevations. While this trend may initially appear counterintuitive given national biodiversity concerns, it can be linked to socio-demographic shifts, specifically declining livestock numbers, shrinking household sizes, and abandoned farmlands. These findings are supported by our survey, which shows a 20 per cent drop in livestock and harvest. Such shifts mirror Nepal's broader agrarian transition, where rural outmigration and remittance-based economies are reshaping land use and labour allocation (Neupane and Poudel 2023). As traditional agricultural practices decline, forest dependence is being reconfigured in complex ways, with important implications for both livelihoods and forest management.

Further, our data reveal a nuanced altitudinal pattern in NTFP availability within the Gaurishankar Conservation Area (GCA). Respondents perceived greater species richness at higher elevations, but also reported declining accessibility, particularly of medicinal plants above 1600 masl. These observations align with prior studies from the Himalayan region, where elevation and human accessibility jointly influence NTFP distribution, harvestability, and the intensity of ecological pressures (Kala 2005; Kunwar *et al.* 2013).

The apparent paradox of increased species diversity but decreased availability of medicinal plants can be explained by a combination of ecological and anthropogenic pressures. Chief among these is overexploitation, cited by 75 per cent of respondents as a primary driver of resource decline. This corroborates previous findings that attribute the unsustainable extraction of high-value species, such as *Curculigo orchioides* (black musli), *Bergenia ciliata* (pakhanbhed), and *Rhododendron anthopogon* (sunpati), to weak regulation, open-access systems, and high market demand (Kunwar *et al.* 2013). These community concerns are validated by GCA's official harvest records (FY 2077/2078 BS), which shows that the collection of key medicinal and aromatic plants exceeded sanctioned quotas. Such overharvesting highlights persistent gaps in enforcement, monitoring, and compliance, especially in protected areas where conservation mandates are often misaligned with local livelihood needs (Shrestha and Bawa 2013; Kunwar *et al.* 2016).

The commercialisation of wild honey and alpine herbs has further intensified harvesting pressure, typically without corresponding investments in sustainable harvesting practices or habitat restoration (Subedi *et al.* 2013). In such contexts, ecological thresholds may be breached, endangering the long-term sustainability of these forest resources.

Climate change was another widely reported factor, cited by 52 per cent of respondents as adversely affecting NTFP availability. Community members observed changes

in rainfall patterns, rising temperatures, winter droughts, and increased incidence of extreme events such as landslides and strong winds. These perceptions are supported by scientific literature showing that climate change is altering the phenology, geographic distribution, and productivity of alpine species across the Central Himalaya (Shrestha *et al.* 2012; Xu *et al.* 2009). The intersection of climatic and human-induced pressures places significant stress on both species and ecosystems, necessitating urgent adaptive responses.

An additional concern emerging from community observations is the proliferation of invasive alien plant species (IAPs) and the rise in pest outbreaks. Invasive species such as *Ageratina adenophora* and *Lantana camara* are known to displace native flora, reducing NTFP availability and compromising ecosystem integrity (Merow *et al.* 2017; Shrestha *et al.* 2019). Communities attributed declines in certain NTFPs due to the rapid spread of these IAPs. Furthermore, the rise in pest outbreaks presents another layer of stress to native ecosystems, potentially weakening plant health and regeneration capacity. These dual threats highlight the urgent need for comprehensive monitoring and management strategies that address both biological invasions and forest health.

Together, these findings underscore the multifactorial nature of threats to NTFP sustainability in the region. Biophysical drivers such as climate extremes, pests, and landslides interact with anthropogenic stressors like overharvesting, fire, and invasive species spread to create complex and dynamic pressures on forest ecosystems. Addressing these challenges requires integrated forest management approaches that balance conservation and livelihood objectives. Key strategies should include regulatory reforms, sustainable harvesting practices, community engagement, and ecosystem restoration.

Lastly, the study reinforces the importance of local ecological knowledge (LEK) in conservation planning. Respondents insights provided valuable early warning signals of ecological change, which can inform adaptive co-management and enhance resilience. When supported by participatory monitoring and validated through scientific research, LEK can serve as a cornerstone for inclusive and context-specific forest governance (Berkes 2009; Uprety *et al.* 2012).

CONCLUSION

This study showcases the enduring and evolving dependence of rural households on NTFPs, with common dependence on fuelwood and fodder, thereby highlighting the critical role of forest resources in sustaining subsistence livelihoods. However, observed declines in medicinal plants and wild honey, along with increased reports of invasive species and pest outbreaks, indicate emerging ecological and socio-economic pressures. Variations in NTFP availability at different altitudes, driven by both environmental factors and access issues, further complicate sustainable resource management in mountainous protected areas like the Gaurishankar Conservation Area.

Our findings emphasise the urgent need to shift NTFP management toward integrated and adaptable strategies. We recommend: (1) strengthening community-based monitoring systems that leverage local ecological knowledge; (2) promoting sustainable harvesting practices and market regulation for high-demand species; (3) expanding restoration efforts focused on degraded habitats and areas overtaken by invasive species; and (4) improving climate-resilient forest management through localised adaptation planning. In particular, formal recognition and integration of local knowledge into policy and practice can improve responsiveness to ecological changes and support more effective and fair NTFP management. Without such

comprehensive actions, the combined effects of overharvesting, land-use changes, climate change, and invasive species could irreparably damage the ecological integrity and resource base that forest-dependent communities rely on. Sustainable NTFP management is therefore not only essential for conservation but also a socio-economic necessity for mountain livelihoods.

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