BILINGUAL PUBLISHING GROUP

Journal of Environmental & Earth Sciences

https://journals.bilpubgroup.com/index.php/jees

ARTICLE

Examining Resource Dependency and Socioeconomic Disparities: A Case Study of Sustaining Rural Livelihoods in India

Preeti Jakhwal [1] **, *Himanshu Sahu*** [2,3] **, *Aman Srivastava*** [4] **, *Arun Pratap Mishra*** [5*] **, *Amit Kumar*** [6] **, *Kiran Rawat*** [1] **, *Mriganka Shekhar Sarkar*** [7] **, *Sachin Sharma*** [8] **, *Upaka Rathnayake*** [9*]

[1] *School of Environment and Natural Resources, Doon University, Dehradun 248001, India*

[2] *Department of Animal Ecology and Biology Conservation, Wildlife Institute of India, Dehradun 248001, India*

[3] *Research and Development, Bhomya Foundation, Dehradun 248001, India*

[4] *Independent Environmental Researcher, Mumbai 400076, India*

[5] *Department of Forestry and Remote Sensing, Earthtree Data Services, Private Limited, Shillong 793006, India*

[6] *Department of Habitat Ecology, Wildlife Institute of India, Dehradun 248001, India*

[7] *North-East Regional Centre, G.B. Pant National Institute of Himalayan Environment (GBPNIHE), Itanagar 791113, India*

[8] *Department of Forest Ecology and Climate Change, Arid Forest Research Institute, Jodhpur 342005, India*

[9] *Department of Civil Engineering and Construction, Faculty of Engineering and Design, Atlantic Technological University, F91 YW50 Sligo, Ireland*

ABSTRACT

Rural communities in developing countries often struggle with resource dependency, economic challenges, and poor infrastructure, and villages in Uttarakhand, India, are no exception. This study aims to examine the socioeconomic factors influencing forest conservation, assess livelihood dependency on forest resources, and evaluate how socioeconomic status shapes sustainable forest management in Shishambara and Buddhi villages in Dehradun. The study employed purposive and random sampling covering 10% of households, using structured surveys, interviews, field observations, market surveys,

*CORRESPONDING AUTHOR:

Arun Pratap Mishra, Department of Forestry and Remote Sensing, Earthtree Data Services, Private Limited, Shillong 793006, India; Email: arunpratap7371@gmail.com; Upaka Rathnayake, Department of Civil Engineering and Construction, Faculty of Engineering and Design, Atlantic Technological University, F91 YW50 Sligo Ireland; Email: upaka.rathnayake@atu.ie

ARTICLE INFO

Received: 25 August 2025 | Revised: 22 September 2025 | Accepted: 25 September 2025 | Published Online: 14 October 2025

DOI: https://doi.org/10.30564/jees.v7i10.11802

CITATION

Jakhwal, P., Rawat, K., Sahu, H., et al., 2026. Examining Resource Dependency and Socioeconomic Disparities: A Case Study of Sustaining Rural Livelihoods in India. Journal of Environmental & Earth Sciences. 7(10): 23–45. DOI: https://doi.org/10.30564/jees.v7i10.11802

and focus group discussions. The survey reveals an agriculture-dominated livelihood, engaging 60% in Buddhi and 65% in Shishambara, alongside private-sector jobs and daily wage labour. Literacy rates differ significantly, with Buddhi at 72% and Shishambara at 58%. Despite accessibility to LPG connections, traditional cooking fuels like fuelwood and cow dung remain predominant, utilized by 70% of households in Buddhi and 75% in Shishambara. Most homes are Pakka, yet only 18.8% in Buddhi and 22% in Shishambara have toilets. Public transport is scarce, leaving villagers reliant on private vehicles. These findings underscore the need for policies that address resource management, improve basic services, and support sustainable development, offering a road map for uplifting rural livelihoods and bridging infrastructure gaps.
Keywords: Agricultural Dependency; Forest Dependency; Health and Hygiene; Rural Livelihoods; Sustainable Development; Socioeconomic Status

1. Introduction

In recent years, India has experienced a substantial increase in population growth[1]. The conduction of socioeconomic surveys has emerged as a pivotal source for obtaining statistical insights into household expenditures, income, housing conditions, and individual and household characteristics[2,3]. The intricate relationship between humanity and forest resources has garnered significant attention due to the multitude of benefits they provide[4]. Approximately 1.6 billion people globally rely on forests for their livelihoods[5,6], underscoring the profound ecological and economic significance of these ecosystems[7]. Tropical forests, renowned for their exceptional biodiversity[8], sustain around 350 million people residing in and around forested areas, where their livelihoods are intricately linked to income and subsistence[9]. Despite their vital role, forests face persistent threats from various correlated factors, including forestry operations, agricultural expansion, and infrastructural development[10,11]. According to Basu & Nayak[12], effective management of forests in tropical regions remains a critical and challenging issue, especially for rural communities in developing countries such as India, which are mainly dependent on forest resources for their livelihood[13].

In India, the socioeconomic challenges experienced by rural communities are multifaceted, due to poverty and limited access to education, healthcare, and infrastructure[14,15]. These challenges result in excessive dependency on natural resources, mainly on the fringe of forests that are critical sources for impoverished households[16]. The material goods and non-timber forest products (NTFPs) obtained from forests contribute to the locals' food security, medicinal needs, and income generation[17]. Notably, the dependency on forest resources is exceptionally high in regions such as Uttarakhand, where economic opportunities are scarce and geographical factors often compromise agricultural productivity. This dependency creates a complex dynamic where the economic survival of rural communities is intricately linked to the health of forest ecosystems[18]. It is crucial to understand these dynamics in order to develop policies and interventions that address conservation goals and forest-dependent communities' socioeconomic well-being.

The relationship between forests and livelihoods highlights the essential role of forests in subsistence living by alleviating poverty through resource provisioning[19]. Forest dependency varies across communities based on location and historical context, influencing how forests are utilized for sustenance[20]. The socioeconomic impact of rural households' reliance on forests has garnered attention in developing economies[21]. According to Sarmah & Arunanchalam[22], forests hold diverse use values encompassing consumptive, economic, recreational, environmental, cultural, and spiritual aspects, reflecting the varied interests of rural households. In the context of India, the ecological dynamics of forests are closely intertwined with the livelihoods of communities residing in and around these ecosystems[23]. The attitudes and patterns of forest resource extraction vary among diverse communities, contributing to the complexity of forest management[13]. At local and national levels, forests significantly contribute to the economy, representing 46% of the total, followed by regional crop and fruit production[24,25]. Over 40% of the impoverished population in rural villages surrounded by forests relies on these ecosystems for their livelihoods[23]. While

forests provide resources such as wood, farmlands, medicinal plants, and hunting grounds, they also offer societal and recreational benefits[26–28]. However, this reliance poses a challenge to the fundamental objectives of forest conservation, potentially leading to deforestation, forest degradation, and biodiversity loss[29]. Previous studies predominantly focused on household dependency on forest resources for income and rural livelihoods, with limited attention to the socioeconomic factors influencing forest conservation.

Population growth, poverty, and limited access to basic services in rural India have intensified community dependency on forests for livelihoods, creating pressure on already threatened ecosystems. Despite forests' critical role in subsistence, income generation, and ecological balance, limited research has examined how socioeconomic factors influence conservation practices. Therefore, this study seeks to bridge this gap by analyzing the interplay between forest dependency and socioeconomic dynamics in Uttarakhand villages to inform sustainable forest management. The study addresses this gap by investigating (i) The socioeconomic factors that influence forest conservation efforts in *Shishambara* and *Buddhi* Village of Dehradun, (ii) Assessing the level of dependency on forest resources for income and livelihoods among the residents of both villages and (iii) Evaluate the relationship between socioeconomic status and forest resource utilization in shaping sustainable forest management practices in these communities. The findings will also contribute to the intricate relationship between communities and forests, aiding decision-makers and forest managers in improving the socioeconomic well-being of the village while promoting sustainable forest management.

Furthermore, this study also seeks to draw inferences from the collected data to propose viable pathways for balancing forest dependency with sustainable development. By examining the socioeconomic dynamics and their impact on forest resource utilization, the study additionally aimed to provide a framework for policymakers to implement strategies that reduce unsustainable dependency while improving livelihood options for rural communities. Findings from this research will help inform approaches that strengthen rural economies through diversified income sources, improve infrastructure, and promote community engagement in forest conservation.

2. Materials and Methods

2.1. Study Area

Uttarakhand covers a total area of 53,483 km^2, with Dehradun spanning 3,088 km^2. The current study was conducted in *Shishambara* and *Buddhi* villages in Uttarakhand, India (refer to **Figure 1**). *Shishambara*, located in the Vikas Nagar tehsil, lies 20 km from the district headquarters in Dehradun and the sub-district headquarters in Vikas Nagar. The village is the gram panchayat of *Shishambara*, covering a land area of 1,650.29 hectares. *Buddhi* village, situated approximately 18 km from the Clock Tower on the Shimla Bypass Road, is known for the Manak Sidh Temple, a significant cultural and religious landmark. The cultural practices of these villages, including the celebration of Budhi Diwali, highlight the community's unique traditions and culture. The geographical location, surrounded by verdant forests and hills, plays an important role in shaping the livelihoods of the local inhabitants.

2.2. Research Design and Rationale

This study employed a social survey research methodology to understand the dependency patterns of local communities on forest resources in the villages of *Shishambara* and *Buddhi* (refer to **Figure 2**). The research design was exploratory and descriptive. It aimed to uncover the socioeconomic factors driving resource utilization and the impact of local or traditional practices on forest conservation. To comprehensively understand the interplay between socioeconomic status and forest dependency, household surveys, field-based observations, key informant interviews (KII), market surveys, and focus group discussions (FGD) were conducted.

2.3. Sampling Strategy

A purposive sampling strategy was employed to select households and participants for interviews and discussions. The sample included 10% of the total population in both villages, encompassing 55 families in *Shishambara* and 45 families in *Buddhi*. The sampling criteria ensured representation across various socio-economic backgrounds and family sizes. This approach aimed to capture the diversity of experiences and dependencies on forest resources within the communities.

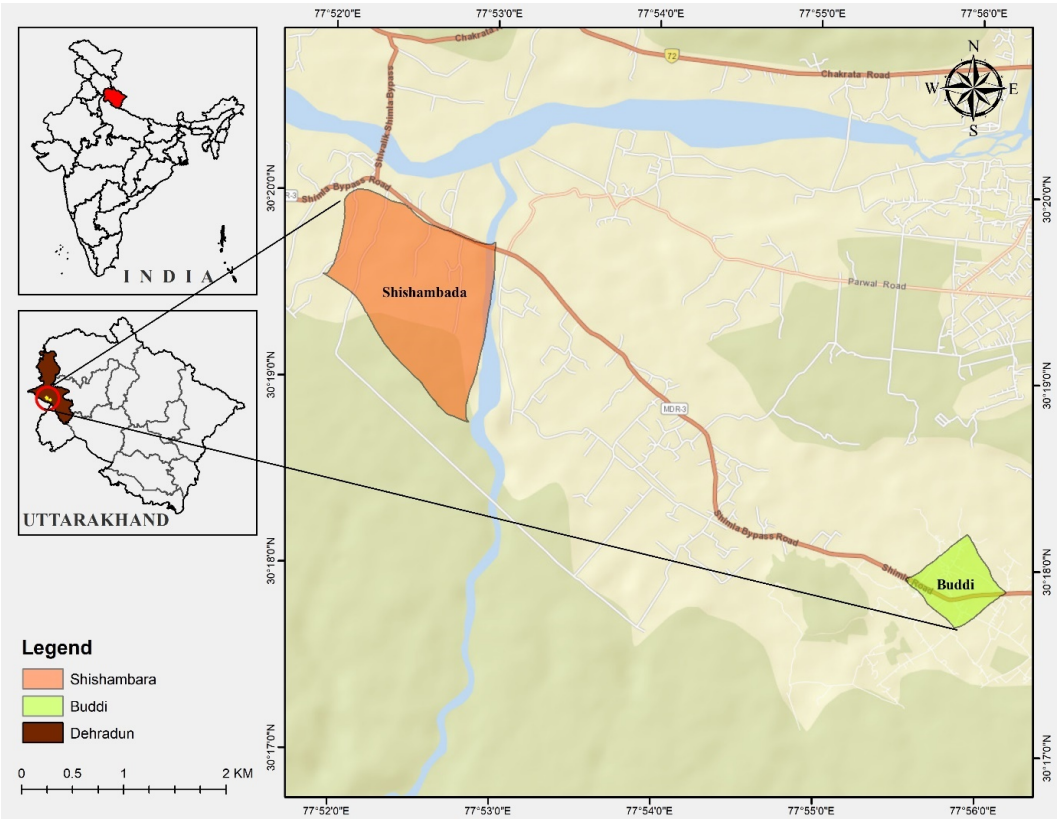

Figure 1. Study area depicting the surveyed villages in Uttarakhand, India.

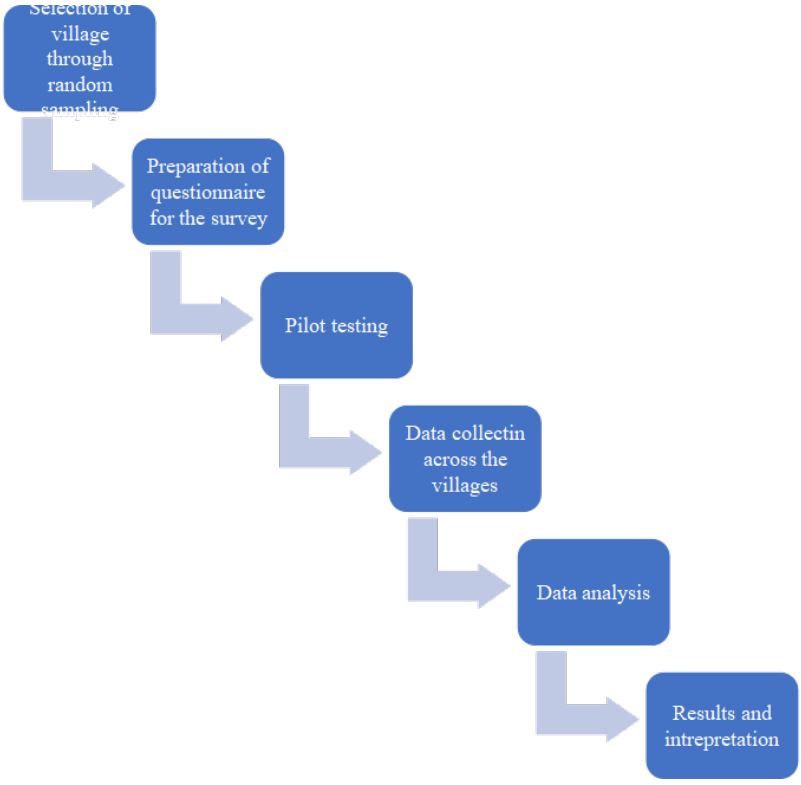

Figure 2. Methodological framework for assessing the study area's socioeconomic status and resource dependency.

2.4. Survey-Based Data Collection Methods

A structured questionnaire survey was conducted using random sampling to gather data from the selected households. To minimize bias and enhance the reliability of the data collected, the method ensured that each household within the identified 10% sample population had an equal opportunity to be selected during the survey. Detailed information on the socio-economic backgrounds of the household, its size, and its dependency on forest resources was included in the questionnaire. The survey also included key aspects such as the types and extent of forest resource use, the frequency of use, and the economic activities linked to these resources. This approach allowed for collecting systematic quantitative data and the gaining qualitative insights using open-ended questions. Thus, using a questionnaire-based survey, we could standardize the responses received from the respondents, making it easier to compare data across both villages and analyze trends related to forest dependency across different socio-economic groups.

2.4.1. Household Surveys

Primary information was collected using standardized questionnaires administered to the selected households. This approach helped gather information on socio-economic parameters, including economic status, housing types, education, health, agricultural production, livestock, population status, income, literacy, land holdings, employment, and non-timber forest products (NTFPs).

2.4.2. Field Observations

Direct field observations were carried out to corroborate the information obtained from surveys and interviews. Observations focused on daily practices related to fuelwood and fodder collection, agricultural activities, and the use of forest resources.

2.4.3. Key Informant Interviews (KII)

In order to gain deeper insights into the dependency of locals on forest resources, key informant interviews with village heads, ward members, and specific households were conducted. Information on the village's history, culture, and socio-economic dynamics was also gathered.

2.4.4. Market Surveys

Market surveys were conducted to assess the economic value of forest products and their contribution to household income. The field surveys and observations also included information on fuelwood and fodder use, demand, supply chains, and other NTFPs within the local markets.

2.4.5. Focus Group Discussions (FGD)

Focus group discussions were also conducted with the local inhabitants to understand collective views on forest resource use and their conservation significance. FGDs were particularly useful in understanding the communal norms, challenges, and strategies related to forest dependency.

2.5. Data Analysis

The data analysis for this study employed a combination of qualitative and quantitative methods to examine the socioeconomic factors influencing forest resource use and conservation in *Shishambara* and *Buddhi* Village. Quantitative data collected through household surveys were analyzed using Microsoft Excel and SPSS, where descriptive statistics such as percentages, means, and medians were calculated to summarize key socioeconomic variables, including household income, education levels, and forest dependency. The results were visually represented through graphs, charts, and radar diagrams, offering insights into key trends. This approach provided a straightforward yet effective means of identifying patterns in the data. For the qualitative analysis, information gathered from individual interviews, FGDs, and field observations was examined using thematic analysis, considering the recurring patterns, forest dependency, and conservation practices.

3. Results

3.1. Forest Dependency and Socioeconomic Status

Based on the questionnaire survey and field observations, the present study observed that the residents of *Shishambara* and *Buddhi* villages heavily depend on forest resources for their daily needs, *including* fuelwood, fodder, medicinal plants, and non-timber forest products (NTFPs). In Shisambara, common species utilized for fuelwood include Sal (*Shorea robusta*), Chir Pine (*Pinus roxburghii*), Kachnar (*Bauhinia variegata*), Khirni (*Manilkara hexandra*), to name a few. Similarly, *Buddhi* village residents mainly rely on

Sal (*Shorea robusta*), Jamun (*Syzygium cumini*), Bamboo (*Bambusa sp.*), and Haldu (*Adina cordifolia*). *Shishambara* villagers frequently use Kharik (Celtis australis) and Bhimal (Grewia optiva) for fodder collection. In contrast, residents of *Buddhi* collect fodder from species such as Sal (*Shorea robusta*), Sissoo (*Dalbergia sissoo*), Bamboo (*Bambusa* sp.), and Amaltas (*Cassia fistula*). NTFPs also play a vital role in the socioeconomic framework of these villages. In *Shishambara*, notable NTFPs include Amla (*Phyllanthus emblica*), Harad (*Terminalia chebula*), and wild honey. *Buddhi* village residents gather Amla (*Phyllanthus emblica*), bamboo shoots (*Bambusa sp.*), and neem leaves (*Azadirachta indica*), contributing to household use and supplemental income. Thus, it is revealed that the residents of both the villages surrounded by forests typically rely exclusively on forest resources for their subsistence. Predominantly, individuals utilize firewood for cooking and heating, even in cases where access to gas is available. Livestock rearing, involving various animals such as cows, buffaloes, and goats, forms another vital aspect of this category. The sustenance of these animals is intricately linked to forests, as they derive their food from the grasses and leaves of significant forest trees.

3.1.1. Social Status

Shishambara village comprises 523 households, of which 53 households (10% of the total) were surveyed in this study, whereas *Buddhi* village comprises 445 households, and 44 (10%) were surveyed. *Buddhi* exhibits a higher educational attainment level, with an overall literacy rate of 82.46% compared to 78.02% in *Shishambara*. Male literacy rates stand at 89.74% in *Buddhi* versus 86.45% in *Shishambara*, while female literacy rates are 73.40% in *Buddhi* and 66.94% in *Shishambara*, highlighting educational disparities between the two communities (refer to **Figure 3**).

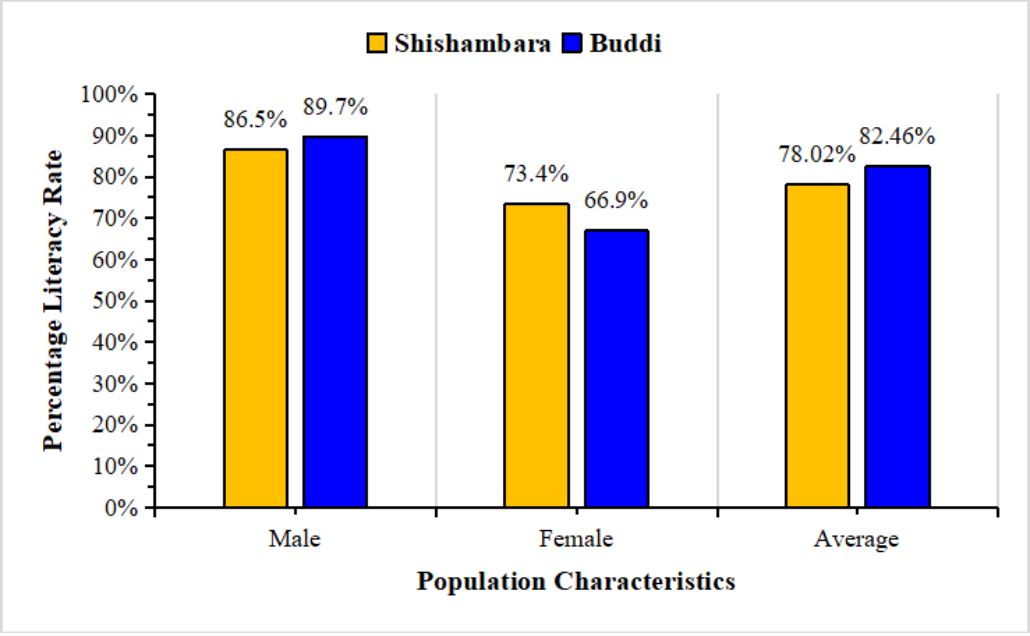

Figure 3. Village-wise literacy rate information for males and females in the total population.

3.1.2. Settlement Morphology and Infrastructure

The study identified three predominant house types, namely, *Pakka* (*Concrete*), *Kutcha* (*Mud*), and *Semi-Pakka* (*Semi-concrete*) (refer to **Figure 4**). In *Shishambara*, 86.79% of residents live in *Pakka* houses, while 3.77% reside in *Kutcha* houses and 9.43% in *Semi-Pakka* houses. In *Buddhi*, 90.91% of the population stays in *Pakka* houses, and 9.09% live in *Semi-Pakka* houses. No Kutcha houses were observed in *Buddhi*. The average daily electricity consumption ranges between 400–420 units in summer and 230–250 units in winter. Interestingly, many households still rely on firewood and cow dung for cooking despite the availability of LPG connections under the Pradhan Mantri Ujjwala Yojana. Furthermore, insufficient drainage systems contribute to health hazards, necessitating improved infrastructure and healthcare services.

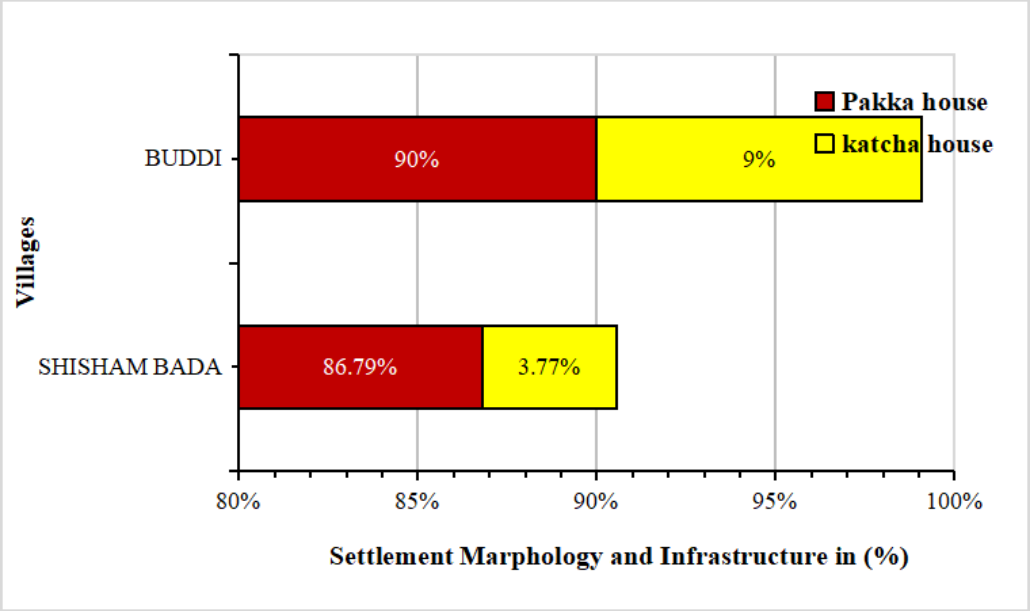

Figure 4. Representation of settlement morphology and infrastructure.

3.1.3. Livelihood Practices and Livestock Management

Livestock rearing is critical for income and agricultural support in both villages. Approximately 55.11% of the surveyed population uses cow rearing for milk production. The diet of these cows broadly includes forest tree leaves from species such as *Shorea robusta*, *Terminalia anogeissiana*, and *Morus alba*, alongside grass sourced from fields or nearby forests. Notably, 14.20% of households rear buffaloes, 9.09% rear bulls, 8.52% engage in poultry farming, and 13.06% rear goats. In *Shishambara*, cow rearing constitutes 61.01%, buffalo rearing 15.25%, bull rearing 8.47%, poultry farming 6.77%, and goat rearing 8.4% (refer to **Figure 5**). Many villagers primarily depend on agriculture and private sector jobs for income, with agricultural activities aimed at self-sufficiency. A smaller proportion engages in daily wage activities, such as labor and fruit or vegetable vending, illustrating the complex interplay between agriculture, livestock management, and supplemental income sources within the communities.

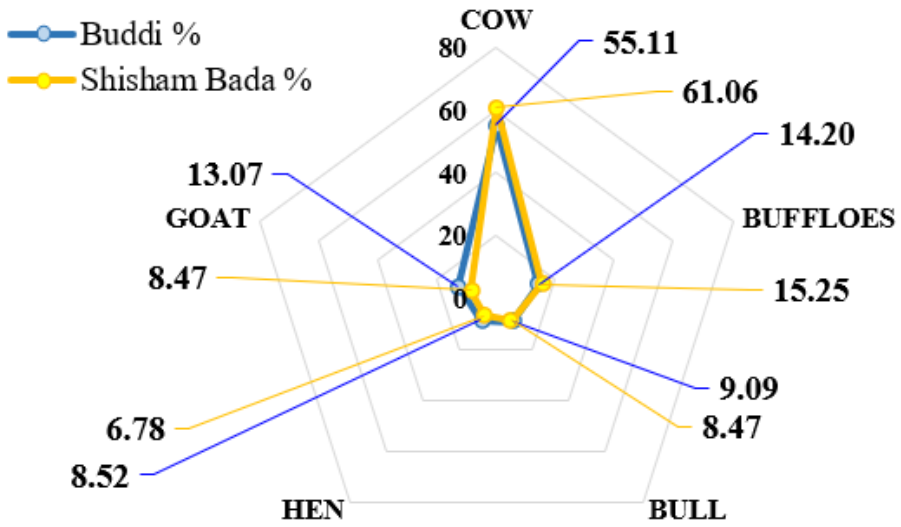

Figure 5. Livestock management in the studied villages.

3.1.4. Occupational Structure

An in-depth examination of the occupational structure in both *Shishambara* and *Buddhi* villages revealed noteworthy insights into the distribution of livelihoods. In *Shishambara*, approximately 10% of the population is employed in government jobs, while 43.3% are engaged in private-sector employment. A significant portion, constituting 34.2%, is involved in various agricultural activities, and the remaining 12.3% is distributed across diverse occupational categories. In *Buddhi* village, the occupational distribution differs slightly, with 7.5% of the populace holding government jobs and a larger proportion, 49.95%, engaged in private sector employment. Furthermore, 29.9% of the population is involved in agricultural occupations, and the remaining 13.1% is allocated to other diverse employment sectors (refer to **Figure 6**). This nuanced analysis provides a comprehensive understanding of the varied economic activities that contribute to the livelihoods of individuals in both villages, demonstrating the diversity and distribution of occupations within these rural settings.

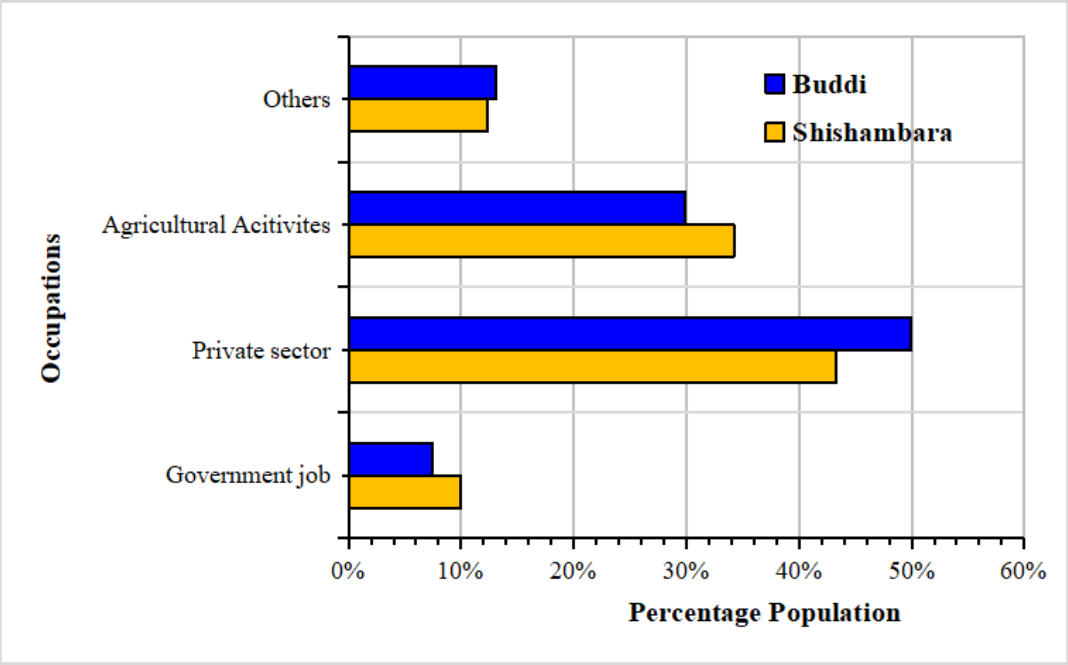

Figure 6. Demonstrated the occupational structure of the villages.

3.1.5. Worker Demography

Examining the worker profile in *Shishambara* and *Buddhi* villages has revealed distinctive patterns regarding primary and marginal workers. In *Shishambara*, 2.50% of the workforce constitutes primary workers, while a predominant 97.50% falls under the category of marginal workers. In *Buddhi* village, the distribution differs slightly, with 8.42% identified as primary workers and 91.58% categorized as marginal workers (refer to **Figure 7**).

Further delving into the specifics, in *Shishambara*, the total worker population is 120 (94 males, 26 females). Main workers account for 117 individuals (91 males, 26 females), while marginal workers number 3 (3 males, 0 females). *Buddhi* village's total worker population is 107 (83 males, 24 females). Among them, 98 are primary workers (76 males, 22 females), while marginal workers constitute nine individuals (7 males, 2 females) (refer to **Figure 8**). This delineation provides a nuanced understanding of the occupational distribution and highlights the prevalence of marginal workers, shedding light on the workforce dynamics in these rural settings.

3.1.6. Agricultural Overview

The agricultural landscape in both *Shishambara* and *Buddhi* villages primarily revolves around cultivating key crops and vegetables. Notably, field crops such as paddy, wheat, and sugarcane dominate the agricultural practices in these regions. *Shishambara*, boasting substantial agricultural land, relies significantly on the crops and vegetables cultivated within its bounds. Residents actively cultivate and sell vegetables, often bringing their produce to the mar-

ket for sale. In *Shishambara*, diverse sources of irrigation contribute to agricultural productivity, with 10% relying on tubewells, 45% on canals, and 30% on tanks, supplemented at times by tap water. Conversely, in *Buddhi* village, the predominant sources of irrigation are canals and tubewells. The mechanization of plowing processes is evident in both villages, primarily through hiring tractors, while using bullocks for plowing remains a rare occurrence. The range of vegetables cultivated includes soybean, Gahat dal, urad dal, and kidney beans, with the sowing period spanning from June to July, while kidney beans are sown explicitly from July to August. Harvesting typically takes place from October to November. This agricultural profile underscores the significance of crop diversity and local practices, providing valuable insights into the agrarian dynamics that sustain the livelihoods of *Shishambara* and *Buddhi* communities.

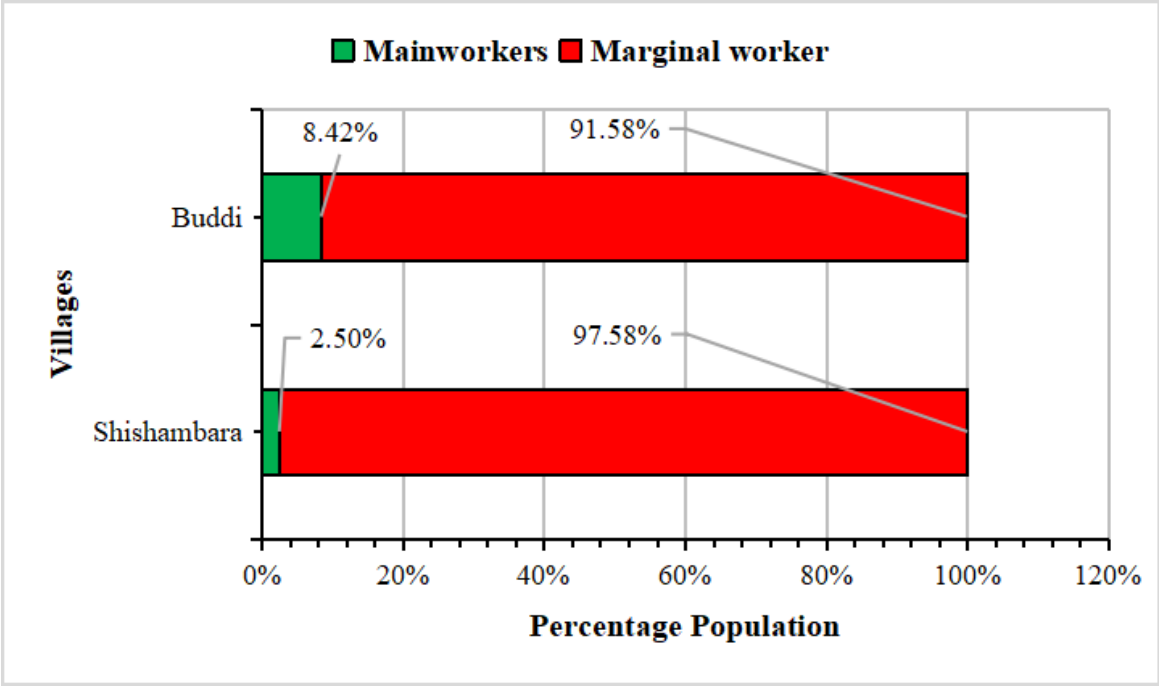

Figure 7. Demonstrated the worker demographics of villages.

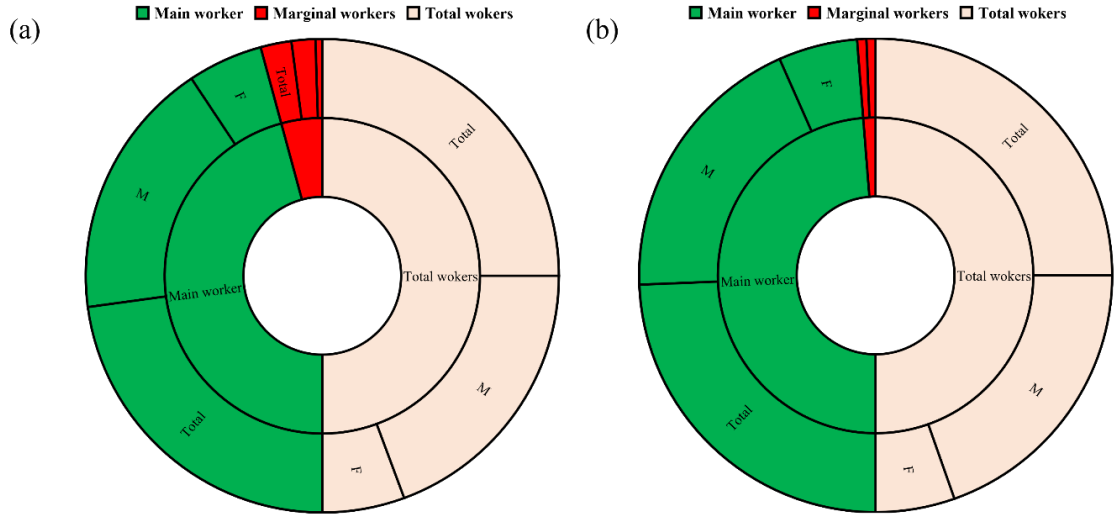

Figure 8. Representation of village workers' profiles (M indicates Male; F indicates Female) (**a**) *Buddhi* village and (**b**) *Shishambada* village.

3.1.7. Forest Composition and Village Dependency

The Malhan range forest, prevalent in the surveyed villages, is characterized by a dominance of broadleaf species, including Sal, Teak, Shisham, Khair, Kanak Champa, and others. This forest ecosystem is a crucial resource for the local population. It plays a pivotal role in meeting their energy needs, providing biodiversity, and delivering essential environmental benefits such as soil protection and water regulation. In the examined villages, the forest is primarily utilized to fulfill household requirements, focusing on collecting wood resources, including timber, fuelwood, and tree branches. Timber and tree branch collection typically involves male members of families, and the harvested timber finds application in rural construction. Fuelwood, a cornerstone for heating and cooking, represents a significant portion of the village's energy consumption. While forest administrators officially sell a small quantity of fuelwood, the majority is directly collected from the forest, often supplemented by agricultural residues. Fuelwood consumption is substantial, with the average daily consumption ranging from 520–540 kg/day in *Buddhi* and 672 kg/day in *Shishambara*. Villagers predominantly utilize wood types such as Sal, Kikkar, and Mango, along with dry leaves and grasses. Notably, honey collection emerges as a noteworthy non-timber forest product (NTFP), albeit on a small scale. Male members of households engage in honey collection, with a mature bee hive yielding up to 10 kg of honey, valued at approximately 500 per kg in the market. Beyond fuelwood and honey, fodder collection is also prevalent, primarily sourced from nearby forests. Fodder trees and grasses in the forest contribute significantly to the livestock's dietary needs. An observed trend indicates that as household income decreases, there is a corresponding increase in dependency on forest resources. This intricate relationship between villages and their forest ecosystems highlights forests' multifaceted role in sustaining livelihoods and environmental equilibrium.

3.1.8. Wood Collection Practices from Forest Sources

Procuring wood resources from forested areas significantly contributes to the energy needs of the villages under study. In *Shishambara*, villagers collect approximately 17–21 kg/day of wood for fuelwood consumption. Similarly, in *Buddhi*, the daily wood collection averages around 15–20 kg/day. Typically, the head of the family assumes the responsibility of venturing into the forest to gather these essential resources. *Shishambara* is situated near the forest, with an average distance of merely 1 km, facilitating convenient access for wood collection.

In contrast, in *Buddhi* village, the distance extends to approximately 3–4 km from the settlement to the forested area. The geographical proximity of residences to the forest is crucial in influencing wood collection practices, with many households residing near these natural resources. Wood collection primarily involves gathering fallen trees from the forest floor. However, villagers resort to felling standing trees for wood procurement when fallen trees are unavailable. This practice underscores the integral role of forests in meeting the daily energy needs of the villages, as well as the sustainable utilization of wood resources for fuelwood consumption.

3.1.9. Fodder Consumption and Agricultural Challenges

Shishambara and *Buddhi* witness variable fodder consumption patterns, ranging from 6–20 kg/day/cattle head in winter and 8–22 kg/day/cattle head in the summer season. The locals employ green and dry fodder for their livestock, with a heightened dependence on dry fodder during winter due to the shortage of green fodder. The quantity of fodder utilized also depends on the family's economic status. Notably, green fodder includes leaves from Sal (*Shorea robusta*) and Mulberry (*Morus alba*) trees, various types of grass, and crops such as Berseem (*Trifolium alexandrinum*), Dhurva grass (*Cynodon dactylon*), Chari (*Sorghum bicolor*), and Makka (*Zea maize*), etc.

Farmers in *Shishambara* and *Buddhi* encounter challenges related to crop damage, primarily attributed to wildlife interference. Notably, rhesus macaques, wild boars, and blue bulls emerge as major contributors, with monkeys and wild boars alone accounting for 70–80% of total crop damage in the surveyed villages. Avian species, including Rock pigeons, House sparrows, Crows, and Parakeets, pose significant threats to fruit and agricultural crops. In response to these challenges, villagers employ crop protection techniques such as scarecrows and agrarian fencing, underscoring the complex interplay between farming practices and wildlife interactions in these rural settings.

3.1.10. Utilization of Medicinal Plants by Villagers

The forested landscapes surrounding the villages of *Shishambara* and *Buddhi* host a rich diversity of medicinal plants, which play a vital role in traditional healthcare (refer to **Table 1**). Among these, *Justicia adhatoda* (Vasa), from the Acanthaceae family, is commonly used to treat colds, coughs, and asthma, with its leaves, roots, and flowers being the most utilized. Singh and Huidrom[30] highlighted its use in the Meitei community, where the plant's leaves are employed as traditional medicine to treat ailments such as cough, fever, asthma, and dysentery. Similarly, *Ficus palmata* (Bedu) from the Moraceae family, using its fruits, leaves, and bark, helps address issues of indigestion and dysentery. Joshi et al.[31] studied its application in gastrointestinal disorders, hypoglycemia, tumors, ulcers, diabetes, hyperlipidemia, and fungal infections, with the plant's stem latex traditionally applied to remove spines lodged in flesh.

Aegle marmelos (Beal) from the Rutaceae family is employed to treat digestive disorders, fever, and cold, with various ethnic communities utilizing its fruits, leaves, and bark for health benefits. Dutta et al.[32] documented the use of *Aegle marmelos* among the ethnic communities of Jharkhand, emphasizing its value in alleviating malnutrition and other severe health conditions. *Azadirachta indica* (Neem) from the Meliaceae family is widely recognized for treating skin diseases, toothaches, and diabetes, utilizing its leaves, flowers, and seeds.

Calotropis gigantea (Ank) from the Apocynaceae family is known for its use in remedies for cough, cold, and body aches. Eid et al.[33] reported that different parts of this plant are traditionally used to treat ailments such as leprosy, eye problems, intestinal worms, skin ulcers, and fever, highlighting its analgesic and curative properties. Another important plant is *Phyllanthus emblica* (Amla) from the Phyllanthaceae family, which is valued for improving eyesight and reducing hair fall. Singh et al.[34] noted that *Phyllanthus emblica* is a key ingredient in the Ayurvedic formulation Chyavanaprasha, celebrated for its rejuvenating properties.

Toona ciliata (Tun), also from the Meliaceae family, treats ulcers and boils. Kumar et al.[35] explored its traditional value in treating chronic dysentery, ulcers, leprosy, and other health issues like fever, headache, and blood complaints. Another Meliaceae member, *Melia azedarachta* (Bakain), is used for skin diseases and other conditions. Sultana et al.[36] documented its use as an anthelmintic, diuretic, and expectorant, employed in cases of hysteria, leprosy, and piles.

Table 1. List of Medicinal Plants Utilized in *Shishambara* and *Buddhi* Villages.

S. No.	Scientific Name	Common Name	Family	Habit	Part Used	Uses	Phytochemical Compounds	Biological Activity	References
1	*Justicia adhatoda*	Vasa	Acanthaceae	Shrub	Leaves, roots, flowers	Cold, cough, and asthma	alkaloids	Antimicrobial activity	[37]
2	*Ficus palmata*	Bedu	Moraceae	Tree	Fruit, leaf, bark	Indigestion and Dysentery	phenolic, flavonoid	Antidiabetic, anticancer	[38]
3	*Aegle marmelos*	Beal	Rutaceae	Tree	Fruit, leaf, bark	Digestive disorder, fever, cold and	carotenoids, phenolic, alkaloids, pectins, tannins, coumarins, flavonoids and terpenoids.	Antibacterial, antiviral, antidiarrheal, anticancer	[39]
4	*Azadirachta indica*	Neem	Meliaceae	Tree	Leaf, flowers, seeds	skin diseases, toothache, diabetes	alkaloids, phenolic ompound, flavonoids and tannins steroids,	Antimicrobial and anti-fungal	[40]
5	*Calotropis gigantea*	Ank	Apocynaceae	Shrub	Leaf, root	Cough and cold, normal ache	phenolic ompound, alkanes, carboxylic acids, aldehydes, aliphatic and aromatic amines, allene, sulfoxides, phenyl ester nitro ompound, and imines	Antibacterial.	[41]
6	*Phyllanthus emblica*	Amla	Phyllanthaceae	Tree	Whole	Vitamin C, to improve eyesight, hair fall	tannins, terpenes, alkaloids, glycosidic ompound, saponins, and flavones	Anticancer Anti-Ageing Antidiabetic.	[42]
7	*Toona ciliata*	Toon	Meliaceae	Tree	Stem, leaf	Ulcer boils	triterpenoids, cedrelone, polyynes, limonoids, sideri	Antioxidant, analgesic, antiulcer,antifungal, antimicrobial, antifeedant,	[35]
8	*Melia azedarachta*	Bakain	Meliaceae	Tree	Leaves, stem	Skin diseases	steroids, alkaloids, phenols, flavonoids, saponins, tannins, anthraquinone and amino acids	Anti-bacterial and anticancer	[43]
9	*Phyllanthus niruri*	Bhoomi amla	Phyllanthaceae	Herb	Fruit, leaves	Digestion and cold	Saponins, tannins, flavonoids, steroids, cardiac glycosides, etc.	Antibacterial.	[44]

Table 1. *Cont.*

S. No.	Scientific Name	Common Name	Family	Habit	Part Used	Uses	Phytochemical Compounds	Biological Activity	References
10	*Ricinus communis*	Arandi	Euphor-biaceae	Shrub	Leaves, seeds	Ache, swelling pain	Flavonoids, saponins, glycosides, alkaloids and steroids	Anti-oxidant, Antidiabetic	[45]
11	*Mesosphaerum suaveolens*	Vilayati tulsi	Lamiaceae	Shrub	Stem, leaves	Wounds, skin diseases	Phenols, Flavonoids, Steroids, Terpenoids	Antibacterial activity	[46]
12	*Abutilon indicum*	Atibala	Malvaceae	Shrub	Leaves, seeds	Fever, cough, piles	alkaloids, saponins, carbohydrates, steroids, glycosides, amino acids, flavonoids, phenolic ompound, and tannins	Analgesic, anti-in-flammatory.	[47]
13	*Clitoria ternatea*	Aparajita	Fabaceae	Herb	Roots, leaf	Heart and respiratory system	alkaloid, saponin, cardiac glycosides	Antimicrobial activity	[48]
14	*Terminalia bellirica*	Baheda	Combre-taceae	Tree	Fruit, bark, seeds	Cough, bronchitis, acidity, digestion	Glucoside, tannins, gallic acid, ellagic acid, ethyl galate,	Antihypertensive, antidiarrhoeal activity, antimicrobial activity, antidiabetic, antioxidant	[49]

Additionally, *Phyllanthus niruri* (Bhoomi amla), another member of the Phyllanthaceae family, is used for digestion and cold-related issues. *The Euphorbiaceae family's Ricinus communis* (*Arandi*) is valued for its leaves and seeds in treating aches and swelling pain. *The Fabaceae family's Clitoria ternatea* (*Aparajita*) is used for heart and respiratory issues. In contrast, *Terminalia bellirica* (Baheda) from the Combretaceae family is applied to treat cough, bronchitis, acidity, and digestive problems. Lastly, *Syzgium cumini* (Jamun) is widely used to manage diabetes. These medicinal plants demonstrate the villagers' deep-rooted traditional knowledge and reliance on the forest for healthcare solutions, underscoring these species' significant role in their daily lives and well-being.

3.1.11. Total Consumption and Sources of Forest Products

In *Shishambara*, fuelwood constitutes approximately 60% of the total consumption and is predominantly directly sourced from the forest. Additionally, bamboo consumption is estimated at an annual rate of 30%. The remaining 10% encompasses a diverse array of forest products. Notably, cultivating fodder is a significant practice, leveraging the ample agricultural land available in *Shishambara*. The cultivation includes various vegetables and crops, while fodder production focuses on green chary and berseem to cater to the dietary needs of cows and buffaloes.

Contrastingly, in *Buddhi* village, fuelwood represents approximately 70% of the total consumption. The fuelwood collection is primarily sourced directly from the village, and occasionally, villagers purchase it from sellers. Fodder cultivation in *Buddhi* is primarily directed towards meeting the needs of cattle, with the cultivation of green chary and berseem prominent. Occasionally, crops such as bajra and mandwa are also grown to supplement the dietary requirements of the livestock. This comprehensive overview elucidates the nuanced patterns of consumption and the diverse sources of forest products within the respective village settings.

3.2. Observations Across Villages

3.2.1. Health and Hygiene

The present study observed several persistent health and hygiene challenges in the *Buddhi* and *Shishambara* villages. In *Buddhi* Village, a mere 18.8% of households have access to toilets, and only 38.9% have tap water. Villagers often rely on natural water sources that may be contaminated. Similarly, *Shishambara* faces issues related to waste management, with burning dumpsites causing respiratory problems. Both villages grapple with medical facilities' inaccessibility and high costs, forcing residents to travel significant distances for healthcare. Potential actions to improve health and sanitation include providing access to sanitary facilities and clean water, waste processing plants, and enhancing medical service accessibility and affordability.

3.2.2. Transportation Challenges

Inadequate transportation infrastructure presents a significant difficulty for the people of *Buddhi* and *Shishambara*. Remote regions and a lack of access to main thoroughfares add to the reliance on costly and dangerous private automobiles. Public transit, which includes buses and e-rickshaws, is limited and unreliable. This lack of mobility impedes access

to essential services such as education and healthcare. Urbanization, population increase, poor planning, and a lack of cooperation among numerous institutions contribute to transportation challenges. Potential solutions include promoting inexpensive and sustainable public transit choices, enacting comprehensive transportation legislation, and supporting alternative forms of transportation such as walking and biking. Raising awareness of the benefits of public transport and including communities in decision-making processes are critical steps toward addressing these issues.

4. Discussion

The relationship between households and forest resources in *Shishambara* and *Buddhi* villages is complex and multifaceted, reflecting broader socio-economic dynamics typical in rural areas with high forest dependency. The engagement of households in collecting and marketing forest products is deeply intertwined with the availability of these resources, their consumption patterns, market access, and the socioeconomic status of the local communities [50]. This section explores these aspects in greater detail, drawing inferences from the data and situating the findings within the broader literature, while comparing with similar forest-dependent communities across India.

4.1. Forest Dependency and Livelihood Strategies

This study elucidates the intricate relationship between forest dependency and socioeconomic development in *Shishambara* and *Buddhi* villages, emphasizing that forests are essential for supporting the livelihoods of these communities. Comparative analysis reveals similarities and regional variations in forest dependency patterns across India. Similar to our findings, where approximately 70% of respondents rely on firewood and 65% engage in livestock rearing, studies from Himachal Pradesh report comparable dependency rates, with 68% of households in forest-adjacent areas relying on fuelwood collection and 72% practicing animal husbandry [51]. However, in Madhya Pradesh's tribal regions, forest dependency is even more pronounced, with up to 85% of households depending on non-timber forest products (NTFPs) for their primary income [52]. Forests provide vital resources, including fuelwood, fodder, medicinal plants, and non-timber forest products (NTFPs), which are crucial for these households' subsistence and economic strategies, particularly in the absence of viable alternatives and low returns on other investments [53]. The correlation between forest dependencies and socioeconomic indicators, such as literacy rates and settlement morphology, is noteworthy; for instance, *Buddhi's* higher literacy rate (82.46%) compared to *Shishambara's* (78.02%) suggests that improved educational opportunities can enhance resource management practices and foster sustainable forest utilization [54]. This correlation finds parallels in other regions. Studies from Himachal Pradesh demonstrate that villages with literacy rates above 80% show 25% better adoption of sustainable harvesting practices than those with lower literacy rates [55]. Similarly, research in Madhya Pradesh's Bundelkhand region reveals that educational interventions increased community participation in forest conservation by 35% over a five-year period [56]. While the predominance of Pakka houses indicates some economic stability, the ongoing reliance on traditional cooking methods, despite the availability of LPG connections, points to gaps in health and hygiene awareness, necessitating targeted education and outreach programs to promote safer practices [57].

Furthermore, the study reveals that inadequate drainage systems and a lack of healthcare facilities present significant challenges, underscoring the urgent need for enhanced local healthcare services. The diverse livestock management practices, with 55.11% of the population engaged in cow rearing, emphasize the economic importance of livestock and the symbiotic relationship between livestock and forest resources, as animals rely on forest tree leaves for feed [58]. Regional variations in forest utilization patterns emerge when comparing across states. While Uttarakhand communities like those in our study primarily depend on fuelwood and fodder, communities in Karnataka's Western Ghats show higher dependence on medicinal plants and honey collection, contributing up to 40% of household income [59,60]. In contrast, forest communities in Odisha's coastal regions demonstrate greater reliance on mangrove-based resources, with fishing and crab collection predominant activities [61].

Additionally, the study identifies a notable proportion of villagers participating in daily wage activities, indicating that income diversification is essential for building economic resilience in rural areas where agricultural productivity is susceptible to environmental factors. This supports the notion

that enhancing income-generating opportunities beyond agriculture can reduce vulnerability and improve overall quality of life[54]. Ultimately, the findings underscore the necessity of a comprehensive policy-oriented research program that emphasizes the importance of forests in sustaining livelihoods and ecological benefits while aligning with global sustainability agendas and goals[62–66].

4.2. Socioeconomic Implications of Forest Use

Forests are crucial in maintaining the natural ecosystem and human social life. As it provides a wide range of ecosystem services, including purifying air, supporting biodiversity, regulating climate, and supplying timber for industrial uses[67,68], it also provides non-timber forest products, including resin, honey, and rubber[69]. India's approximately 27 million rural people depend on non-forest timber products[69]. It also contributes to the GDP of many regions[70]; it often supplements agricultural income, provides essential cash flow, and holds cultural significance, such as fostering community identity and cohesion. Cross-regional analysis reveals that forest dependency follows similar socioeconomic gradients across India, but with varying intensities. While our study shows forest dependency as a crucial safety net for poorer households, research from Jharkhand's tribal districts demonstrates even higher dependency levels, with forest income comprising up to 65% of total household income among the poorest quintile. Conversely, studies from more developed forest regions show lower dependency rates due to better alternative livelihood opportunities. Forest-dependent communities face multiple challenges, as unsustainable forest exploitation often leads to degradation and threatens the forest resources they rely on for food, fuel, fodder, and livelihoods[67]. In addition, limited infrastructure and poor market access further constrain their opportunities[71]. India's Sunderbans provide several ecosystem services[72], which need sustainable exploitation since forest dwellers depend heavily on the forest[72]. They conducted a study to estimate the option value of forest dwellers in India to restore and conserve ecosystem services. Findings show that forest dwellers have a positive option value and are willing to forgo extraction for future use. The role of forests in ecosystem services provision shows similarities and regional specificities[60]. Like the communities in our study, forest-dependent populations across the Himalayas rely heavily on watershed services and biodiversity conservation benefits. However, communities in the Western Ghats demonstrate higher awareness and economic valuation of biodiversity conservation, with ecotourism contributing 15–20% of village income in some areas, a livelihood option largely unexplored in our study region[73]. This indicates their willingness to participate in forest conservation, suggesting the need for institutions like Joint Forest Management for efficient mangrove management. Barua and Rahman[74], Das et. al.[61] studied the relationship between tribal societies and ecological units in the Barind region, Eastern India, to evaluate the delivery of ecosystem services (Ess) and their dependence on them. Their research developed an ES dependency index and an ecosystem services prominence index, revealing a strong connection between livelihood strategies and Ess. Their study found significant variation in dependency across villages and seasonal variations, with the monsoon season being the most important contributor. The socioeconomic status of households significantly influences their patterns of forest resource use. For poorer households, the forest represents a crucial safety net that helps mitigate the impacts of poverty and economic vulnerability. Due to their limited access to other types of capital, including land, labor, and financial resources, these families depend more on forest resources for sustenance and revenue generation[75]. Although this dependence offers immediate financial advantages, it can also result in the unsustainable use of forest resources, which might eventually worsen poverty if forest damage takes place. Richer households, on the other hand, are less reliant on forest resources as their main source of income, even though they still use them. These households may have access to more diversified income streams, reducing their reliance on forests. However, their consumption patterns, particularly for fuelwood and fodder, still place significant pressure on local forest ecosystems. This dynamic highlights the need for differentiated forest management strategies that account for varying levels of dependency and socioeconomic status within the community.

4.3. Market Dynamics and Resource Utilization

Comparative analysis of market dynamics reveals diverse approaches to forest product commercialization

across India. While our study indicates limited market integration, successful models from other regions provide valuable lessons. In Karnataka's Western Ghats, community-based enterprises have increased forest product prices by 60% through value addition and direct marketing[76]. Similarly, in Gujarat's dry forests, women's self-help groups have established processing units for gum and resin, increasing household incomes by 45%[77]. The market dynamics surrounding forest products play a key role in shaping household engagement with these resources across all regions. The study indicates that the marketing of forest products is influenced by factors such as market accessibility, the pricing of forest goods, and the availability of buyers. Households that are more integrated into market economies tend to engage more actively in the sale of forest products, which can provide a significant source of income[78]. Forest utilization and resilience are two independent concepts related to livelihood dependency. Forest usage includes collecting forest products, using forests for provisioning services (e.g., water), and using forest resilience as financial insurance and customer support for poverty[79,80]. Several individuals rely not only on their jobs for income but also on natural capital in the form of farming and harvested forest products, such as wild food, fuelwood, fiber, and so on, for personal use or sale in local markets[81]. Understanding how resources are channeled is crucial, including who has access to them and how they are extracted. Without this knowledge, the gap between the science of recognizing ES and the evaluation by people or the Government cannot be intensified[82].

With their incredible biodiversity, the Himalayas are affected by human stresses and are home to an increasing number of rural poor who rely on forests and ecosystem services. Efforts to integrate poverty alleviation and biodiversity protection in the region remain difficult. Ashoka Trust for Research in Ecology and the Environment (ATREE) in India has successfully integrated biodiversity concerns with livelihood security[78]. The study suggests creating a Hindu-Kush Himalayan Ecosystem Services Network to tackle the problem of combining livelihood and environmental concerns. It offers a conceptual framework for integrating livelihood-generating activities with sustainable development goals. However, not everyone participates in the market; poorer households frequently face obstacles such as a lack of negotiation strength, market knowledge, and transportation. Imbalances in revenue from forest products might result from unequal market access, further solidifying existing socioeconomic imbalances. These challenges remain consistent across regions. Research from Chhattisgarh shows that poorer households continue to face market access barriers, with only 25% able to participate in higher-value markets compared to 65% of better-off households[83]. This pattern is replicated in Assam's forest communities, where lack of storage facilities and transportation limits market participation[84]. Furthermore, overharvesting may result from market-driven forest resource exploitation, particularly when there is a high demand for specific goods. This trend calls for adopting sustainable harvesting methods and creating value-added goods to increase the potential revenue from forest resources without causing their depletion.

4.4. Agriculture and Forest Conservation

The agricultural-forest interface observed in our study finds similar patterns across India but with varying intensities of conflict and integration. In Himachal Pradesh, agroforestry adoption rates of 45% are higher than we observed, partly due to better extension services and government support[85,86]. However, in Madhya Pradesh's tribal regions, agriculture-forest conflicts are more severe, with crop damage by wildlife affecting 80% of farming households compared to the levels observed in our study. Agriculture continues to constitute the backbone of the local economy, with most families being either farming-centric or agriculturally dependent[87]. The interaction between agricultural practices and forest resource use is crucial because unsustainable agricultural growth can result in deforestation and forest degradation. According to the report, while forests provide critical resources for farming operations, such as fodder and fuelwood, there is also a need to encourage sustainable farming techniques that have a minimal detrimental impact on forest ecosystems. Agroforestry, soil conservation measures, and sustainable farming practices can all contribute to relieving forest pressures while increasing agricultural output.

Furthermore, including forest protection in agricultural development plans can help to ensure the overall sustainability of rural lives. Successful integration models from other regions offer valuable insights. In Andhra Pradesh's

region, community-managed agroforestry systems have reduced pressure on natural forests by 35% while increasing agricultural productivity by 25%[88]. This integrated strategy is critical for reconciling the requirements of local populations with the importance of forest protection[89].

4.5. Policy and Practice Implications

Policy analysis across states reveals both successful models and persistent challenges. While our study identifies the need for participatory forest management, states like Odisha have made significant progress with 65% of forests under community management compared to the national average of 24%[90]. However, policy implementation remains weak in remote areas across all states, including regions similar to our study area.

The findings of the study have many policy and practical ramifications. First, as impoverished households are the ones that rely on forest resources the most, customized interventions are required to meet their unique needs and vulnerabilities. Successful interventions from other regions provide implementation blueprints. Himachal Pradesh's Van Panchayat system has successfully integrated forest conservation with livelihood security, resulting in 30% improvement in forest cover and 40% increase in household incomes over the past decade[91]. Similarly, Gujarat's participatory forest management program has achieved 95% community participation in forest protection activities[92]. Alternative livelihood options, microfinance accessibility, and capacity-building initiatives focused on sustainable resource management are a few examples of these interventions. Second, the revenue potential of forest resources for nearby people may be increased by expanding market access and creating value-added forest products. This strategy would necessitate the creation of cooperatives or other collective businesses that may increase producers' negotiating power and investments in market information systems and infrastructure. Lastly, the study emphasizes how crucial it is to incorporate forest protection into more comprehensive plans for rural development. Participatory forest management, in which local communities actively participate in decisions on the conservation and use of forests, might help accomplish this integration. By ensuring that local communities' needs and expertise are included in conservation policy, such an approach would produce fairer and sustainable results.

4.6. Recommendations for Sustainable Development

Drawing from successful models across India, our recommendations gain broader relevance and practical grounding. The community-based programs we propose find successful precedents in multiple states. For instance, Rajasthan's desert communities have successfully adopted alternative energy sources through solar cooperatives, reducing fuelwood dependency by 50%[93]. Similarly, capacity-building programs in Tamil Nadu have resulted in 60% adoption of sustainable harvesting practices[94]. To promote sustainable development in these communities, community-based programs that increase knowledge of sustainable livestock management techniques and alternative energy sources must be implemented, drawing from these successful models. Programs that educate parents and children can close the knowledge gap in environmental stewardship, cleanliness, and health. Additionally, these communities' socioeconomic well-being may be enhanced by supporting sustainable agriculture techniques, upgrading drainage systems, and increasing healthcare facilities. Investing in capacity-building initiatives can enable local communities to participate in sustainable forest management techniques, enhancing resource preservation and generating economic benefits. Collaborative efforts involving local governments, NGOs, and community members are essential to address the challenges faced by these villages and ensure that the benefits of forest resources are maximized sustainably. Cross-regional learning opportunities emerge from this comparative analysis. The integrated approach we recommend for Uttarakhand communities could benefit from successful models like Andhra Pradesh's community-based natural resource management program, which has improved forest cover and household incomes across 2,000 villages. Regional variations also highlight the importance of context-specific adaptations, with different agro-climatic zones requiring different focus areas.

The contributions of this study are presented In **Table 2**, which highlights how the findings from *Shishambara* and *Buddhi* villages extend beyond the local context to offer implementable actions for global readers/stakeholders. It illustrates how the study's results can inform sustainable forest management, livelihood resilience, and environmental conservation practices worldwide in similar rural, forest-

dependent regions. By addressing key dimensions such as socioeconomic vulnerabilities, forest product utilization, and market dynamics under changing climate and environmental conditions, this study provides a framework that can be adapted to other forest-reliant communities. Thus, the study underscores the importance of integrating forest conservation with broader sustainable development goals, providing a holistic approach for policymakers, researchers, and practitioners to tackle the challenges of rural livelihoods and forest sustainability in diverse ecological settings.

Table 2. Global contribution of the present study on forest dependency and livelihoods.

Dimension	Contribution from *Shishambara* and *Buddhi* Case Study	Global Relevance	Application to Case Studies Elsewhere	References
Forest Dependency and Livelihoods	Highlights the role of forests in sustaining rural livelihoods, with 70% of respondents reliant on firewood and 65% engaged in livestock rearing.	Can inform global forest-dependent communities, especially in developing countries, about strategies for balancing livelihoods and forest conservation.	Sub-Saharan Africa, Southeast Asia: Helps communities navigate forest dependency amid environmental degradation.	[95,96]
Socioeconomic Status and Resource Use	Shows how literacy rates and settlement morphology influence forest management practices and resource utilization.	Promotes the understanding that education and socioeconomic factors are critical in improving sustainable resource management practices globally.	Latin America: Similar rural areas can use literacy improvements to improve conservation efforts.	[97]
Market Access and Forest Resource Utilization	Discusses market dynamics, including access to markets and value addition to forest products.	Globally relevant for improving market participation and equitable resource distribution, especially for marginalized communities relying on natural capital.	South Asia, Central America: Provides strategies to integrate rural communities into forest product markets.	[14,98]
Sustainability and Forest Management	Emphasizes agroforestry and sustainable farming practices to balance agricultural expansion and forest conservation.	Global relevance in promoting land-use strategies integrating forest conservation into rural economic systems, aligning with global sustainability agendas.	Eastern Europe, East Asia: Encourages sustainable agricultural practices to prevent deforestation.	[99]
Climate Resilience and Adaptation	Identifies the role of forests in climate resilience and suggests strategies like capacity building for forest-dependent communities.	Relevant to global efforts focused on building climate resilience in vulnerable rural areas, where ecosystems provide natural buffers against environmental changes.	Africa's Sahel region, the Himalayas: Guides adaptation strategies where rural communities depend on ecosystem services.	[100,101]
Policy Implications and Participatory Governance	Advocates for integrating forest conservation into rural development policies, emphasizing participatory forest management.	Globally applicable to regions focused on participatory governance to ensure equitable outcomes in forest conservation and sustainable development efforts.	Southeast Asia, Amazon basin: Inspires participatory models in rural development and forest governance.	[102,103]
Sustainable Development Goals (SDGs)	Aligns with SDGs by addressing issues of poverty alleviation, forest conservation, health infrastructure, and sustainable practices.	Contributes to international policy discourse on achieving SDGs in rural, forest-dependent areas by promoting holistic approaches considering socio-economic and environmental factors.	Global South, Tropical forests: Demonstrates how to align local actions with international sustainability goals.	[104]
Livelihood Diversification and Income Security	Identifies income diversification as crucial for resilience, reducing dependency on agriculture, and enhancing livelihood security.	Relevant to global initiatives aimed at reducing poverty through diversified livelihood strategies, especially in areas prone to climate variability and resource scarcity.	Mediterranean, Caribbean islands: Informs policies to diversify rural economies to withstand environmental shocks.	[105,106]

5. Conclusions

This study offers a holistic exploration of the socioeconomic dynamics and resource dependency of the villages of *Shishambara* and *Buddhi* of Uttarakhand state, India, highlighting the complex relationship between local communities and their surrounding forest ecosystems. While the villages possess essential amenities such as electricity, water supply, sanitation facilities, and access to primary and high school education, the findings reveal a significant gap in the coordinated implementation of beneficial government initiatives. Despite a decent literacy rate and a predominantly agriculture-based economy, the villagers' heavy reliance on forest resources remains a critical concern. The study identifies several challenges that exacerbate this dependency, including the impact of wildlife on crop patterns, particularly

from animals such as monkeys, wild pigs, etc. To address these challenges, policy interventions should prioritize: (i) promoting alternative livelihood opportunities and income diversification to reduce unsustainable reliance on forests, (ii) supporting community-led agroforestry, fodder, and fuelwood plantations to ease pressure on natural forests, (iii) enhancing access to education, healthcare, and sanitation to improve overall resilience, and (iv) integrating participatory forest governance into rural development plans. Strengthening local institutions and market linkages for value-added forest products can further ensure conservation efforts generate tangible economic benefits. The success of these interventions hinges on a comprehensive understanding of the socioeconomic needs of the rural population and the implementation of sustainable practices that balance human needs with environmental conservation. Hence, the study highlights the urgent need for sustainable interventions to prevent the depletion and conservation of forest resources and ensure the villages' long-term viability. Without such measures, future generations will be jeopardized, leading to increased migration or declining living standards. The findings from this study call for a concerted effort to integrate forest conservation into rural development strategies, ensuring that the needs of local inhabitants are met without compromising the ecological integrity of their environment.

Author Contributions

P.J. and H.S. contributed to the conceptualization, fieldwork, and original draft preparation. K.R. supported fieldwork and draft writing. A.S. provided visualization, technical inputs, original draft writing, editing and revisions. A.P.M. contributed to methodology design, draft writing, review, and revisions. A.K. supervised the work and provided key edits. M.S.S. offered supervision, technical inputs, and valuable edits. S.S. contributed through review and edits, while U.R. provided supervision, technical guidance and critical review. All authors contributed according to their expertise and collectively enhanced the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding

Not applicable.

Institutional Review Board Statement

Ethical review and approval were waived for this study, as it was entirely based on a questionnaire survey and did not involve any invasive sampling methods on animals.

Informed Consent Statement

Informed consent was obtained from the respondents. Further, the confidentiality and anonymity of respondents were also maintained to ensure ethical guidelines which were given Doon University, India.

Data Availability Statement

The data supporting this study's findings are available on request from the corresponding author.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Gandhi, A., 2024. Economic Implications of Population Growth in India. Innovative Research Thoughts. 10(2), 80–91.

[2] Chinnasamy, P., Srivastava, A., 2021. Revival of Traditional Cascade Tanks for Achieving Climate Resilience in Drylands of South India. Frontiers in Water. 3, 639637. DOI: https://doi.org/10.3389/frwa.2021.639637

[3] Kandapan, B., Pradhan, J., Pradhan, I., 2023. An Individual-Specific Approach to Multidimensional Child Poverty in India: A Study of Regional Disparities. Child Indicators Research. 16(5), 2075–2105.

[4] Jannat, M., Hossain, M.K., Uddin, M.M., 2020. Socioeconomic Factors of Forest Dependency in Developing Countries: Lessons Learned from the Bandarban Hill District of Bangladesh. American Journal of Pure and Applied Sciences. 2(3), 77–84. DOI: https://doi.org/10.34104/ajpab.020.077084

[5] Vedeld, P., Angelsen, A., Bojö, J., et al., 2007. Forest Environmental Incomes and the Rural Poor. Forest Policy and Economics. 9(7), 869–879.

[6] Lebedys, A., 2008. Contribution of the Forestry Sector to National Economies, 1990–2006. Forest Finance Working Paper (FAO). 8.

[7] Ojea, E., Loureiro, M.L., Alló, M., et al., 2016. Ecosystem Services and REDD: Estimating the Benefits of Non-Carbon Services in Worldwide Forests. World Development. 78, 246–261.

[8] Gaston, K.J., 2000. Global Patterns in Biodiversity. Nature. 405(6783), 220–227.

[9] Chao, S., 2012. Forest Peoples: Numbers Across the World. Forest Peoples Programme. 10. DOI: https://doi.org/10.13140/RG.2.2.21192.14088

[10] Davidar, P., Sahoo, S., Mammen, P.C., et al., 2010. Assessing the Extent and Causes of Forest Degradation in India: Where Do We Stand? Biological Conservation. 143(12), 2937–2944.

[11] Gardner, T.A., Barlow, J., Chazdon, R., et al., 2009. Prospects for Tropical Forest Biodiversity in a Human-Modified World. Ecology Letters. 12(6), 561–582.

[12] Basu, A., Nayak, N.C., 2011. Underlying Causes of Forest Cover Change in Odisha, India. Forest Policy and Economics. 13(7), 563–569.

[13] Prado Córdova, J.P., Wunder, S., Smith-Hall, C., et al., 2013. Rural Income and Forest Reliance in Highland Guatemala. Environmental Management. 51, 1034–1043.

[14] Jain, S., Srivastava, A., Vishwakarma, D.K., et al., 2024. Protecting Ancient Water Harvesting Technologies in India: Strategies for Climate Adaptation and Sustainable Development with Global Lessons. Frontiers in Water. 6, 1441365. DOI: https://doi.org/10.3389/frwa.2024.1441365

[15] Kumar, H., Namrata, 2024. Socio-Economic Environment and Motivation to Innovate: Exploring Grassroots Innovations Process in India. Technology Analysis & Strategic Management. 36(6), 1234–1247. DOI: https://doi.org/10.1080/09537325.2022.2088345

[16] Mukhlis, I., Rizaludin, M.S., Hidayah, I., 2022. Understanding Socio-Economic and Environmental Impacts of Agroforestry on Rural Communities. Forests. 13(4), 556. DOI: https://doi.org/10.3390/f13040556

[17] Talukdar, N.R., Choudhury, P., Barbhuiya, R.A., et al., 2021. Importance of Non-Timber Forest Products (NTFPs) in Rural Livelihood: A Study in Patharia Hills Reserve Forest, Northeast India. Trees, Forests and People. 3, 100042. DOI: https://doi.org/10.1016/j.tfp.2020.100042

[18] Dasgupta, S., Badola, R., Ali, S.Z., et al., 2022. Bioresource, Energy and Forest Sustainability: A Case Study from Indian Himalayan Region. Journal of Cleaner Production. 337, 130497. DOI: https://doi.org/10.1016/j.jclepro.2022.130497

[19] Mukul, S.A., Rashid, A.M., Uddin, M.B., et al., 2016. Role of Non-Timber Forest Products in Sustaining Forest-Based Livelihoods and Rural Households' Resilience Capacity in and Around Protected Area: A Bangladesh Study. Journal of Environmental Planning and Management. 59(4), 628–642.

[20] Babulo, B., Muys, B., Nega, F., et al., 2008. Household Livelihood Strategies and Forest Dependence in the Highlands of Tigray, Northern Ethiopia. Agricultural Systems. 98(2), 147–155.

[21] Saha, D., Sundriyal, R.C., 2012. Utilization of Non-Timber Forest Products in Humid Tropics: Implications for Management and Livelihood. Forest Policy and Economics. 14(1), 28–40.

[22] Sarmah, R., Arunachalam, A., 2011. Contribution of Non-Timber Forest Products (NTFPS) to Livelihood Economy of the People Living in Forest Fringes in Changlang District of Arunachal Pradesh, India. Indian Journal of Fundamental and Applied Life Sciences. 1(2), 157–169.

[23] Ministry of Environment and Forests, 2006. Report of the National Forest Commission. 700.REP031, 28 March 2006. The Government of India: New Delhi, India.

[24] Rasul, G., Tripura, N.B.K., 2016. Achieving the Sustainable Development Goals in Chittagong Hill Tracts—Challenges and Opportunities. International Centre for Integrated Mountain Development (ICIMOD): Kathmandu, Nepal.

[25] Ahammad, R., Stacey, N., 2016. Forest and Agrarian Change in the Chittagong Hill Tracts Region of Bangladesh. Agrarian Change in Tropical Landscapes. 190.

[26] Etongo, D.B., Glover, E.K., 2012. Participatory Resource Mapping for Livelihood Values Derived from the Forest in Ekondo-Titi Subregion, Cameroon: A Gender Analysis. International Journal of Forestry Research. 9, 871068.

[27] Tieguhong, J.C., Grouwels, S., Ndoye, O., et al., 2012. Financial Status of Small and Medium Scale Enterprises Based on Non-Wood Forest Products (NWFP) in Central Africa. Forest Policy and Economics. 20, 112–119.

[28] Beckline, M., Yujun, S., Eric, Z., et al., 2016. Paper Consumption and Environmental Impact in an Emerging Economy. Journal of Energy, Environmental & Chemical Engineering. 1(1), 13–18.

[29] Mukete, B., Sun, Y., Etongo, D., et al., 2018. Household Characteristics and Forest Resources Dependence in the Rumpi Hills of Cameroon. Applied Ecology & Environmental Research. 16(3).

[30] Singh, K.J., Huidrom, D., 2013. Ethnobotanical Uses of Medicinal Plant, *Justicia adhatoda* L. by Meitei Community of Manipur, India. Journal of Coastal Life Medicine. 1(4), 322–325.

[31] Joshi, Y., Joshi, A.K., Prasad, N., et al., 2014. A Review on *Ficus palmata* (Wild Himalayan Fig). The Journal of Phytopharmacology. 3(5), 374–377.

[32] Dutta, A., Lal, N., Naaz, M., et al., 2014. Ethnological and Ethno-Medicinal Importance of *Aegle marmelos* (L.) Corr (Bael) Among Indigenous People of India.

American Journal of Ethnomedicine. 1(5), 290–312.

[33] Eid, A., Jaradat, N., Elmarzugi, N., 2017. A Review of Chemical Constituents and Traditional Usage of Neem Plant (*Azadirachta indica*). Palestinian Medical and Pharmaceutical Journal. 2(2), 3.

[34] Singh, E., Sharma, S., Pareek, A., et al., 2012. Phytochemistry, Traditional Uses and Cancer Chemopreventive Activity of Amla (*Phyllanthus emblica*): The Sustainer. Journal of Applied Pharmaceutical Science. 2(1), 176–183.

[35] Kumar, S., Rana, M., Kumar, D., et al., 2012. A Mini Review on the Phytochemistry and Pharmacological Activities of the Plant *Toona ciliata* (Meliaceae). International Journal of Phytotherapy Research. 2(1), 8–18.

[36] Sultana, S., Asif, H.M., Naveed, A., et al., 2014. Comprehensive Review on Ethanobotanical Uses, Phytochemistry and Pharmacological Properties of *Melia azedarach* Linn. Asian Journal of Pharmaceutical Research and Health Care. 6(1), 26–32.

[37] Pa, R., Mathew, L., 2012. Antimicrobial Activity of Leaf Extracts of *Justicia adhatoda* L. in Comparison with Vasicine. Asian Pacific Journal of Tropical Biomedicine. 2(3), S1556–S1560.

[38] Al-Qahtani, J., Abbasi, A., Aati, H.Y., et al., 2023. Phytochemical, Antimicrobial, Antidiabetic, Thrombolytic, Anticancer Activities, and In Silico Studies of *Ficus palmata* Forssk. Arabian Journal of Chemistry. 16(2), 104455.

[39] Manandhar, B., Paudel, K.R., Sharma, B., et al., 2018. Phytochemical Profile and Pharmacological Activity of *Aegle marmelos* Linn. Journal of Integrative Medicine. 16(3), 153–163.

[40] Vinoth, B., Manivasagaperumal, R., Rajaravindran, M., 2012. Phytochemical Analysis and Antibacterial Activity of *Azadirachta indica* A. Juss. International Journal of Research in Plant Science. 2(3), 50–55.

[41] Rani, R., Sharma, D., Chaturvedi, M., et al., 2019. Phytochemical Analysis, Antibacterial and Antioxidant Activity of *Calotropis procera* and *Calotropis gigantea*. The Natural Products Journal. 9(1), 47–60.

[42] Nisar, M.F., He, J., Ahmed, A., et al., 2018. Chemical Components and Biological Activities of the Genus *Phyllanthus*: A Review of the Recent Literature. Molecules. 23(10), 2567.

[43] Malar, T.J., Antonyswamy, J., Vijayaraghavan, P., et al., 2020. In-Vitro Phytochemical and Pharmacological Bio-Efficacy Studies on *Azadirachta indica* A. Juss and *Melia azedarach* Linn for Anticancer Activity. Saudi Journal of Biological Sciences. 27(2), 682–688.

[44] Shanmugam, B.S.K.R., Shanmugam, K.R., Ravi, S., et al., 2014. Antibacterial Activity and Phytochemical Screening of *Phyllanthus niruri* in Ethanolic, Methanolic and Aqueous Extracts. International Journal of Pharmaceutical Sciences Review and Research. 27(2), 85–89.

[45] Jena, J., Gupta, A.K., 2012. Ricinus Communis Linn: A Phytopharmacological Review. International Journal of Pharmacy and Pharmaceutical Sciences. 4(4), 25–29.

[46] Mozhiyarasi, P., Anuradha, R., 2016. A Study on Phytochemical Analysis and Antimicrobial Activity of *Hyptis suaveolens* (L.) Poit. Journal of Chemical and Pharmaceutical Research. 8(6), 438–442.

[47] Saraswathi, R., Upadhyay, L., Venkatakrishnan, R., et al., 2011. Phytochemical Investigation, Analgesic and Anti-Inflammatory Activity of *Abutilon indicum* Linn. International Journal of Pharmaceutics & Pharmacy. 3(2), 154–156.

[48] Kamilla, L., Mnsor, S.M., Ramanathan, S., et al., 2009. Antimicrobial Activity of *Clitoria ternatea* (L.) Extracts. Pharmacologyonline. 1, 731–738.

[49] Kumar, N., Khurana, S.M., 2018. Phytochemistry and Medicinal Potential of *Terminalia bellirica* Roxb. (Bahera). Indian Journal of Natural Products and Resources (IJNPR). 9(2), 97–107.

[50] Chakraborty, P., Tewari, H.R., 2009. Sustainable Rural Livelihoods Through Participatory Natural Resources Management: A Case Study. Journal of Rural Development. 28(1), 85–100.

[51] Chauhan, A., 2016. Common Pool Resource Management: A Case Study of Chilgoza (Pinus gerardiana) in District Kinnaur of Himachal Pradesh [Master's thesis]. Dr. Yashwant Singh Parmar University of Horticulture and Forestry: Nauni, India.

[52] Bhattacharya, P., Bhattacharya, R., 2025. Sustainable Management of Non-Timber Forest Products. In: Mandal, A.K., Nicodemus, A. (eds.). Textbook of Forest Science. Springer Nature: Singapore. pp. 865–893.

[53] Maske, M., Mungole, A., Kamble, R., et al., 2011. Impact of Non-Timber Forest Produces (NTFPs) on Rural Tribes Economy in Gondia District of Maharashtra, India. Archives of Applied Science Research. 3(3), 109–114.

[54] Teshwar, A., 2016. Status of Dependency of Villagers on Forest for Their Livelihood. International Journal of Forestry and Horticulture (IJFH). 2, 11–14.

[55] Ghosh, A., Sharma, P., Vashisht, D., et al., 2024. Socio-Economic-Environmental Challenges at Himachal Villages: Findings from Five Unnat Bharat Abhiyan Adopted Villages. GeoJournal. 89(1), 3.

[56] Gupta, A.K., Nair, S.S., Ghosh, O., et al., 2014. Bundelkhand Drought: Retrospective Analysis and Way Ahead. Indian Council of Social Science Research, National Institute of Disaster Management: New Delhi, India. pp. 148.

[57] Myers, N., 1990. The Biodiversity Challenge: Expanded Hot-Spots Analysis. Environmentalist. 10(4),

243–256.

[58] Nautiyal, S., Rajan, K.S., Shibasaki, R., 2005. Interaction of Biodiversity and Economic Welfare: A Case Study from the Himalayas of India. Journal of Environmental Informatics. 6(2), 111–119.

[59] Singh, R.D., Tewari, P., Dhaila, P., et al., 2018. Diversifying Livelihood Options of Timberline Resource Dependent Communities in Uttarakhand Himalayas: Conservation and Development Implications. Tropical Ecology. 59(2), 327–338.

[60] Chandra, N., Joshi, V.C., Mishra, A.P., 2020. Ecological Status of Fodder and Fuelwood Species in Banari Devi Sacred Grove of Kumaun Himalaya, Uttarakhand. Indian Journal of Ecology. 47(4), 1044–1048.

[61] Das, S.C., Das, S., Tah, J., 2022. Mangrove Forests and People's Livelihoods. In: Das, S.C., Pullaiah, Ashton, E.C. (eds). Mangroves: Biodiversity, Livelihoods and Conservation. Springer: Singapore. pp. 153–173.

[62] Timko, J., Le Billon, P., Zerriffi, H., et al., 2018. A Policy Nexus Approach to Forests and the SDGs: Tradeoffs and Synergies. Current Opinion in Environmental Sustainability. 34, 7–12.

[63] Katila, P., Galloway, J., Taalas, P., et al., 2019. Sustainable Development Goals: Their Impacts on Forests and People. Cambridge University Press: Cambridge, UK.

[64] Grassi, G., et al., 2017. The Key Role of Forests in Meeting Climate Targets Requires Science for Credible Mitigation. Nature Climate Change. 7, 220–226.

[65] Butchart, S.H.M., et al., 2015. Shortfalls and Solutions for Meeting National and Global Conservation Area Targets. Conservation Letters. 8, 329–337.

[66] Suding, K., Higgs, E., Palmer, M., et al., 2015. Committing to Ecological Restoration. Science. 348(6235), 638–640. DOI: https://doi.org/10.1126/science.aaa4216

[67] Borgomeo, E., Vadheim, B., Woldeyes, F.B., et al., 2018. The Distributional and Multi-Sectoral Impacts of Rainfall Shocks: Evidence From Computable General Equilibrium Modelling for the Awash Basin, Ethiopia. Ecological Economics. 146, 621–632. DOI: https://doi.org/10.1016/j.ecolecon.2017.11.038

[68] Das, M., Das, A., Pandey, R., 2022. Exploring Nexus Between Ecosystem Services and Livelihood Dependency for Sustainable Ecosystem Management in Lower Gangetic Plains, Eastern India. Environmental Science and Pollution Research. 29(42), 63692–63708. DOI: https://doi.org/10.1007/s11356-022-20057-9

[69] Pandey, A.K., Tripathi, Y.C., Kumar, A., 2016. Non-Timber Forest Products (NTFPs) for Sustained Livelihood: Challenges and Strategies. Research Journal of Forestry. 10(1), 1–7. DOI: https://doi.org/10.3923/rjf.2016.1.7

[70] Das, A., Mallick, P.H., 2024. Exploring Livelihood Dependency on Provisioning Ecosystem Services in a Protected Tropical Forest Area of Eastern India: Keys to Sustainable Forest Management. Environment, Development and Sustainability. 2024. DOI: https://doi.org/10.1007/s10668-024-04933-7

[71] Chishaleshale, M., Chirwa, P.W., Zekeng, J.C., et al., 2024. How Do Socio-Economic Characteristics of Communities Influence Resource Use and Forest Cover in the *Cryptosepalum* Forest of North-Western Zambia. Heliyon. 10(8), e28658. DOI: https://doi.org/10.1016/j.heliyon.2024.e28658

[72] Saha, D., Taron, A., 2023. Economic Valuation of Restoring and Conserving Ecosystem Services of Indian Sundarbans. Environmental Development. 46, 100846. DOI: https://doi.org/10.1016/j.envdev.2023.100846

[73] Balasubramanian, M., Sangha, K.K., 2023. Valuing Ecosystem Services Applying Indigenous Perspectives from a Global Biodiversity Hotspot, the Western Ghats, India. Frontiers in Ecology and Evolution. 11, 1026793.

[74] Barua, P., Rahman, S.H., 2019. Sustainable Livelihood of Vulnerable Communities in Southern Coast of Bangladesh Through the Utilization of Mangroves. Asian Journal of Water Environment and Pollution. 16(1), 59–67. DOI: https://doi.org/10.3233/ajw190007

[75] Rigg, J., Salamanca, A., Thompson, E.C., 2016. The Puzzle of East and Southeast Asia's Persistent Smallholder. Journal of Rural Studies. 43, 118–133. DOI: https://doi.org/10.1016/j.jrurstud.2015.11.003

[76] Krishnakumar, J., 2014. An Assessment of Non-Timber Forest Products Certification in Western Ghats, Kerala—A Multi-Stakeholder Study [Doctoral Dissertation]. University of Hawai'i at Manoa: Honolulu, HI, USA.

[77] de Melo, M., Denizer, C., Gelb, A., et al., 1991. Women in Forestry in India. World Bank Policy Research Working Paper. 714.

[78] Sandhu, H., Sandhu, S., 2015. Poverty, Development, and Himalayan Ecosystems. Ambio. 44(4), 297–307. DOI: https://doi.org/10.1007/s13280-014-0569-9

[79] Nerfa, L., Rhemtulla, J.M., Zerriffi, H., 2020. Forest Dependence is More Than Forest Income: Development of a New Index of Forest Product Collection and Livelihood Resources. World Development. 125, 104689. DOI: https://doi.org/10.1016/j.worlddev.2019.104689

[80] Anthwal, A., Gupta, N., Sharma, A., et al., 2010. Conserving Biodiversity Through Traditional Beliefs in Sacred Groves in Uttarakhand Himalaya, India. Resources, Conservation and Recycling. 54(11), 962–971. DOI: https://doi.org/10.1016/j.resconrec.2010.02.003

[81] Ryan, C.M., Pritchard, R., McNicol, I., et al., 2016. Ecosystem Services from Southern African Wood-

lands and Their Future Under Global Change. Philosophical Transactions of the Royal Society B: Biological Sciences. 371(1703). DOI: https://doi.org/10.1098/rstb.2015.0312

[82] Hill, C.M., 2004. Farmers' Perspectives of Conflict at the Wildlife–Agriculture Boundary: Some Lessons Learned from African Subsistence Farmers. Human Dimensions of Wildlife. 9(4), 279–286. DOI: https://doi.org/10.1080/10871200490505710

[83] Ghosh, S., Gupta, N.D., 2017. Targeting and Effects of Rashtriya Swasthya Bima Yojana on Access to Care and Financial Protection. Economic and Political Weekly. 52(4), 61–70.

[84] Dinda, S., Ghosh, S., Chatterjee, N.D., 2020. Understanding the Commercialization Patterns of Non-Timber Forest Products and Their Contribution to the Enhancement of Tribal Livelihoods: An Empirical Study from Paschim Medinipur District, India. Small-Scale Forestry. 19(3), 371–397.

[85] Kumar, N., 2004. Appraisal of Existing Agroforestry Systems in Sub-Tropical Region of Himachal Pradesh [Doctoral Dissertation]. Dr. Yashwant Singh Parmar University of Horticulture and Forestry: Nauni, India.

[86] Sharma, V., 2022. Appraisal of Existing Agroforestry Systems in Sujanpur Tehsil of Hamirpur District, Himachal Pradesh [Doctoral Dissertation]. Dr. Yashwant Singh Parmar University of Horticulture and Forestry: Nauni, India.

[87] Geetha, G.S., Devi, R.G., 2008. Technology Adoption and Training Needs of Sericulture Farmers—A Case Study in NGO. Indian Journal of Agricultural Research. 42(3), 157–163.

[88] Thallam, V.K., 2023. Community-Managed Natural Farming in Andhra Pradesh, India. In: Uphoff, N., Thies, J. (eds). Biological Approaches to Regenerative Soil Systems, 2nd ed. CRC Press: Boca Raton, FL, USA. pp. 431–448.

[89] Sahu, H., Purohit, P., Srivastava, A., et al., 2024. Comparative Assessment of Soil Parameters and Ecological Dynamics in the Western Himalayan Wetland and Its Surrounding Periphery. Environmental Quality Management. 34(1), e22283. DOI: https://doi.org/10.1002/tqem.22283

[90] Mishra, B., Nayak, B.K., 2011. Community Forest Management in Odisha: Macro and Micro Views. In Proceedings of the Thirteenth Biennial Conference of the International Association for the Study of the Commons, Hyderabad, India, 10–14 January 2011; pp. 1–23.

[91] Bhattacharya, P., Pradhan, L., Yadav, G., 2010. Joint Forest Management in India: Experiences of Two Decades. Resources, Conservation and Recycling. 54(8), 469–480.

[92] Misra, D., Kant, S., 2004. Production Analysis of Collaborative Forest Management Using an Example of Joint Forest Management from Gujarat, India. Forest Policy and Economics. 6(3–4), 301–320.

[93] Pandey, S., Singh, V.S., Gangwar, N.P., et al., 2012. Determinants of Success for Promoting Solar Energy in Rajasthan, India. Renewable and Sustainable Energy Reviews. 16(6), 3593–3598.

[94] Paramasivam, S., Henry, P., Seethapathy, P., et al., 2022. A Strategic Model for Empowering Farmers by Improving Livelihood Security Through Organic Farming Practices in Tamil Nadu, India. Journal of Agricultural Sciences–Sri Lanka. 17(3).

[95] Chapman, C.A., Abernathy, K., Chapman, L.J., et al., 2022. The Future of Sub-Saharan Africa's Biodiversity in the Face of Climate and Societal Change. Frontiers in Ecology and Evolution. 10, 790552. DOI: https://doi.org/10.3389/fevo.2022.790552

[96] Srivastava, A., Chinnasamy, P., 2024. Watershed Development Interventions for Rural Water Safety, Security, and Sustainability in Semi-Arid Region of Western India. Environment, Development and Sustainability. 26(7), 18231–18265. DOI: https://doi.org/10.1007/s10668-023-03387-7

[97] Parra, M.A., Baez, S., Sedeño, L., et al., 2021. Dementia in Latin America: Paving the Way Toward a Regional Action Plan. Alzheimer's & Dementia. 17(2), 295–313. DOI: https://doi.org/10.1002/alz.12202

[98] Lopez-Ridaura, S., Sanders, A., Barba-Escoto, L., et al., 2021. Immediate Impact of COVID-19 Pandemic on Farming Systems in Central America and Mexico. Agricultural Systems. 192, 103178. DOI: https://doi.org/10.1016/j.agsy.2021.103178

[99] Chopra, R., Magazzino, C., Shah, M.I., et al., 2022. The Role of Renewable Energy and Natural Resources for Sustainable Agriculture in ASEAN Countries: Do Carbon Emissions and Deforestation Affect Agriculture Productivity? Resources Policy. 76, 102578. DOI: https://doi.org/10.1016/j.resourpol.2022.102578

[100] Sanogo, K., Dayamba, D.S., Villamor, G.B., et al., 2020. Impacts of Climate Change on Ecosystem Services of Agroforestry Systems in the West African Sahel: A Review. In: Dagar, J.C., Gupta, S.R., Teketay, D. (eds.) Agroforestry for Degraded Landscapes. Springer: Singapore. pp. 213–224.

[101] Jain, S., Srivastava, A., Khadke, L., et al., 2024. Global-Scale Water Security and Desertification Management Amidst Climate Change. Environmental Science and Pollution Research. 31, 58720–58744. DOI: https://doi.org/10.1007/s11356-024-34916-0

[102] Hecht, S., Schmink, M., Abers, R., et al., 2021. The Amazon in Motion: Changing Politics, Development Strategies, Peoples, Landscapes, and Livelihoods. Available from: https://www.research-collection.ethz.ch/handle/20.500.11850/526184 (cited 17 October 2024).

[103] Miller, M.A., Middleton, C., Rigg, J., et al., 2020.

Hybrid Governance of Transboundary Commons: Insights from Southeast Asia. Annals of the American Association of Geographers. 110(1), 297–313. DOI: https://doi.org/10.1080/24694452.2019.1624148

[104] Delabre, I., Alexander, A., Rodrigues, C., 2020. Strategies for Tropical Forest Protection and Sustainable Supply Chains: Challenges and Opportunities for Alignment with the UN Sustainable Development Goals. Sustainability Science. 15(6), 1637–1651. DOI: https://doi.org/10.1007/s11625-019-00747-z

[105] Prosperi, P., Galli, F., Moreno-Pérez, O.M., et al., 2023. Disentangling the Diversity of Small Farm Business Models in Euro-Mediterranean Contexts: A Resilience Perspective. Sociologia Ruralis. 63(1), 89–116. DOI: https://doi.org/10.1111/soru.12407

[106] Friedman, E., 2023. Constructing the Adaptation Economy: Climate Resilient Development and the Economization of Vulnerability. Global Environmental Change. 80, 102673. DOI: https://doi.org/10.1016/j.gloenvcha.2023.102673