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Assessment of Consumption Pattern of Fuelwood and Fodder Species in Chamba Block, Tehri Garhwal, Uttarakhand

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Abstract

The study was conducted during 2023–2024 in nine villages of the Chamba block, Tehri Garhwal district, Uttarakhand, to assess seasonal patterns of fuelwood and fodder consumption and the associated socio-economic characteristics of rural households. A participatory rural appraisal approach was adopted. A total of 135 households were selected through stratified random sampling, and primary data were collected using semi-structured questionnaires, household surveys, and direct field measurements. Fuelwood consumption was estimated using a 24-hour weight-survey method, while fodder consumption was quantified based on livestock numbers standardized to cattle equivalent units. The results indicated a predominance of nuclear families (80%) and an ageing population, with agriculture remaining the primary occupation. Fuelwood was identified as the principal household energy source across all villages. Per capita fuelwood consumption increased from 1.67 kg day^{-1} in summer to 2.59 kg day^{-1} in winter. Fodder consumption showed seasonal variation, with a mean intake of 16.65 kg day^{-1} cattle^{-1} in summer and 15.36 kg day^{-1} in winter, largely derived from forest vegetation and multipurpose tree species. Fuelwood and fodder collection required substantial labour input, long travel distances, and significant time investment. The findings indicated strong seasonal dependence on forest resources and highlighted the need for sustainable biomass management and agroforestry-based fodder development.

Keywords: Demographics, fodder, fuelwood, rural livelihoods, socio-economic status

1. Introduction

Forests play a critical role in sustaining rural livelihoods in developing countries by providing essential biomass resources such as fuelwood, fodder, timber, and non-timber forest products. In mountain ecosystems, particularly the Himalayas, fuelwood and fodder constitute indispensable components of household energy systems and livestock-based agriculture due to limited access to alternative energy sources and constrained fodder cultivation (Singh and Sundriyal, 2009; Rawat et al., 2022). Despite rapid socio-economic transitions, a large proportion of rural households in the Indian Himalayan region continue to depend heavily on forest resources to meet daily subsistence needs (Pandey et al., 2020; Navale et al., 2022).

Globally, biomass remains the primary source of domestic energy for nearly 2.8 billion people, especially in rural and mountainous regions where clean energy access is limited (Annonymous, 2019; Annonymous, 2022). In India, fuelwood accounts for a major share of household energy consumption in hill states, where climatic severity, dispersed settlements, and economic constraints restrict large-scale adoption of modern fuels (Tripathi et al., 2016; Lam et al., 2017). Seasonal variations strongly influence fuelwood demand, with winter months showing increased consumption for space heating and water warming, thereby intensifying pressure on nearby forest ecosystems (Singh et al., 2018; Rawat et al., 2022).

Livestock rearing forms the backbone of mountain farming systems and plays a vital role in food security, income generation, and nutrient recycling. However, fodder availability in Himalayan regions remains a persistent challenge due to fragmented landholdings, limited pasturelands, and low on-farm fodder production (Bisht et al., 2018). Consequently, forests supply a substantial proportion of green and dry fodder, primarily through tree leaves, grasses, and shrubs (Navale et al., 2022). Multipurpose tree species such as *Quercus*, *Grewia*, *Celtis*, *Bauhinia*, and *Ficus* are widely preferred due to their high palatability and nutritional value, but increasing extraction has raised concerns regarding forest degradation and sustainability (Rawat et al., 2022; Pandey et al., 2020).

Socio-economic characteristics of households, including family

structure, education level, occupation, and livestock holdings, significantly influence patterns of biomass consumption and resource dependence (Demurger and Fournier, 2011; Sanwal et al., 2018). In recent decades, Himalayan villages have experienced demographic shifts marked by population ageing, migration of youth to urban centres, and transformation from joint to nuclear family systems, which collectively affect labour availability and resource-use dynamics (Singh et al., 2018; Xuan and Li, 2024). Understanding these socio-economic drivers is therefore essential for developing context-specific interventions aimed at reducing pressure on forest resources while sustaining rural livelihoods.

Although several studies have examined fuelwood or fodder use independently in Himalayan regions, comprehensive village-level assessments integrating demographic characteristics with seasonal consumption patterns remain limited, particularly for the mid-hill regions of Uttarakhand (Pandey et al., 2020; Rawat et al., 2022). Quantifying seasonal variation in fuelwood and fodder demand is crucial for planning sustainable forest management, promoting agroforestry-based alternatives, and improving energy and fodder security under changing climatic and socio-economic conditions (Anonymous, 2022; Kumar et al., 2022).

In this context, the present study was undertaken in the Chamba block of Tehri Garhwal district, Uttarakhand, with the objectives to (i) document the demographic and socio-economic characteristics of rural households, and (ii) quantify seasonal patterns of fuelwood and fodder consumption at household and village levels. The findings are expected to support sustainable biomass management strategies and inform policy interventions for Himalayan rural development.

2. Materials and Methods

2.1. Study region

The study was conducted in nine villages of the Chamba block, Tehri Garhwal district, Uttarakhand: Uniyal Gaon, Semwal Gaon, Pujaldi, Khuret, Jadipani, Chaupdiyal Gaon, Dhungli, Saur, and Naughar (Figure 1). The area lies between 1644–2393 masl, representing a sub-tropical to temperate transition zone with hilly terrain, cold winters, mild summers, and an average annual rainfall of 108.88 mm. Geographic coordinates and elevations were recorded using GPS, and a location map was prepared to depict site distribution.

2.2. *Field sampling and household selection*

A participatory rural appraisal (PRA) approach was used from December 2023 to August 2024 to document resource-use patterns. Using stratified random sampling, 135 households (15/village) representing small, medium, and large family categories were surveyed. Household heads or elder members served as key respondents.

2.3. *Questionnaire survey and data collection*

Primary data were collected through a semi-structured

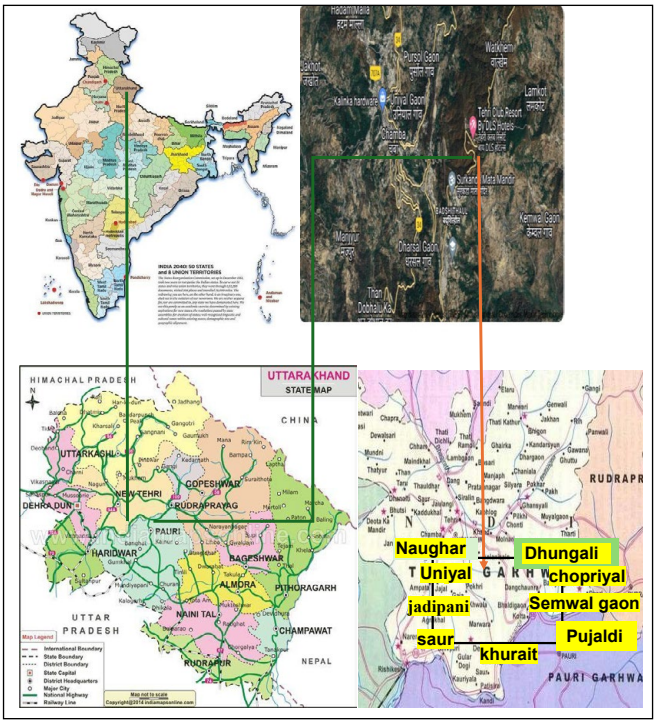

Figure 1: Geographical location of the nine selected villages in Chamba block, Tehri Garhwal district, Uttarakhand, showing elevation range (1644–2393 masl) and spatial distribution within the study area

questionnaire and house-to-house visits. Information included demographic details, landholdings, livestock population, frequency and distance of fuelwood and fodder collection, and seasonal variation in use. Secondary information from government records, literature, and village administrative offices supported data validation.

2.4. Fuelwood consumption assessment

Daily household fuelwood use was measured using a 24-hour weight-survey method. Per capita consumption was calculated as:

Daily per head consumption (kg)=(Fuelwood used/day)/ Household size

Village-level demand was obtained by multiplying per capita consumption by village population. Seasonal estimates were made for summer and winter.

2.5. Fodder consumption assessment

Fodder consumption was quantified through direct measurement and household reporting. Livestock numbers were standardized using the cattle equivalent unit (CEU): 1 adult cow/bullock/buffalo=1 CEU (Singh and Sundriyal, 2009).

Daily fodder intake was estimated as:

Daily fodder intake/animal=(Total fodder offered-leftover)/ No. of livestock

Village-level fodder requirement was calculated for summer, rainy, and winter seasons, considering fodder sourced from forests, agricultural fields, agroforestry trees, grasslands, and crop residues.

2.6. Land-use documentation

Land-use categories (agriculture, agroforestry, habitation, wasteland, orchards, and roads) were recorded through field observations, GPS measurements, and verification with the revenue department and gram panchayat offices.

2.7. Data analysis

Data were analyzed in Microsoft Excel to generate descriptive statistics (mean, standard deviation, and percentage). Consumption patterns of fuelwood and fodder were compared across households and villages.

3. Results and Discussion

3.1. Demographic features and socio-economic status of respondents

The socio-economic assessment of nine villages in the Chamba block revealed distinct demographic and livelihood patterns. The villages were located between 1644–2393 masl, with household numbers ranging from 42 (Dhungali) to 323 (Saur). A uniform sample of 15 households per village ensured balanced representation. Population distribution showed slight gender variations, with villages such as Chaupdiyal and Khuret having a higher proportion of females than males. Age classification indicated a predominantly older population, with 47.32% of respondents above 50 years, 35.60% in the middle-aged category, and only 17.07% in the younger age group (Figure 2). Family structure analysis showed that nuclear families predominated (80%), while joint families accounted for only 20% of the total households (Figure 3). Educational status indicated low higher-education attainment, with 47.61% completing primary education, 38.94% intermediate education, and only 13.44% attaining graduate-level education (Figure 4). Occupational analysis confirmed the agrarian nature of the region. About 50.87% of respondents were engaged in agriculture, followed by business (21.32%), government service (13.84%), private sector employment (7.73%), and wage labour (6.23%) (Figure 5). Housing characteristics showed that pucca houses

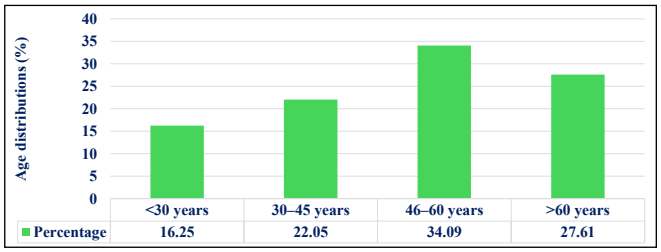

Figure 2: Age distribution (%) of respondents in the selected villages, showing predominance of the older age group (>50 years)

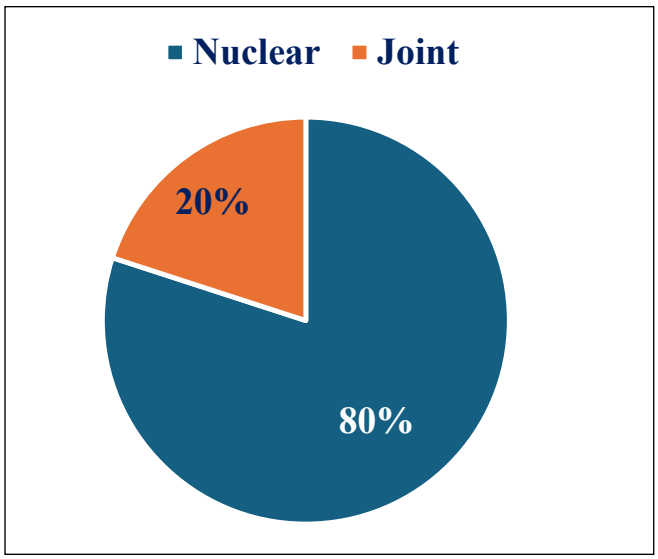

Figure 3: Distribution of family types (%) among surveyed households, indicating dominance of nuclear families over joint families

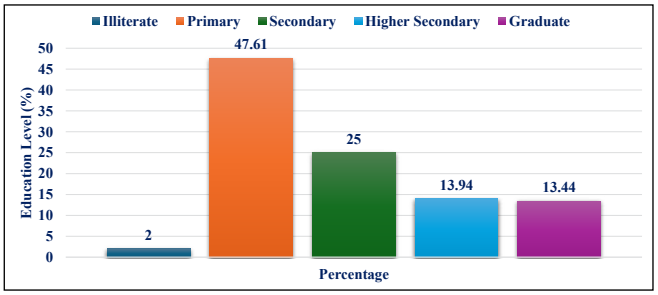

Figure 4: Educational status (%) of respondents across the nine study villages, showing primary and intermediate education as the dominant levels

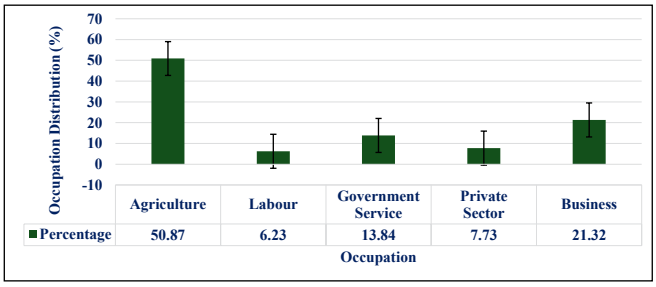

Figure 5: Occupational structure (%) of surveyed households, highlighting the predominance of agriculture as the primary livelihood activity

constituted 64.44% of total dwellings, whereas kuccha houses accounted for 14.07% (Figure 6). Livestock distribution across villages (Figure 7) totalled 411 animals. Cows (39.17%) and buffaloes (34.54%) predominated, followed by goats (15.08%), poultry (5.83%), and sheep (5.35%). Village-wise differences in species composition were observed. Overall, the study area represented a predominantly rural, agrarian society

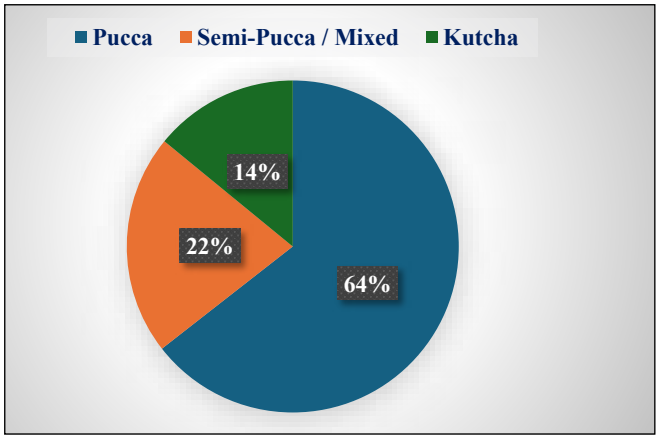

Figure 6: Housing type distribution (%) among households, showing the proportion of pucca, semi-pucca, and kuccha houses in the study area

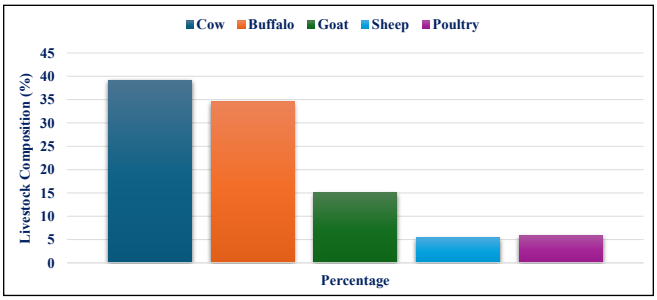

Figure 7: Livestock composition (%) across the selected villages, indicating dominance of cows and buffaloes in total livestock holdings

characterized by nuclear families, moderate literacy levels, limited higher education, and diversified livestock holdings.

The demographic profile of the surveyed villages revealed a shift toward an ageing population, with nearly half of the respondents belonging to the older age category. This structure suggested rural out-migration of younger individuals in search of education and employment opportunities. Similar demographic transitions have been reported in other rural regions experiencing economic constraints and infrastructural limitations (Xuan and Li, 2024). Such demographic imbalance may reduce agricultural labour availability and increase dependency ratios. The predominance of nuclear families reflected changing socio-cultural dynamics. The decline of joint family systems corresponded with increasing mobility and economic aspirations, as observed in other rural Indian settings (Gregory, 2009). Smaller family units may influence labour availability for agriculture and forest-based activities. Educational attainment remained moderate, with most respondents completing primary or intermediate schooling, but few attaining higher educations. Limited access to higher education may have constrained occupational diversification, consistent with earlier observations in Himalayan regions (Negi, 1996).

The occupational structure confirmed the agrarian foundation of the rural economy, although gradual diversification into business and service sectors was observed. Diversification may enhance livelihood resilience in mountain ecosystems that are highly vulnerable to climatic variability (Kumar et al., 2022; Niroula and Thapa, 2005). Housing improvements suggested gradual socio-economic advancement, possibly supported by government housing schemes (Alam et al., 2022). The dominance of cows and buffaloes highlighted their importance in sustaining rural livelihoods, consistent with findings in mixed crop-livestock systems (Herrero et al., 2013). The diversity of fuelwood species used reflected the ecological richness of Himalayan forests and the adaptive selection of high-calorific and multipurpose tree species (Rawat et al., 2022). Such diversity indicated sustained dependence on forest ecosystems for household energy.

3.2. Fuelwood and fodder consumption patterns under two seasons

Fuelwood remained the primary household energy source across all nine villages, despite partial availability of LPG or kerosene. Seasonal variation was observed, with winter showing higher demand due to space heating and water warming requirements. The most preferred fuelwood species included oak (*Quercus leucotrichophora* and *Q. semecarpifolia*), Chir pine (*Pinus roxburghii*), *Rhododendron arboreum*, and several deciduous hardwood species such as *Grewia optiva, Pyrus pashia,* and *Celtis australis*. Per capita fuelwood consumption averaged 1.67 kg day^{-1} in summer and increased to 2.59 kg day^{-1} in winter. Household consumption increased from 9.58 kg day^{-1} in summer to 13.63 kg day^{-1} in winter. At the village level, summer consumption ranged from 869.75–1267.21 kg day^{-1} (mean 999.11 kg day^{-1}), while winter consumption ranged from 1085.45–1944 kg day^{-1} (mean 1458.76 kg day^{-1}). These trends indicated stronger dependence during winter months (Figure 8). Fuelwood collection involved travelling 3–5 km to forest areas, typically engaging two household members, and required 2–5 hours per trip. Although LPG and room heaters were used as supplementary energy sources, they did not replace traditional fuelwood.

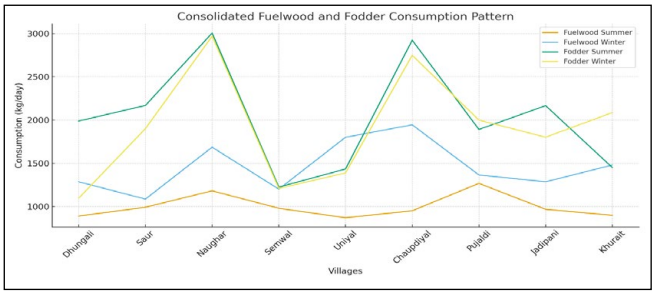

Figure 8: Seasonal comparison of per capita, household, and village-level fuelwood and fodder consumption (kg day^{-1}), showing higher winter fuelwood demand and seasonal variation in fodder use

Fodder consumption also exhibited seasonal variation. Ten major fodder species were identified, including *Grewia optiva, Quercus leucotrichophora, Celtis australis, Toona ciliata, Bauhinia variegata, and Ficus roxburghii*. Mean fodder consumption was 16.65 kg day^{-1} cattle^{-1} in summer and 15.36 kg day^{-1} in winter. Village-level totals averaged 2027.53 kg day^{-1} in summer and 1910.55 kg day^{-1} in winter. High-consumption villages included Naughar and Chaupdiyal, reflecting larger livestock populations. Fodder collection required travelling 2–5 km, involving 2–4 household members, and required 3–5 hours depending on terrain. Forests remained the principal source of fodder for all villages. Overall, fuelwood and fodder use demonstrated clear seasonal dependence and strong reliance on forest ecosystems.

Fuelwood consumption increased significantly during winter, reflecting elevated heating demands. Similar seasonal trends have been documented in mountain regions where climatic severity influences biomass use (Lam et al., 2017). Village-level variations likely resulted from differences in household size, livestock numbers, and forest accessibility (Rao and Sharma, 2019). The continued reliance on fuelwood, despite partial LPG adoption, suggested limited energy transition in the study area. Comparable observations have been reported where affordability and supply constraints restricted cleaner fuel adoption (Guta, 2014). Fuelwood collection imposed substantial labour burdens, with long travel distances and time investments. Similar patterns have been reported in Himalayan communities facing forest resource pressures (Singh et al., 2018). Fodder consumption decreased slightly during winter due to reduced forage availability and increased dependence on stored feed. Village-level differences corresponded with livestock population density and production intensity (Tanner et al., 2001). The heavy reliance on forest-derived fodder underscored the importance of forest conservation and the need for agroforestry-based fodder interventions (Bisht et al., 2018; Navale et al., 2022). Overall, the study findings highlighted strong seasonal dependence on forest resources and emphasized the need for sustainable biomass management strategies to reduce ecological pressure while maintaining rural livelihoods.

4. Conclusion

A strong seasonal dependence was observed on forest resources, with higher fuelwood consumption during winter and consistent reliance on forest-derived fodder for livestock. Rural livelihoods remained predominantly agrarian and were characterized by ageing populations and nuclear family structures. The findings emphasized the need for sustainable biomass management, promotion of agroforestry-based fodder systems, and diversification of rural livelihoods to reduce pressure on Himalayan forest ecosystems.

5. Acknowledgment

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