



Socio-economy and dependency of Van Gujjars on the forests of Tarai region of Central Himalaya

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Abstract

Forests play a vital role in protecting biodiversity, maintaining ecological equilibrium and hold substantial economic importance, offering critical livelihood opportunities for millions of individuals globally. Rural livelihood is significantly dependent on forest essentials like fuelwood, fodder, timber, medicine and food. The study focused on assessing the socio-economic conditions and forest resource dependency of the *Van Gujjars* in the Tarai region of Uttarakhand, India. *Van Gujjars* is a semi-nomadic community residing in the forest area of northern regions in India and their livelihood is heavily dependent on forest resources. They are major pastoral tribes of India and generate income from the milk production. The present study estimated the level of dependency on forests for households and identified the factors that influence this dependency. Additionally, the study examined how the consumption of fuelwood and fodder varies among the different settlements of the Van Gujjar community. Three different settlements were selected based on the dominance and population of the *Van Gujjars*. To assess the impact of socio-economic factors on forest resource dependence, logistic binary regression analysis was employed. The analysis revealed that age ($\beta = -0.00$, $p = 0.049^*$), household size ($\beta = 0.346$, $p = 0.005^*$), and livestock ownership ($\beta = 0.026$, $p = 0.025^*$), significantly influenced forest dependency. In each settlement, animal husbandry was the primary source of livelihood, with an average of 24.19 ± 6.6 adult cattle unit per household. Firewood consumption in the study area averaged 12.30 ± 0.82 kg per day per household, varying with settlement, household size, and seasons. Similarly, livestock consumed an average of 20.09 ± 0.7 kg of fodder per day per household. For the assessment of preferred tree species by the Van Gujjars for firewood, fodder, timber, and medicinal purposes the study identified 22 tree species which meet their diverse needs. The study concludes that the heavy reliance of the Van Gujjars on forest resources poses challenges to forest management sustainability efforts. As long as the demand of forest products exceeds the supply, neither sustainability nor the improvement of living conditions for the Van Gujjars can be achieved in the region. This study also suggests the steps to implement cross-sectoral and long-term strategies to address the issue of forest resource dependency. This involves the participation of all stakeholders, including local communities, in the decision-making process.

Keywords Household · Livelihood · Animal husbandry · Forest resources · Marginality · Unustainable consumption

Introduction

Forests are valuable for sustaining biodiversity, maintaining ecological balance and serve as an essential habitat for a wide range of flora and fauna, contributing to the overall biological diversity on earth (Gora et al. 2022), along with mitigating climate change (Semwal et al. 2004). Accounting their ecological significance, forests also have economic significance since they provide crucial livelihood opportunities for millions of people worldwide (Hussain et al. 2016a, b), in particular in the rural areas of developing nations. Across the world there are more than 2 billion people meeting their primary energy demands depending upon forest

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resources (IPBES 2019). It is estimated that approximately 70% of rural households in developing countries rely heavily on forest wood for heating and cooking purpose, timber, medicine even as single source of income (Shahsavari and Akbari 2018; Galik et al. 2021). However, people's dependency on forests and its contribution on livelihood is a complex aspect, and its significance changes across communities, geographical region along with period of time. Since residents of the peripheral villages of forest are not homogenous, the variance in dependency of households on forests is inevitable.

With a population of over 1.4 billion people, India faces significant energy demands across various sectors of its economy (Nain et al. 2017), which highlights the substantial role of forests in providing the necessary energy resources to various sectors of the country's economy and livelihoods (Negi et al. 2018; Bhatt et al. 2016). Currently, about 500 million people in India rely on forests for their basic needs, including fodder, firewood, timber, leaf litter, and a wide range of non-timber forest products (Negi and Maikhuri 2017), which serve as an essential input for their daily lives and economic activities. Among the important contributions of forests, fodder is most significant produce for communities that depend on livestock rearing, supporting the sustenance of livestock and enabling dairy production (Roy et al. 2019), firewood as a primary energy source (Adanguidi et al. 2020), and forests timber is utilized for construction purposes (Adhikari et al. 2022).

In India, there are approximately 13 million people practicing pastoralism, which is nearly 1% of the country's population. Among the numerous castes and communities about 46 have distinct pastoralist individualities in India (Rollefson and Kishore 2021). Pastoralists are people who mostly depend on livestock for their livelihood and income generation (Harihar et al. 2014). The tribal groups found in the different part of India are the goat and sheep herders called *Gaddis*, *Kanets*, *Kaulis* and *Kinnauras* in Himachal Pradesh, the sheep herding *Bhotias* of Uttarakhand, yak herding *Sherpas* of Sikkim and the northern portion of West Bengal (Sharma et al. 2003). In northern India these tribal groups are known as Van-Gujjars, representing a diverse community, both ethnically and religiously. Due to their pastoral lifestyle, this community has been isolated from Indian culture since colonial rule (Gooch 2009). The Van Gujjars used to transmigrate every year, moving between summer grazing places in the upper Himalayas and winter pastures in the foothills of Himalayas (Sharma et al. 2012). In 1983, after the establishment of Rajaji National Park in the Shiwalik hills of Uttarakhand, the Forest Department of India rehabilitated Van Gujjars in the different forests in Tarai region of Uttarakhand (Parween 2021). They inhabited in traditional huts called *Deras* and *Khatta* inside the forests. These huts are majorly built out of forest products including

wood, bamboo, and grasses. Similarly, livestock sheds are constructed near to the huts which are also made from forest materials (Hussain et al. 2012).

This study emphasizes the importance of understanding the dependency of Van Gujjar's on forest resources in the Tarai region of Uttarakhand, along with their socio-economic conditions. It also investigates their preferences for different tree species for traditional medicinal purposes, consumption of fuelwood, fodder and timber. The primary goal is to identify socio-economic and demographic factors that determine Van Gujjar's dependency on forest resources. The research questions include: (1) What factors influence a household's dependency on forest products? (2) To what degree does a household consume forest resources?

We hypothesize that the dependency level of Van Gujjar's on forest resources differs significantly with socio-economic features. The study could be valuable for policymakers to comprehend forest dependency, income sources, and rising apprehensions regarding forest degradation and deforestation in the Tarai region.

Materials and methods

Study area: The study was conducted in the Tarai region of Uttarakhand (Fig. 1), India, which is inhabited by the Van Gujjar tribe (Ghimire 2019). Tarai region is a lowland area located in northern India and southern Nepal, lying to the south of the outer foothills of the Himalayas. The Tarai region holds significant ecological importance and is known for its diverse flora and fauna (Rawat and Adhikari 2015). The landscape in this lowland belt is characterized by grasslands, forests dominated by *Tectona grandis* L. f. and *Shorea robusta* C.F. Gaertn., and clay-rich swamps (Johnsingh et al. 2004). Moreover, the Tarai region represents a complex mosaic of forests, agricultural land, and human settlements. It is also home to various indigenous communities, including the Van Gujjars, who have historically relied heavily on the forests for their livelihoods and cultural identity (Harihar et al. 2014).

Study sites: The study was conducted in three distinct settlements (*Khatta*) of the Van Gujjars which were selected on the basis of their dominance in the Tarai region of Kumaun, Uttarakhand (Table 1). All three settlements come under the Central Tarai Region of Kumaun, Uttarakhand. The first settlement—Patheliya Khatta, settled within the Barheni forest range, offers insights into traditional practices and resource management of Van Gujjars, the second is Tilpuri Khatta, situated in the Pipalpadao forest range and third is Jayanagar Khatta, within the Tanda forest range, reveals the dynamic interplay between tradition and modernity, reflecting the Van Gujjar's resilience amidst social and environmental changes.



Fig. 1 Location of the study area showing three settlements of Van Gujjars in the Tarai region of Uttarakhand

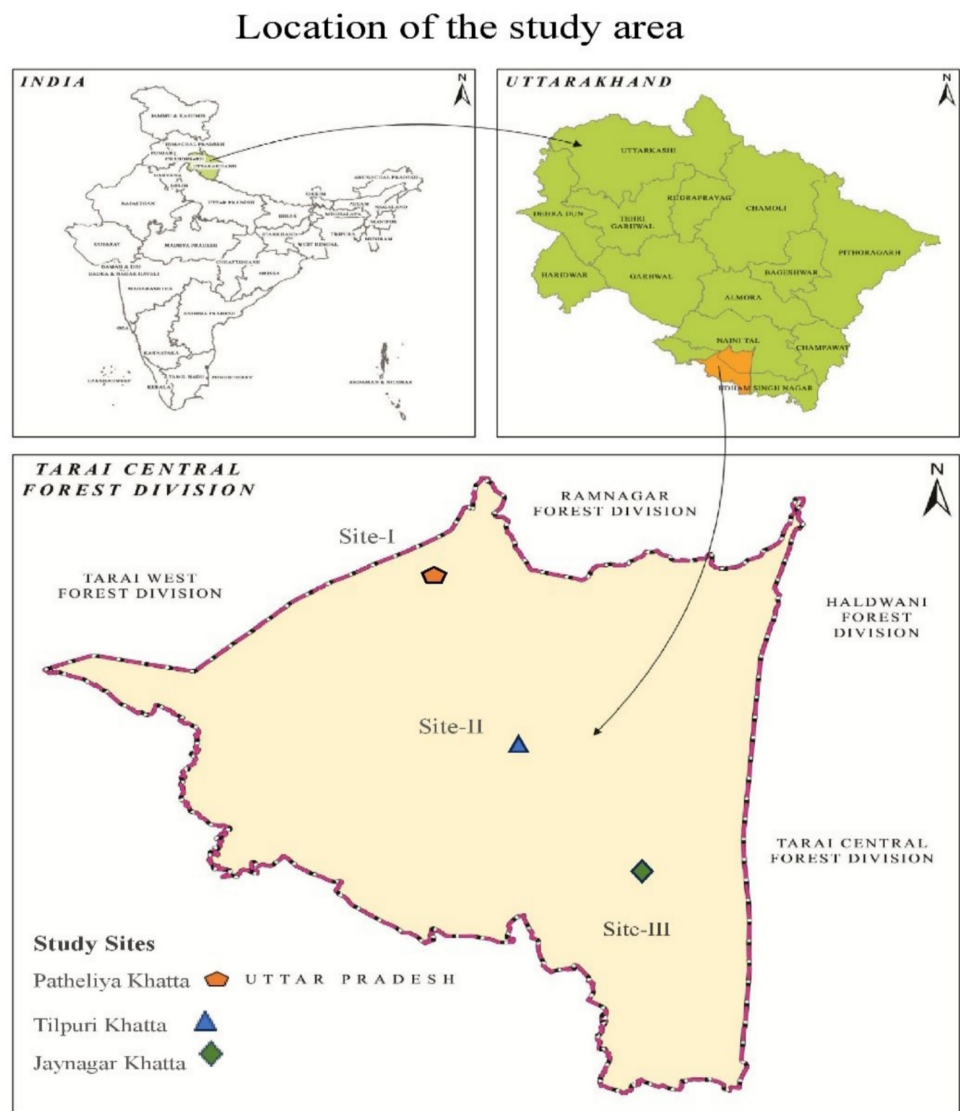


Table 1 Description of the study sites with their latitude–longitude and forest ranges

Study sites	Name of the settlements	Latitude/Longitude	Forest range	Dominant forest
I	Patheliya Khatta	N29°13'54.1" E79°13'35.1"	Barheni	<i>Tectona grandis</i> and <i>Trewia nudiflora</i>
II	Tilpuri Khatta	29°08'79.2" E79°41'70.2"	Pipalpadao	<i>Shorea robusta</i> and <i>Tectona grandis</i>
III	Jaynagar Khatta	29°11'46.8" E79°36'60.9"	Tanda	<i>Trewia nudiflora</i> and <i>Mallotus philippensis</i>

Methods

Data collection

A preliminary survey was conducted for the socio-economic assessment at Van Gujjar *Khatta* (Gujjar settlements). In total, 81 households were selected for this survey which were categorised based with equal consideration for all socio-economic groups and household sizes.

In all three settlements the household sizes were divided into small (1–4 individuals), medium (5–8 individuals) and large size (8 and more individuals) encompassing 27 households in each household class.

The sample size was determined following Bartlett et al. (2001).

$$n = p(100 - p)z^2 / E^2$$

n is the required sample size.

P is the percentage occurrence of a state or condition.

E is the percentage maximum error required.

Z is the value corresponding to level of confidence required.

In the social research a 5% margin of error is acceptable by this formula 27 households were sufficient to represent the whole population of each study site.

A well-structured questionnaire was prepared for the gathering of information on population of the settlements and livestock, their annual income, literacy level, land ownership, source of income, fire wood and fodder consumption per household (Martin 1995). For the assessment of the precise economic condition of Van Gujjars data were collected into different income groups (30,000–60,000, 90,000–120,000, 120,000–240,000 and more than 240,000 INR).

Descriptive statistics were employed to summarize the factors that influenced households' dependence on forests. A binary logistic regression model was used to determine the impact of socio-economic factors on forest dependency (Garekai et al. 2017). In this model, forest dependency was considered the dependent variable, while the socio-economic factors were treated as independent variables. Forest dependency, the outcome variable, was measured as a dichotomous response with two possible values: 1 or 0. A value of 1 indicated a high level of forest dependency, while a value of 0 represented a low level of forest dependency.

Since there is no set conventional cut-off point for classifying forest dependency, the average value across the study villages was considered as the threshold for categorising forest dependency into two levels: low and high (Kumar and Gupta 2023). This approach has been widely used in forest dependency literature (Jannat et al. 2018) Hence, the cut-off point value of 0.5 was used in this study. The forest dependency value of $P \leq 0.5$ therefore denotes low dependency while a value of $P \geq 0.5$ indicates high dependency. Although, the study investigated how socio-economic factors, represented by age, household size, sex, education, and employment, relate to the level of forest dependency among households (Pandey 2011).

Livestock and forest resource consumption

Livestock: The population of livestock was determined using conversion factors to compute Adult Cattle Units (ACU). In these calculations, buffaloes were considered as 1.33 adult units, while cows and oxen were assumed to be 1.0 adult units. Calves and goats were estimated as 0.5 adult units (Chand et al. 2013).

Fuelwood and fodder: Although, the consumption of firewood was determined based on the size of the household (categorized as small, medium, large) and different seasons, i.e. winter (post-monsoon), summer

(pre-monsoon) and the rainy season (monsoon) in the study area. To estimate the daily consumption of fuelwood and fodder per household, a survey was conducted on 33% of the total households. Their consumption amounts were recorded for three consecutive days. Each day, they were provided with a pre-weighed quantity of fuelwood and fodder then leftover was weighed the following morning.

The average firewood consumption of the settlement was calculated by multiplying the average daily per household consumption of fuel wood with the total number of households.

$$TFc = AFcH * TNH$$

where TFC is total fuelwood consumption of the settlement (Khatta), AFcH is average fuelwood consumption of sampled household and TNH is total number of households.

Subsequently, the daily per capita consumption of fuelwood was then calculated by dividing the total amount of wood consumed by the household by the total number of household members, following the method used by Gupta et al. (1997).

$$FcP = \frac{TFc}{TFm}$$

where F per day per capita fuelwood consumption, TFC total fuelwood consumption by the sample household, and TFM total number of members in the household.

The fuelwood consumption also varies with the different seasons in a year therefore, fuelwood consumption was also determined based on the various seasons i.e. winter (post-monsoon), summer (pre-monsoon) and the rainy season (monsoon). Total days of the year, divided into three main seasons winter, summer and rainy giving equal consideration (4 months each). Fuelwood consumption further calculated separately in each season by following this formula:

$$TFc = FcW + FcS + FcR$$

where TFC is total fuelwood consumption, FcW is fuelwood consumption in winter days, FcS is fuelwood consumption in summer days and FcR is Fuelwood consumption in Rainy days. The source and supply of fodder for livestock was quantified as contribution of market purchases and forests (Mamo et al. 2007).

Utility value of tree species: The average daily household consumption of the preference of different species by households for different uses, such as fire wood, fodder, timber, and medicinal uses, was also identified on the basis of the utility value of tree species following Johnson (1980), Kala (2007). This method ranks tree species based on their importance to a population. The ranking is determined by the number of uses and the number of citations for each species. The use value (UV) is calculated using the formula:



$$UV = \frac{\sum U_i}{n}$$

where U_i is the number of uses cited by each respondent for a species, and n is the total number of respondents. Species are then ranked from 1 (most important) to 20 (least important) based on their average utility value. In-depth interviews were also conducted with the village head for gathering additional information related to the nature of settlement (Mears 2012).

Data analysis

The quantitative and qualitative data collected through the questionnaire were coded and analysed using SPSS version 20 for descriptive analyses.

The data collected from the survey was first crosschecked, qualitative data was summarized by way of text analyses, while quantitative data was analysed by descriptive and inferential statistics. Descriptive statistics, including proportions or percentages, averages, and others, were used for describing socioeconomic characteristics of sample respondents. Inferential statistics was used to study relationships between variables using different statistical tests. To test statistical differences among all three sites in the firewood and fodder consumption, one-way ANOVA test was employed. A binary logistic regression model was used to determine the impact of socio-economic factors on forest dependency.

Results

Socioeconomic status of Van Gujjars in the study area

The demographic, economic, and educational status of Van Gujjars for three different sites in the study area is represented in Table 2. The total number of households and the human population are slightly higher in Site-III in comparison to Site-I and Site-II and the sex ratio, i.e., the number of females per thousand males in the study area, was 957.

Education: The literacy rate of the Van Gujjars was 25.66% across all the study sites, however, education status, amongst households in all three settlements had no schooling. The highest percentage of illiteracy was observed in Site-I (78.1%) followed by Site-II (75.1%) and Site-III (69.6%). The highest percentage of households with primary education was observed in Site-III (15.6%), while the highest percentage of households with secondary education was observed in Site-II (12.2%). Graduation was only reported in Site-I with a low percentage of 3.7%.

Source of income: Dairy production is the primary source of income for the Van Gujjars at all three sites. In the study

Table 2 Socio-economic observations of the Van Gujjars in the all three settlements of the study area

Settlements (Khatta)	Site-I	Site-II	Site-III
Total household	38	47	51
Total human population	227	330	341
Sampled household	27	27	27
<i>Education status (%)</i>			
No schooling	78.3	75.1	69.6
Primary	9.9	5.2	15.6
Secondary	3.7	12.2	11.1
Higher secondary	4.4	7.5	3.7
Graduation	3.7	0	0
<i>Sources of income (%)</i>			
Sole dairy production	96.30	85.19	92.59
Dairy production + Daily wages	3.70	11.11	7.41
Dairy production + Private Employed	0.00	3.70	0.00
<i>Annual income Indian Rupees (%)</i>			
30,000–60,000	15.9	3.7	7.4
90,000–120,000	48.1	42.2	37.7
120,000–240,000	24.8	22.2	39.7
More than 240,000	11.2	31.9	15.2

*Site-I (Patheliya Khatta), Site-II (Tilpuri Khatta), Site-III (Jaynagar Khatta)

area, a significant 96.3% of respondents from Site-I mainly depend on dairy production. This is closely followed by Site-III at 92.59%, and Site-II at 85.19%. However, some households in Site-II (11.11%) and Site-III (7.41%) also supplement their income with daily wage labour.

Animal husbandry has been the primary means of livelihood for the Van Gujjars since the time of their ancestors. This economic system is deeply rooted in their culture and lifestyle, which could explain their preference for animal husbandry as their main source of income. They generate income by selling their milk to nearby locations. They generate income by selling their milk to nearby locations. However, the economic conditions vary, and they were categorized into different income brackets: average (Rs. 0.60–0.90 lakh annually), below average (Rs. 0.30–0.60 lakh annually), and above average (Rs. 0.90 lakh annually). In the study area, 9% of households had an annual income ranging from INR 30,000 to 60,000. Additionally, 42.6% of households earned between INR 60,000 and 90,000 per year. Moreover, approximately 28.9% of households had incomes falling in the range of INR 120,000–240,000 annually, while 19.50% of households earned over INR 250,000 annually.

Socio-economic determinants influencing household dependence on forest resource

Binary logistic regression model was run to assess the predictive ability of the selected socio-economic factors on household forest dependency. The findings of the binary logistic model indicated that the model with independent variables (PAC: 77.7) performed better than the null model (PAC: 55.6). The Omnibus Tests of Model Coefficients ($\chi^2 85.25$, $P < 0.05$) indicated that there was a significant relationship between socioeconomic factors of Van Gujjars and their dependency of forest. Similarly, based on the Hosmer and Lemeshow Test ($\chi^2 11.54$), the p-value of 0.172 indicated that there was no significant evidence of lack of fit between the predicted and observed value. This suggests that the model fits the observed data reasonably well. The likelihood ratio test shows that the regression model was significant ($\chi^2 20.44$, $p > 0.05$). The results also indicates that a significant relationship exists between the socio-economic status of Van Gujjars and forest dependency. The model explained between 65.0% (Cox and Snell R^2) and 79% (Nagelkerke R^2) of the variance on forest dependency. This signify that this model able to explain a significant amount

of the variability or differences observed in forest dependency among the households.

Three predictors: age, household size and livestock ownership made a statistically significant contribution towards predicting forest dependency (Table 3). Since, the coefficient of age was negative, the odds of reporting high forest dependency decreased with age (OR = 0.94). This suggests that an increase on the age of household head results in decrease on forest dependency by a factor of 0.96, all other factors being equal. The results implies that the young aged was likely to gather more forest products compared to the middle aged and the elderly. On the other hand, gender did not reach statistical significance ($\beta = -0.795$, $p = 0.178$), suggesting that its influence on the forest dependency may not be substantial.

A significant finding suggested that the significant impact of household size ($\beta = 0.346$, $p = 0.005^*$) on forest, revealing that a one-unit increase in household size resulted in a 41.4% increase in the odds of the outcome variable. Furthermore, Livestock's Own demonstrated a significant effect ($\beta = 0.026$, $p = 0.023^*$), indicating that a one-unit increase in Livestock ownership corresponded to 1.974-fold higher odds of the outcome variable.

Table 3 Socio-economic factors of the Van Gujjars and dependency on the forests

	B	SE	Wald	Sig	Exp(B)	95% C.I. for EXP(B)	
						Lower	Upper
Age	− 0.006	0.023	0.079	0.049*	0.941	0.963	1.052
Gender	− 0.795	0.590	1.815	0.178	0.452	0.142	1.436
Household size	0.346	0.123	7.859	0.005*	1.414	1.110	1.801
Livestock ownership	0.026	0.050	0.0275	0.023*	1.974	1.283	1.074
Education category							
Primary	− 0.093	0.943	0.010	0.921	0.911	0.143	5.784
Secondary	− 0.695	1.061	0.429	0.513	2.003	0.250	16.026
Tertiary			1.411	0.494			
Income category							
> 30,000	0.813	1.005	0.654	0.419	2.254	0.314	16.163
30,000–90000	0.115	0.756	0.023	0.879	1.122	0.255	4.937
< 90,000	1.222	0.860	2.020	0.155	3.393	0.629	18.294
Constant	− 2.005	1.669	1.443	0.230	0.135		
Tests			χ^2		Df		P-value
Model evaluation (overall)							
Likelihood ratio test			20.414		8		0.005
Goodness of fit test							
H–L Statists			11.54		8		0.173

*The mean difference is significant at the 0.05 level

PAC percentage of accurate classification.

Null model—64.20, Model with independent variable – 77.70.

Cox & Snell R^2 – 0.65, Nagelkerke R^2 – 0.79.

Sample size used in the analysis (n) = 81



The secondary and Primary education level had negative relations but nonsignificant ($P > 0.05$), with a likelihood of decreasing dependence by a factor of 0.911 and 2.00 respectively, indicating that these education levels at the tribal level may not have a significant role on forest dependency. The income categories of Van Gujjars had a non-significant ($P > 0.05$), but a positive coefficient relation on forest dependency.

Livestock population of the Van Gujjars in the study area

Livestock is an integral part of the household and has been major component and primary source of economy of Van Gujjars. Buffaloes, cows, goats, ox, and calves constitute the major livestock types. The total count of buffalo was highest (1056) followed by cow (273) and calf (185) in the study area (Fig. 2). In term of settlements the highest buffalo count was recorded in site-III (364) and followed by Site-I (357) and site-II (335) respectively. The total Adult Cattle Unit (ACU) was 1960, with average of 24.19 ± 6.6 per household all across the tree sites of study area.

Energy consumption by Van Gujjars

In the present study, all household (100%) used wood as the main source of energy for cooking and heating purposes,

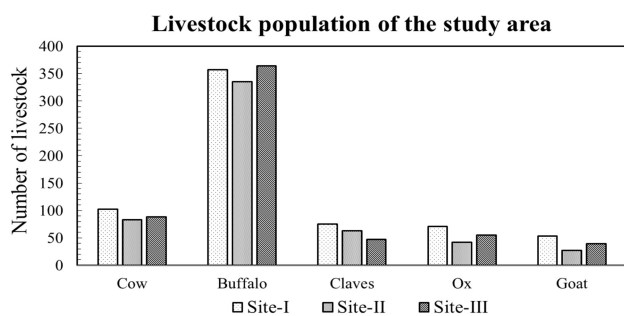


Fig. 2 Livestock population of Van Gujjars in all three settlements (Site-I Patheliya Khatta, Site-II Tilpuri Khatta, Site-III Jaynagar Khatta)

Table 4 Firewood consumption (in kg) of household based on household size (Mean $\pm$ SE)

Household size classes	Average fuelwood consumption (in Kg)			
	Household/day	Household/year	Capita/day	Capita/year
Small	8.62 ± 0.31^a	3146.66 ± 112.97^a	1.89 ± 0.07^a	689.56 ± 25.63
Medium	12.09 ± 0.50^b	4415.55 ± 185.31^b	1.56 ± 0.06^b	569.75 ± 22.55
Large	16.17 ± 0.44^c	5902.22 ± 160.64^c	1.51 ± 0.40^b	553.84 ± 14.66

Values are Mean + Standard error and different superscripts (a, b, c) on each value signify noteworthy statistical differences, at the 0.05 significance threshold

which reflects very high dependency on forests firewood. Firewood consumption varied in different household in each settlement, with the average firewood consumption of each household was 12.30 ± 0.82 kg/day, and in terms of average per capita fuel wood consumption, it was about 1.65 ± 0.34 kg/day all across the study area. The total annual firewood consumption was 448.95 tonnes in all across the three sites. Although, total numbers of members collecting firewood from nearby forest were 148 individuals per day and average number of members collecting firewood per household per day was 1.83 ± 0.70 members. They are mainly preferring trees such as *Shorea robusta*, *Tectona grandis*, *Mallotus philippensis*, *Populus deltoides*, *Dalbergia sissoo* and *Trewia nudiflora* as firewood for cooking, heating, and other domestic purposes. Subsequent unsustainable logging was taking place for the collection of firewood throughout the year in all three sites. This high amount of firewood consumptions and can also lead the degradation of preferred species in the region.

Variation in firewood consumption based on household size and seasons

Firewood consumption varied with different household class (Small, Medium and Large). It was observed that lower average firewood consumption (8.62 ± 0.31 kg day⁻¹ household⁻¹) was found in small Households, while the highest average consumption (16.17 ± 0.44 kg day⁻¹ household⁻¹) was found in very large households (Table 4), and statistical analysis indicated that the firewood consumption patterns per household per day were significantly different ($p > 0.05$) among small, medium and large households (Table 4). Understanding these patterns can inform energy conservation strategies, with targeted interventions for small, medium and large households. The average firewood per capita consumption also varied with the different household size classes. Average firewood consumption capita⁻¹ day⁻¹ (1.89 ± 0.07) and capita⁻¹ year⁻¹ (689.56 ± 25.63) was highest in the small households. Similarly lowest average firewood consumption capita⁻¹ day⁻¹ (1.51 ± 0.06) and capita⁻¹ year⁻¹ (553.84 ± 14.66) was recorded for large households. ANOVA analysis also revealed that average

capita⁻¹ day⁻¹ consumption is not significantly different in term of medium and large household. This clearly indicates that firewood consumption rates per capita decreases with increasing household size. Therefore, households of larger family sizes tend to consume less firewood per capita compared with smaller households. This indicates that larger family households consume firewood more efficiently than smaller ones. The negligence and lack of willingness to use LPG facility due to their remote location in forests areas could be another reason of high consumption of firewood on daily basis.

Firewood consumption also varied with the different seasons in all three settlements. The average per day firewood consumption of household was recorded maximum (14.27 ± 4.24) in the winter season and minimum (10.42 ± 3.51) in the summer season (Table 5). The firewood consumption of household (Kg/day) shows a significant difference among the summer, winter and monsoon seasons in all three sites of study area. In the winter season site-I (15.07 ± 0.95) showing the highest firewood consumption of household followed by site-II (14.06 ± 0.77) and site-III (13.67 ± 0.72). The firewood consumption was recorded higher in the winter season because households also used the firewood for house and water heating purposes.

Fodder consumption patterns of Van Gujjars from forests and markets among the three settlements of the study area

Large portion of the fodder is utilized from the forest by the Van Gujjars. In term of percentage around 70–75% fodder is consumed from the forest and remaining fodder requirements are met from the market. At site-I, livestock of household consumed an average of 51.42 ± 1.69 kg of forest-derived fodder per day, while site-II and site-III showed corresponding figures of 46.89 ± 1.22 kg and 47.94 ± 1.33 kg, respectively (Table 6).

In contrast, market-sourced fodder constituted a smaller portion of the overall consumption. Site-I households procured on an average 15.79 ± 0.52 kg of fodder from

Table 6 Fodder requirement per household (in kilograms) from both forest and marketplace Sources (Mean $\pm$ SE)

Sources of animal feed	Fodder consumption household ⁻¹ day ⁻¹ (kg)		
	Site-I	Site-II	Site-III
Fodder from forest	51.42 ± 1.69	46.89 ± 1.22	47.94 ± 1.33
Fodder from market	15.79 ± 0.52	14.40 ± 0.37	14.72 ± 0.40
Total fodder consumption	67.22 ± 2.21	61.29 ± 1.60	62.66 ± 1.74

Values are mean + Standard error

markets, with slightly lower quantities observed at site-II (14.40 ± 0.37) and site-III ($14.72 \text{ kg} \pm 0.40$). Cumulatively, the combined daily fodder consumption households of site-I demonstrated the highest total consumption of 67.22 ± 2.21 kg, closely followed by site-III (62.66 ± 1.74) and site-II ($61.29 \text{ kg} \pm 1.60$) in the study area.

Preferred tree species by Van Gujjars for fodder, Firewood, timber and medicinal requirement and their availability in the Tarai region of Uttarakhand

Van Gujjars generally value indigenous tree species for firewood, timber, food/ fruit, fodder, charcoal and sources of herbal medicine. In this study, the overall tree species use values generally correspond to the number of uses of a particular tree species and vary between 0.65 and 0.32. In the study area, Van Gujjars mostly preferred *Trewia nudiflora* for its high utility value of 0.68, making it the most versatile species for firewood, fodder, timber, and medicine, aided by its abundant availability in the region. *Tectona grandis* and *Mallotus philippensis* followed closely with average utility values of 0.65 and 0.63, respectively, indicating their importance in daily energy and livestock feed needs. For construction of house, livestock fencing and household energy, *Syzygium cumini*, *Shorea robusta*, and *Populus deltoides* were favoured, each with a utility value around 0.61. *Dalbergia sissoo*, *Butea monosperma*, and *Holoptelea integrifolia* ranked slightly lower but were still valued for fodder and firewood. While *Cassia fistula* and *Terminalia arjuna* were specifically used for medicinal purposes, *Bombax ceiba* and *Alstonia scholaris* were the least preferred despite being readily available, which could be attributed to their lesser utility or cultural preferences among the Van Gujjars. However, these low values could be associated with processes of losing traditional uses of indigenous trees, generational changes of preferences and probably the diminishing of traditional knowledge of Van Gujjars in the study area. Low use value scores of some indigenous tree species could also be associated in part with their scarcity due to their poor regeneration and past over exploitation. This assessment also

Table 5 Firewood consumption (Kg/day) of settlements based on seasons—summer, winter and monsoon (Mean $\pm$ SE)

Average firewood consumption of household (Kg/day)			
Settlements	Summer	Winter	Monsoon
Site-1	11.46 ± 0.79^a	15.07 ± 0.95^a	11.96 ± 0.79^a
Site-2	10.96 ± 0.77^b	14.06 ± 0.77^b	13.98 ± 0.80^b
Site-3	8.85 ± 0.50^c	13.67 ± 0.72^c	12.06 ± 1.23^c

Values are Mean + Standard error and different superscripts on each value signify noteworthy statistical differences, at the 0.05 significance threshold



highlights the critical role of these species in meeting the multifaceted needs of the Gujjars community (Table 7).

Discussion

In the region under study, forest resources like firewood, fodder, and timber significantly contribute to the livelihood of the Van Gujjars. The economy of Van Gujjars is completely based on milk production and supply of milk products to the nearby areas, which not only provides them with a steady income but also forms an integral part of their cultural identity. Socio-economic factors such as education, household size, and income influence their dependency on these forest resources (Masozera and Alavalapati 2004). The study reveals that the average Van Gujjar household comprises of 7.24 members being larger than the household size compared to other communities living in the mountainous regions of Uttarakhand, including the Bhotiyas, Jaunsari, and Tharus (Bergmann et al. 2008) along with the national average household size which is 5.3 individuals per family (Census of India 2011). Large families could also be associated with the pastoralist practices of community, which necessitate a greater labour force for their livelihood.

Similarly, the literacy rate (25.66) was found higher than the previous studies, which could possibly be due to the permanent settlements of Van Gujjars from past few decades and their un-followed transmigration in this region. A considerable educational disparity, with a mere 12.90% literacy rate has been observed in Van Gujjars residing in the rehabilitation colony in the Gandhi Khatta area of the Haridwar District, (Sharma et al. 2012) and the Gujjars in the Corbett Tiger Reserve, Ramnagar Uttarakhand (Hussain et al. 2016a, b), which was inconsistent to our study. Marginality from the main steam and traditional pastoralist practices were observed to be major key factors contributing to their lower literacy rates (Sharma et al. 2013).

The communities residing in the Himalayan region such as Gaddis, Kinnar, Lauhalas and the Pangwalas and some other smaller tribe groups like the Bhot/Bodh, the Beda, the Jad/Lamba/ Khampa, and the Swangla have a long-standing practice of selectively using a diverse range of forest resources for firewood, fodder, timber based on their quality and availability (Chettri and Sharma 2009; Kumar and Gupta 2023). However, many of the preferred and higher quality tree species are currently under pressure, leading to changes in species compositions and forest succession patterns. The present study identified 22 tree species that are

Table 7 Preferred tree species by Van Gujjars for fodder, Firewood, timber and medicinal requirement and their availability

Rank	Scientific name	Vernacular name	Family	F	Fo	T	M	Avg	Ava
I	<i>Trewia nudiflora</i> L	Gutel	Euphorbiaceae	0.71	0.98	0.77	0.25	0.68	+++
II	<i>Tectona grandis</i> L. f	Sagoan	Verbenaceae	0.98	0.35	0.99	0.25	0.65	+++
III	<i>Mallotus philippensis</i> (Lam.) Muell. -Arg	Rohini	Euphorbiaceae	0.93	0.82	0.51	0.25	0.63	++
IV	<i>Syzygium cumini</i> (L.) Skeels	Jamun	Myrtaceae	0.98	0.25	0.98	0.25	0.62	++
V	<i>Shorea robusta</i> C.F. Gaertn	Sal	Dipterocarpaceae	0.99	0.25	0.97	0.25	0.61	+++
V	<i>Populus deltoides</i> var. <i>angulata</i> Sarg	Poplar	Salicaceae	0.98	0.27	0.96	0.25	0.61	+++
VI	<i>Dalbergia sissoo</i> Roxb	Shisam	Fabaceae	0.81	0.58	0.77	0.25	0.60	++
VI	<i>Butea monosperma</i> (Lam.) Kuntze	Dhaak	Fabaceae	0.93	0.50	0.54	0.45	0.60	++
VI	<i>Holoptelea integrifolia</i> (Roxb.) Planch	Kanju	Ulmaceae	0.80	0.56	0.77	0.25	0.60	++
VII	<i>Eucalyptus</i> Hybrid	Liptis	Myrtaceae	0.81	0.25	0.97	0.25	0.57	+++
VIII	<i>Toona ciliata</i> M. Roem	Toon	Meliaceae	0.65	0.82	0.51	0.27	0.56	+
VIII	<i>Acacia catechu</i> (L.f.) Willd	Khair	Mimosaceae	0.81	0.56	0.61	0.27	0.56	++
VIII	<i>Cassia fistula</i> L	Karangal	Caesalpiniaceae	0.80	0.70	0.31	0.44	0.56	+
IX	<i>Cordia dichotoma</i> Forster f	Lasoda	Ehretiaceae	0.36	0.90	0.25	0.39	0.48	+
X	<i>Ficus benghalensis</i> L	Bargad	Moraceae	0.61	0.77	0.48	0.02	0.47	++
XI	<i>Broussonetia papyrifera</i> Ventenat	Poolbutton	Moraceae	0.31	0.97	0.31	0.25	0.46	+++
XII	<i>Terminalia bellirica</i> (Gaertner) Roxb	Baheda	Combretaceae	0.35	0.35	0.35	0.70	0.44	+
XIII	<i>Artocarpus lacucha</i> Buch. -Ham	Badaar	Moraceae	0.27	0.82	0.26	0.25	0.40	++
XIV	<i>Phyllanthus emblica</i> L	Awla	Euporbiaceae	0.29	0.56	0.27	0.41	0.38	+
XV	<i>Terminalia arjuna</i> (Roxb. Ex DC.)	Arjun	Combretaceae	0.34	0.31	0.30	0.54	0.37	+
XVI	<i>Bombax ceiba</i> L	Semal	Bombacaceae	0.63	0.25	0.33	0.25	0.36	+++
XVII	<i>Alstoniascholaris</i> (L.) R.Br	Saptpadni	Apocynaceae	0.54	0.25	0.25	0.25	0.32	++

Rank Ranking (based on the combined points given for preference for various uses), F Firewood, Fo Fodder, T Timber, M Medicinal, Avg Average, Ava Availability (+++ Highly Available, ++ Moderately Available, + Least Available)

preferred for various forest resources. The indiscriminate lopping of trees for fodder and extraction of firewood was observed during the study. Our current study also resonances with Sharma et al. 2023 which describes the utilization of medicinal plants among the Van Gujjars, revealing their dependence on various species for treating a range of health issues, including allergies, blisters, cracked feet, cuts, sores, and wounds, underscoring the continued dependence of the Van Gujjars on medicinal plants for various disease treatments. The primary reason for this high consumption of firewood is the widespread use of kutchha chulha, a traditional stove design, for cooking purposes (Bhatt et al. 2016; Bhatt et al. 1994). The prevalence of kutchha chulha usage in the region can be attributed to two key factors; firstly, the easy availability of firewood makes it a convenient and accessible fuel source for cooking, secondly, the lack of cost-effective and easily accessible alternatives (Mehetre et al. 2017).

The current study demonstrates that the average firewood consumption across various settlements of the Van Gujjar community ranged approximately between 11 and 13 kg per household per day. Additionally, the average per capita firewood consumption was comparatively higher (1.6 kg per day), when compared to previous studies conducted in the Himalayan region of Nepal and in Uttarakhand, India, which is reported as daily per capita consumption of 1 kg/day on average (Hussain et al. 2013; Khan et al. 2018). The higher consumption of fuelwood could be possible due to ease access to the fuelwood and the sedentary settlement of Van Gujjars in the Tarai region of Uttarakhand, discontinuing the tradition transhumance from alpine to Tarai in summers (Hussain et al. 2017).

In the present study large household consume around 16 kg per day more firewood than small household which is approximately 8 kg per day similar to the results given by Shekhar et al. (2016). However, the per capita consumption of firewood is inversely proportion to the household size. Larger households had low per capita consumption of firewood due to collective household activities, which in comparison to small household was observed otherwise (Singh et al. 2010).

The average cattle unit per household (24 ± 2.6) of Van Gujjars closely aligns with the other studies like Hussain et al. (2012), which indicates that the large number of cattle units per household could be indicative of the Gujjars' high dependence on livestock for various potential sources of income as well as personal consumption such as milk production, meat, sales etc. The households in the study area have an average daily extraction of 63.72 kg of fodder from the forest, which is similar to study near the Kedarnath Wildlife Sanctuary, Dhyani et al. (2011), which suggests that the practice of fodder extraction from forests is prevalent practice across various regions in Uttarakhand. However, it is important to note that the amount of fodder extracted

can vary due to several factors, including differences in forest type, topography, and the specific needs of each household (Mazumder et al. 2014).

There is an interesting finding in the present study which implies a negative relationship between education levels and forest dependency, indicating that individuals with higher levels of education have access to a broader spectrum of employment opportunities in comparison to the families with low or no education. Consequently, their reliance on forest resources, particularly fuel wood collection, diminishes with literacy rate, which is similar to findings reported by Gunatilake (1998) and Ofoegbu et al. (2017), which demonstrate that the education level of a family is inversely associated with their dependence on forests. The studies from Jain (2010), Bansal et al. (2013), Awasti et al. (2003) also support the results of our study which concludes that the household size, education and household income are the most significant factors for determining the dependency on the forest resources.

This suggests that the community's economic practices may play a significant role in shaping their family structures. However, despite these efforts, the Van Gujjars residing within the forest continuously experience marginalization and exhibit lower literacy rates in comparison to other tribes in country.

Conclusion

The Van Gujjar community in the study area depend heavily on the forests for their livelihoods, with dairy production and the utilization of forest resources for firewood and fodder being central to their economic activities. Dairy production serves as the primary source of income for most households, highlighting the vital role of livestock in sustaining their economic well-being. Socioeconomically, the Van Gujjars face significant challenges, including low literacy rates, scarcity of fodder for their livestock and limited employment opportunities. The community exhibits low levels of literacy and employment, necessitating the provision of improved educational and employment prospects to uplift their socio-economic conditions (Hussain et al. 2012). Livestock, particularly buffaloes and cows, play a critical role in the Van Gujjars' livelihoods, with milk production serving as a major source of income. Furthermore, the findings shed light on the heavy reliance on firewood for cooking and heating purposes, with all households relying on wood as their primary source of energy. Firewood consumption varies among households, with larger families consuming relatively less firewood per capita compared to smaller households. This high level of dependency and unsustainable consumption of forests resources also degrading the forests composition and structure.



The study emphasizes the importance of sustainable forest management practices and conservation efforts to ensure the long-term well-being of the Van Gujjar community and maintain the ecological balance of the region. Promoting alternative energy sources and reducing dependency on firewood and fodder are crucial objectives, along with providing access to education and improving socioeconomic conditions within the community.

Overall, the findings highlight the dependence of the Van Gujjars' livelihoods with the forest resources, and the necessity of implementing holistic approaches that address their economic, social, and environmental needs. By promoting sustainable practices, fostering educational opportunities, and enhancing socioeconomic conditions, the Van Gujjars can achieve greater resilience and prosperity while preserving the ecological integrity of their surroundings.

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Declarations

Conflict of interest The authors affirm that they have no competing interests.

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