

Tharu Ethnoecology in Pakali, Sunsari, Nepal: Medicinal Plant Knowledge, Home Gardens, and Conservation Willingness

Rejina Dhungana

rejinadhungana01@gmail.com

Tribhuvan University

Subodh Khanal

Tribhuvan University

Article

Keywords: Ethnoecology, Tharu, Traditional ecological knowledge, Medicinal plants, Home gardens, Stated conservation willingness

Posted Date: October 14th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10741805/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Household medicinal-plant knowledge is shaped by social learning and access to plant resources, but household-level evidence on knowledge preservation and transmission from Tharu communities in eastern Nepal remains limited. This study described reported medicinal plant-use, attributed sources of knowledge, sources of plant sources, and stated conservation willingness among Tharu households in Pakali, Sunsari.

Methods

A cross-sectional survey was conducted with 140 Tharu households in 2025. Face-to-face semi-structured interviews recorded household characteristics, reported plant uses, attributed sources of knowledge and plant material, environmental perceptions, and stated willingness to participate in conservation programs. Descriptive statistics, informant consensus factor, fidelity level, bivariate tests, and binomial logistic regression were used for data analysis.

Results

Respondents reported 40 putative medicinal taxa. *Ocimum tenuiflorum*, *Zingiber officinale*, *Aloe vera*, *Azadirachta indica*, *Allium sativum*, and *Curcuma longa* were the most frequently mentioned, highlighting the importance of accessible home gardens and household plants in primary healthcare. Ethnomedicinal knowledge was transmitted predominantly through family tradition (81.3%), and home gardens were the primary source of medicinal plants (79.1%). Informant consensus factor (ICF) ranged from 0.14 to 1.00, with the highest agreement observed for burns (ICF = 1.00), followed by colds (0.90), skin diseases (0.87), and body aches (0.86). fidelity level (FL) analysis showed high use specificity for *Calotropis gigantea* for body aches (100%), *Ocimum tenuiflorum* for colds (94.88%), *Azadirachta indica* for skin conditions (85.00%), and *Aloe vera* for burns (84.84%). Binomial logistic regression indicated that higher income and longer residency were associated with lower stated willingness to participate in medicinal plant conservation, whereas perceiving environmental change as a threat to cultural traditions was associated with greater stated willingness to participate.

Conclusions

This study provides an updated baseline of reported household medicinal-plant knowledge and use among Tharu households in Pakali, highlighting the importance of family tradition and home gardens in ethnomedicinal practices. The findings contribute contemporary household-level evidence to support future ethnobotanical research and culturally informed conservation initiatives.

Background

Indigenous and local communities maintain detailed ecological knowledge through long-term interactions with landscapes, species, livelihoods, and cultural practices. In agrarian and forest-adjacent societies, such knowledge often includes plant identification, medicinal uses, seasonal indicators, soil and water relations, crop choices, animal care, and culturally grounded interpretations of environmental change. Ethnoecology provides an appropriate framework for studying these knowledge systems because it examines how people understand, use, manage, and relate to the natural environments in which they live, including relationships among human communities, plants,

animals, and landscape processes [1, 2]. Indigenous and local knowledge systems are increasingly recognized for their contributions to biodiversity conservation, ecosystem management, and climate adaptation because they represent cumulative observations and practices developed through sustained ecosystem interactions [3, 4]. Such knowledge has been linked to adaptive management and social-ecological resilience [5], while research from Himalayan regions of Nepal demonstrates that medicinal plant knowledge varies according to ecological settings, institutional contexts, and practical experiences [6]. Rather than treating ecological knowledge simply as a list of useful species, contemporary ethnoecology asks how knowledge is produced, transmitted, maintained, and transformed under changing social and environmental conditions. Because plant availability, knowledge holders, and patterns of use differ across places, local documentation remains necessary even where regional baseline exist.

Home gardens represent important socio-ecological spaces where biodiversity conservation, household food security, and traditional knowledge maintenance intersect. In many rural and indigenous communities, home gardens function as reservoirs of medicinal plants, food crops, and culturally important species, enabling continuous interactions between households and plant resources. Through cultivation, management, and everyday use, these spaces support the maintenance and transmission of ethnobotanical knowledge across generations while contributing to the conservation of local plant diversity [7, 8].

Nepal provides an important setting for such research given its exceptional biological, ecological, and ethnic diversity. Reviewing 264 studies on ethnobotany, ethnomedicine, and medicinal and aromatic plants in the Nepali Himalaya, Kunwar and Bussmann [9] show that plant-use knowledge has been widely recorded but remains fragmented across regions and ecological zones and vulnerable to social and economic change, while community-level work demonstrates that traditions, beliefs, customs, religion, and livelihood systems shape how specific ethnic groups interact with their environments [10]. Together, these studies suggest that documentation alone is insufficient; a stronger ethnoecological approach should examine how medicinal plant knowledge is transmitted across generations, where medicinal plants are obtained, and how local communities perceive environmental change and relate these perceptions to conservation practices.

The Tharu are one of Nepal's largest indigenous (Adivasi/Janajati) communities, primarily inhabiting the Terai plains and inner Terai valleys [11]. The National Population and Housing Census 2021 reports a population of 1,807,124, accounting for 6.2% of the total population [12]. Historically, the Tharu have maintained close interactions with forested landscapes, riverine systems, agricultural fields, and home gardens, shaping rich indigenous knowledge of plant use, ethnomedicine, agriculture, and climate adaptation [13, 14]. The term "Tharu" is often interpreted as deriving from "Tha" (Terai) and "Ru" (permanent inhabitant), reflecting their long-standing settlement in the Tharuwan/Tharuhat region across northern India and Nepal's Terai below the Chure (Siwalik) foothills [15].

Existing studies show that Tharu communities possess substantial ethnobotanical and ethnomedicinal knowledge, though this evidence remains geographically uneven. In Pakali, Sunsari, Chaudhary and Rai [15] documented 119 plant species from 92 genera and 52 families used by the Tharu community for medicinal, edible, cultural, religious, and fodder purposes, providing an important ethnobotanical baseline for this locality. However, as ethnomedicinal knowledge is locally variable, this inventory provides only a baseline for understanding current knowledge and practice in Pakali. The study did not examine how knowledge is transmitted across households, how it relates to socio-demographic conditions, or how it connects to conservation attitudes. Gachhadar [16] documented extensive medicinal plant knowledge among Tharu communities in eastern Nepal, including Pakali, and noted that both medicinal plant resources and associated knowledge face pressure from deforestation, habitat destruction, unsustainable harvesting, and broader socio-economic change. Elsewhere, Khanal et al. [11] documented medicinal plant use among the Kathariya Tharu of Kailali district, Thapa [17] recorded ethnomedicinal practices among Tharu communities in Rupandehi and Nawalparasi, and Chaudhary et al. [18] show that Tharu knowledge extends beyond

medicinal plants to agricultural and climate-related practices. Together, these studies establish that Tharu ecological knowledge is empirically significant and locally variable, but they also reveal a shared limitation: most remain focused on plant-use inventories, with less attention given to the social and environmental factors that shape knowledge transmission, conservation attitudes, and participation in environmental management.

This gap is especially important in Pakali, Sunsari, where a previous ethnobotanical inventory provides a valuable baseline but does not explain how current households acquire and maintain ethnomedicinal knowledge, where medicinal plants are sourced, how socio-demographic conditions relate to ecological practice, or what motivates participation in conservation programs. These questions matter because traditional ecological knowledge is not preserved simply by recording plant names and uses; it is sustained through households, family structures, community elders, home gardens, agricultural decisions, cultural values, and perceptions of environmental change. If these channels weaken, knowledge may decline even where individual plant species remain available; conversely, conservation programs designed around culturally meaningful ecological relationships may strengthen both biodiversity conservation and cultural continuity.

The present study therefore examines the ethnoecological knowledge and conservation attitudes of the Tharu community in Pakali, Ward 17, Itahari Sub-Metropolitan City, Sunsari District, Nepal. Through semi-structured household interviews, the study documents reported medicinal plant knowledge, sources of knowledge, sources of medicinal plants, socio-demographic characteristics, agricultural and environmental practices, and stated willingness to participate in conservation programs. It applies descriptive statistics, informant consensus factor (ICF) and fidelity level (FL), chi-square tests and binomial logistic regression to address three linked questions: first, what forms of ethnomedicinal and ecological knowledge are currently reported by Tharu households in Pakali; second, how are this knowledge and related practices associated with household, livelihood, education, family, and environmental variables; and third, what factors predict stated willingness to participate in environmental conservation programs? The conservation component of the study also connects to Nepal's broader literature on community-based natural resource management, where participation in community forestry has been linked to socio-economic, demographic, and locational factors [19] and local attitudes toward conservation are shaped by community characteristics and perceived benefits [20]. Building on this literature, the present study examines whether similar associations are evident among Tharu households in Pakali. Consistent with its cross-sectional design, the study interprets these relationships as associations rather than causal effects.

Methods

Study area

The study was conducted in Pakali, Ward 17, Itahari Sub-Metropolitan City, Sunsari District, Koshi Province. Pakali lies in eastern Terai, a lowland region where settlements, agriculture, home gardens, and household plant-use practices remain closely connected. Chaudhary and Rai [15] described Pakali as being located on the northeastern side of Sunsari District, bordering Baklauri to the north, Hansposa to the east, Ekamba to the south, and Bhasi to the west. The geographic database places Pakali at approximately 26.678° N and 87.22° E, with an elevation of approximately 110 meters above sea level. The area falls within a monsoon-influenced humid subtropical climate zone, and nearby Itahari has an estimated mean annual temperature of about 23.2°C and annual precipitation of about 1,796 mm. Because these climate values are reported for Itahari rather than from a Pakali-specific meteorological station, they are used only to describe the broader local climate [15, 21, 22, 23].

Title:

Figure 1. Study area map of Pakali, Sunsari District, Nepal.

Legend:

Panel (a) shows a map of Nepal with district boundaries; Sunsari District (green) is highlighted in the southeastern Terai. Panel (b) shows the ward-level map of Itahari Sub-Metropolitan City, Sunsari District, with Ward 17 (Pakali), the study area, delineated in blue.

Study design, population, and sample size

This study used a cross-sectional household survey design. The target population was Tharu households living in Pakali, Ward 17 of Itahari Sub-Metropolitan City, Sunsari, Nepal. The Ward 17 profile reports a total population of 12,107 for Pakali, but it does not provide a separate ward-level count of Tharu residents or Tharu households [24]. Therefore, the Tharu population used for sample-size planning was derived rather than treated as an official ward-level census count.

Because a ward-level caste/ethnicity breakdown for Pakali was unavailable, the study applied the Itahari-level Tharu proportion to the Ward 17 population. According to the Itahari demographic profile, Tharu comprise approximately 15.9% of the sub-metropolitan population based on the 2021 Nepal Census caste/ethnicity data [25]. Applying this proportion to Ward 17 gives:

Estimated Tharu population in Pakali = $12,107 \times 0.159 = 1925.01 \approx 1925$ persons

Because the sampling unit was the household rather than the individual, the estimated Tharu population was converted into an estimated number of Tharu households. The Itahari municipal profile reports a total population of 197,241, with 50,350 households, and an average household size of 3.92 persons per household in the 2021 census [26]. Using this average household size:

Estimated Tharu households = $1925 / 3.92 = 491.07 \approx 491$ households

The sample size was then assessed via Yamane's finite-population formula: $n = \frac{N}{1+N(e^2)}$

where n is the required sample size, N is the estimated number of eligible households, and e is the desired level of precision (margin of error) [27]. Israel [28] noted that sample size depends on the purpose of the study, population size, desired precision, confidence level and when used for proportions.

Using $N = 491$ and a precision level of $e = 0.075$ (7.5%) gives: $n = \frac{491}{1+491(0.075)^2}$

$n = 130.52 \approx 131$ households

A total of 140 households were surveyed, exceeding the estimated minimum sample size. Because the number of Tharu households was estimated from the Ward 17 population and Itahari caste/ethnicity profile, the Yamane calculation was used to guide sample size planning. Households were selected from the target Tharu households in Pakali, and one eligible respondent from each selected household was interviewed to document household-level ethnoecological knowledge, medicinal plant use, plant sourcing, environmental perceptions, and stated willingness to participate in conservation.

Data collection

Data were collected through face-to-face interviews using a semi-structured questionnaire developed on the mWater platform. The questionnaire covered household characteristics, livelihood sources, major crops, medicinal plant knowledge, sources of ethnomedicinal knowledge, sources of medicinal plants, perceptions of environmental change, and stated willingness to participate in conservation programs.

The interviews were conducted with household heads or adult household members who were familiar with household medicinal plant use and local ethnomedicinal practices. Translation assistance from a native speaker was used when needed so that respondents could explain plant names, uses, and local meanings more accurately.

Before each interview, the respondents were informed about the purpose of the study. Participation was voluntary, and verbal consent was obtained. Respondents were also assured that their responses would be used solely for research purposes and would be reported in a manner that protected the anonymity of individual households.

Ethics approval and informed consent

Under Tribhuvan University policy, central Ethical Review Board, Tribhuvan University (ERB-TU) clearance was not required because this study did not fall within either category requiring central ERB-TU review. Ethical permission was obtained from the Ethical Review Committee (ERC) of the Dean’s Office, Institute of Agriculture and Animal Science (IAAS), Tribhuvan University, the relevant institutional ethics authority for this study. All study protocols were approved by this committee, and all methods were performed in accordance with the relevant guidelines and regulations and the Declaration of Helsinki. Participation was voluntary, and verbal informed consent was obtained from all participants before the interviews were conducted.

Plant use documentation

For each medicinal plant reported by the respondents, the local name, plant part used, reported ailment or purpose, and number of respondents mentioning the plant were recorded. Scientific names were assigned where possible using the revised plant list prepared for this manuscript. Because voucher samples were not collected from reported plants, the plant list is presented as a record of reported local medicinal use. Species with uncertain identification should be checked in future work through voucher collection and verification by a botanist.

The reported ailments were grouped into broader ailment categories for analysis. These included burns, cold, skin disease, body ache, cough, gastric problems, sore throat, period cramps, and fever. This grouping made it possible to calculate informant consensus across comparable ailment categories.

Informant consensus factor

The informant consensus factor was used to examine the degree of agreement among respondents for plant use within each ailment category. The informant consensus approach is commonly attributed to Trotter and Logan [29]. In this study, the ICF was calculated as: $ICF = \frac{N_{ur}-N_t}{N_{ur}-1} \dots \dots \dots (1)$

where N_{ur} is the number of use reports for a given ailment category, N_t is the number of plant taxa reported for that category.

The ICF values range from 0 to 1. Values closer to 1 indicate stronger agreement among respondents because many use reports are concentrated on a smaller number of taxa. Values closer to 0 indicate that reports are spread across many plants. In this study, the ICF was used to identify ailment categories with high local agreement, not to make claims about clinical effectiveness.

Fidelity level

The fidelity level was used to examine how strongly a plant was associated with a particular ailment. Friedman et al. [30] introduced this measure in ethnopharmacological field research. The FL was calculated as:

$$FL (\%) = \left(\frac{N_p}{N} \right) \times 100 \dots \dots (2)$$

where, N_p is the number of respondents who cited a plant species for a specific ailment, and N is the total number of respondents who cited that plant species for any ailment.

Higher FL values indicate greater use specificity. For example, a high FL means that respondents who mentioned a plant tended to associate it with the same main ailment. Lower FL values may indicate either weaker agreement or broader multipurpose use.

Statistical analysis

The analysis combined descriptive and inferential methods. Frequencies and percentages were used to summarize household characteristics, livelihood sources, major crops, medicinal plant reports, knowledge sources, plant sources, and conservation attitudes. ICF and FL were then calculated to identify consensus by ailment category and specificity by plant species.

Chi-square tests were used to examine associations among categorical variables, including willingness to participate in conservation programs, the gender of the household head, education level, residency years, family type, and belief that environmental change affects tradition. Fisher's exact test was used when the expected cell counts were small. These tests were used to identify patterns of association in the sample.

A binomial logistic regression was used to examine factors associated with stated willingness to participate in conservation programs. Logistic regression is appropriate when the dependent variable is binary [31]. The dependent variable was coded as follows:

$$Y_i = \left\{ \begin{array}{l} 1 = \text{Willing to participate in conservation program} \\ 0 = \text{Not willing to participate in conservation program} \end{array} \right\} \dots \dots (3)$$

The probability of willingness to participate was defined as:

$$p_i = Pr(Y_i = 1 \mid X_i) \dots \dots (4)$$

The model is specified as:

$$\log \left(\frac{p_i}{1 - p_i} \right) = \beta_0 + \beta_1 \text{Income}_i + \beta_2 \text{Age}_i + \beta_3 \text{Education}_i + \beta_4 \text{Belief}_i + \beta_5 \text{Residency}_i + \epsilon_i \dots (5)$$

where Income_i is the average monthly household income of respondent i , Age_i is the age of the household head, Education_i is a set of education-category indicators, Belief_i equals 1 if the respondent believes that

environmental change affects cultural tradition and Residency_i is a set of residency-duration indicators. The reference category for education was illiterate, and the reference category for residency was less than five years.

Odds ratios were calculated as follows:

$$OR_j = \exp \left(\beta_j \right) \dots \dots (6)$$

For continuous variables, the marginal effect was calculated as follows:

$$\frac{\partial p_i}{\partial x_{ij}} = \beta_j p_i (1 - p_i) \dots \dots (7)$$

The average marginal effect was then calculated as follows:

$$AME_j = \frac{1}{n} \sum_{i=1}^n \beta_j p_i (1 - p_i) \dots \dots (8)$$

For categorical variables, average marginal effects were calculated as the average difference in predicted probabilities between a category and its reference group:

All analyses were conducted in R. The statistical results were interpreted as associations between household characteristics, environmental beliefs, and conservation willingness.

Results

Household context and livelihood setting

The survey covered 140 Tharu households in Pakali, Sunsari. Table 1 reports the gender of household head and the family type. Most household heads were male (59.29%); 40.00%, were female, and one respondent preferred not to report gender. Nuclear families were common than joint families, representing 62.86% and 37.14% of households, respectively.

Table 1
Socio-demographic characteristics of the surveyed Tharu households in Pakali, Sunsari, 2025.

Variable	Category	n	%
Gender of household head			
	Male	83	59.29
	Female	56	40.00
	Prefer not to say	1	0.71
Family type			
	Nuclear	88	62.86
	Joint	52	37.14
Total		140	100.00
Note. All the respondents were of Tharu origin. Percentages are rounded to two decimal places.			

Table 2 shows the primary sources of livelihood and major crops grown by Tharu people in the surveyed area. The socio-economic profile also reveals that the community is undergoing livelihood diversification. Remittance and business were the most frequently reported primary livelihood sources, each accounting for 30.7% of households, whereas agriculture was the primary livelihood for 25.0% of households. Service employment, animal husbandry, and other occupations accounted for smaller shares. Although agriculture remains present in the community, the relatively high share of non-farm income suggests that Pakali households are not fully dependent on subsistence agriculture.

Cereals were the most frequently reported major crop (68.4%), followed by vegetables and other crops (e.g., oilseeds and spices), with each representing 15.4% of respondents. Legumes were rarely reported as the principal crop.

Table 2

Primary livelihood sources and major crops grown by surveyed Tharu households in Pakali, Sunsari, 2025.

Variable	Category	n	%
Primary livelihood source			
	Remittance	43	30.7
	Business	43	30.7
	Agriculture	35	25.0
	Service	17	12.1
	Animal husbandry	1	0.7
	Other	1	0.7
Major crop cultivated			
	Cereals	93	68.4
	Vegetables	21	15.4
	Other (oilseeds, spices, etc.)	21	15.4
	Legumes	1	0.7
Total households		140	100.0
Note. Livelihood percentages of 140 surveyed households. Crop percentages are those of households that cultivate crops.			

Reported ethnomedicinal plant knowledge

Respondents reported 40 medicinal plant species used for treating common ailments (Table A1 of Additional file 1 for a complete list). Tulsi (*Ocimum tenuiflorum* L.) was by far the most frequently cited species, mentioned by 117 respondents. Ginger (*Zingiber officinale* Roscoe; n = 41), Aloe vera (*Aloe vera* L. Burm. f.; n = 33), Neem (*Azadirachta indica* A. Juss.; n = 20), Garlic (*Allium sativum* L.; n = 19), and Turmeric (*Curcuma longa* L.; n = 15) were also among the most frequently mentioned plants.

Leaves were the most frequently used plant parts, particularly for species such as Tulsi, Neem, Titepati, Guava, and Parijat. Rhizomes, bulbs, fruits, seeds, flowers, and latex were also reported depending on the species and ailment.

Several species were mentioned only once or twice, including Bel, Bhumiraj, Chandmaruwa, Jalkumbhi, Karela, Marigold, Methi, Rose, Satkamla, Siris, Soop, Sukumel, and Timur (Table A1 in Additional file 1).

Table 3

Abbreviated ethnomedicinal plant inventory: fifteen most frequently cited species in Pakali, Sunsari, 2025.

Rank	Local name	Scientific name	Part(s) used	Reported use(s)	n
1	Tulsi	<i>Ocimum tenuiflorum</i> L.	Leaves	Cold, cough, sore throat	117
2	Ginger	<i>Zingiber officinale</i> Roscoe	Rhizome	Back pain, cold, cough, sore throat	41
3	Aloe vera	<i>Aloe vera</i> (L.) Burm.f.	Leaves	Burns, cold, skin conditions	33
4	Neem	<i>Azadirachta indica</i> A.Juss.	Leaves, branches	Cold, cough, skin conditions	20
5	Garlic	<i>Allium sativum</i> L.	Bulb	Cold, fever, gastric, sore throat	19
6	Turmeric	<i>Curcuma longa</i> L.	Rhizome	Cold, cough, sore throat	15
7	Marich	<i>Piper nigrum</i> L.	Fruit, seeds	Cold, cough, diabetes, sore throat	12
8	Jwano	<i>Trachyspermum ammi</i> (L.) Sprague	Seeds	Cold, cough, gastric, sore throat	11
9	Parijat	<i>Nyctanthes arbor-tristis</i> L.	Flower, leaves	Cold, constipation, diabetes, fever, period cramps	11
10	Jeera	<i>Cuminum cyminum</i> L.	Seeds	Cold, cough, fever, sore throat	9
11	Aank	<i>Calotropis gigantea</i> (L.) Dryand.	Latex	Body ache	7
12	Bojho	<i>Acorus calamus</i> L.	Rhizome	Cold, cough	6
13	Guava	<i>Psidium guajava</i> L.	Leaves, tip	Cold, constipation, diabetes, gastric	4
13	Lemon	<i>Citrus limon</i> (L.) Osbeck	Fruit	Cold, fever, sore throat	4
13	Titepati	<i>Artemisia indica</i> Willd.	Leaves	Bleeding, joint pain, cold, skin	4
Note. Rank reflects household citation frequency (n). The equally ranked species are listed alphabetically. The scientific names follow those of the Plants of the World Online (POWO) and Flora of Nepal. See Table A1 for the complete 40-species inventory.					

Knowledge transmission and sources of medicinal plants

The strongest pattern was the dominance of family-based knowledge transmission (Fig. 2a). More respondents (81.3%), reported acquiring ethnomedicinal plant knowledge through family tradition. Community elders and other sources accounted for smaller shares.

Home gardens were the dominant source of medicinal plants, reported by 79.1% of the respondents (Fig. 2b), followed by local markets. Collection from forests were relatively limited in the reported responses.

Title:

Figure 2. Reported sources of ethnomedicinal knowledge and medicinal plants among surveyed Tharu households in Pakali.

Legend:

Figure 2. (a) Reported source of ethnomedicinal knowledge among surveyed Tharu households in Pakali (n = 139). (b) Primary reported source from which respondents obtained medicinal plants (n = 140). Percentages are based on the number of respondents answering each question; one respondent did not report a knowledge source.

Family type was significantly associated with the reported source of ethnomedicinal knowledge (Table A2, panel C), suggesting that household structure may influence how medicinal plant knowledge circulates. Family tradition remained the dominant source overall, but joint households showed greater reliance on community elders than nuclear households did.

Informant consensus and use specificity

The informant consensus factor values varied substantially across ailment categories (Table 4), ranging from 0.14 for fever to 1.00 for burns. Burns had the highest ICF value because all burn-related use reports focused on one species, Aloe vera. Cold also showed high consensus (ICF = 0.90), with many use reports concentrated among a smaller set of commonly known species. Skin disease and body aches also produced high ICF values, while fever produced the lowest value.

Table 4
Informant consensus factor (ICF) by ailment category derived from 40 ethnomedicinal plant species reported by Tharu households in Pakali, Sunsari, 2025.

Ailment category	Nt	Nur	Nur – Nt	Nur – 1	ICF
Burns	1	28	27	27	1.00
Cold	17	169	152	168	0.90
Skin disease	4	24	20	23	0.87
Body ache	2	8	6	7	0.86
Cough	11	39	28	38	0.74
Gastric	3	8	5	7	0.71
Sore throat	11	34	23	33	0.69
Period cramps	2	3	1	2	0.50
Fever	7	8	1	7	0.14
Note. ICF = (Nur – Nt) / (Nur – 1); Nur = number of use-reports in each ailment category; Nt = number of plant taxa used for that category [29, 32].					

Fidelity level results (Table 5) complement the ICF analysis by showing which plants are strongly associated with uses. Aank (*Calotropis gigantea*) had the highest FL value for body ache (100%), meaning that all respondents who cited Aank associated it with that use. Tulsi had a very high FL for cold (94.88%), Neem showed strong use specificity for skin conditions (85.00%), and Aloe vera showed strong use specificity for burns (84.84%). These results suggest that a small number of species occupy highly specific positions in local therapeutic knowledge.

Table 5

Fidelity level (FL) of the ten most frequently cited ethnomedicinal plant species for their primary reported ailment in Pakali, Sunsari, 2025 (ordered by descending FL).

Local name	Scientific name	Primary ailment	Np	N	FL (%)
Aank	<i>Calotropis gigantea</i> (L.) Dryand.	Body ache	7	7	100.00
Tulsi	<i>Ocimum tenuiflorum</i> L.	Cold	111	117	94.88
Neem	<i>Azadirachta indica</i> A.Juss.	Skin conditions	17	20	85.00
Aloe vera	<i>Aloe vera</i> (L.) Burm.f.	Burns	28	33	84.84
Amala	<i>Phyllanthus emblica</i> L.	Diarrhoea	1	3	33.33
Ginger	<i>Zingiber officinale</i> Roscoe	Sore throat	13	41	31.70
Garlic	<i>Allium sativum</i> L.	Gastric	5	19	26.31
Titepati	<i>Artemisia indica</i> Willd.	Joint pain	1	4	25.00
Guava	<i>Psidium guajava</i> L.	Diabetes	1	4	25.00
Parijat	<i>Nyctanthes arbor-tristis</i> L.	Period cramps	2	11	18.18
Note. FL (%) = (Np / N) × 100; Np = respondents citing the species for the specified primary ailment; N = total respondents citing that species for any ailment [30].					

Conservation attitudes and perceived environmental priorities

A majority of respondents (63.58%) reported stated willingness to participate in conservation programs (Fig. 3a). This result suggests that conservation engagement has a social foundation in Pakali; however, the findings should not be overstated because willingness to participate is a stated preference rather observed participation. It indicates potential openness to conservation programs, but actual participation would depend on program design, trust, time costs, perceived benefits, land access, and institutional arrangements.

When asked about measures needed for environmental conservation, 73.6% of respondents identified reforestation as the most important measure, followed by community education and government policy (Fig. 3b). This finding is consistent with the community's reported concern for environmental change and with the broader importance of plant resources in household practice. However, this result should not be interpreted as evidence that deforestation is the dominant ecological problem in Pakali because the study did not directly measured land-cover change or forest loss.

The perception is analytically important because it shows that conservation is locally imagined in ecological and landscape terms, not only as formal policy. In a community where medicinal plants, agriculture, and cultural practice are closely connected, reforestation may symbolize both environmental recovery and cultural continuity. This interpretation aligns with the study's broader argument that conservation programs may be more effective when they engage local ecological meanings rather than relying only on general awareness campaigns.

Title:

Figure 3. Stated conservation willingness and preferred conservation measures among surveyed Tharu households in Pakali.

Legend:

Figure 3. (a) Stated willingness of surveyed Tharu households to participate in environmental conservation programs in Pakali (n = 140). (b) Preferred environmental conservation measures reported by respondents (n = 140). Values represent the percentage of respondents in each category.

Factors associated with respondents' stated willingness to participate in conservation programs

The binomial logistic regression examined factors associated with respondents' stated willingness to participate in conservation programs (Table 6). The strongest positive association was observed for the belief that environmental change affects cultural traditions. Respondents who held this belief had substantially higher odds of stated willingness to participate than those who did not. The odds ratio was 5.32, and the average marginal effect was 0.328, indicating an estimated increase of approximately 32.8 percentage points in the probability of reporting stated willingness to participate, holding other variables constant.

Average monthly income was negatively associated with stated willingness to participate. The marginal effect implies that an increase of NPR 10,000 in monthly income is associated with approximately a 4-percentage-point decline in the probability of stated willingness to participate. This result is counterintuitive if one expects wealthier households to have more resources for conservation engagement. However, it may reflect higher opportunity costs of time, weaker dependence on local plant resources, or greater livelihood separation from agricultural and home-based ecological practice. Because the study is cross-sectional and observational, this result should be interpreted as an association rather than a causal effect.

The 11–20 year residency category was negatively associated with willingness to participate relative to households residing in Pakali for less than five years. This result should be handled cautiously because the reference group is small. It may reflect compositional differences among recent movers, medium-term residents, and long-term residents, but the data are not sufficient to establish a strong explanation. The results therefore suggest only that residency effects do not appear to be linear and may depend on household history, livelihood, and social integration.

Age and education were not significantly associated with respondents' stated willingness to participate in conservation programs in the multivariable logistic regression. This finding is consistent with the bivariate analyses and suggests that respondents' perceptions of the cultural impacts of environmental change were more strongly associated with stated willingness than these demographic characteristics. Although the study cannot determine how conservation initiatives should be designed, the findings indicate that recognizing the cultural significance of medicinal plants, home gardens, and traditional ecological knowledge may be important when developing community-based conservation programs. Further research is needed to examine whether these associations are reflected in actual participation in conservation activities.

Table 6

Binomial logistic regression predicting stated willingness to participate in conservation programs among Tharu households in Pakali, Sunsari, 2025.

Variable	Logistic regression		Average marginal effects	
	Coef.	(SE)	AME	(SE)
Average monthly income (NPR)	-0.0000179*	(0.0000089)	-0.000004**	(0.000002)
Age of household head	-0.0072	(0.0179)	-0.001	(0.004)
Read and write (ref: illiterate)	0.746	(0.575)	0.141	(0.104)
Primary education	0.582	(0.713)	0.113	(0.132)
Secondary education	-0.275	(0.541)	-0.059	(0.116)
Intermediate education	0.687	(0.831)	0.131	(0.147)
University education	0.199	(1.547)	0.041	(0.309)
Env. change affects tradition (= 1)	1.672*	(0.678)	0.328**	(0.122)
5–10 yrs residency (ref: < 5 yrs)	-0.510	(1.693)	-0.087	(0.291)
11–20 yrs residency	-2.813†	(1.436)	-0.564*	(0.223)
> 20 yrs residency	-0.703	(1.189)	-0.125	(0.183)
N 139 139				
AIC	184.5		184.5	
RMSE	0.45		0.45	
Note. Dependent variable: stated willingness to participate (Yes = 1). Coefficients estimated by maximum likelihood. Average marginal effects (AME) computed using the margins package in R. † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$. Standard errors in parentheses. Reference categories: illiterate (education); < 5 years (residency). Income interpretation: an NPR 10,000 increase in monthly income is associated with approximately a 4 percentage-point decrease in predicted probability of stated willingness.				

Discussion

The central contribution of this study is that it places medicinal-plant knowledge within a household ethnoecological system rather than treating it only as a species inventory. The findings demonstrate clear links among reported medicinal use, family-based learning, domestic access to plants, and cultural concern about environmental change. This pattern fits the knowledge-practice-belief perspective, in which ecological knowledge is sustained through use, social relationships, and values attached to local environments [3, 5]. For Pakali, the household therefore emerges as an important interface between ethnomedicine and ethnoecology: it is where remedies are remembered, plant materials are obtained, and environmental change is interpreted in relation to cultural life.

The prominence of familiar, readily accessible remedies and sourcing from home gardens suggests that ethnomedicine in Pakali remains embedded in everyday household healthcare. Unlike studies that focus primarily on specialist healers, the present study documents medicinal-plant practices among ordinary households. Research in Nepal's Terai similarly shows that wild and tended plants contribute to healthcare, livelihoods, and cultural practices

within agricultural landscapes [33]. Recent work among Tharu communities in eastern Nepal reported that many frequently cited medicinal plants were terrestrial and primarily agroforestry-based, highlighting the importance of agroforestry landscapes in supporting local ethnomedicinal practices [34]. More broadly, home garden research highlights the important role of home gardens in supporting household livelihoods and providing a wide range of useful plant resources for daily life [35]. These findings support viewing home gardens as part of the social and material infrastructure of household ethnomedicine in Pakali. Although fewer medicinal plant species were documented than in the earlier Pakali inventory, this difference alone should not be interpreted as evidence of ethnobotanical knowledge erosion. Hanazaki et al. [36] caution that apparent differences in ethnobotanical repertoires may also reflect changes in plant availability, environmental conditions, and other social factors, and that the number of plant species reported represents only one dimension of ethnobotanical knowledge.

Family tradition as the principal reported knowledge source adds a social dimension that earlier inventories from Pakali did not examine. Ethnobotanical knowledge is commonly transmitted through close interpersonal networks, and relatives often play especially important roles in learning medicinal-plant uses, preparation, and application [37]. In Nepal, plant-use knowledge also varies with cultural heritage, livelihood, accessibility, and local ecological conditions, showing that knowledge is produced within specific social and environmental settings rather than distributed uniformly across a community [6, 38]. The present study strengthens this literature by identifying the family and household as the principal reported pathway through which Tharu ethnomedicinal knowledge is shared and maintained in Pakali. Although other sources such as peers, traditional healers, educational institutions, and media may also contribute to medicinal-plant learning [37, 39], the findings highlight the central role of families in sustaining local ethnomedicinal knowledge and support involving elders, experienced household members, and younger generations in future documentation and knowledge-sharing initiatives.

The ICF and FL results further indicate that household knowledge is not entirely diffuse: some ailment categories and plant-use relationships are strongly concentrated within the reported repertoire. In ethnomedicine, such agreement is valuable because it identifies remedies with high cultural salience and repeated recognition across informants [29, 30, 32]. Read together, the two indices show both agreement at the ailment-category level and specificity at the plant-use level. Together, these indices help identify culturally important remedies that may warrant further botanical, pharmacological, and safety investigations. They should not, however, be interpreted as direct evidence of clinical effectiveness.

The association between perceiving environmental change as a threat to tradition and greater stated willingness to participate in conservation is the study's most distinctive finding. It suggests that conservation concern among Tharu households is not only ecological but also cultural: people may be more willing to engage when environmental change is understood as affecting valued practices, knowledge, and identity. This interpretation is consistent with recent research from eastern Nepal showing that Tharu ethnobotanical knowledge is closely tied to landscapes, livelihoods, and cultural practices, and that modernization, changing resource access, and land-use change are placing increasing pressure on these relationships [34]. It also aligns with evidence from community-based conservation in Nepal indicating that local support for conservation depends not only on ecological outcomes but also on how conservation is experienced, including perceived benefits, costs, and opportunities for meaningful participation [20]. Together, these findings suggest that conservation initiatives in Pakali may be more effective when they recognize the cultural significance of ethnobotanical knowledge and actively involve Tharu knowledge holders in planning and decision-making. Approaches such as supporting household medicinal plant cultivation, strengthening intergenerational knowledge transmission, promoting home garden management, and community-led documentation of traditional knowledge could therefore help align conservation efforts with locally valued practices and priorities.

Taken together, this study extends the earlier Pakali inventory by providing a household-level perspective on how ethnomedicinal knowledge is maintained, how access to medicinal plants is organized, and how cultural perceptions relate to stated willingness to participate in conservation. While Chaudhary and Rai [15] documented the diversity of medicinal plants used by the Tharu community in Pakali, the present study complements that baseline by demonstrating the social and domestic processes through which ethnomedicinal knowledge continues to be practiced and transmitted in contemporary household life. These findings are important for ethnoecology because traditional ecological knowledge is not simply a body of information about useful species, but a dynamic knowledge-practice-belief complex in which knowledge is developed through experience, embedded in practice and cultural institutions, and transmitted across generations [3]. By linking household patterns of medicinal plant knowledge, access, and cultural values with conservation attitudes, the study also contributes to understanding how traditional ecological knowledge and cultural practices can inform local conservation efforts.

Several limitations should be considered when interpreting the study’s conclusions. The cross-sectional design limits population-level generalization and does not establish temporal or causal relationships. The study relies on self-reported knowledge, sources, and willingness rather than direct observations of teaching, preparation, garden management, or conservation participation. Plant identifications were not verified through voucher specimens, and the survey did not systematically document dosage, preparation, route, or safety. The regression analysis identifies correlational associations between variables and should be interpreted as exploratory rather than as evidence of causal effects. Future research should build on this baseline through voucher-supported identification, direct home garden and collection-site inventories, interviews with multiple generations and recognized knowledge holders, and prospective measurement of actual conservation participation. These additions would test the mechanisms suggested by the present findings while retaining the study’s household and biocultural focus.

Conclusions

This study demonstrates that Tharu ethnomedicinal knowledge in Pakali is closely embedded within household relationships, family-based learning, home garden access, and culturally meaningful perceptions of environmental change. Beyond documenting medicinal-plant use, it highlights how knowledge is maintained through everyday household practices and identifies culturally important remedies through patterns of agreement among respondents. The observed association between perceiving environmental change as a threat to tradition and stated willingness to participate in conservation further emphasizes the close relationship between cultural continuity and environmental stewardship.

The findings suggest that households, home gardens, elders, and other local knowledge holders provide practical entry points for community-based documentation and conservation of medicinal-plant knowledge. Future research should combine voucher-supported plant identification with detailed documentation of medicinal practices, intergenerational studies of knowledge transmission, and evaluation of actual conservation participation. Within the limitations of its cross-sectional household design, this study provides a contemporary baseline for understanding Tharu ethnomedicinal knowledge and contributes to future research on biocultural conservation in Pakali.

List of Abbreviations

- AIC Akaike Information Criterion
- AME Average Marginal Effect
- ERB Ethical Review Board

FL	Fidelity Level
IAAS	Institute of Agriculture and Animal Science
ICF	Informant Consensus Factor
KTWR	Koshi Tappu Wildlife Reserve
NPR	Nepalese Rupees
OR	Odds Ratio
POWO	Plants of the World Online
RMSE	Root Mean Square Error
SE	Standard Error
TEK	Traditional Ecological Knowledge
TU	Tribhuvan University

Declarations

Ethics approval and consent to participate

This study was conducted as part of an undergraduate research project at Tribhuvan University, Nepal. Under Tribhuvan University policy, central Ethical Review Board, Tribhuvan University (ERB-TU) clearance was not required because this study did not fall within either category requiring central ERB-TU review. Ethical permission was obtained from the Ethical Review Committee (ERC) of the Dean's Office, Institute of Agriculture and Animal Science (IAAS), Tribhuvan University, the relevant institutional ethics authority for this study. All study protocols were approved by this committee, and all methods were performed in accordance with the relevant guidelines and regulations and the Declaration of Helsinki. Before each interview, the purpose of the study was explained to all participants. Participation was voluntary, confidentiality was explained, and verbal informed consent was obtained from all participants before the interviews were conducted.

Consent for publication

Not applicable

Availability of data and materials

The data collected and analyzed during this study are included in this article. Additional data are available from the corresponding author upon reasonable request, subject to ethical and community consent considerations.

Competing interests

The authors declare that they have no competing interests.

Funding

No funding was received for this study. The study was conducted using the author's own resources.

Author's contribution

RD conceived and designed the study, conducted the fieldwork, collected and analyzed the data, interpreted the findings, and wrote the manuscript. SK supervised the research and provided guidance throughout the study. Both authors read and approved the final manuscript.

Acknowledgements

The authors sincerely thank the Tharu community of Pakali, Sunsari, for their willingness to participate in this study and for generously sharing their knowledge and experiences.

References

1. Davidson-Hunt, I. Ecological ethnobotany: stumbling toward new practices and paradigms. *MASA J.* **16** (1), 1–13 (2000).
2. Rodrigues, E., Seixas, C. S., Sauini, T. & Adams, C. The importance of ethnoecological studies for the conservation and sustainable use of biodiversity: a critical analysis of six decades of support by FAPESP. *Biota. Neotrop.* **22** (spe), e20221403. 10.1590/1676-0611-BN-2022-1403 (2022).
3. Berkes, F. *Sacred ecology* 4th edn (Routledge, 2018). 10.4324/9781315114644
4. IPBES. *Global assessment report on biodiversity and ecosystem services* (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019).
5. Berkes, F., Colding, J. & Folke, C. Rediscovery of traditional ecological knowledge as adaptive management. *Ecol. Appl.* **10** (5), 1251–1262. 10.1890/1051-0761 (2000). (2000)010[1251:ROTEKA]2.0.CO;2.
6. Ghimire, S. K., McKey, D. & Aumeeruddy-Thomas, Y. Heterogeneity in ethnoecological knowledge and management of medicinal plants in the Himalayas of Nepal: implications for conservation. *Ecol. Soc.* **9** (3), 6 (2004).
7. Kumar, B. M. & Nair, P. K. R. The enigma of tropical homegardens. *Agrofor. Syst.* **61** (1–3), 135–152. 10.1023/B:0000028995.13227.ca (2004).
8. Sharma, R., Mina, U. & Kumar, B. M. Homegarden agroforestry systems in achievement of Sustainable Development Goals: a review. *Agron. Sustain. Dev.* **42** (3), 44. 10.1007/s13593-022-00781-9 (2022).
9. Kunwar, R. M. & Bussmann, R. W. Ethnobotany in the Nepal Himalaya. *J. Ethnobiol. Ethnomed.* **4**, 24. 10.1186/1746-4269-4-24 (2008).
10. Sapkota, P. P. Ethno-ecological observation of Magar of Bukini, Baglung, Western, Nepal. *Dhaulagiri J. Sociol. Anthropol.* **2**, 227–252. 10.3126/dsaj.v2i0.1366 (2008).
11. Khanal, C., Neupane, S. & Thapa Magar, M. S. Ethnobotany of medicinal plants used by Kathariya (Tharu) community in Kailali District, Nepal. *J. Plant. Resour.* **20** (2), 190–199. 10.3126/bdpr.v20i2.57038 (2022).
12. National Statistics Office. National Population and Housing Census. : national report on caste/ethnicity, language and religion. Kathmandu: Government of Nepal, Office of the Prime Minister and Council of Ministers; 2023. (2021). Available from: https://censusnepal.cbs.gov.np/results/files/result-folder/Caste%20Ethnicity_report_NPHC_2021.pdf. Accessed 22 May 2026.
13. Ghimire, K. & Bastakoti, R. R. Ethnomedicinal knowledge and healthcare practices among the Tharus of Nawalparasi district in central Nepal. *Ecol. Manage.* **257** (10), 2066–2072. 10.1016/j.foreco.2009.01.039 (2009).
14. Chaudhary, S., Magar, G. T., Sah, S. N. & Parajuli, S. Ethnic plants of Tharu community of Eastern Nepal. *Int. J. Appl. Sci. Biotechnol.* **8** (2), 223–230. 10.3126/ijasbt.v8i2.28325 (2020).

15. Chaudhary, S. K. & Rai, S. K. Ethnobotany of Tharu community of Pakali, Sunsari, Nepal. *Nepal. J. Biosci.* **7** (1), 58–71. 10.3126/njbs.v7i1.41767 (2017).
16. Gachhadar, P. Indigenous knowledge and practices on medicinal plants among Tharu community in Eastern Nepal. Kathmandu: ICIMOD; (2000). Available from: <https://lib.icimod.org/records/wmrg7-24m60>. Accessed 24 May 2026.
17. Thapa, C. B. Ethnomedicinal practices by Tharu ethnic community in Rupandehi and Nawalparasi districts, Western Nepal. *J. Inst. Sci. Technol.* **25** (2), 93–106. 10.3126/jist.v25i2.33745 (2020).
18. Chaudhary, B. R., Erskine, W. & Acciaioli, G. Hybrid knowledge and climate-resilient agriculture practices of the Tharu in the western Tarai, Nepal. *Front. Polit Sci.* **4**, 969835. 10.3389/fpos.2022.969835 (2022).
19. Chhetri, B. B. K., Johnsen, F. H., Konoshima, M. & Yoshimoto, A. Community forestry in the hills of Nepal: Determinants of user participation in forest management. *Policy Econ.* **30**, 6–13. 10.1016/j.forpol.2013.01.010 (2013).
20. Mehta, J. N. & Heinen, J. T. Does community-based conservation shape favorable attitudes among locals? An empirical study from Nepal. *Environ. Manage.* **28** (2), 165–177. 10.1007/s002670010215 (2001).
21. Climate-Data.org. Weather Itahari & temperature by month. (2026). Available from: <https://en.climate-data.org/asia/nepal/eastern-development-region/itahari-29979/>. Accessed 24 May 2026.
22. Mapcarta. Pakali map: locality, Itahari, Nepal. (2026). Available from: <https://mapcarta.com/28341978>. Accessed 24 May 2026.
23. Mindat.org, Pakali, S., Zone, K. & Purwanchal, N. (2026). Available from: <https://www.mindat.org/feature-7802581.html>. Accessed 24 May 2026.
24. Itahari Sub-Metropolitan City Office. Ward No. 17 Office, Pakali. Itahari: Itahari Sub-Metropolitan City Office. Available from: link_Itahari Accessed 24 May 2026. (2026).
25. Wikipedia contributors. Itahari. In: Wikipedia, the free encyclopedia. (2026). Available from: <https://en.wikipedia.org/wiki/Itahari>. Accessed 24 May 2026.
26. EduSanjal. Itahari: sub-metropolitan city. (2026). Available from: <https://edusanjal.com/local-level/itahari/>. Accessed 24 May 2026.
27. Yamane, T. *Statistics: an introductory analysis* 2nd edn (Harper & Row, 1967).
28. Israel, G. D. *Determining sample size. PEOD-6. Gainesville (FL)* (University of Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, 1992).
29. Trotter, R. T. I. I. & Logan, M. H. Informant consensus: a new approach for identifying potentially effective medicinal plants. In: (ed Etkin, N. L.) *Plants in indigenous medicine and diet: biobehavioral approaches*. Bedford Hills (NY): Redgrave Publishing Company; 91–112. (1986).
30. Friedman, J., Yaniv, Z., Dafni, A. & Palewitch, D. A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. *J. Ethnopharmacol.* **16** (2–3), 275–287. 10.1016/0378-8741(86)90094-2 (1986).
31. Hosmer, D. W. Jr, Lemeshow, S. & Sturdivant, R. X. *Applied logistic regression* 3rd edn (Wiley, 2013).
32. Heinrich, M., Ankli, A., Frei, B., Weimann, C. & Sticher, O. Medicinal plants in Mexico: healers' consensus and cultural importance. *Soc. Sci. Med.* **47** (11), 1859–1871. 10.1016/S0277-9536(98)00181-6 (1998).
33. Thorn, J. P. R., Thornton, T. F., Helfgott, A. & Willis, K. J. Indigenous uses of wild and tended plant biodiversity maintain ecosystem services in agricultural landscapes of the Terai Plains of Nepal. *J. Ethnobiol. Ethnomed.* **16**, 33. 10.1186/s13002-020-00382-4 (2020).

34. Kutal, D. et al. Ethnobotanical knowledge of Tharu people living nearby Koshi River and Koshi Tappu Wildlife Reserve (KTWR), eastern Nepal. *J. Ethnobiol. Ethnomed.* **22**, 53. 10.1186/s13002-026-00886-5 (2026).
35. Hou, S., Yu, M. & Yao, Z. Ethnobotanical study on factors influencing plant composition and traditional knowledge in homegardens of Laifeng Tujia ethnic communities, the hinterland of the Wuling mountain area, central China. *J. Ethnobiol. Ethnomed.* **20**, 103. 10.1186/s13002-024-00742-4 (2024).
36. Hanazaki, N., Herbst, D. F., Marques, M. S. & Vandebroek, I. Evidence of the shifting baseline syndrome in ethnobotanical research. *J. Ethnobiol. Ethnomed.* **9**, 75. 10.1186/1746-4269-9-75 (2013).
37. Haselmair, R., Pirker, H., Kuhn, E. & Vogl, C. R. Personal networks: a tool for gaining insight into the transmission of knowledge about food and medicinal plants among Tyrolean (Austrian) migrants in Australia, Brazil and Peru. *J. Ethnobiol. Ethnomed.* **10**, 1. 10.1186/1746-4269-10-1 (2014).
38. Kunwar, R. M. et al. Cross-cultural comparison of plant use knowledge in Baitadi and Darchula districts, Nepal Himalaya. *J. Ethnobiol. Ethnomed.* **14**, 40. 10.1186/s13002-018-0242-7 (2018).
39. Reyes-García, V. The relevance of traditional knowledge systems for ethnopharmacological research: theoretical and methodological contributions. *J. Ethnobiol. Ethnomed.* **6**, 32. 10.1186/1746-4269-6-32 (2010).
40. Subba, Y., Hazra, S. & Rahaman, C. H. Quantitative ethnobotany of medicinal plants from Darjeeling District of West Bengal, India, along with phytochemistry and toxicity study of *Betula alnoides* Buch.-Ham. ex D. Don bark. *Plants. (Basel)* **13** (24), 3505. 10.3390/plants13243505 (2024).

Figures

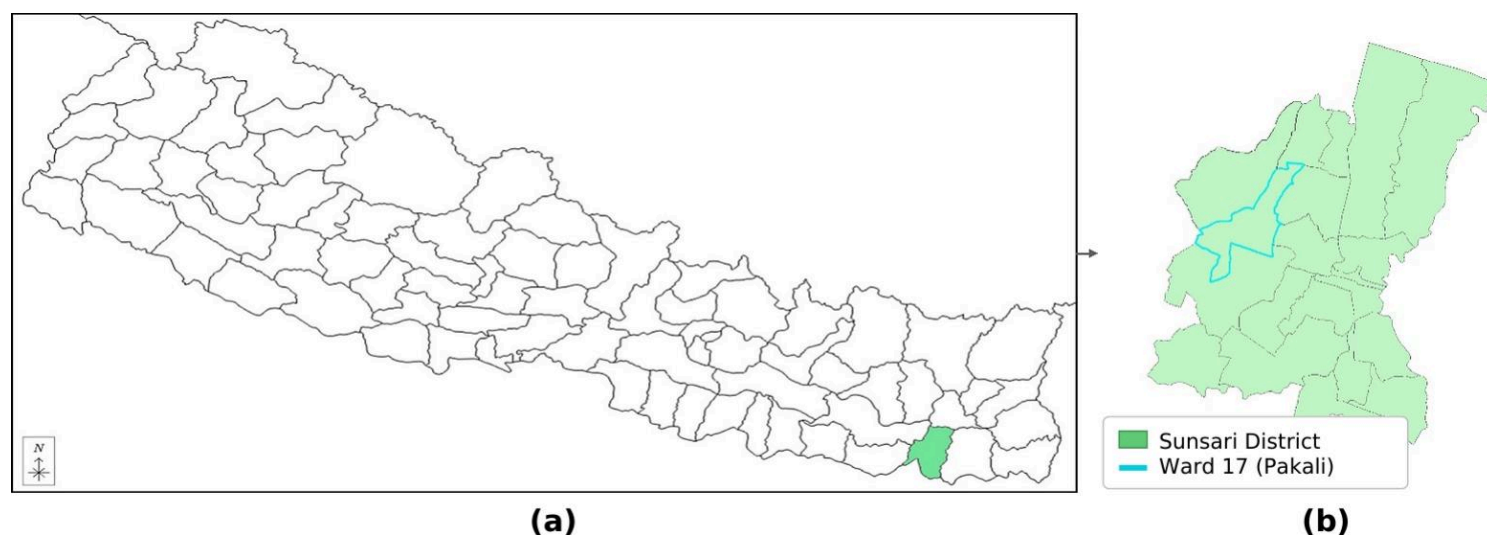


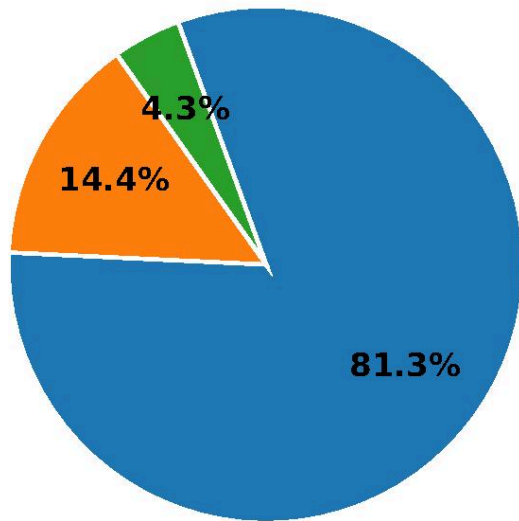
Figure 1

Study area map of Pakali, Sunsari District, Nepal.

Legend:

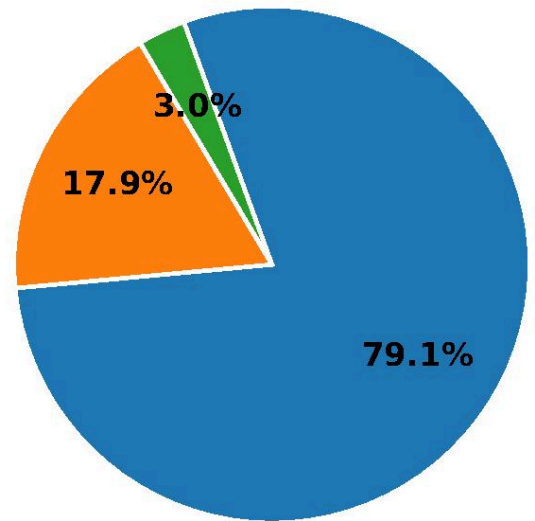
Panel (a) shows a map of Nepal with district boundaries; Sunsari District (green) is highlighted in the southeastern Terai. Panel (b) shows the ward-level map of Itahari Sub-Metropolitan City, Sunsari District, with Ward 17 (Pakali), the study area, delineated in blue.

(a)



■ Family tradition ■ Others ■ Community elders

(b)



■ Home garden ■ Market ■ Others

Figure 2

Reported sources of ethnomedicinal knowledge and medicinal plants among surveyed Tharu households in Pakali.

Legend:

Figure 2. (a) Reported source of ethnomedicinal knowledge among surveyed Tharu households in Pakali (n = 139). (b) Primary reported source from which respondents obtained medicinal plants (n = 140). Percentages are based on the number of respondents answering each question; one respondent did not report a knowledge source.

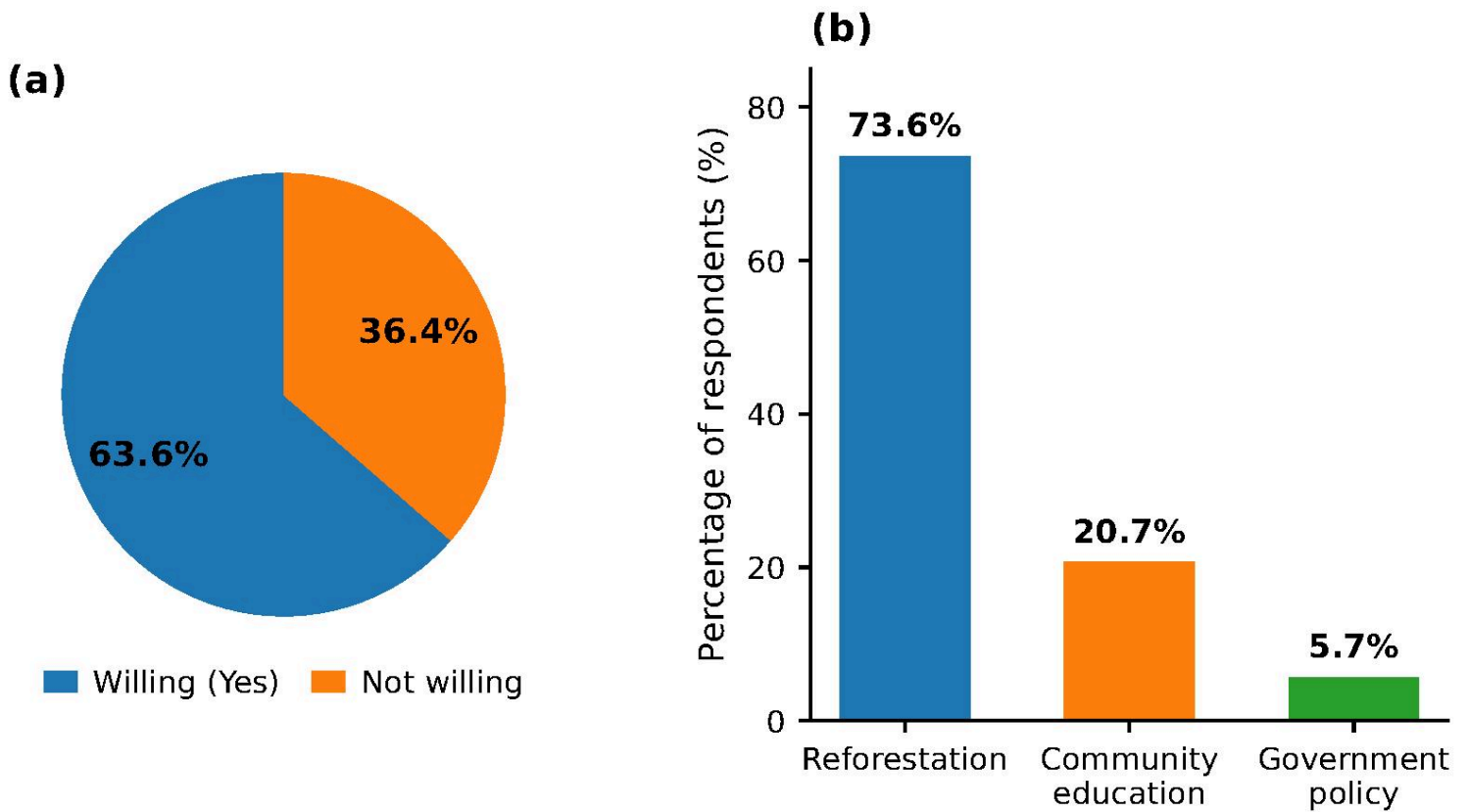


Figure 3

Stated conservation willingness and preferred conservation measures among surveyed Tharu households in Pakali.

Legend:

Figure 3. (a) Stated willingness of surveyed Tharu households to participate in environmental conservation programs in Pakali (n = 140). (b) Preferred environmental conservation measures reported by respondents (n = 140). Values represent the percentage of respondents in each category.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Additionalfile4.pdf](#)
- [Additionalfile3.pdf](#)
- [Additionalfile2.pdf](#)
- [Additionalfile1.pdf](#)