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Stakeholder Perception and Priority Gaps in Ecosystem Services of Different Land-Uses in Rural Laos

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Abstract

Conflicting priorities between policymakers and local communities often compromise conservation outcomes in landscapes reliant on natural resources. Understanding how diverse stakeholders value ecosystem services (ESs) across coexisting land uses is essential; however, empirical evidence from rural Southeast Asia remains limited. This study examined ES perceptions and priorities among community members ($n = 500$) and experts ($n = 30$) within a bamboo forest, rice paddy, and teak plantation in Sangthong District, Lao PDR. A two-step survey methodology was employed: initially assessing ES perceptions to filter locally relevant services using a $\geq 50\%$ recognition threshold, followed by quantifying priorities for this subset through a 100-point allocation task. The results revealed a systematic divergence in priorities rooted in differing knowledge systems. Communities, grounded in traditional ecological knowledge (TEK), prioritized tangible provisioning and cultural services (e.g., food and raw materials). In contrast, experts emphasized regulating services (e.g., carbon sequestration and hazard regulation) and habitat services (e.g., biodiversity and habitat provision). Distinct “ES bundles” also emerged by land use: bamboo (raw materials and freshwater), rice (food and medicine), and teak (timber/bioenergy and regulating services). Our findings suggest a policy transition from single-objective management toward optimizing landscape-level ES portfolios, alongside institutionalizing participatory co-management that formally integrates local knowledge and enhances ES literacy.

Keywords: stakeholder perceptions; priority; land-use; Laos; social valuation; co-management; traditional ecological knowledge



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1. Introduction

Forests provide diverse ecosystem services (ESs)—including provisioning, regulating, cultural, and habitat functions—that are essential for human well-being [1]. The ES framework is a widely used tool, informing major international policy arenas like the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Sustainable Development Goals (SDGs), the Convention on Biological Diversity (CBD), and the United Nations Framework Convention on Climate Change (UNFCCC) [2]. Despite this prominence, field-based evidence on how different stakeholder groups value ESs across coexisting land uses in rural Southeast Asia remains limited and fragmented [3–6].

Southeast Asia (SEA) is a critical context for ES research. The region contains ~15% of the world’s tropical forests, 21.6% of global fishery production, and 15% of Asia’s agricultural output [7–9]. With rapid land-use change and resource dependence, ES degradation

can lead to cascading effects on food security, climate regulation, and biodiversity. In Laos, a large share of rural livelihoods relies on forests for food, fuel, and income [10]. Identifying which ESs different stakeholders perceive as important within land-use mosaics is therefore a practical challenge for local development and global sustainability goals [6,11].

Methodologies for assessing ESs have evolved beyond macroeconomic valuation to include spatial modeling [1,12–17] and structured surveys that quantify socio-cultural values [18–22]. Yet, a persistent gap remains between outputs from biophysical and economic indicators and the importance that local stakeholders assign to services [17,23]. This divergence is often pronounced in resource-dependent communities, where modeled ES supply does not align with perceived benefits [24,25]. International case studies confirm that ES perceptions are context-dependent, varying with livelihood and land-use types [26–28]. However, many studies focus on a single ecosystem or a narrow set of stakeholders [29–31], and comparative, multi-land-use analyses in developing country settings remain scarce [6,32–43].

This study empirically compares ES perceptions and priorities among community members ($n = 500$) and experts ($n = 30$) across three representative land-use systems in Sangthong District, Laos: (1) bamboo forests (traditional NTFP-based livelihoods), (2) rice paddies (agroforestry interface), and (3) teak plantations (commercial forestry). To enable reliable comparisons in a data-scarce setting, we employed a sequential, two-step survey design—first eliciting perceptions (Step 1), then priority allocation (Step 2). We investigated: (RQ1) how ESs are perceived and prioritized within each land-use system; (RQ2) whether significant differences exist between groups; and (RQ3) how patterns of differentiation manifest across land uses. Ultimately, this study makes two key contributions. First, it provides a comparative analysis of ES perceptions and priorities across three coexisting land-use systems in a rural developing-country context. Second, it offers a methodological insight into the implications of the Step 1 $\geq 50\%$ perception threshold for subsequent prioritization and interpretation.

2. Materials and Methods

2.1. Study Area

The study area is Sangthong District, approximately 55 km northwest of Vientiane Capital, Laos. Comprehensive details are in the previous study [44]; this section provides a summary. Table 1 shows the land-use composition.

Table 1. Land use of Sangthong district in 2015.

Land Use Type	Area (ha)	%
Forest land	42,365	55.76
Agriculture land	25,567	33.65
Wetland	4238	5.58
Other land use	3810	5.01
Total	75,982	100

Source: Lee (2021) [44].

Remote sensing analyses [45] reported that, within a 10 km radius centered on the villages of Houay Tom and Maipaksang in Sangthong, the forest cover decreased from 65% to 60% between 2001 and 2018. Concurrently, the number of forest patches also grew by approximately 1.6 times. These findings suggest potential changes in the structure of ES supply within rural landscapes with a mosaic of forest and agriculture. Building on the previous study [44], single analysis of bamboo forests, this study incorporates rice paddies

and teak plantations to compare perceptions and priorities regarding ESs across diverse land-use types.

2.2. Data Collection

2.2.1. Selection of Land-Use Types and ES List

Rural livelihoods in Laos vary markedly between the rainy and dry seasons, which directly affects reliance on natural resources [46]. The primary economic activities in Sangthong District include rainfed paddy rice, fishing, livestock rearing, and bamboo harvesting and processing. Bamboo is a major source of cash income [47]. Teak plantations also help meet timber demand and contribute to poverty alleviation [48].

An analysis of agricultural and forestry income records from Nongboua village for 2017–2019 showed that agriculture and forestry contributed about 46.7% of total household income. Rice paddies made up 68% of the cultivated area and 66.3% of total income, while teak plantations, despite their small area, represented 69% of the plantation timber harvest. Approximately 45% of households engaged in bamboo-related activities, such as harvesting, weaving, processing, and sales. Consequently, the selected land-use types were bamboo forest, rice paddy, and teak plantation. The selection was confirmed by evaluations from the Department of Forestry (DoF), District Agriculture and Forestry Office (DAFO) in Lao People's Democratic Republic, and both domestic and international ES experts.

ES categories were defined into four groups [49]: provisioning, regulating, cultural, and habitat services. Candidate ES items were identified by incorporating land-use-specific contributions from previous research [50]. This identification involved three sequential steps: (i) preliminary interviews with local residents and experts; (ii) translation and back-translation with a pilot survey; and (iii) review by an expert panel. Through this process, a final list of 15 ESs was created: six provisioning, five regulating, two cultural, and two habitat services (Supplementary Table S1). The final list was confirmed by the DoF/DAFO and external experts, and the detailed survey questions and instructions are in Supplementary Figure S1.

2.2.2. Participants and Sampling

Respondents were classified into community and expert groups. The community group comprised residents who directly or indirectly participated in or were affected by the targeted land use. The expert group included personnel from public institutions and academia in the forestry, agriculture, and environment fields [18]. Five villages served as the first stratum; target samples were assigned by village. Supplementary Table S2 summarizes respondent characteristics by group and village, including sample sizes, gender and age distributions, and education levels.

2.2.3. Public Perception and Priority Survey

This study adapted methodologies from prior research [19,20] refining survey procedures and instructions to fit the field context and enable comparative analysis across land use types (bamboo forest, rice paddy, and teak plantation). We used a structured, interviewer-assisted paper questionnaire. We translated all questions into Lao and then back-translated them into English before fielding the survey. The full survey instruments are in Supplementary Figure S1.

Step 1: Perception assessment and selection of ES

We assessed the current use level of ES for each land-use type on a four-point scale (1 = no use; 4 = high use). The standardized question was: "In your opinion, what is the level of use of (bamboo forest/rice paddy/teak plantation) around the village?" For analysis, responses of 1 or 2 were considered low use, and 3 or 4 were considered high use. Items rated as high use by $\geq 50\%$ of respondents advanced to Step 2 for priority

assessment [40]. The survey took place through face-to-face interviews over approximately three weeks (10–30 November 2020). Interviewers received orientation, verbally explained the questions and terminology, and then recorded responses.

Step 2: Priority evaluation

For the ESs selected in Step 1, respondents allocated a total of 100 points in 10-point increments to reflect the relative importance of each item. Before administration, we gave detailed instructions on the allocation method via sample questionnaires. During interviews, interviewers used repeated read-backs, verbal reviews, and probing questions to promptly identify and correct biases or misunderstandings. This phase took place over three weeks in December 2020 with the same respondents as in Step 1.

2.2.4. Field Administration and Data Quality Assurance (QA/QC)

Field Team and Training

To improve response reliability, we chose three interviewers with prior ES field experience despite the variability in participants' literacy and educational backgrounds. They took part in a three-day training session on ES concepts and terminology from 4 to 6 November 2020. The operational procedure, which included repeated field validations and verbal reviews, enhanced the accuracy and reliability of the survey data in a data-scarce environment, consistent with the qualitative evaluation framework proposed by Dorji and others [20]. Building on previous studies, this research enhanced comparability by concurrently examining three land-use types using a consistent question framework.

Administration

We conducted face-to-face interviews in community venues during November–December 2020. Interviewers read items aloud, used standardized prompts, and recorded responses. For the Step-2 100-point allocations, interviewers performed read-backs to verify totals and resolve misunderstandings before concluding each interview.

Preliminary Quality Checks

We implemented immediate on-site completeness checks (reviewing for missing pages or rows), range/logic checks (ensuring valid response ranges and consistency of Step-1 to Step-2 carry-over), and a 100-point budget validation (with a tolerance of 100 ± 1). We flagged and excluded duplicate or insincere response patterns during data entry. A total of six cases were excluded under these QA/QC rules (see Supplementary Table S3).

2.3. Data Analysis

This study examined ES perception and priority using data from 530 participants (500 community members and 30 experts). Descriptive statistics, including the median and interquartile range (IQR), are reported. Because tests for normality (Kolmogorov–Smirnov) and homogeneity indicated violations for all ES items ($p < 0.001$), we used nonparametric statistical methods. The specific tests are detailed below for each research question.

2.3.1. RQ 1: Perceived Importance and Ranking

For Step 1 perception, we summarized the share of respondents who rated each ES as “high use” (3 or 4 on a four-point scale) based on stakeholder group and land-use type. For reporting purposes, the “high use” share was categorized as High ($\geq 70\%$), Moderate (50.0–69.9%), and Low ($< 50.0\%$). These labels were assigned separately for each stakeholder group and land-use type.

As for Step 2 priorities, respondents allocated a 100-point budget (in 10-point increments) to the ESs retained from Step 1. We summarized the priority scores for each ES using

medians and IQRs. These summaries provide the basis for the rank-based comparisons that follow.

2.3.2. RQ 2: Between-Group Differences

We used the two-sided Mann–Whitney U test for between-group comparisons (community vs. experts) for each land-use $\times$ ES combination. To control the family-wise error rate (FWER) when evaluating multiple comparisons, we applied a Bonferroni adjustment ($\alpha' = \alpha/n$).

To mitigate pooling bias from the sample-size imbalance (500 vs. 30), analyses were conducted and reported separately for the community and expert samples, using group medians, U statistics, and p -values. This separation avoids distortions from the indiscriminate aggregation of heterogeneous samples [51]. While nonparametric tests are generally robust to differences in sample size, the significant imbalance between the community and expert groups can still affect statistical power. The smaller expert sample may have limited the ability to detect significant differences, while the large community sample may yield significant results even for small effect sizes. Accordingly, we summarize statistical significance in the main text and figures, and we provide the corresponding effect-size estimates in Supplementary Tables S5 and S6 for a more complete interpretation.

2.3.3. RQ 3: Within-Group Differences Across Land Uses

To examine how priorities differed across land-use types within a single stakeholder group, we used a nonparametric repeated-measures approach. For each ES, we first used the Friedman test to assess overall differences among land uses. For ESs with significant overall differences, we performed pairwise Wilcoxon signed-rank tests (bamboo forest vs. rice paddy; bamboo forest vs. teak plantation; rice paddy vs. teak plantation). To control the FWER from these three pairwise comparisons, a Bonferroni correction was applied with $\alpha' = \alpha/3 = 0.0167$ (assuming $\alpha = 0.05$) [52].

2.3.4. Justification and Precedent

The study design—sequential perception assessment followed by prioritization—and the use of nonparametric comparisons align with established methodologies in prior research. For example, Tessema and Nayak [53] used sequential surveys in Ethiopian forests and applied Kruskal–Wallis and Mann–Whitney tests to examine group differences. In addition, Ureta and others [54] incorporated stakeholder preferences by assigning priorities after perception surveys on satisfaction and awareness in state-level conservation planning. These examples support the appropriateness of rank-based tests for non-normal, ordinal data and the validity of a multi-step research design. All participants provided informed consent before participating. The present study reanalyzed data collected in 2020.

3. Results

3.1. Perceptions of ES Across Land-Use Types and Stakeholder Groups

3.1.1. Provisioning Services

Perceptions of provisioning services exhibited distinct land-use patterns (Figure 1). Both groups consistently rated food and raw materials as “high use” in bamboo forests and rice paddies, whereas teak plantations received considerably lower recognition for food provision. Timber was perceived as moderate in both bamboo and teak, with rice paddies being not applicable. Bioenergy received a moderate rating across both groups, and medicinal value was most strongly associated with rice paddies. Freshwater provision was primarily linked to bamboo forests. Items that met the $\geq 50\%$ recognition threshold for inclusion in the Step 2 priority ranking are highlighted in Table 2.

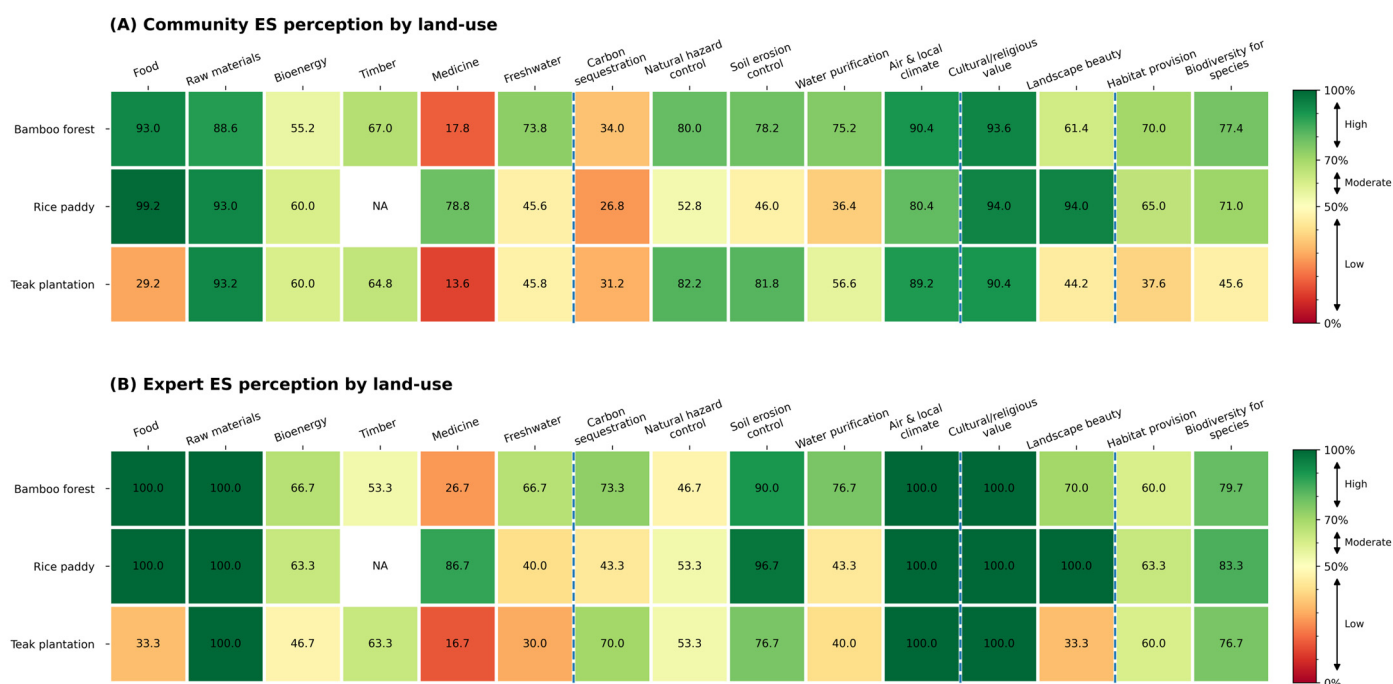


Figure 1. Perception rates (%) of ESs across three land-use types—Bamboo forest, Rice paddy, and Teak plantation. Panels (A,B) show the perception rates of ES for the Community group ($n = 500$) and the Expert group ($n = 30$), respectively, based on Step 1 survey results across three land-use types: Bamboo forest, Rice paddy, and Teak plantation. Each cell indicates the proportion of respondents who scored an ES as “3” or “4” on a four-point scale (1 = No use, 4 = High use).

Table 2. Selection of ESs for Step 2 priority ranking.

ES Category		Bamboo Forest		Rice Paddy		Teak Plantation	
		C *	E *	C	E	C	E
Provisioning	Food	93.0 (H **)	100 (H)	99.2 (H)	100 (H)	29.2 (L)	33.3 (L)
	Raw materials	88.6 (H)	100 (H)	93.0 (H)	100 (H)	93.2 (H)	100 (H)
	Bioenergy	55.2 (M)	66.7 (M)	60.0 (M)	63.3 (M)	60.0 (M)	46.7 (L)
	Timber	67.0 (M)	53.3 (M)	n/a	n/a	67.8 (M)	63.3 (M)
	Medicine	17.8 (L)	26.7 (L)	78.8 (H)	86.7 (H)	13.6 (L)	16.7 (L)
	Freshwater	73.8 (H)	66.7 (M)	45.6 (L)	40.0 (L)	45.8 (L)	30.0 (L)
Regulating	Carbon sequestration	34.0 (L)	73.3 (H)	26.8 (L)	43.3 (L)	31.2 (L)	70.0 (H)
	Natural hazard control	80.0 (H)	46.7 (L)	52.8 (M)	53.3 (M)	82.2 (H)	53.3 (M)
	Soil erosion control	78.2 (H)	90.0 (H)	46.0 (L)	97.7 (H)	81.8 (H)	76.7 (H)
	Water purification	75.2 (H)	76.7 (H)	36.4 (L)	43.3 (L)	56.6 (M)	40.0 (L)
	Air & local climate regulation	90.4 (H)	100 (H)	80.4 (H)	100 (H)	89.2 (H)	100 (H)
Cultural	Cultural/religious value	93.6 (H)	100 (H)	94.0 (H)	100 (H)	90.4 (H)	100 (H)
	Landscape beauty	61.4 (M)	70.0 (H)	94.0 (H)	100 (H)	44.2 (L)	33.3 (L)
Habitat	Habitat provision	70.0 (H)	60.0 (M)	65.0 (M)	63.3 (M)	37.6 (L)	60.0 (M)
	Biodiversity for species	77.4 (H)	79.7 (H)	71.0 (H)	83.3 (H)	45.6 (L)	76.7 (H)

Note. The asterisk (*) indicates that uppercase C denotes Community and E denotes Expert. Double asterisks (**) indicates that H/M/L labels represent High ($\geq 70\%$), Moderate (50.0–69.9%), and Low ($< 50\%$). Cells shaded in gray denote items meeting the Step 1 criterion ($\geq 50\%$ rated “high use”) and included in Step 2.

3.1.2. Regulating Services

Experts generally placed greater emphasis on regulating services than the community (Figure 1). Air and local climate regulation and soil-erosion control were widely perceived

as high use. In contrast, carbon sequestration exhibited the most pronounced difference between groups, with experts rating it as high use and the community as low use. Water purification was primarily associated with bamboo forests. Community recognition of natural-hazard control was high across land-use types.

3.1.3. Cultural Services and Habitat Services

Cultural and religious values were consistently rated as high across all land uses for both groups. Perceived landscape beauty was highest in rice paddies and lowest in teak plantations. For habitat provision and biodiversity, experts typically reported moderate-to-high recognition, while community recognition was lower in teak plantations. Figure 1 shows specific percentages; Table 2 summarizes inclusion in the Step 2 analysis.

3.2. ES Priorities of Land-Use Types and Stakeholders

3.2.1. Comparison Across Land-Use Types

A follow-up priority survey was conducted for ES items that met the $\geq 50\%$ high-use perception threshold (Table 2). For the expert group, significant differences among land-use types were found for all items except carbon sequestration and water purification ($p < 0.05$). Figure 2 presents post hoc groupings (letters a–c): identical letters denote no significant difference, while different letters signify a significant difference based on median rankings. To aid synthesis, we provide a descriptive ES bundle schematic in Supplementary Figure S2. This visualizes the functional specializations summarized above by plotting the median Step 2 priority scores for each ES by land-use.

Within the community group (Figure 2A), provisioning services exhibited a clear three-tier pattern for raw materials and bioenergy: teak plantations ranked highest, followed by bamboo forests, and then rice paddies. Food was rated higher in rice paddies than in bamboo forests; teak plantations were excluded from this comparison at the perception step. Freshwater was prioritized only in bamboo forests (rice paddies and teak plantations excluded). Medicine was prioritized only in rice paddies (bamboo forests and teak plantations excluded).

Among regulating services, air and local climate regulation was rated higher in teak plantations than in bamboo forests and rice paddies, with no significant difference found between the latter two. Natural hazard control received similarly high ratings in rice paddies and teak plantations, while bamboo forests were rated lower. Soil erosion control was rated higher in teak plantations than in bamboo forests (rice paddies excluded). Water purification was rated higher in teak plantations than in bamboo forests (rice paddies excluded).

For cultural services, landscape beauty was rated higher in teak plantations and bamboo forests than in rice paddies, with no significant difference between the former two. Cultural/religious values were rated higher in rice paddies than in bamboo forests (teak plantations excluded). Regarding habitat services, no significant difference was found between bamboo forests and rice paddies for habitat provision (teak plantations excluded). However, biodiversity was rated higher in bamboo forests than in rice paddies (teak plantations excluded).

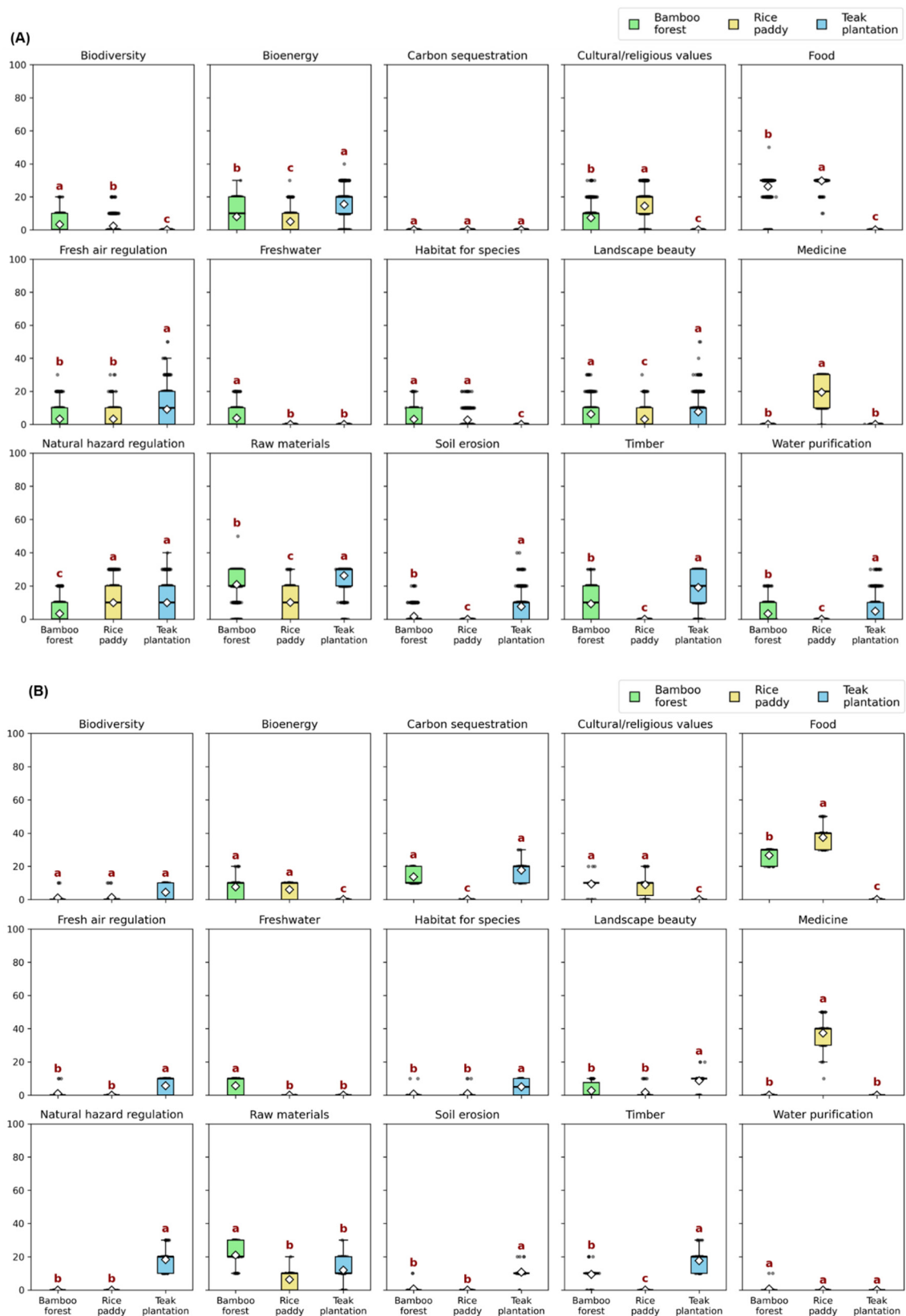


Figure 2. Perceived priority of ESs by stakeholder groups. This figure presents the perceived priority of ESs for the community sample (A) and the expert sample (B) across three land-use types. The box plots illustrate score distributions, with the box indicating the IQR and the central line showing the median. Different letters above the boxes denote statistically significant differences (Wilcoxon test with Bonferroni adjustment, $\alpha = 0.05$). Land-use types sharing a letter do not differ significantly. Summary statistics are available in Supplementary Table S5.

Compared with the community group, the expert group (Figure 2B) showed clearer differentiation in ES priorities across land-use types. For provisioning services, bioenergy did not differ between bamboo forests and rice paddies (teak plantations excluded). Food was prioritized higher in rice paddies than in bamboo forests, opposite the community pattern. Freshwater was rated higher in bamboo forests than in teak plantations, and medicine was rated higher in rice paddies than in bamboo forests (teak plantations excluded).

Among regulating services, carbon sequestration did not differ significantly between teak plantations and bamboo forests (rice paddies excluded). In contrast to the community group, natural hazard control was rated highest in teak plantations, while bamboo forests and rice paddies were similar. Soil erosion control was rated higher in teak plantations.

For cultural services, landscape value was rated highest in teak plantations, while bamboo forests and rice paddies were similar. Cultural/religious values were rated higher in bamboo forests and rice paddies than in teak plantations, with no significant difference found between the former two. Regarding habitat services, habitat provision differed between teak plantations and the other land-use types, with no difference between bamboo forests and rice paddies. Biodiversity did not differ among the three land-use types.

In summary, bamboo forests showed strengths in raw materials and freshwater; rice paddies in food and medicine; and teak plantations in bioenergy, timber, and several regulating functions. The expert group distinguished functional differences among land-use types more clearly than the community group.

3.2.2. Comparison Among Stakeholder Groups

This study compared ES priorities perceived by local community and expert groups across three land-use types—bamboo forest, rice paddy, and teak plantation. Using the Mann–Whitney U test, we focused on median differences between the groups to determine the statistical significance of their divergent perceptions. Detailed statistics, including group medians, U, p -values, and Cliff's δ values, are provided in Supplementary Table S6.

In bamboo forests, experts assigned higher priority to carbon sequestration and freshwater (medians: experts 10 vs. community 0; $p < 0.001$ and $p < 0.05$, respectively). For several other services—biodiversity, air and local climate regulation, habitat provision, landscape beauty (all $p < 0.05$), natural hazard control ($p < 0.001$), and water purification ($p < 0.001$)—the two groups shared the same median (0 or 10), yet differences were still significant due to distributional contrasts.

In rice paddies, experts assigned higher priority to food (40 vs. 30; $p < 0.001$) and medicinal resources (40 vs. 20; $p < 0.001$) than the community. Conversely, the community gave greater weight to cultural/religious values (20 vs. 10; $p < 0.001$) and natural hazard control (10 vs. 0; $p < 0.001$) than experts. For air and local climate regulation ($p < 0.001$) and raw materials ($p < 0.05$), the groups had identical medians yet still differed significantly—again reflecting distributional differences beyond the median.

In teak plantations, experts assigned higher priority to carbon sequestration (20 vs. 0; $p < 0.001$), habitat provision (5 vs. 0; $p < 0.001$), and natural hazard control (20 vs. 10; $p < 0.001$). By contrast, the community prioritized bioenergy (20 vs. 0; $p < 0.001$) and raw materials (30 vs. 10; $p < 0.001$) more than experts. For soil erosion control and water purification, both groups shared the same median (10 and 0, respectively), yet differences were significant ($p < 0.001$), indicating distributional contrasts.

Overall, the community tended to prioritize daily-life-related services (e.g., food, cultural/religious values, raw materials, bioenergy), whereas experts were more inclined to prioritize ecosystem-function services (e.g., carbon sequestration, habitat provision, natural hazard control). This pattern held across land-use types, with some service-specific exceptions.

4. Discussion

4.1. Similarities and Differences in ES Perception and Prioritization Among Land-Use Types and Stakeholders

This study indicates that perceptions and priorities regarding ESs in the rural landscape of Sangthong District, Laos vary systematically by stakeholder group and land-use type. A key finding is the consistent divergence in ES valuation between local communities and experts: local communities tend to prioritize tangible benefits directly linked to livelihoods, whereas experts emphasize functional and longer-term ecosystem values, including more intangible benefits.

The prevailing pattern is that community groups generally prioritize provisioning services tied to daily livelihoods—such as food, raw materials, and bioenergy—along with cultural services associated with cultural and religious values. For example, bamboo forests and rice paddies were widely perceived as important sources of food (community shares perceiving “high use” of 93.0–99.2%) and raw materials (88.6–93.2%). Similar patterns have been reported in rural areas with high dependence on natural resources: in the Hindu Kush Himalaya, a meta-analysis found that communities placed the highest value on provisioning services, followed by cultural, then regulating and supporting services [9]; in protected areas of Benin, provisioning services (e.g., crops, firewood) were recognized most, followed by cultural services [31]. Prior research in the same region also found that forests contributed to improved dietary quality among the poorest households [45], underscoring the livelihood importance of provisioning services.

Exceptions to this general trend exist. Institutional frameworks and restrictions on resource use can reshape community ES perceptions. For instance, in Northeast China’s Tiger and Leopard National Park—under strict protection—local residents prioritized ecological security services (regulating and habitat) above provisioning services, with cultural services ranked last [55]. This suggests that stringent regulatory policies and conservation objectives may, in some contexts, override traditional livelihood-based perceptions; thus, the patterns identified here may not be universally applicable.

A primary contribution of this study is providing empirical evidence that ES bundles are differentiated by land-use type even within a single region. Local communities prioritized raw materials in bamboo forests, food in rice paddies, and bioenergy and timber in teak plantations. Conversely, expert groups assigned greater importance to carbon sequestration and natural hazard regulation in teak plantations, while emphasizing food and raw materials more in bamboo forests. Rice paddies exhibited high food and medicinal functions, consistent with community perceptions. These findings suggest that the ecological functions and socio-economic uses associated with each land-use type interact to form distinct ES bundles, yielding divergent stakeholder perceptions. Accordingly, ES assessment and management should consider both land-use type and stakeholder group rather than adopting a uniform approach [56]. Importantly, forest management focused solely on single objectives, such as timber production, may induce trade-offs that diminish other important ESs [57,58].

The observed perception patterns appear to be shaped primarily by differences in education, exposure to environmental knowledge, and access to information. In this study, the expert panel largely comprised professors, government officials, and researchers based in Vientiane, who are likely more exposed to environmental education and policy discussions. This exposure may help explain the high prioritization of regulating services such as carbon sequestration and soil erosion prevention [59,60]. By contrast, local communities often showed limited awareness of regulating and supporting services, consistent with restricted access to formal information on ecological and biophysical processes [27,61]. Because these gaps are structurally shaped rather than incidental, there is a need for culturally sensitive,

context-appropriate environmental education that links abstract ecological concepts to local livelihoods and well-being [44].

Local community perceptions should not be framed simply as a “lack of knowledge,” but also through the lens of TEK grounded in experiential understanding. TEK comprises accumulated knowledge, practices, and beliefs specific to place, transmitted across generations [61,62]. This framework helps explain why communities in this study valued the food and medicinal functions of rice paddies and the raw-material and food values of bamboo forests—the empirically experienced utility of ES. TEK offers qualitative, holistic insights that complement the quantitative and shorter-term emphases of Western scientific approaches [63,64]. Excluding TEK from ES assessments may yield interpretations misaligned with local contexts [6].

Carbon sequestration illustrates perception differences and methodological implications. Experts assigned high importance to carbon sequestration in teak plantations and bamboo forests, whereas community shares perceiving “high use” were <50% (26.8–34.0%) in the perception survey, so this item was excluded from the secondary priority ranking. This pattern aligns with prior work showing that the intangible and long-term nature of carbon sequestration makes it harder for communities to link it intuitively to specific land uses [65,66]. Thus, it may be more appropriate to interpret that communities do not “fail to recognize” carbon sequestration, but rather perceive it as less important given its abstract nature. Future studies of a similar design might consider conditionally including globally significant yet locally less perceptible ESs (e.g., carbon sequestration, habitat provision) in the secondary priority step—even when primary perception shares are low—to reduce selection bias and produce more balanced outcomes.

4.2. Policy and Management Implications for the Promotion of Sustainable Land-Use

The heterogeneity in ES perceptions and priorities among stakeholders identified in this study poses both challenges and opportunities for sustainable land management and conservation policies. Particularly in rapidly urbanizing developing-country contexts, aligning ES supply and demand with heterogeneous social perceptions is a critical prerequisite for effective policy implementation [67–69]. In light of these challenges, our findings provide a clear foundation for evidence-based policy.

This section distills three policy and management implications that are directly anchored in our research questions and the corresponding findings: (i) addressing stakeholder perception and priority differences (RQ1–RQ2); (ii) optimizing land-use-specific ES portfolios at the landscape scale (RQ3); and (iii) bridging perception gaps through governance options that integrate TEK where supported by our data (RQ1–RQ2).

4.2.1. Addressing Perception and Priority Difference

Building on our results for RQ 1 and 2, this study identifies significant differences in perceptions and priorities regarding ESs across stakeholder groups. These disparities are not interpreted as discrepancies with biophysical ES supply, which was not quantified; rather, they reflect stakeholder-specific perceptions and priority patterns. In particular, the community group often shows limited awareness of less tangible regulating services (e.g., carbon sequestration), which are likely a consequence of limited exposure to underlying ecological processes. Such perceptual differences can pose considerable challenges for sustainable land management. For instance, if communities undervalue critical regulating services, they may adopt land-use practices that compromise these very services [38]. Conversely, overestimating the availability of certain services may lead to unsustainable resource use.

Policy and management should, therefore, actively address these perceptual disparities. Beyond the one-way dissemination of scientific information, communication strategies should be designed to translate abstract ecological benefits into tangible, livelihood-relevant terms [70]. For instance, the significance of carbon sequestration can be explained through locally salient co-benefits, such as climate regulation that enhances crop stability or reduces disaster risk. Ultimately, effective environmental policies should not rely solely on biophysical evaluations but must also incorporate social perceptions across diverse socioeconomic contexts [31,55,71–74]. Integrating these perspectives can foster mutual understanding and shared responsibility for ES management through collaborative governance frameworks [75,76].

While our empirical analysis focuses on stakeholder perception and priority differences within the study area (RQ1–RQ2), we also recognize that broader spatial imbalances between ES supply and demand present a key policy challenge. Urban areas, for example, generally exhibit high demand for ESs but have limited local supply, necessitating reliance on ESs from external regions [77]. This reliance increases interregional interdependence and introduces potential sustainability risks, underscoring the need for region-specific strategies that account for distinct supply–demand dynamics [78].

4.2.2. Optimization of ES Portfolios via Functional Specialization

Our within-group, across-land-use comparisons (RQ3; see Figure 2 and Supplementary Tables S5 and S6) reveal that each land-use type exhibits distinct ES strengths. Specifically, bamboo forests tend to provide raw materials and freshwater; rice paddies support food and medicinal production; and teak plantations are prominent in bioenergy, timber production, and regulating functions. Recognizing these functional specializations is crucial for optimizing the overall ES portfolio at the landscape scale [56,79,80].

Consequently, land-use policies should move beyond uniform strategies and encourage a landscape mosaic that leverages each type's comparative advantages. This approach aligns with the principles of integrated landscape management [13,81]. For example, preserving rice paddies to safeguard food security, conserving and expanding bamboo forests to sustain raw materials and freshwater, and strategically managing teak plantations for timber production and climate regulation exemplify this strategy. Such integrated approaches can enhance overall ES supply and improve landscape resilience. Accordingly, land-use planning should shift from single-resource management toward a multifunctional landscape perspective [82], including policies that foster diversification and complementarity of land uses through targeted incentive mechanisms.

4.2.3. Governance Options to Bridge Perception Gaps: Integrating TEK

Building on the perception and priority differences identified between communities and experts (RQ1–RQ2), a transition to sustainable land management may benefit from institutionalizing co-management or Participatory Forest Management (PFM). This approach empowers local communities with genuine decision-making authority and management responsibilities, moving beyond mere consultation (e.g., surveys and interviews). Empirical evidence from Asia and Africa indicates that PFM has been used to pursue conservation objectives alongside livelihood improvements [83,84]. For instance, Indonesia's Social Forestry program illustrates this model by expanding local forest access and rights, thereby supporting food security and income [85]. These cases collectively suggest that the equitable sharing of rights, responsibilities, and benefits can foster participation and that bottom-up governance mechanisms may help address limitations of top-down approaches [86,87].

The success of co-management appears more likely when local knowledge—particularly TEK—is integrated with a comprehensive understanding of ES. Translating community-valued provisioning and cultural services into policy, and re-contextualizing less visible regulating and habitat services (e.g., carbon sequestration) as tangible, everyday benefits (e.g., crop stability and disaster mitigation), may help reduce perception gaps [44,88–90]. Achieving this may require co-designed, culturally and linguistically appropriate education programs alongside deliberative platforms that facilitate collaborative learning among residents, experts, and administrators [91,92].

From a policy perspective, the pillars of effective co-management can include (i) legal recognition of local rights (access, use, and monitoring); (ii) capacity building across organizational, financial, and technical domains; and (iii) equitable benefit-sharing mechanisms that combine monetary and non-monetary incentives [93–95]. Moreover, institutionalizing learning–feedback–adjustment cycles through participatory monitoring and adaptive management can contribute to improved long-term conservation outcomes and greater social acceptance [96,97]. Multi-level participation (village, district, and national) and regular communication (e.g., seminars and field visits) can also help policymakers develop concrete, context-specific alternatives [98].

Co-management approaches grounded in local knowledge tend to promote concurrent conservation and livelihood outcomes [99,100], and increased participation is often observed when rights, responsibilities, and benefits are equitably shared [101]. Nevertheless, institutional constraints, capacity gaps, and uneven market access can yield heterogeneous outcomes [102]. Without improvements in ES literacy and effective benefit-sharing, expected impacts may remain limited [103]. Despite these challenges, integrated approaches help systematically incorporate stakeholder values into conservation planning [104].

5. Conclusions

This study demonstrates that perceptions and priorities regarding ESs differ systematically by stakeholder group and land-use type in Sangthong District. Local communities generally prioritized tangible provisioning and cultural services, while experts emphasized less visible regulating and habitat services. Our analysis also revealed distinct ES bundles for each land-use type—bamboo forest (raw materials and freshwater), rice paddy (food and medicinal resources), and teak plantation (timber and bioenergy). These findings underscore the limitations of a uniform management approach and highlight the potential for value conflicts among different stakeholders.

Ultimately, this study makes two key contributions. First, it provides a comparative analysis of ES perceptions and priorities across three coexisting land-use systems within a rural, developing-country context in Laos. Second, it offers methodological insight into the Step 1 $\geq 50\%$ perception threshold, specifically its implications for subsequent prioritization and interpretation.

Based on our findings, we recommend that policy and management shift toward optimizing landscape portfolios by leveraging each land-use type's comparative advantages. Co-management that integrates traditional ecological knowledge (TEK) can help move beyond top-down decision-making. Tailored ES-literacy programs and multi-stakeholder dialogue platforms are also needed to bridge perception gaps.

While our study has limitations, relying on a cross-sectional design and perception data without quantifying the biophysical supply, we propose a staged roadmap for future research. This roadmap links “actual ES supply $\rightarrow$ cognitive priorities $\rightarrow$ causes of deviation $\rightarrow$ policy,” aiming for a more integrated understanding of ES dynamics by combining social perception data with spatial modeling and empirically assessing governance interventions.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/f16101581/s1>, Figure S1: Survey instruments for ES perception and prioritization; Table S1: Ecosystem services across land-use types in Sangthong District, classified under the TEEB scheme; Table S2: Respondents' demographic profile; Table S3: QC exclusions: respondent-level records with total preference scores outside the tolerance (100 ± 1) or flagged as insincere/duplicate; Table S4: Friedman test results for within-group differences in ES priorities across land-use types, by stakeholder group; Table S5: Pairwise post hoc comparisons of ES priorities across land-use types (Wilcoxon signed-rank, Bonferroni-adjusted), by stakeholder group; Table S6: Mann–Whitney U results for community–expert differences in ES priority by land-use type; Figure S2: Schematic “ecosystem-service bundles” by land-use. Radial wedges show median Step 2 priority scores (0–100) for each ES, grouped by category.

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