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Perception and Prioritization of Ecosystem Services from Bamboo Forest in Lao PDR: Case Study of Sangthong District

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Abstract: Bamboo is a widely used natural resource, yet it cannot be managed sustainably without considering its social and environmental potentials. This study compared and evaluated the difference in demands and values of two stakeholder groups (local community and forestry experts) toward various ecosystem services for local bamboo forests and suggested interventions for decision-makers in Laos. This study selected six provisioning, five regulating, two cultural, and two habitat services and evaluated each group for its public perception of and priorities for bamboo forests using a 4-point Likert scale and 100 preference points. Both groups showed higher perceptions and priorities for provisioning and cultural services, which are helpful for sustaining livelihoods. The perceptions and priorities of the community group concerning regulating services (e.g., natural hazard regulation, water purification, and fresh air regulation) to improve crop production were higher than those of the expert group, but regarding the carbon sequestration, the expert group scored higher. Carbon sequestration, a public good provided on a large scale, could be perceived when there is a high level of understanding and interest in bamboo forests through environmental education. In habitat services, there was no significant difference between the groups. Experts should actively consider these differences in demands and public perception when making decisions about bamboo management to promote services that villagers have difficulty perceiving and draw intervention points accordingly in national policies for bamboo resources.

Keywords: bamboo forest; ecosystem service; Laos; community; public perception; prioritization

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1. Introduction

Bamboo is known as an important woody plant that provides a variety of social and environmental functions, such as carbon absorption, fuel, furniture material, food, and soil improvement in wasteland [1–3]. Its biomass and carbon storage capacity (100–400 ton/ha) is about twice that of fast-growing trees or tropical forests due to its rapid growth cycle (120–150 days) and high annual growth rate even after logging [4,5]. Bamboo is also recognized as a key natural resource that can respond to climate change [6–8].

Bamboo contributes to the maintenance of the livelihood of the poorer classes of people worldwide [6]. The Mekong River region, which covers Laos, Vietnam, and Cambodia, has the highest level of bamboo use [9,10]. Laos, a landlocked country in the center of the Mekong River region, in recent years has emerged as a strategic hub linking China, Vietnam, and Thailand in a new bamboo market. The transportation infrastructure in northern Laos has improved over the past few decades, and the demand for bamboo from neighboring countries, such as Vietnam, has also increased [11]. In Laos, bamboo is easily accessible, widely distributed for daily use for household items such as baskets and chopsticks, food (bamboo shoots), and handicrafts. The Lao government-designated bamboo as "Green Gold" [12] in a national policy to promote bamboo production, processing, and trade among small-scale independent farmers, to alleviate poverty and help Laos escape its status as a Least Developed Country (LDC) by 2024.

Bamboo is an important cash crop in the dry season for local communities of Laos, and most of it is exported to Vietnam as a raw material. However, most villagers harvest

large amounts of bamboo without permission, so the supply of bamboo on the market has rapidly increased. Consequently, Vietnamese bamboo companies are paying less for bamboo, which makes local villagers harvest and sell even larger amounts of bamboo for extra income. Accordingly, in 2016, the Lao government introduced a bamboo quota for the protection and sustainable use of bamboo, and the Ministry of Agriculture and Forestry determines the bamboo yield every year according to local demand. Bamboo is among 12-types of forest products [13] included in processed exports items, and the quota is exceeded every year. The Lao government temporarily suspended the quota system in 2020 as it sought additional measures to control the bamboo harvest [14]. Currently, bamboo use in Laos threatens the long-term livelihood of local villagers and is devastating the resource. To exploit bamboo resources sustainably, we need to recognize and promote the benefits and values of bamboo forests [15]. However, these environmental benefits have not been specifically identified, so in local communities, their importance is not properly understood [16]. In addition, the forestry experts, as well as local communities, are in charge of proposing the measurements to manage in a sustainable way the bamboo forest in the decision-making process. Therefore, analyzing public perceptions and priorities of the bamboo ecosystem service (ES) would need communication between both groups and understanding each other's priorities to improve management measurements. This process contributes to the recognition and understanding of the benefits of Laos's bamboo forests and prioritizes decision-making to support the management of these services.

This study aims to compare and evaluate the differences in demands and values of two stakeholder groups (local community and forestry experts) toward ES to suggest interventions for decision-makers so that bamboo resources can be managed rationally. Four categories of ES were identified based on the definition and classification system in *The Economics of Ecosystem and Biodiversity* (TEEB) [17]. In addition, applicable ES analysis tools were selected from prior research, and priorities were analyzed according to the public perceptions and preferences in the study area.

2. Materials and Methods

2.1. Study Area

The district of Sangthong, 60 km north of the capital, Vientiane, in the heart of Vientiane Capital Province, comprises 37 villages and is the region with the lowest income. The total land area is 75,980 ha, of which forests account for 55.8% (42,365 ha), farmland 33.7% (25,567 ha), wetland 5.6% (4238 ha), and others 5.0%. According to an interview with the Department of Forestry (DoF), the bamboo area in Sangthong in 2020 was estimated to be 20,565 ha, about 27% of the district [18] or 1.3% of the total area of Laos (1,612,000 ha). In 1990, bamboo covered 5365 ha [19], which shows that the bamboo area in Sangthong increased by more than 3.8 times in 20 years. However, it is difficult to estimate the area accurately because bamboo grows in different land-use types: deciduous and evergreen forests, settlements, and paddy fields. In Sangthong, forest fragmentation has deepened, and forest degradation has accelerated due to excessive commercial logging, poverty, shifting cultivation, livestock pressure, and forest fires [19]. Accordingly, the Lao government has designated the fragmented and degraded forest as a protected area for reforestation and restoration [19–21].

Among the 37 villages in the district, Nongboua, Nachalern, Tao Hai, Kuay, and Xor are in the northern part (Figure 1). As of 2020, there are 1106 households with a combined population of 5162: 2717 men (52.6%) and 2445 women (47.3%) (Supplementary Materials Table S1). More than 80% are engaged in self-sufficient rice farming, and various non-farm incomes are generated from shifting cultivation, grazing, collection of non-timber forest products, and construction work in the dry season (November to April).

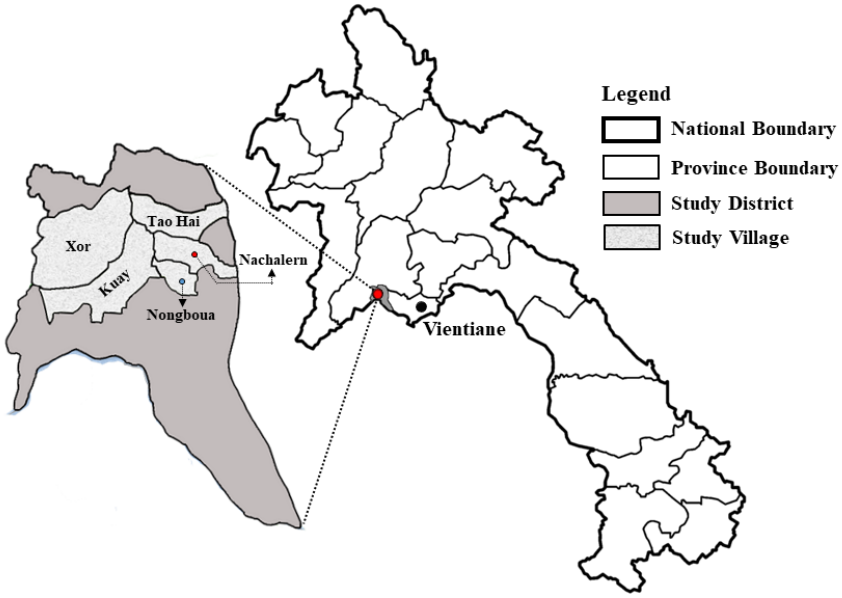

Figure 1. Study area.

The total land area is 16,647 ha, with farmland accounting for 48.7% (8109 ha), forests 42.2% (7021 ha), residential area 0.6% (104 ha), and other use 8.5% (1412 ha). Regarding farmland, shifting cultivation accounted for the highest share at 50.6% (4106.9 ha), and in mountainous areas, village-utilized forest (3480.6 ha) accounted for more than half at 49.6% (Supplementary Materials Table S2). The shifting cultivation is one of the main causes of accelerating forest degradation in Sangthong, and the forest is also targeted for use rather than protection. To solve this situation, the Lao government is promoting various projects for reforestation and restoration of forests. Therefore, human, physical, and social networks have been relatively well-established in the five villages compared to other villages in the district. These five villages have favorable conditions for promoting new income projects, such as proximity to the capital, ease of selection of tree species due to abundant forest resources, local tree nurseries, and continuous participation of local residents based on their experience in external support projects [22]. Thus, this study selected these five villages as study areas out of 37 villages in the district.

2.2. Sample Selection

The samples were selected separately from local community and forestry expert groups. The community group consisted of local villagers, village heads, and smallholder farmers, whose livelihood is directly connected to bamboo, and the expert group consisted of policymakers engaged in forest management, conservation, and protection. For the samples of the community group, the use of the bamboo forest was checked first. A total of 500 villagers and 30 experts, including public officials and university researchers engaged in forestry and environment, were finally selected. Each group was evenly distributed among men and women. The proportion of those in their 30s (27.4 and 33.3%) and 20s (26.4 and 53.3%) was high in both groups, but the community group showed a more diverse age distribution. The educational level in the expert group was 100% university or higher, while 40.8% in the community group were under high school, and 36.4% were below elementary school level. For occupation, 66.2% of the community group were engaged in agriculture and forestry, while most in the expert group (53.3%) were civil servants (Table 1).

Table 1. Demographic characteristics.

Classification		Group 1: Community		Group 2: Expert	
		(N = 500)	%	(N = 30)	%
Gender	Men	254	50.8	15	50.0
	Women	246	49.2	15	50.0
Age(year)	<20	20	4.0	0	0.0
	21–30	132	26.4	16	53.3
	31–40	137	27.4	10	33.3
	41–50	113	22.6	4	13.3
	51–60	67	13.4	0	0.0
	>60	31	6.2	0	0.0
Education	Illiterate	25	5.0	0	0.0
	Literate < elementary	182	36.4	0	0.0
	Higher	204	40.8	0	0.0
	Undergraduate	89	17.8	30	100.0
	Postgraduate	0	0.0	0	0.0
Occupation	Farmer	331	66.2	0	0.0
	Labor	30	6.0	0	0.0
	Business	41	8.2	0	0.0
	Employee	29	5.8	0	0.0
	Government	50	10	16	53.3
	Education	19	3.8	14	46.7

2.3. Data Collection

2.3.1. Framework for ES Assessment from Bamboo Forest

The bamboo forest provides various ES to local communities and can be classified in various ways according to its purpose of use and forest type. An integrated system is required for the effective planning and management of bamboo, but there is a lack of appropriate regional frameworks, methods, and evaluation tools [23–26]. Figure 2 proposes a common evaluation framework [27].

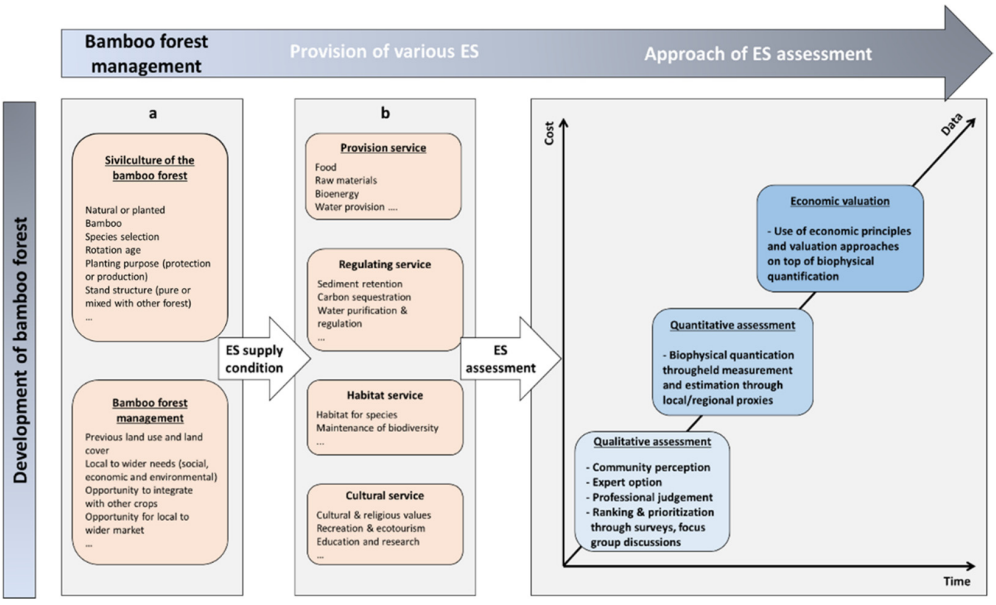

Figure 2. Framework for assessing ES from bamboo forests (after [27]).

It begins with an analysis of the silviculture and management that affect the bamboo forest health and the supply of ES (Figure 2 part a). At this step, the evaluator should define the scope, purpose, and process of the evaluation based on the type and management of the

bamboo forest and the selected stakeholders. To grasp supply conditions of the ES from the bamboo forest, we asked the DoF for the type and management status of the bamboo forest in the study area. Then, we surveyed relevant ES services through prior research. The bamboo forest in the Sangthong district was a secondary forest, using community-based forest, and the government carried out management for sustainable use. Thus, we selected the user and expert groups as stakeholders of the bamboo forest and identified that the bamboo forest in this area could provide 15 types of services on the ES list. Second, the ES of bamboo forests should be potentially selected using the four classification systems (provisioning, regulating, culture, and habitat services) of TEEB (Figure 2 part b) [17]. This study classified the 15 services of ES selected into four categories based on TEEB. Third, once the beneficiaries of ES are determined, appropriate approaches and tools should be selected according to cost, time, available data, and resources (Figure 2 third part). Finally, data on the provisioning of ES should be provided to them. Accordingly, the analysis tools for evaluating the ES were selected as shown below.

2.3.2. Approach of Assessing the ES: Assessment Tools for Bamboo Forest

When selecting assessment tools, it is important to consider the strengths of each tool and the required data, capabilities, time, and cost. Among these, a qualitative assessment was also recently discussed [28], but in regional surveys of data-poor developing countries, non-economic approaches that analyze socio-cultural values are mainly used [25]. In particular, the ES perception and preference survey can help understand who the beneficiaries are and how to respond to them from the perspective of human values, attitudes, and beliefs [29].

In other words, considering the beneficiaries as the focus of an evaluation can provide a way to discover how people perceive the differences in the value of the ES [30,31]. Furthermore, identifying views, interests, and beliefs can lead to a better understanding of the relationship between humans and nature and determine points of possible intervention to resolve conflicts [32,33]. Therefore, this study focused on the different beneficiaries of the bamboo ES in Sangthong and selected a stakeholder analysis among the qualitative assessment methods to discover the difference in value (priority) perception to prepare responses.

2.3.3. Public Perception Survey of Bamboo Forest ES

Before conducting the public perception survey, it was important to select interviewers who majored in ES or had enough relevant experience, to help the villagers understand the terminology related to ES [34]. This study selected three ES experts as interviewers with the cooperation of the DoF (Supplementary Materials Table S3). Prior to the survey, the interviewers conducted pre-education for the residents of the five villages on the terminology and general knowledge of ES.

After the pre-education, the interviewers conducted a public perception survey on various services provided by bamboo forests on the targeted groups (community group and expert group). Based on Supplementary Materials Table S4, the survey respondents were asked to answer on a four-point scale of the "current use" of ES from bamboo forests [35]. A score of 1 indicates "no use", 2 indicates "little use", 3 indicates "moderate use", and 4 indicates "high use". The interview was conducted for about 3 weeks. If more than 50% of the respondents selected 3 and 4 on the ES category, which was considered positive responses, the item was regarded as an important bamboo ES for the study area. If more than 50% of the respondents selected 1 and 2, the item was regarded to have a low level of recognition and excluded from the final list for the ES priority survey.

2.3.4. Priority Survey of Bamboo Forest ES

Major ES with a high level of use were identified through a public perception survey, and their priority was accessed over 3 weeks in December 2020 based on the same respondents. The method of the priority survey included ranking [26] or scoring [34] in order

of importance for each of the selected ES. In this study, a scoring method was used for statistical analysis of the differences in the perceived priorities.

The interviewers asked the two groups about the importance of the ES and distributed 100 preference points for items that the interviewees answered in units of 10 points (Supplementary Materials Figure S1). To prevent the respondents from focusing on a specific service only, the interviewers presented 15 services of bamboo ES and selected more than 10 services that were considered important to the respondents. Then, respondents distributed a total of 100 points to the items. At this time, interviewers informed respondents that it was not necessary to give 100 points for all services. In order to analyze the statistically significant differences in the priority of ES between the groups, this study used the non-parametric Mann–Whitney U test at a significance level of 0.05 [36].

3. Results

3.1. Perception of ES from Bamboo Forst

The community and expert groups showed a positive response in 13 out of 15 ES (Figure 3 and Supplementary Materials Tables S5 and S6). Except for medicine of the provisioning services, both groups showed mostly positive perceptions (Figure 3a). For the regulating services, the community and expert groups were differently perceived. The perception of carbon sequestration was the lowest in the community, while the expert group showed the lowest perception of natural hazard regulation (Figure 3b). For the cultural and habitat services, two stakeholders were at a similar level of perception (Figure 3c,d).

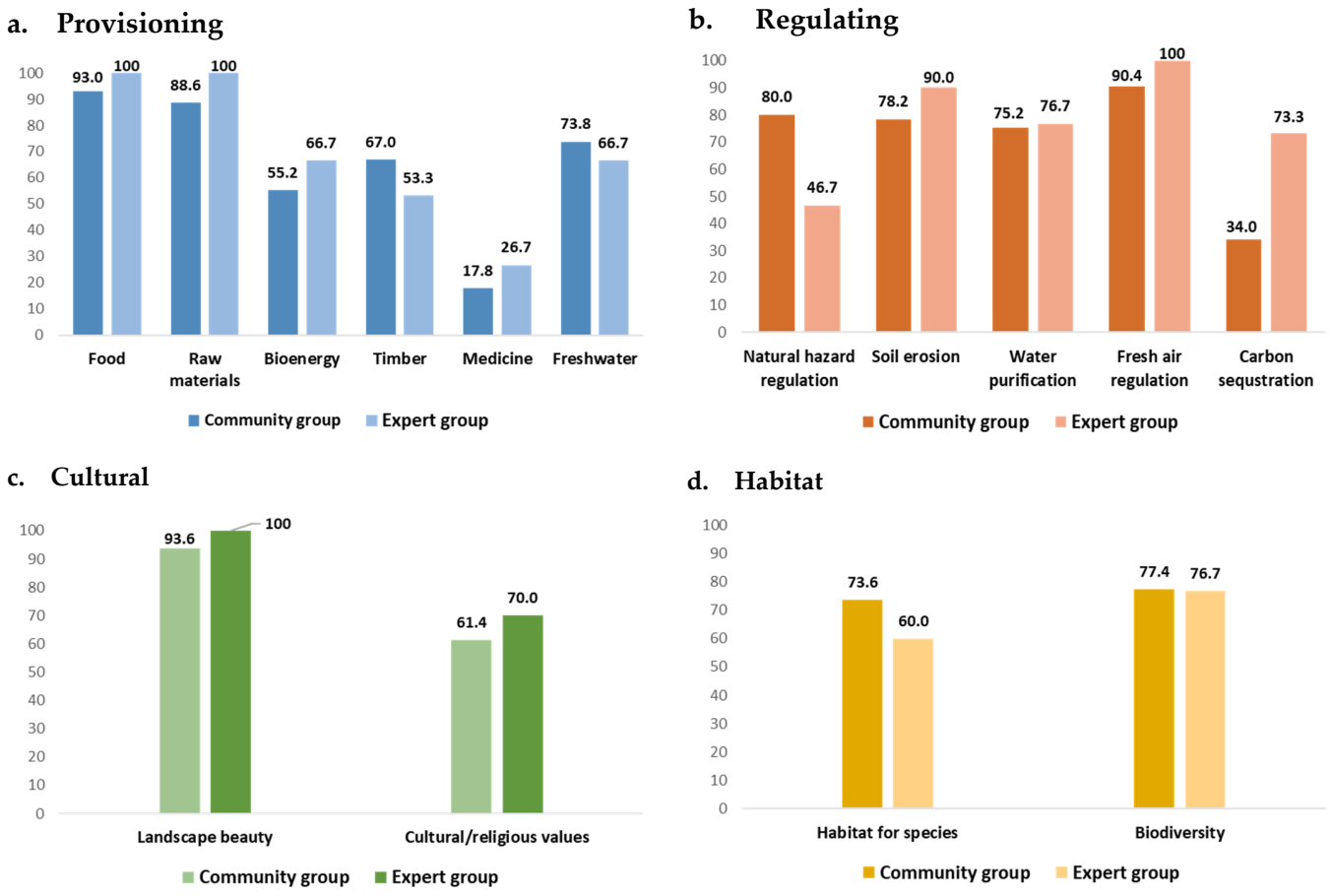

Figure 3. Stakeholder groups' public perception results of ES from bamboo forests. (**a**) Provision services (**b**) Regulating services (**c**) Cultural services (**d**) Habitat services.

3.2. Prioritization of ES from Bamboo Forests

Most of the scores were concentrated on the top 1 and 2 priorities, and fewer than 5 points were scored in the top 6 or lower (Figure 4). For the priorities of the ES, food provision ranked the highest with an average of 26.3 points for the community and 26.7 points for the expert group, followed by raw materials with 20.8 points for the community and 21.0 points for the expert group.

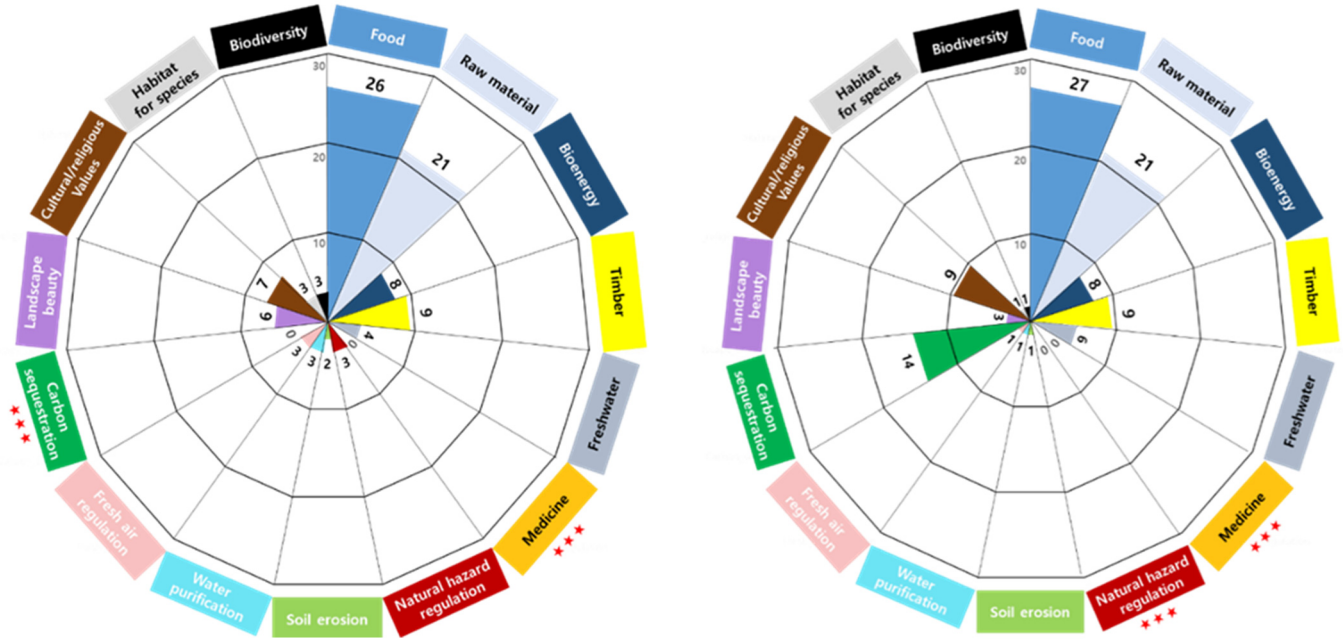

Figure 4. Preferences of communities (**left**) and experts (**right**) based on 100-point scale. "★★★" indicates ES divisions of bamboo forest excluded from the perception survey.

Carbon sequestration was a service excluded from the first public perception survey for the community group, but the expert group gave it the third highest score (13.7 points). Instead, the third priority of the community group was timber at 9.2 points (Table 2). In the top 6 ES, both groups focused on provisioning and cultural services. However, in the expert group, carbon sequestration ranked third, a more important service than timber and cultural/religious value.

Table 2. Ranking of ES top 6 by stakeholders based on 100 preference points.

Classification	ES Ranking by Average Scores					
	Top 1	**Top 2**	**Top 3**	**Top 4**	**Top 5**	**Top 6**
Community	Food (P1)	Raw material (P)	Timber (P)	Bioenergy (P)	Cultural/ religious value (C2)	Landscape beauty (C)
Mean	26.3	20.8	9.2	8.1	7.4	6.2
Expert	Food (P)	Raw mater al (P)	Carbon sequestration (R3)	Timber (P) and Cultural/religious value (C)		Bioenergy (P)
Mean	26.7	21.0	13.7	9.3		7.7

"P" indicates provision service. "C" indicates cultural service. "R" indicates regulating service.

The community group considered the raw material service more important, but the score for freshwater was higher in the expert group (M–W test, $p < 0.05$) (Figure 5a and Supplementary Material Table S7). The remainder—food, bioenergy, and timber

services—were also in the top 6 priorities. For the regulating services (Figure 5b), there were significant differences between natural hazard regulation, water purification, fresh air regulation, and carbon sequestration ($p < 0.05$). The three regulating services (natural hazard regulation, water purification, and fresh air regulation) were considered more important by the community group. However, carbon sequestration was considered more important by the expert group as in the results of public perception and priority surveys. Additionally, there were no significant differences between groups in cultural services and habitat services (Figure 5c,d).

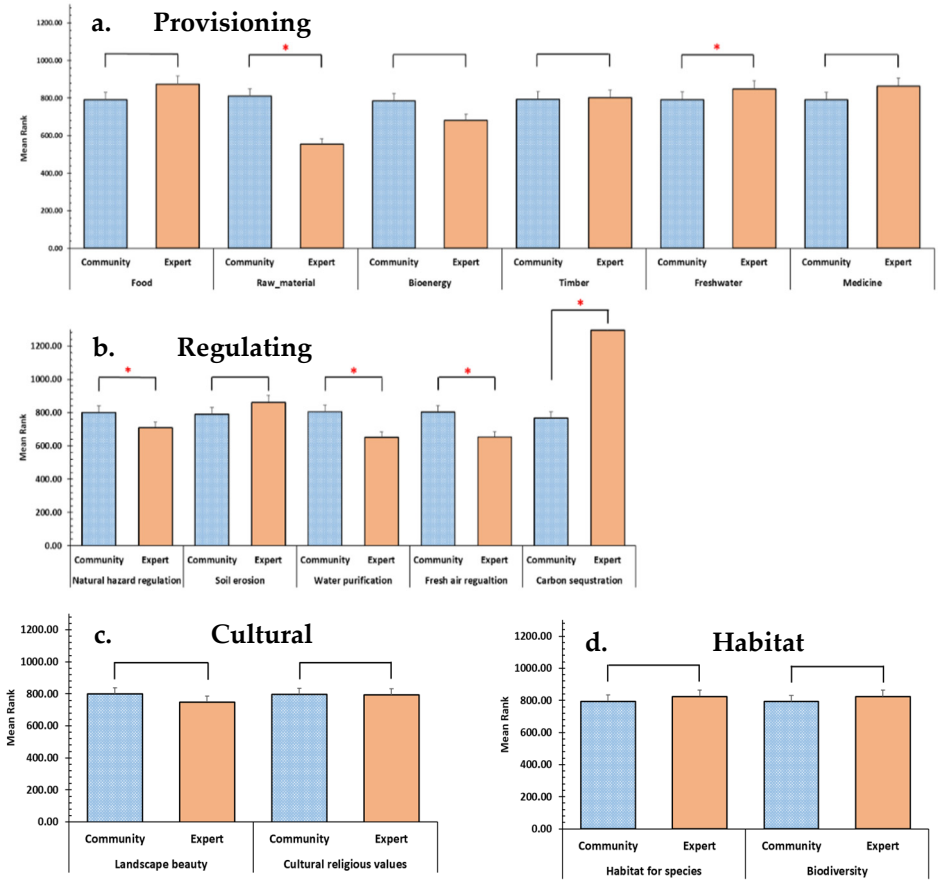

Figure 5. Difference among the community and forestry expert groups in the prioritization of bamboo ES after M–W test. Significant differences are shown by * ($p < 0.05$). Means rank and standard error are shown (n community = 500; n forestry expert = 30). (**a**) Provisioning services (**b**) Regulating services (**c**) Cultural services (**d**) Habitat services.

4. Discussion

This study explored the social demands and values of ES from a local bamboo forest and analyzed differences in the public perception and prioritization of stakeholder groups (local communities and forestry experts). In both groups, the top six of bamboo ES consisted of obtaining materials directly and aesthetic function. Among the four categories of ES, the priorities of the provisioning and cultural services were high, matching similar results in the research trend on the ES assessment of Southeast Asia [16]. Physical provisioning (water, timber, raw materials, and cultural/religious facilities) were important services in both groups because they can be directly felt by local residents and help sustain livelihoods [37]. The community group showed higher values for raw materials because the community group uses local bamboo resources for a variety of activities, and therefore they place more importance on the raw material function of bamboo. On the other hand, bamboo helps supply fresh water and protect water sources, so the expert group showed a strong desire to

conserve the bamboo forest because it considers the freshwater service more important. For the cultural services, Tribot et al. [38] reported that the landscape value as a cultural service contributed to human welfare, which was also confirmed in this study. However, the cultural services showed no significant difference. A key point here is that in both groups, not only the physical goods but also the conceptual functions of the bamboo ES were highly prioritized. Cultural services are an important factor that provides psychological satisfaction and happiness to local culture and rural life. The cultural background was the main force in determining the importance of cultural services in the region; thus, experts considered that it has an effect on happiness and satisfaction for local residents and policymakers [25,34,39].

In the regulating services, the carbon sequestration showed a significant difference. The expert group considered it to be a very important service, but the community group did not. For this reason, it had a higher understanding of climate change and carbon sequestration. However, water and climate-related services (natural hazard regulation, water purification, and fresh air regulation) were high priority regulating services in the community group because these are necessary for improving crop production. A similar finding was reported in Nigerian villages [40], where the public perception and prioritization level of indirect regulating and support services (together with habitat services) was generally low, but perception and prioritization of air quality and natural disaster regulating services were relatively high. This study found that carbon sequestration is a public good provided by bamboo forests and is a service provided on a large scale, such as a landscape or watershed. Thus, it may be difficult for villagers to perceive this service. However, the other services (natural hazard regulation, water purification, and fresh air regulation) were on the scale of a field or farm, so they are perceived more easily. However, this also means that the expert group had difficulty perceiving the above three regulating services as a priority. Therefore, the differences in prioritization of both groups in the category of these regulating services should give them importance in the decision-making process, as they are significant ES for the community that values the bamboo forest. Accordingly, the community should recognize the importance of carbon sequestration information, but also, the forestry experts should focus more on natural hazard regulation, water purification, and fresh air when making decisions. In the habitat services, there was no statistically significant difference between the groups. Generally, these services support provisioning, regulating, and cultural services, and it occurs indirectly over the long term due to human influence [41]. For this reason, it is difficult for most people to perceive habitat service ES [42]. Thus, this study suggests that, through environmental programs or education, it needs to be strengthened more than other services [43].

The difference in priorities between the two groups might have been due to their background, interest, experience, and education levels [35]. Because regulating and habitat services are invisible and indirect, environmental education has a great impact on promoting their benefits [34,39,44]. In this study, both groups need to increase the public perception of the ES of bamboo forests through environmental education and training, taking into account the values, concerns, and needs of the community (such as fresh air, water purification, or natural hazards). First, the community group needs to enhance the public perception of regulating and habitat services by focusing on provisioning and cultural services. The regulating services can produce synergistic effects by improving both material and non-material productions (e.g., bamboo shoot production and soil erosion prevention/water purification/biomass production/carbon sequestration, raw materials and wood production and conservation through bamboo reforestation). The habitat services will be able to provide biodiversity and habitat by creating various NTFP (Non-Timber Forest Product)-growing environments in bamboo forests. For example, "hak tin hag (*Helminthostachys* spp.)", a fern that grows only in bamboo forests, can be used as a commercial or a major export product. In addition, "het puak (*Termitomycetes* sp., *Agaricus integer Loureiro*)", a mushroom species that grows only in termite mounds in bamboo forests, can improve both provisioning and habitat services in an economic context. Next, the

expert group needs to enhance indirect service to improve the welfare and livelihood of the local community. Especially, the forestry experts should consider it essential in the decision-making process and provide it so that the community can understand carbon sequestration in the long term, including other regulating services (fresh air, water purification, etc.). Government support should also be provided to expand community-based bamboo forests and to clarify their ownership and the community's authority for resource management. In addition, the national policy mechanism should be used for bamboo resources. If the importance and public perception of bamboo resources are enhanced, it would have a positive effect on individual attitudes and behaviors as well as on policy change [45]. The process of identifying ES at the regional level is useful not only for capturing the various benefits of material and non-material services but also for managing the forest landscape and resources on an integrated national scale.

This research has some limitations. First, we did not present the effectiveness of improving bamboo ES perception by environmental education of community groups. In prior research on stakeholder groups interested in forest development and ES perception, the groups who were younger with a higher level of environmental knowledge had a higher correlation with a preference for natural forest scenery and worked to protect it [46–49]. The community groups in the study area are younger, but the level of education is low compared with the expert group. According to Boualaphet et al. (2020), the net enrollment rate of elementary schools in rural areas of Laos was 93% in 2017, but the net enrollment rate and final complication of secondary education are still low due to maintenance of livelihood and poverty [50]. For this reason, the secondary education level of community groups in the study area is only 17.8%. Thus, future research on the public perception levels affected by environmental education needs to test two separate groups, especially local villagers. One group should be surveyed after the additional educational activities, but the second group should not be surveyed at that time. Second, for this study to be used effectively in decision-making, there will have to be a process for collecting and analyzing data for quantitative evaluation and economic valuation. To this end, it is necessary to first take into account the regulating services, carbon sequestration, and natural hazard regulation, which have a large difference in perception and preference between the two groups. Third, the number of stakeholders is very different in the two groups (500 vs. 30), so the results of this study might show bias. Therefore, future research should supplement the number of those in the expert group.

5. Conclusions

The eco–socio–cultural values of the bamboo forests perceived by the local community and forestry experts in the Sangthong district were analyzed using a stakeholder analysis method, a non-economic approach. This study provided the Lao government with decision-making data so that local bamboo resources could be effectively used and managed. This study also found the necessity of education to strengthen non-material perceptions of the environmental benefits of bamboo forests in the local community and to promote the active use of bamboo in the national policy mechanism and also the inclusion of community interests on ES in environmental policies.

The two groups had different public perceptions of the importance of bamboo ES, especially regulating services. The community group had a higher level of public perception of natural disasters, water regulation, and climate services, which were highly related to crop production and local livelihoods. On the other hand, they did not have a strong perception of carbon sequestration. This is a large-scale public good that bamboo forests provide, but it is difficult to perceive unless people have a high understanding of it. This is why the expert group, with its higher environmental training experience, interest, and education, showed a strong perception. Therefore, the sustainable use of bamboo forests in Laos requires an improved perception of its material benefits as well as invisible and indirect services. In particular, forestry experts need to take into account regulating services for the livelihood of the community and their value on the bamboo forest in the decision-

making process. In this way, it could be that the community uses the forest in a more sustainable way and that their relationship of trust in the institutions will be as strong as their needs and values. In addition, the analysis of group results could be used in decision-making and have a positive effect on policy change. Identifying the needs of a local community can also provide useful information for intervention points for forest policymakers, local communities in Laos, and even other developing countries.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su132313060/s1: Figure S1: The questionnaire form of 100 preference points for priority survey; Table S1: Population of villages, Sangthong district in 2020; Table S2: Land use of 5 villages in 2020; Table S3: Interviewer information; Table S4: List of ES from bamboo forest identified in Sangthong district. Ecosystem services based on TEEB categories; Table S5: Community (n = 500) public perception result of ES from bamboo forest; Table S6: Expert (n = 30) public perception result of ES from bamboo forest; Table S7: Mann–Whitney test result of prioritizing bamboo ES for stakeholder groups.

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Data Availability Statement: The data presented in this study are available on request from the first and corresponding author. The data are not publicly available due to personal information protection.

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