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Edible Biological Resource Use in an Agricultural Heritage System and Its Driving Forces: A Case of the Shuangjiang Mengku Ancient Tea and Culture System

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Abstract: An agricultural heritage system is a special type of protected area that is both culturally and ecologically important. Biological resources are an essential component of an agricultural heritage system. They are necessary to support human livelihood, and their usage is key to ensuring biodiversity. This study used a survey questionnaire and key informant interviews to investigate the use of edible biological resources (EBRs) in the Shuangjiang Mengku ancient tea and culture system (SMATCS). We investigated similarities and differences in EBR use between four minority groups as well as the driving forces behind them. The four groups used 245 EBR species in 113 families, and diversity of EBR use was found in terms of species, edible parts, harvest season, and usage. EBR use within groups was driven by natural, cultural, social, and economic forces. Two social factors (infrastructure and communication), two economic factors (overall economic development and farmer income), and a biological resource (species diversity) drove EBR utilization in all the groups convergently, while three cultural factors drove EBR utilization divergently. To assure the long-term sustainability of EBRs, the preservation of cultural diversity should be combined with the conservation of biodiversity. Targets must be set to adjust the impacts of the driving factors, and more stakeholders must be involved in the conservation of EBRs.

Keywords: agricultural heritage systems; edible biological resources (EBRs); resource conservation area; resources use; driving forces; Shuangjiang Mengku ancient tea and culture system (SMATCS); China–NIAHS

1. Introduction

Biological resources are organisms that have direct, indirect, or potential economic and scientific value to human beings. They are an important natural resource [1]. Biological resources are consumed as food [2–5], medicine [6–9], and fuel [10,11], and, in many other ways [12–15], support human livelihoods [16,17]. Biological resources affect the natural environment [1,2,13]. Agricultural heritage is a newly recognized form of heritage. Agriculture has developed from ancient agricultural practices to form coordinated and sustainable systems full of natural, cultural, social, and economic values [18], including the FAO globally important agricultural heritage systems such as the Hani rice terraces in China, the Engaresero Maasai pastoralist heritage area in Tanzania, and Kunisaki Peninsula Usa integrated forestry, agriculture, and fisheries system in Japan.

Biological resources are important in agricultural heritage systems because they are the bases of rural livelihoods. Research into different heritage systems has shown that the protection and sustainable use of biological resources contribute to the multifunctionality of an agricultural heritage system [18,19]. For example, research into maintaining biodiversity has found that some unique varieties of plant species have good resistance to disease [20–22] and can maintain a high yield with little external input such as pesticides or herbicides [19]. Local traditional knowledge has been accumulated and culturally transmitted through generations and is seen in current practices [23,24]. One of the most important and necessary ways of maintaining the multifunctionality of an agricultural heritage system and conserving the system is to protect the biological resources within it [25] and ensure that residents act towards sustainability.

The primary consumption of biological resources occurs when wild or cultivated biological resources, such as staple foods, vegetables, or spices, are eaten [26]. Such resources, when collected as food from the natural environment, are referred to as edible biological resources (EBRs). The use of EBRs is responsible for a large proportion of the total consumption of biological resources in an area, and it affects the domestication [27,28], distribution [27,29], and variety of species in the local environment, thus affecting local biodiversity and local ecosystems [28,30,31]. Sustainable use of EBRs eases the destructive pressure on ecosystem biodiversity and supports human life by conserving natural resources in agricultural heritage systems. The diversity of EBR usage is due to differences in culture and differences in traditional knowledge between minority groups [24], but conserving EBRs is critical to maintaining both ecosystem biodiversity and cultural diversity. In efforts to increase EBR conservation, researchers around the world have identified different types of EBRs [32,33], the intensity of EBR utilization [28,34], and human behavior surrounding EBR use and have gathered other related information [35,36]. Research has revealed the pressure on local biodiversity from the consumption behavior of local inhabitants [34] as researchers try to understand the driving forces of EBR consumption [20,37–39].

The driving forces of EBR consumption have both positive and negative effects on EBR use, and the forces themselves vary in force. Thus, sustainable use of EBRs can be guaranteed by taking measures that have the desired effects on the driving forces. However, understanding of the driving forces that determine the utilization of biological resources in agricultural heritage systems is inadequate for the creation of targeted conservation policies that motivate human behavior. Several factors that influence behavior around EBR utilization have been identified, including geographical location [19,40], policy [41], tourism [42], and culture [19,20]. An important aspect of traditional culture is the behavior surrounding EBR use [37,38], which illustrates how culture can influence behavior [19,20]. Policy and tourism affect traditional cultures in agricultural heritage systems [41,42] and thus influence EBR use. However, most of the literature devotes no more than a few sentences to EBRs and the factors that influence them [19,40–42], and there has been little research into the driving forces of EBRs in agricultural heritage systems. Much of the existing research focuses on the investigation [32,35] and cataloging [33,34] of EBRs, but an agricultural heritage system is biophysically, socially, and culturally unique, so individual case studies become important in researching conservation practices.

The Shuangjiang Mengku ancient tea and culture system (SMATCS) is a unique Chinese nationally important agricultural heritage system (China–NIAHS) that has maintained ecological integrity and contributed significantly to the conservation of regional and national biodiversity [40]. It is abundant in traditional knowledge that has been preserved, which is practiced in the daily lives of system inhabitants as they manage the resources. The small body of existing research into SMATCS, which is in an area inhabited by ethnic minorities, has been mainly concerned with ethnology [43,44], sociology [45], petrology [46,47], and other fields [48,49]. EBR research has investigated tissue composition and tissue culture of single species [50,51]. Previous research into wild edible plants in SMATCS found that although the dietary practices of different minority groups in the region influenced each other, they developed and were inherited independently and differ from those of the same minority groups in other regions [37,38,40]. There has been little research into the diversity of regional biological resources or EBRs and the forces that drive them. Research of EBR use in SMATCS will provide a basic reference for the conservation of biological resources in the heritage system and identify the adverse pressures on SMATCS so that EBRs in the system can be managed sustainably.

Our study aims to reveal the EBR consumption pattern and the driving forces in SMATCS. Additionally, it aims to answer three main questions of what the similarities and differences in EBR use between the four different minority groups are, what the driving forces for these similarities and differences are, and how we can conserve the agricultural heritage systems as well as their biological resources. Therefore, our goals in this study are (1) to show EBR consumption patterns in SMATCS and identify the forces that drive them; (2) to identify the similarities and differences in EBR use between the four different minority groups and what drives them; (3) to recommend how to conserve the agricultural heritage system and its biological resources. We gathered data using a survey questionnaire and key informant interviews to determine EBR usage by the four minority groups.

2. Materials and Methods

2.1. Study Area

The Shuangjiang Mengku ancient tea and culture system (SMATCS) is located in the mountainous area of western Yunnan Province, China. Shuangjiang County is the major distribution center of the area (Figure 1). Three factors influenced our decision to investigate the use of biological resources in this system. The area is rich in biodiversity; Shuangjiang County (99°35′15′′–100°09′30′′ E, 23°11′58′′–23°48′50′′ N) is located in one of the 34 biodiversity hotspots of the world. SMATCS also has great cultural diversity; Shuangjiang is the only county in China inhabited by four minority groups that practice their traditional lifestyles, which are reflected in culture, resource utilization, and traditional knowledge and are well preserved. SMATCS, which was designated as China–NIAHS in 2015 due to its unique ecology, has to conserve its environment and its culture by controlling the use of biological resources because its inhabitants are greatly dependent on the natural ecosystems in this ecologically fragile area.

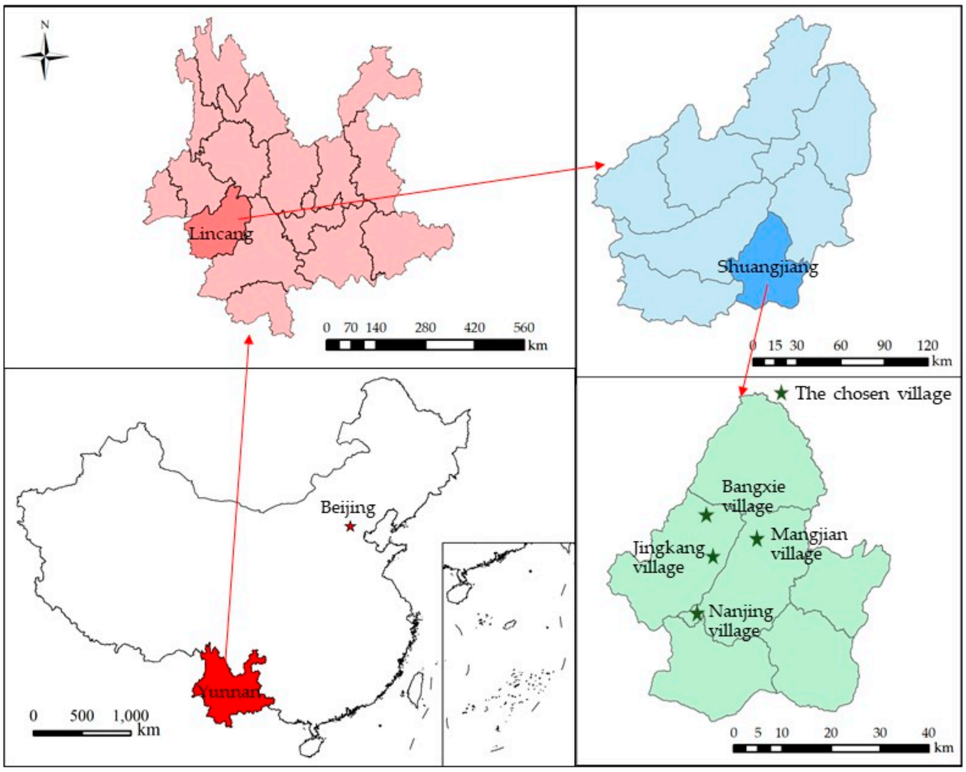

Figure 1. The location of the study area and the villages selected for edible biological resource (EBR) investigations.

Four villages in Shuangjiang County were selected for investigation: Mangjian, Nanjing, Bangxie, and Jingkang (Figure 1). Table 1 shows that each village has a different ethnic majority population and that there are differences in religion and cuisine between the villages.

Table 1. Natural, social, and cultural features of Shuangjiang County.

Village	Mangjian	Nanjing	Bangxie	Jingkang
Minority group	Lahu	Wa	Bulang	Dai
Proportion of the minority in the village	99.2%	100%	98.66%	97.1%
Religions	Primitive religion	Primitive religion and Buddhism	Buddhism	Buddhism
Eating preference	Spicy food, boiled food, and grilled food	Boiled food and white spirit	Spicy and sour food, and tea	Spicy and sour food, and white spirit
Altitude (meters)	1300	1400	1500	1050
Climate	South subtropical warm and humid monsoon climate			

2.2. Methodology

We used qualitative research (QR) methods tailored for and adapted to ethnobotany research. QR methods can illuminate the reasons behind observed behavior, which is important as we strive to promote behavioral change in edible resource use. In November 2014 and January 2015, we used a survey questionnaire and key informant interviews, which are the most commonly used ethnobotanical survey instruments [52,53], in each of the four natural villages to investigate EBRs and their related use. Additionally, we used theoretical sampling to select interviewees and determine the sample size of each of the four natural villages (it is a commonly used sampling method based on grounded theory) [54]. Furthermore, there are two conditions for judging the theoretical saturation of the information in theoretical sampling. One is that the possibility of information emergence is very low when continuing the investigation, and the other is that the information obtained is sufficient to carry out analysis and research around the research topic [54,55]. Therefore, we did not preset the sample size at first in the information collection process, but following the expectation of the data's theoretical saturation, we selected the first interviewee with the help of relevant staff. This interviewee was supposed to have abundant information on the use of EBRs. After that, based on the analysis of collected information, we selected the second interviewee, who was expected to provide us with different or more information than the first interviewee. We repeated the selection–interview–analysis procedure until we found that little new information appeared after no more than seven rounds of information collected from interviewees from the four villages. Meanwhile, the collected information was enough for our research. This situation is in line with the requirement of theoretical saturation of data in theoretical sampling. Thus, we set the sample size to 10 to ensure information saturation. The EBRs were divided into edible plants (crops, vegetables, fruits, wild vegetables, nuts, seasonings, and tea), edible animals (poultry, livestock, aquatic foods, and insects), and edible fungi. The driving forces of direct consumption by the inhabitants were identified from the literature and discussion with workers from local government agriculture departments and ethnological researchers.

A list of biological resources, derived from a literature review [56–59], was provided to interviewees to select from and supplement, if necessary, before administering the survey questionnaire. The questionnaire was divided into two parts. The first part asked for demographic information such as householders' age, gender, education level, the total number of family members, and household per capita annual income. The second part contained questions about EBR species that the respondent's family consumed and their use, including names of species, whether they were traditional varieties, names in the minority language or vernacular, edible parts, cooking methods, and other information regarding their usage. Edible plants were divided into different plant organs, and edible animal parts were divided according to the life history stage of the animal. Other information, such as the location where EBRs were gathered, usage other than direct consumption, and the most favored species of each type, was requested to provide data for eating preferences.

After the survey questionnaires were administered, semistructured interviews were conducted with elderly village inhabitants as key informants. The elderly have been less influenced by the outside world and had lived in a traditional way for a longer time than younger inhabitants. Open-ended questions were asked during the interviews. The intention of the questions was to gather data on the driving forces of resource utilization, the driving forces of direct consumption, and actions directed towards EBR conservation as well as indicators of the use of traditional knowledge related to the use of EBRs in nondaily activities. Data indicating driving forces of other EBR uses were also recorded. The two-step inductive method was used to identify the driving forces of EBR utilization, following [60]. The first step was to form a master list of the driving factors of different EBR uses for the minority groups in the study area, derived from relevant literature [18,20,37,39,61] and the data obtained from the key informant interviews. The second step was to determine the relationships between EBR uses and items on the list. When the relations had been established, they were discussed with the staff of the local agricultural departments and ethnologists. The driving factors and the causal relations were validated by information held by the agriculture departments and their staff, the experience and knowledge of experts, and research results in similar areas. Finally, the driving factors and the ways in which they impacted EBR use were further adjusted.

3. Results

3.1. Demographic Features of Surveyed Households

The survey data showed that the main householder was usually a male with six or more years of education. The average age of the householders was 52.2 years, and more than 60% of householders were older than 50. Thus, they had a relatively high level of knowledge of the traditional ways of life in their community. The average household annual per capita income was 8600 Yuan, ranging from 1400 to 30,000 Yuan. Seventy-five percent of households had an average annual per capita income of no more than 10,000 Yuan, which was lower than the average annual per capita income of rural households in China (10,489 Yuan in 2014, 11,422 Yuan in 2015) when the research was conducted [62]. The households were dependent on natural ecosystems; 75% of the households surveyed were mainly engaged in agriculture. The average number of migrant workers (workers who go out of the village to work) in each household was 0.7, and 62.5% of the households had no family members working outside of the village (Table 2).

Table 2. The demographic features of the surveyed households.

Variable	Average Value/Percentage
Total number of family members (person)	5.3
Male householder	67.5%
Female householder	32.5%
Average age of the householder (year)	52.2
Householder age (≤40)	20%
Householder age (40~50)	20%
Householder age (50~60)	42.5%
Householder age (60~70)	15%
Householder age (70~80)	2.5%
Household average annual per capita income (≤5000 Yuan)	32.5%
Household average annual per capita income (5000~10,000 Yuan)	42.5%
Household average annual per capita income (10000~15,000 Yuan)	17.5%
Household average annual per capita income (>15,000 Yuan)	7.5%
Education level of householder (primary school)	75%
Education level of householder (junior high school)	22.5%
Education level of householder (high school)	2.5%
Average number of migrant workers per household	0.7

3.2. Diversity of EBRs in SMATCS

3.2.1. Species diversity

In total, 245 species in 113 families were identified as EBRs. The Lahu people consumed 186 species, Wa 198, Bulang 162, and Dai 198 (Table 3, Figure 2).

Table 3. EBR species consumption by the various minority groups.

Types		Number			
		Lahu	Wa	Bulang	Dai
Total species	Plants	131	117	116	140
	Animals	36	59	27	39
	Fungi	19	22	19	19
Traditional varieties	Plants	74	63	59	78
	Animals	18	18	17	18
	Fungi	18	18	16	19
Endemic edible varieties	Plants	7	4	1	16
	Animals	0	14	0	0
	Fungi	1	2	0	0

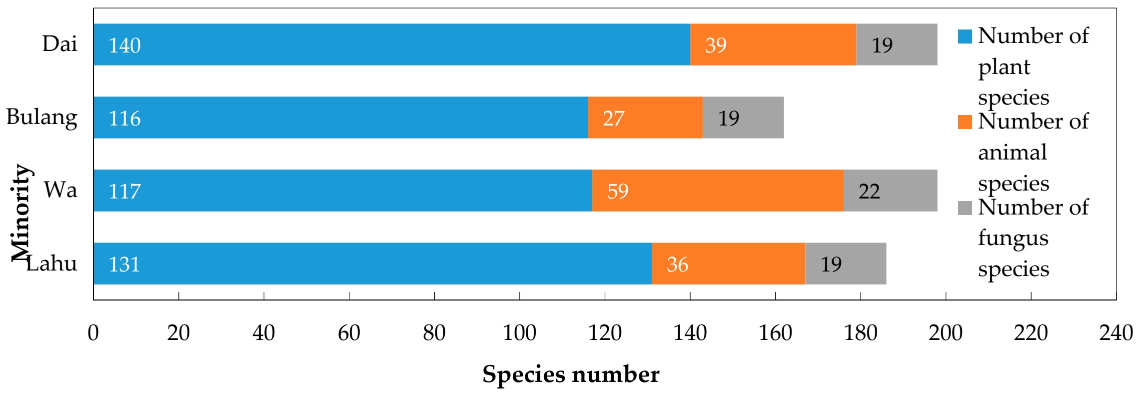

Figure 2. EBR species consumption by the four minority groups.

There were differences between the numbers of EBR species consumed by the four minority groups. Figure 2 shows that the Wa people and the Dai people had identified the highest numbers of EBR species consumed. The Wa people consumed the most animal species, while the Dai people consumed the most plant species. The proportions of traditional varieties in the total numbers of EBR species consumed by the Lahu, Wa, Bulang, and Dai people were 59.13%, 50.00%, 56.79%, and 58.08%.

1. Edible plant diversity

Plants were the main EBR consumed by the four groups of villagers, accounting for more than 58% of the total number of EBR species in each group. We recorded 162 plant species that belonged to 68 families. The plant species were categorized into seven consumption types (crops, vegetables, fruits, wild vegetables, nuts, seasonings, and tea; Figure 3). In total, 62.35% of species were eaten by all four minority groups, 5.56% by three, 14.81% by two, and 17.28% by only one minority group.

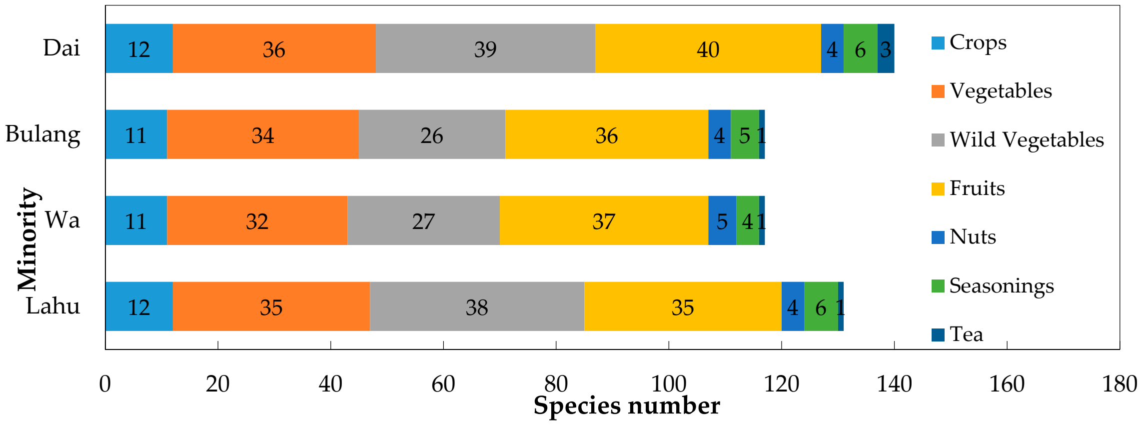

Figure 3. Numbers of species of edible plant types used by the four minority groups.

There were similarities and differences in the species of crops and seasonings identified as being consumed by the four groups. Nine of the crop species identified were eaten by all four groups, including rice (*Oryza sativa* L.) and corn (*Zea mays* L.). Wheat (*Triticum aestivum* L.) was eaten only by the Lahu people and the Bulang people. Runner beans (*Phaseolus coccineus* L.) were eaten only by the Lahu people and the Wa people. Buckwheat (Fagopyrum esculentum Moench.) was eaten only by the Lahu people. Tartary buckwheat (*F. tataricum* (L.) Gaertn.) was eaten only by the Wa people. Sticky yam (*Dioscorea hemsleyi* Prain. et Burkill) was eaten only by the Bulang people. Only the Dai people eat sorghum (*Sorghum bicolor* (L.) Moench.), purple sweet potato (*Ipomoea batatas* (L.) Poir.), and bitter yam (*D. glabra* Roxb.).

In seasonings, all four groups ate sesame (*Sesamum indicum* L.), Sichuan pepper (*Zanthoxylum bungeanum* Maxim.), and *Amomum tsao-ko* Crevost et Lemarié. Fennel (*Foeniculum vulgare* Mill.) and star anise (*Illicium verum* Hook. fil.) were eaten only by the Lahu people and the Bulang people; fructus amomi (*A. villosum* Lour. nom. con.) was eaten only by the Lahu people and the Wa people. Only the Dai people eat *Polygonum viscosum* Buch.-Ham. ex D. Don, *Eleutherococcus nodiflorus* (Dunn) S. Y. Hu, and *Jasminum duclouxii* (H. Lév.) Rehder.

There were slight differences between vegetable species consumed by the four groups. Thirty-two species were eaten by all four groups, including *Allium tuberosum* Rottler ex Spreng. and field pumpkin (*Cucurbita pepo* L.). Only the Wa people did not consume *Hemerocallis citrina* Baroni or cowpea (*Vigna unguiculata* (L.) Walp.). Only the Lahu people and the Dai people ate asparagus (*Asparagus officinalis* L.).

There were considerable differences between the groups in the consumption of wild vegetables. The Dai people and the Lahu people consumed 39 and 38 species, and the Wa and Bulang people consumed 27 and 26 species. Twenty species of wild vegetables were eaten by all four groups, including *Musa balbisiana* Colla and *Elsholtzia kachinensis* Prain. Three groups (excluding the Wa people) ate *Valeriana tangutica* Bat. and *Ardisia solanacea* Roxb. Fifteen species were eaten by only two minority groups. Six species, including *Plumeria rubra* cv. Acutifolia and *Clerodendrum bungei* Steud., were eaten by only the Dai people, and six species, including *Crassocephalum crepidioides* (Benth.) S. Moore and *Anaphalis flavescens* Hand.-Mazz., were eaten only by the Lahu people. Mango leaves (*Mangifera indica* L.) were eaten only by the Bulang people and *Zingiber mioga* (Thunb.) Roscoe was eaten only by the Wa people.

The Dai people consumed the largest number of fruit species (40), followed by the Wa people (37), the Bulang people (36), and the Lahu people (35). Among the fruit species, 32 were consumed by all four groups, including banana (*M. nana* Lour.) and pawpaw (*Chaenomeles sinensis* (Thouin) Koehne). Three groups (the Wa people excepted) consumed myrobalan (*Terminalia chebula* Retz.) and *Lindera longipedunculata* Allen, three groups (the Bulang people excepted) consumed custard apple (*Annona squamosa* L.), and three (the Lahu people excepted) consumed guava (*Psidium guajava* L.). Only the Wa people and the Dai people ate rambutan (*Nephelium lappaceum* L.) and fig (*Ficus carica* L.), and only the Bulang people and the Dai people ate areca (*Areca catechu* L.). Only the Wa people ate *Baccaurea ramiflora* Lour., and only the Dai people ate citron (*Citrus medica* L.).

Of the nuts identified, all four groups ate Chinese chestnut (*Castanea mollissima* Blume), sunflower (*Helianthus annuus* L.) seeds, peanuts (*Arachis hypogaea* L.), and walnuts (*Juglans regia* L.). The Wa people ate *macadamias* (Macadamia ternifolia F. Muell.).

All the four groups drank *Camellia sinensis* var. *assamica* (J. W. Mast.) Kitamura, which is a specialty of SMATCS. The Dai people also drank *C. taliensis* (W. W. Sm.) Melch. and *C. assamica* var. *kucha* (Hung T. Chang and Wang) Hang T. Chang.

2. Edible animal diversity

Edible animal species, of which there were 59 species in 26 families, were classified as poultry, livestock, aquatic foods, and insects. Fifty-nine species were consumed by the Wa people, 39 by Dai, 36 by Lahu and 27 by Bulang (Figure 4). All groups consumed 45.76% of the 59 species; 5.08% of the species were consumed by three groups, 25.42% were consumed by two groups, and 23.73% were consumed by one group only.

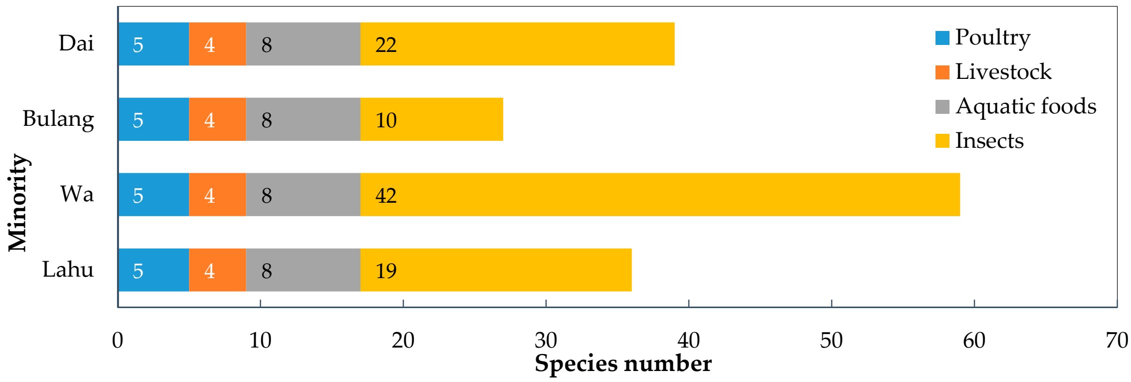

Figure 4. Numbers animal species consumed by the four minority groups.

The four groups consumed identical species of poultry, livestock, and aquatic foods, including chicken (*Gallus gallus domesticus*), beef (*Bos taurus domesticus*), and fish (*Tor sinensis*). In contrast, there were great differences in the edible insects consumed. The Wa people consumed the greatest number of insect species, 42 species in 16 families, such as locusts and cicadas. The Dai people ate the second largest number of insect species, 22 species in 10 families, such as bees and stinkbugs. The Lahu people ate 19 species in 7 families, such as ants, and the Bulang people ate the smallest number of insect species, 10 species from 4 families, such as pine moths.

3. Edible fungus diversity

We identified 24 edible fungus species in 19 families. The Wa people consumed 22 species, and the other three groups consumed 19 species each (Figure 5). Oyster mushrooms (*Pleurotus ostreatus* (Jacq.) P. Kumm.), *Cantharellus cibarius* Fr., and 17 other fungus species were consumed by all four groups. *Pleurotus eryngii* Quel. and *Agaricus bisporus* (J.E. Lange) Imbach were eaten only by the Wa people and the Bulang people. *Dictyophora indusiate* was eaten only by the Lahu people and the Dai people, and *Agrocybe aegerita* was eaten only by the Wa people and the Dai people. Only the Lahu people ate oyster mushrooms, and only the Wa people ate *Copyinds comatus* (MUII. Fr) Gray and *A. blazei* Murrill.

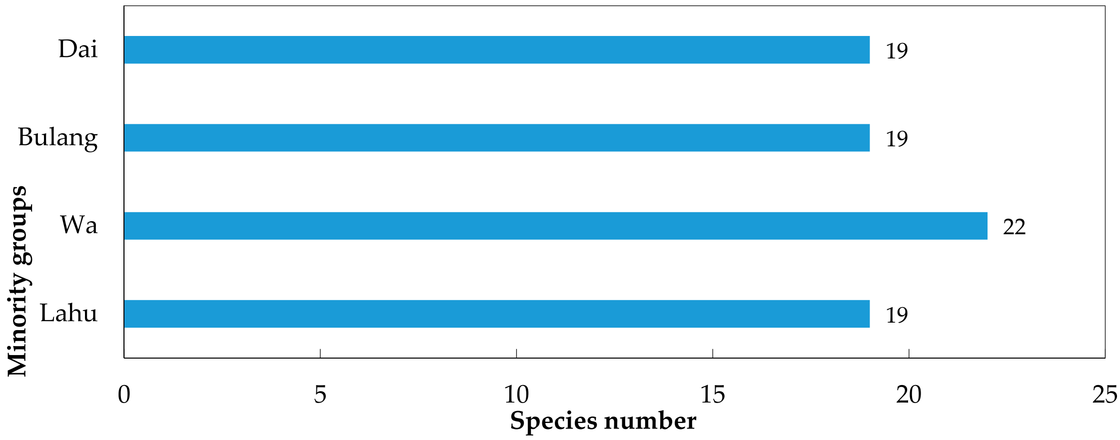

Figure 5. Numbers of edible fungus species consumed by the four minority groups.

3.2.2. Edible Part Diversity

EBRs were diverse in terms of the parts of organisms that were eaten. Of the 162 edible plant species, almost every plant organ was consumed as food, including roots, stems, and leaves (Figure 6), and in general, more than one organ was eaten per plant. The most widely consumed plant organs were fruits (63), leaves (48), and stems (35).

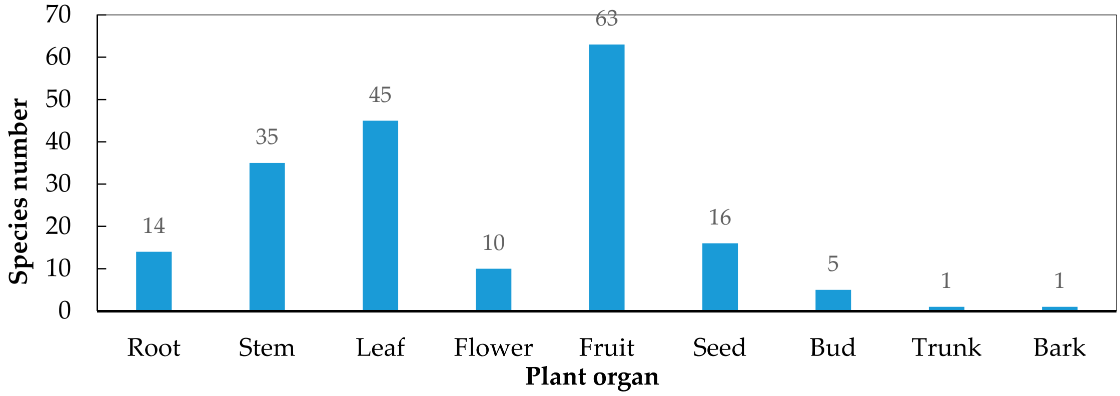

Figure 6. Numbers of plant species of which various organs were eaten.

Fruits, from either wild or cultivated plants, were the organ most eaten; fruits of 38.89% of all species were consumed. Leaves and stems of vegetables were usually consumed. For example, villagers consumed the leaves of *Parabaena sagittata* Miers and the stems of *V. tangutica* Bat. Leaves were eaten in 29.63% of the plant species, and the stems were consumed in 21.60%. Domesticated crop species were consumed mainly for seeds and roots and wild vegetables for their flowers and buds. The bark of *Cinnamomum cassia* (L.) Presl was used as a seasoning.

Diversity in the edible parts of animals was mainly seen in the consumption of insect species at different life stages. The four groups generally preferred certain insects to be at a particular stage of development (Figure 7). Adult insects were preferred for 20 species (e.g., locusts), pupae for 18 species (e.g., bees), and larvae for 4 species (e.g., *Cyrtotracjelus longimanu*).

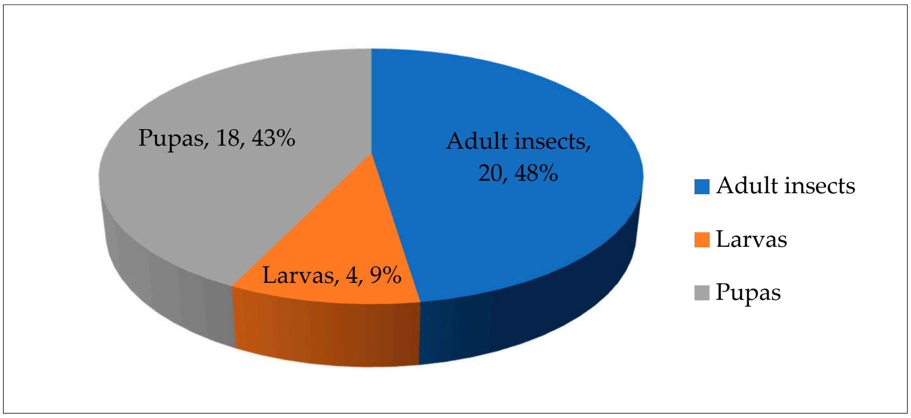

Figure 7. Percentage of insects consumed at different life history stages.

3.2.3. Harvest Season Diversity

Diversity in EBR consumption during the harvest season was greatest during months of wild vegetable harvesting. Wild vegetables were gathered all year round by all four groups, although most were harvested from March to June (average number of species >20), and few were collected in January (average number of species <10; Figure 8).

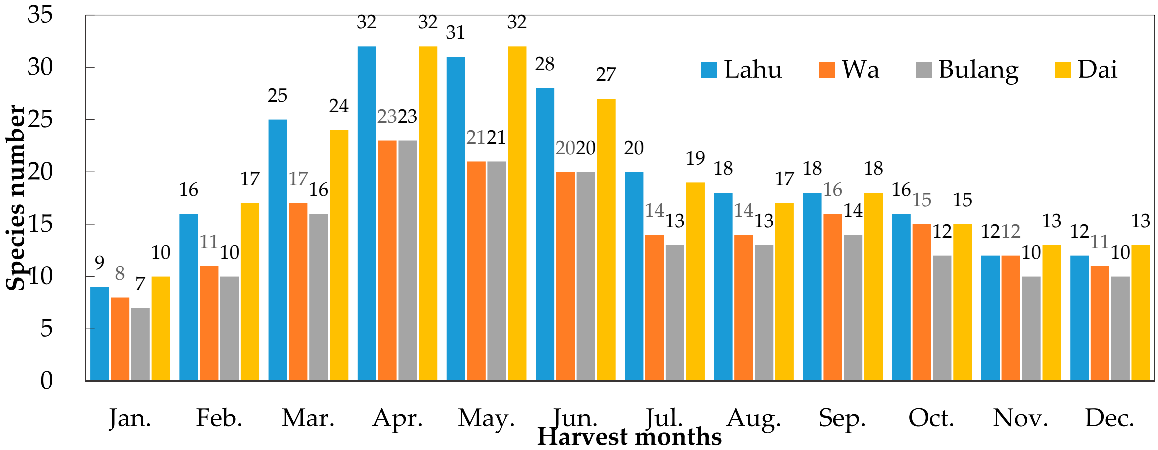

Figure 8. The number of wild vegetable species collected in different months.

The within-year distributions of the numbers of wild vegetable species eaten were similar for the four groups (Figure 8). The number of species consumed began to increase in January and reached a peak in April. The number then gradually decreased but had a minor rebound in September before decreasing to the next January. The numbers of wild vegetable species eaten in spring (from March to May) were the greatest, and the harvest season for all wild vegetables could last for at least two months. Some wild vegetables, like *Canna edulis* Ker Gawl. and jicama (*Pachyrhizus erosus* (L.) Urb.), were eaten all year.

3.2.4. Utilization Diversity

Although eating is the major mode of EBR consumption, our results showed that some edible species were also used as medicine or fodder (Table 4 and Appendix A).

Table 4 shows that 22 species, 11.11% of the edible species consumed by the Dai people, were also used in other ways. Similar patterns were observed in the other groups: Wa (20 species, 10.10%), Lahu (18 species, 9.68%), and Bulang (16 species, 9.88%). More than 50% of the households surveyed in each group mentioned that they used edible species as medicine, for feed, or in winemaking. We also found that the four groups usually made "*Niusapie*", "*Ganlansheng*", and other traditional ethnic dishes during marriage ceremonies, festivals, and celebrations of other special events (Appendix A). In the past, the standard of living in the villages was low, and these dishes require the consumption of many EBR species and are intricate to prepare, so they were made only for special occasions. These celebratory dishes are imbued with the happy expectations of the farmer for life, the blessings of the family, gratitude for life, and other ethnic and cultural tokens. Continual improvement in living standards has made it more practical to create these dishes more often in daily life, but their cultural and religious significance is still alive and influential in the villagers' lives.

Table 4. Numbers of species of EBRs with nonedible uses in the Shuangjiang Mengku ancient tea and culture system (SMATCS).

Minority Group	Other Uses of EBR	Number of EBR Species	Percentage of All EBR Species
Lahu	Used as medicine, extract oil, used as feed, in obsequies and sacrifices.	18	9.68%
Wa	Used as medicine, extract oil, used as feed, in obsequies, winemaking, and in sacrifices	20	10.10%
Bulang	Used as medicine, extract oil, used as feed, in making ethnic artifacts, and in sacrifices	15	9.88%
Dai	Used as medicine, extract oil, used as feed, in winemaking, brewing vinegar, and in sacrifices	22	11.11%

3.2.5. Food Preferences

Another aspect of diversity in EBR consumption is in eating preferences, which we determined by the species that were identified by the majority in each minority group. There were both similarities and differences in eating preferences (Table 5).

Table 5. Food preferences of the various groups.

Consumption Type	Preferred Food Species			
	Lahu	Wa	Bulang	Dai
Crop	*O. sativa* L.	*O. sativa* L.	*O. sativa* L.	*O. sativa* L.
Vegetable	*B. rapa* var. *glabra* Regel	*B. rapa* var. *chinensis* (L.) Kitamura	*B. rapa* var. *chinensis* (L.) Kitamura	*B. rapa* var. *glabra* Regel
Wild vegetable	*H. cordata* Thunb.	*Pteridium aquilinum* var. *latiusculum*	*H. cordata* Thunb.	*H. cordata* Thunb.
Fruit	*C. reticulata* Blanco	*C. reticulata* Blanco	*Malus pumila* Mill.	*M. pumila* Mill.
Nut	*A. hypogaea* L.	*M. ternifolia* F. Muell.	*J. regia* L.	*J. regia* L.
Seasoning	*A. tsao-ko* Crevost et Lemarié	*A. tsao-ko* Crevost et Lemarié	*A. tsao-ko* Crevost et Lemarié	*P. viscosum* Buch.-Ham. ex D. Don
Tea	*C. sinensis* var. *assamica* (J. W. Mast.) Kitamura	*C. sinensis* var. *assamica* (J. W. Mast.) Kitamura	*C. sinensis* var. *assamica* (J. W. Mast.) Kitamura	*C. sinensis* var. *assamica* (J. W. Mast.) Kitamura
Poultry	*Gallus gallus domesticus*	*Gallus gallus domesticus*	*Gallus gallus domesticus*	*Gallus gallus domesticus*
Livestock	*Sus scrofa*	*Sus scrofa*	*Sus scrofa*	*Bos taurus domesticus*
Aquatic food	Tor sinensis	*Tor sinensis*	*Tor sinensis*	*Tor sinensis*
Insect	Pine moth	Stinkbug	Bee	Pine moth
Fungus	*Lactarius volemus* Fr.	*L. volemus* Fr.	*Termitornyces albuminosus* (Berk) Heim	*T. albuminosus* (Berk) Heim

Table 5 shows that the four groups (Lahu, Wa, Bulang, and Dai) had the same preferences for crop, tea, poultry, and aquatic food species (rice (*O. sativa* L.), tea (*C. sinensis* var. *assamica* (J. W. Mast.)

Kitamura), native chicken (*Gallus gallus domesticus*), and fish (*Tor sinensis*)). Preferences for insect species differed (pine moth, stinkbug, bee, and pine moth). In preferences for wild vegetables, seasonings, and livestock, one group had a different preference from the other three. For wild vegetables, the Wa people preferred *P. aquilinum* var. *latiusculum*, but the other groups preferred *H. cordata* Thunb. For seasoning and livestock, the Dai people preferred *P. viscosum* Buch.-Ham. ex D. Don and beef, but the other three groups preferred *A. tsao-ko* Crevost et Lemarié and pigs (*Sus scrofa*). For vegetables, fruit, and fungi, two groups had a preference for one pair and the other two groups a preference for another pair: the Lahu and Wa people chose orange (*C. reticulata* Blanco) and *L. volemus* Fr. as their favorite fruit and fungus, and the Bulang and Dai people chose apple (*M. pumila* Mill.) and *T. albuminosus* (Berk) Heim. The Lahu and Dai people preferred Chinese cabbage (*B. rapa* var. *glabra* Regel), and the Wa and Bulang people preferred pakchoi cabbage (*B. rapa* var. *chinensis* (L.) Kitamura). The biggest difference in preferences between the groups was for nuts: the Lahu people preferred peanuts (*Arachis hypogaea* L.), the Wa people preferred macadamias (*Macadamia ternifolia* F. Muell.) and the other two groups preferred walnuts (*J. regia* L.)

3.3. Driving Forces of EBR Use

EBR use among the four minority groups included species selection, edible parts, harvest season, food preferences, and other usages of EBRs. We identified, through our analysis, four major forces that drove these uses: natural conditions, cultural conditions, social conditions, and economic conditions. Each driving force included several major factors and affected different aspects of EBR use (Figure 9).

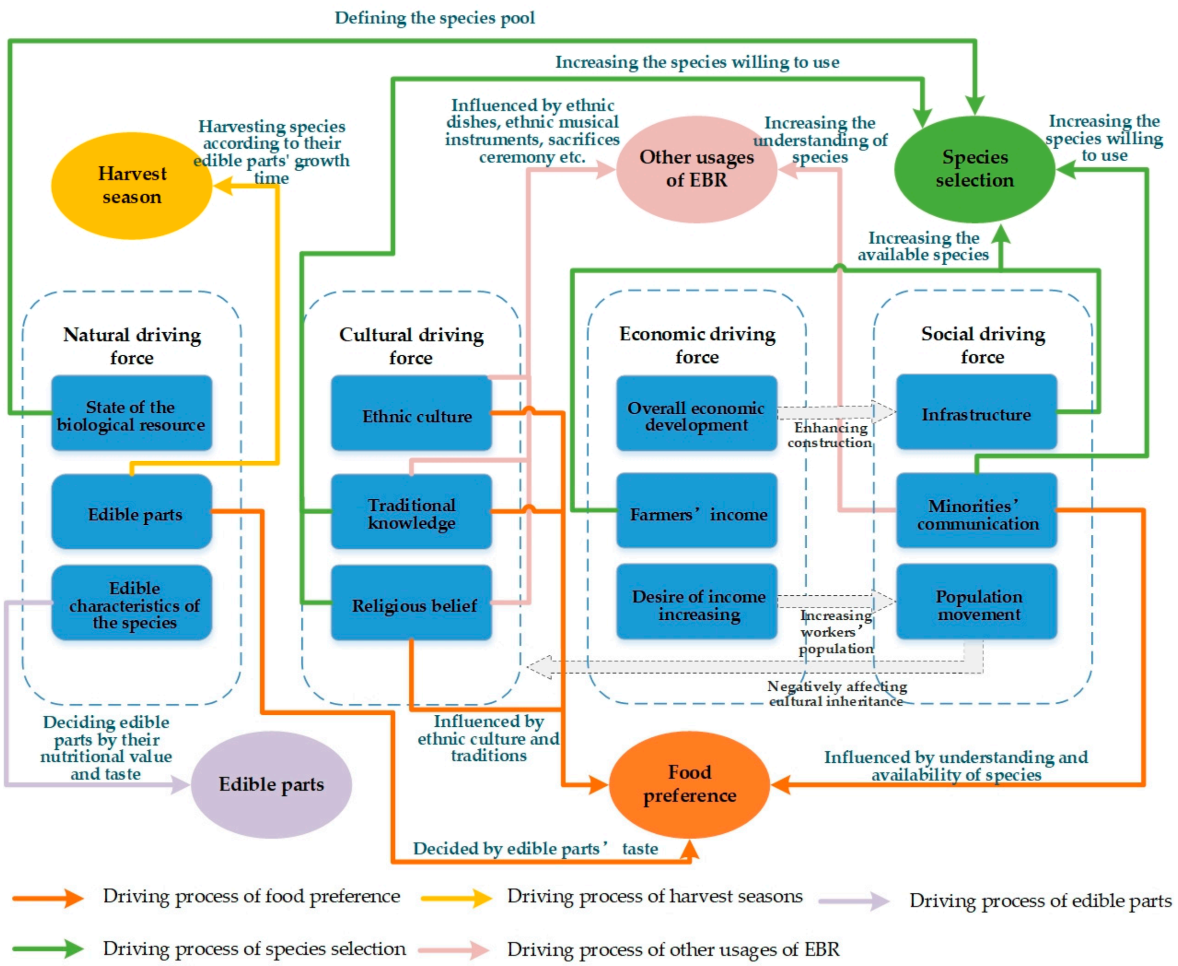

Figure 9. The driving process of EBR use.

There were three aspects of natural conditions that acted as a driving factor. The first was the state of the biological resource (species diversity) in the immediate environment of each group, which defined the pool of species available for selection. This was the basic factor that determined the choice of species used by each group. If a species did not grow or was present only in a small quantity around a village, it was unlikely to be consumed. For example, macadamia nuts were only consumed by the Wa people (Table 5) because they were not found beyond the environs of Nanjing village where the Wa people lived. The second driving factor was the edible characteristics of the species. For example, the leaves of Chinese cabbage are nutritious and soft, so the leaf is the primary edible characteristic, whereas the root of the carrot (*Daucus carota* var. *sativa*) contains most of the nutrients, so the root is the primary characteristic. The edible parts of a plant determine its harvest season, so it is the third factor. As another example, wild vegetables, of which the edible parts are the young stems and leaves, were mostly gathered from March to May, whereas fruits were mostly gathered from September to November (Figure 8).

Major cultural driving factors of EBR use included ethnic culture, traditional knowledge, and religious belief (Figure 9). Traditional knowledge directly influenced the use of EBRs for each group. For example, the Dai people had traditional knowledge of brewing vinegar, so they used tamarind (*Tamarindus indica* L.) as an ingredient, but they also consumed tamarind as a fruit, as did the other three minority groups (Appendix A). The other two factors indirectly affected EBR use through deciding which EBR was to be used for ethnic dishes, ethnic musical instruments, sacrifices, and ceremonies. For example, the Dai people were unique in consuming beef and using *P. viscosum* Buch-Ham. ex D. Don as a seasoning because these were two indispensable ingredients for their ethnic dish "*Niusapie*" (Appendix A).

The major social driving factors included regional infrastructure, communication between the different minority groups, and population movement (i.e., migrant workers; Figure 9). Infrastructure and intergroup communication increased the homogenization of diet among the four groups. Improvements in local transportation have greatly increased the distribution of goods within the system, resulting in food preferences for poultry, livestock, aquatic products, and vegetables being similar or identical between the four groups. Frequent communication between people in the same area for a long time has also led to a similarity in diet, which is reflected in the selection of edible species in each group. Among the EBR species, 62.35% of the edible plant species, 45.76% of the edible animal species, and 70.83% of the edible fungus species were consumed by all four groups. The effects of population movement (migrant workers) on EBR use are indirect. They have an adverse effect on ethnic cultural inheritance, which is translated into changes in the use of EBRs.

There are three economic driving factors (Figure 9). The first is the overall level of economic development across the system, which has an indirect effect. It increases the construction of regional infrastructure, which, in turn, promotes the circulation of goods and promotes communication among groups, thereby changing EBR use. The second factor is income. As a farmers' incomes increase, they can not only choose the EBR species they grow, cultivate, or collect from the wild, but they can also buy EBRs at the market, which may increase the number of EBR species they choose to consume. The third economic driving factor is the desire of farmers to increase their income, which indirectly affects EBR usage. Farmers who desire to increase their income and improve their standards of living may choose to work outside the village. This action can adversely affect cultural inheritance and then affect EBR use.

Figure 9 shows that with the exception of the harvest season and the edible parts of organisms, which were affected by only a single driving force, all other characteristics were related to a combination of four driving forces that had either direct or indirect effects. EBR uses other than eating were driven by culture (ethnic culture, traditional knowledge, and religious beliefs), economics (the overall level of economic development), and social forces (communication among different minority groups). Ethnic culture is manifested in farmers from different groups having their own unique customs in daily life and for special events such as funerals and sacrifices. Such behaviors expand EBR use from direct consumption to multiple uses bearing cultural significance. Communication between people of different minority groups has been facilitated by improved economic conditions, and increased communication has led to increased information exchange, expanding the use of EBRs as medicine, animal feed, and oil and spreading knowledge of the techniques of manufacture and preparation, resulting in a homogenization of use across the four groups. However, EBR use in cultural rituals (such as funerals and sacrifices) maintains its unique character since it is inherited by intragroup transmission only.

Species selection of fungus, tea, and fruit has been mainly driven by natural conditions, i.e., the biological resource condition. Species diversity in the place where a certain minority group resides has provided them with a basic selection of species in the EBR categories. However, selections of insects, wild vegetables, and seasonings have also been driven by cultural conditions, i.e., ethnic culture and religious beliefs, because various minority groups made further selections based on the need of their ethnic dishes, the applicability of ethnic equipment, and other cultural factors when species diversity provided only a basic selection. The selection of crops was also driven by both natural and cultural factors. The main cultural driving factor was, however, traditional knowledge (the accumulated knowledge of cultivation and domestication that has guided people's choices from the species pool).

The driving forces of food preferences varied between the groups. The Dai people's preferences for seasoning and livestock are driven mainly by cultural factors, whereas for the other groups, their preferences are driven mainly by natural and social factors. Otherwise, preferences for crops, tea, poultry, aquatic products, fruits, nuts, and fungi were driven by economics (the overall level of economic development), social force (intergroup communication), and natural forces (the condition of biological resources). The frequent communication between people living in SMATCS, which has been driven by increased economic development, has led to the homogenization of their preferences for crops, tea, poultry, and aquatic foods. Similarly, preferences for fruits and fungi were the same in the two groups that lived near each other. However, although the Lahu people and the Wa people lived in proximity, they had different preferences for nuts because macadamias only grew in the Wa village but not the Lahu village. The preferences for insects were driven by natural forces (edible parts) and cultural force (ethnic culture, traditional knowledge, and religious beliefs). The Bulang people preferred to eat bee larvae because of their ethnic culture and religious belief, while the Wa people preferred to eat stinkbugs due to their traditional knowledge of cooking insects. Both the Dai and Lahu people had preferences for pine moths.

4. Discussion and Conclusions

4.1. Discussion

SMATCS supports very diverse EBRs. This is evident from the numbers of species that the four minority groups consumed and is also shown by the variety of edible parts, the range of harvest times, and the multiplicity of EBR uses. This multifaceted diversity in EBR use in the agricultural heritage system shows that biological resources constitute a critical element of the natural environment [18,63] in maintaining biodiversity [20] and are fundamental to sustaining the livelihood of farmers in the system [61,64,65]. A wealth of agricultural wisdom and cultural knowledge has been indicated by the sustainable use of EBRs [18,20]. However, overuse of EBRs due to the low income of the inhabitants and their high dependence on biological resources is becoming a major threat to biodiversity [40]. However, reducing or even eliminating the use of EBRs eventually results in loss of knowledge and traditions, which decreases cultural diversity [66]. Thus, harnessing the driving forces of EBR use and maintaining EBR sustainability are necessary to ensure the continuation of ecological and agricultural biodiversity in an agricultural heritage system and are critical to continued cultural diversity.

Of the four driving forces (nature, culture, society, and the economy) of EBR use for the four minority groups, two social factors (regional infrastructure construction and communication between different groups), two economic factors (overall economic development level and farmers' income), and species diversity are convergent. This is because, in the shared pool of species that occupy the entire system, similarity in infrastructure development and accompanying growth in intergroup communication among the four minority groups have homogenized EBR use. In contrast, cultural factors drive divergence in consumption because of the uniqueness of each minority group culture. As an example, differences in food preferences are seen in preferences for insects. The Bulang people prefer to eat bee larvae while the Lahu and Dai people prefer pine moths and the Wa people prefer stinkbugs (Table 5). Preferences for seasonings are different between the groups: the Dai people are distinguished from the other groups by a preference for the seasoning *P. viscosum* Buch.-Ham. ex D. Don in their ethnic dishes of "*Niusapie*", while the preference of the other three groups is for *A. tsao-ko* Crevost et Lemarié (Table 5).

Some driving factors, such as religious belief [20,67], traditional knowledge [37,39], and consumption of edible parts [37,38], are also found in other regions that have similar natural or social conditions or are inhabited by the same minority groups. Traditional knowledge and religious beliefs increase the diversity of EBR use as well as the number of species used [20,37,39], as we found. Elsewhere, religious beliefs have been found to affect EBR use [37,39]. The action of edible parts as a driving factor is seen mainly in species preference, as we have shown [40]. We also found that for geographical and historical reasons, the same minority group who lives in SMATCS and other regions shows differences in EBR species use [37,38,40]. Some driving factors, such as government policy [41] and tourism [42], were not identified by interviewees or experts. One reason for this is that when we collected data, SMATCS had not been listed as a China–NIAHS site, and, therefore, this government declaration did not show any effect on EBR use. We inferred that it was also because the local government had paid little attention to EBR management in SMATCS and had not, therefore, implemented any policies that affected EBR use. SMATCS was little known among outsiders and inaccessible to them at that time, so EBR use was not affected by the development of tourism. We speculate that media and communications outlets, also the social factors that drive EBR use, did not show an effect in our study. When we conducted our research, we found that communication between local people and the outside world depended mostly on communication between local farmers and their relatives and neighbors who worked outside the village. There was little computer use or network access (the penetration rate is <25%), and farmers mostly use television to watch TV shows. We surmise that this is why we found little evidence of media impact on EBR use.

Much EBR use is beneficial to the sustainability of local biological resources, even if unintentionally so. The minority groups balanced quantity and quality for a sustained EBR harvest. They have adopted strategies, such as picking large plants and leaving small ones and periodically changing locations for capturing insects and excavating wild plants, which encourage growth in both plant and animal populations. Lack of competition for EBRs between different minority groups also acts towards the sustainability of local EBRs. For example, the Wa people eat more insects, which reduces the consumption of other EBR species. Farmers in SMATCS also plant traditional crop varieties that have adapted to local environmental conditions, which increases food security and maintains agricultural biodiversity.

Despite the diversity of EBRs and smart strategies for EBR use in SMATCS, convergence in food preferences and the weakening effects of some cultural driving factors indicate that this agricultural heritage system is faced with a loss of traditional culture and agrobiodiversity. Traditional crops are gradually substituted by nontraditional varieties. Seeds of nontraditional varieties are easy to obtain, while seeds of traditional varieties must be carefully gathered and preserved by farmers through extra work. Traditional varieties also require more labor in planting and so are not adapted to modern techniques. Traditional varieties cannot be allowed to pollinate with nontraditional varieties planted in the same farmland; however, the latter are already planted by many farmers. Hybrid rice and other imported exotic varieties have been planted, changing the structure of the agricultural ecosystem and the wider environment and further decreasing the use and preservation of traditional varieties. Some traditional knowledge was disclosed to us by only a few people. For example, only one Bulang person mentioned "*Fengtonggu*" (bee barrel drum), which is an ethnic musical instrument made from a bucket used as a beehive, and only a few people knew the dance that came with it, the "*Fengtongguwu*", despite it being officially listed as a national intangible cultural heritage item. Traditions like this face being lost forever when farmers' goals are to continually increase their incomes. As the numbers of migrant workers increase and the number of farmers who are willing to farm traditionally and to cultivate and consume EBRs in traditional ways decreases, the cultural driving force is weakened and the traditional uses of EBR disappear together with the traditional knowledge of cultivating traditional species.

We propose two approaches to increase EBR sustainability: *Make full use of existing protections* and *strengthen protection for the inheritance of traditional knowledge related to EBRs*. Actions currently taken by farmers that protect EBRs must be identified, categorized, publicized, advocated, and encouraged by local governments. Traditional knowledge is full of wisdom concerning the management of natural resources. Raising awareness of traditional knowledge among farmers and students is a priority, and the valorization of culture is essential. For example, cultural tourism must be encouraged and regulated, and specific agricultural products must be developed and promoted to increase farmers' incomes and support cultural protection and heritability.

4.2. Conclusions

Sustainable use of EBR is critical to agricultural heritage. EBR use directly affects local biodiversity and ecosystem integrity, which are fundamental to promoting agricultural heritage. However, EBR use is partly driven by social–cultural factors that agricultural heritage must preserve. EBR can only be sustained if we understand how the resources are utilized and how EBR use is driven, which we must do in order to provide incentivized targets for conservation. In this research into the Shuangjiang Mengku ancient tea and culture system (SMATCS), we analyzed the use of EBRs by four minority groups by examining species selection, edible parts, harvest seasons, and other usages other than eating. We recorded 245 EBR species belonging to 113 families (Table 3) and identified the forces that drive their utilization (Figure 9). Our study showed that EBR utilization involved species selection (Table 3 and Figure 2), edible parts of plants and animals (Figures 6 and 7), harvest season analysis (Figure 8), identification of food preferences (Table 5), and recognition of other uses of EBRs (Table 4 and Appendix A). The similarities and differences in EBR use between the four minority groups were influenced by complex biological, cultural, social, and economic driving factors (Figure 9). Two major approaches are recommended to ensure the long-term sustainability of EBRs, and they have important implications for policy-making and heritage development. We draw three major conclusions from our work.

First, conserving EBRs is necessary to conserve local biodiversity and cultural diversity. Animal and plant species identified as EBRs, 245 species from 113 families, accounted for 55.25% of local animal and plant species. Conserving these EBR species is essential for conserving local biodiversity. Other features of EBR diversity, including edible parts of plants and animals, length of the harvest season, and multiple uses of EBR, represent different aspects of ethnic cultures and traditional knowledge. Thus, sustainable utilization of EBR will, in turn, sustain unique local ethnic cultures.

Second, regulating the driving factors is necessary to promote sustainable EBR use. There are natural factors that act directly to conserve EBRs, and measures must be taken to protect natural biodiversity. Cultural factors also influence EBR use, so it is necessary to identify and distinguish relevant cultures, knowledge, and beliefs. By increasing the breadth of awareness of the importance of traditional knowledge, introducing cultural tourism, and developing locally crafted products, farmers and students can be encouraged to act for their heritability and conservation. We note that social factors have a double-edged influence; although social influences can strengthen the exchange of goods and information, it is also necessary to prevent unique ethnic cultures from being irreversibly damaged by other cultures. Preservation of diversity in EBR use by minority groups must go hand-in-hand with the preservation of cultural diversity.

Third, increasing stakeholder involvement will ensure the conservation of EBR use. Although we did not find any direct influence of government policy on EBR use in this study, the importance of government policies cannot be ignored. It is desirable to increase and strengthen communication between policymakers and local communities to encourage mutual understanding and acceptance of the aims and plans for conserving agricultural heritage systems and managing EBRs. It is fair and necessary to respect local traditions and wisdom for their cultural value and to engage the support of the local people for conservation outcomes, so as to help local people benefit from the improvement of ecological conditions and increase in cultural significance.

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Appendix A

Table A1. The information of other usages of EBRs in SMATCS.

Usage	Ethnic group (L—Lahu, W—Wa, B—Bulang, D—Dai)	Species	Specific Usage
Medicine	L, W, B, and D	*Houttuynia cordata* Thunb.	Treating asthma, sore throat, and indigestion, eliminating inflammation, and detoxifying.
		A. villosum Lour.	Treating indigestion, diarrhea, and preventing miscarriages.
		Tricholoma matsutake (lto et lmai) Sing.	Treating dizziness, vomiting, and backache and such.
		Ganoderma Lucidum (Leyss. ex Fr.) Karst.	Calming the nerves, eliminating phlegm, and enhancing immunity.
	L, W and D	*A. tsaoko* Crevost et Lemarié	Treating indigestion, abdominal pain, and vomiting.
		Polyrhachis vicina Roger	Anti-inflammatory, antiaging, toning the kidney, strengthening the spleen.
	L and W	*Plantago depressa* Willd.	Clearing heat, eliminating phlegm and inflammation, and detoxifying.
	W and B	*C. japonica* L.	Relieving a cough, eliminating inflammation, and hemostasis.
	L	*O. sativa* L.	Treating heatstroke and diarrhea.
	B	*C. cassia* Presl	Treating impotence, pain, and cold.
	D	*J. duclouxii* (H. Levl.) Rehd.	Relieving pain, swelling, and hemostasis
		P. rubra cv. Acutifolia	Treating diarrhea, bacillary dysentery, indigestion, and such.
		C. bungei Steud.	Clearing heat, eliminating inflammation, and relieving pain.
		Capsicum annuum L.	Increasing appetite, and clearing damp.
Squeeze oil	L, W, B, and D	*Brassica rapa* var. *oleifera* de Candolle	Extracting edible oil from mature individuals.
		A. hypogaea L.	
	L, B, and D	*S. indicum* L.	
	L, W, and B	*Glycine max* (L.) Merr.	
Animal feed	L, W, B, and D	*Z. mays* L.	Feeding poultry such as chickens and ducks.
	L, B, and D	*I. batatas* (L.) Lam.	Feeding pigs.
	W, B, and D	*G. max* (L.) Merr.	Feeding pigs and chicken.
Make ethnic equipment	B	*Bos taurus domesticus*	Made from the hide of cattle and the bark of *J. sambac* (L.) Aid. to make the *Fengtonggu* (bee barrel drum).

Table A1. *Cont.*

Usage	Minority (L—Lahu, W—Wa, B—Bulang, D—Dai)	Species	Specific Usage
Obsequies	L	*Gallus gallus domesticus* and *O. sativa* L.	Dedicating rice and chicken to the dead before interment.
		Gallus gallus domesticus and *Sus scrofa*	Relatives and villagers who attend the funeral carry away these in consolation.
	W	*C. sinensis* var. *assamica* (J. W. Mast.) Kitamura	Putting tea, salt, or sugar in the mouth of the dead person.
		C. sinensis var. *assamica* (J. W. Mast.) Kitamura, *O. sativa* L., *Nicotiana tabacum* L.	Relatives and villagers who attend the funeral carry away these in consolation.
Brew wine	W and D	*Z. mays* L.	Fermentation using cooked corn, sugar, cold water, and enzymes.
	W	*O. sativa* L.	Fermentation using cooked rice and enzymes.
	D	*Saccharum officinarum* L.	Fermentation using squeezed fruits and enzymes.
		Solanum tuberosum L.	Fermentation using cooked potato (*S. tuberosum* L.), mud, and enzymes.
Brew vinegar	D	*O. sativa* L. and *Tamarindus indica* L.	Fermentation using the fruits of tamarind (*T. indica* L.), glutinous rice, brown sugar, wine and cold water.
Sacrifice	L	*Gallus gallus domesticus*	Divination through observing the comb, feet and skeleton of a chicken.
		O. sativa L., *Z. mioga* (Thunb.) Rosc. and *Gallus gallus domesticus*	(1) Dedicating glutinous rice to the Fire God and their ancestors (New Year's Day); (2) burning the stem and leaves of *Z. mioga* (Thunb.) Rosc. to exorcise the spirit and dedicating a chicken to pray for safety (second day of the first month of the lunar calendar).
		Sus scrofa and *C. sinensis* var. *assamica* (J. W. Mast.) Kitamura	Worshiping ancestors (8th day of the second month of the lunar calendar).
	B	*Gallus gallus domesticus*, *O. sativa* L.	Plugging feathers of chicken beside the root of the Dragon Tree to worship the tree, dropping chicken blood around the altar, and offering chicken and glutinous rice as sacrifices on the altar (Songkran Festival).
	W	*M. basjoo*, *Sus scrofa*, *S. officinarum* L., *C. sinensis* var. *assamica* (J. W. Mast.) Kitamura, *O. sativa* L., *Z. mays* L.	Dedicating items to their ancestors to pray for safety and happiness.
	D	*Bos taurus domesticus*, *Sus scrofa*, *O. sativa* L., *S. officinarum* L., *Z. mays* L. and *S. tuberosum* L.	Dedicating items in the Buddhist temple to pray for safety.

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