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Research Article

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Posted Date: August 26th, 2025

DOI: https://doi.org/10.21203/rs.3.rs-7378301/v1

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Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Journal of Ethnobiology and Ethnomedicine on November 24th, 2025. See the published version at https://doi.org/10.1186/s13002-025-00832-x.

Traditional Utilization of Weeds and Ethnic Ecological Wisdom in Longsheng Terraces——A Study Based on Globally Important Agricultural Heritage Systems

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Abstract:

Background: Weeds, which are long seen as nutrient competitors for crops, have made chemical weeding mainstream in agriculture. However, in Guangxi's Longsheng Terraces, a global agricultural heritage site, the Zhuang, Yao and Dong peoples value them as medicine, food, feed and even tools. This undocumented traditional knowledge, under chemical agriculture and tourism pressures, is on the verge of extinction.

Methods: This study integrates research methods from ethnobotany and weed science and conducts a survey on 189 weed species across 11 types of farmlands, including paddy fields and corn fields in the Longsheng Terraces. It focuses on traditional knowledge of weed utilization among the Zhuang, Yao, and Dong ethnic groups. Through semistructured interviews, data on the local names, uses, utilized parts, and frequency of use of these weeds were recorded. Additionally, indicators such as frequency of citation (FC), informant consensus factor (Fic), use value (UV), and relative importance (RI) were employed to analyze their value quantitatively.

Results: Among the 189 weed species, 49 have traditional utilization value, covering four major categories: medicinal use (41 species, accounting for 81.6%), edible, forage, and tool material use. Among them, *Phytolacca americana*, *Polygonum hydropiper*, *Plantago asiatica*, and *Erigeron annuus* had the highest relative importance. In terms of usage consensus, there was a high level of consensus within the community regarding weed utilization knowledge for conditions such as coryza and snake bites. Notably, 29 medicinal weeds were not included in the *Pharmacopoeia of the People's Republic of China*, and among the 14 weeds included therein, 9 species remain unrecorded, indicating that these weeds have potential development value. Analysis of ethnic differences revealed that the Yao ethnic group utilized the most abundant weed species, followed by the Zhuang and the Dong. The similarity coefficient analysis revealed that the Zhuang and Yao ethnic groups presented the highest similarity in weed utilization knowledge, whereas the similarity between the Zhuang and Dong ethnic groups was the lowest. The inheritance of traditional knowledge showed a significant intergenerational decreasing trend, with no gender difference observed. Additionally, the impact of tourism development on the weed utilization rate did not reach statistical significance.

Conclusions: This study reveals the multidimensional value of weeds in the Longsheng Terraces and the traditional ecological wisdom they embody, providing significant reference values for biodiversity conservation, traditional knowledge inheritance, and sustainable agricultural development at global agricultural cultural heritage sites. Moreover, systematic research and protective measures are needed to prevent the loss of these valuable resources due to improper management.

Keywords: Weed traditional utilization, Ethnobotany, Globally important agricultural heritage system (GIAHS), Ethnic differences, Agrobiodiversity conservation

1 Background

Farmland weeds have long been considered harmful organisms that threaten crop yields. Years of practice have shown that chemical control of farmland weeds is not only costly and of limited effectiveness but also often triggers a series of environmental and food safety issues [1, 2]. However, this perspective overlooks the multidimensional value of weeds in maintaining agricultural biodiversity and supporting community livelihoods [3, 4]. Current research has focused mostly on the negative ecological impacts of weeds, with insufficient recognition of their ecological service functions and cultural value in traditional agricultural systems. Although the Food and Agriculture Organization (FAO) has warned that global agricultural biodiversity is being lost at an alarming rate [5], systematic documentation of traditional knowledge on weed utilization remains severely lacking, particularly in global agricultural cultural heritage sites facing the dual pressures of chemical agriculture expansion and tourism development. Despite being impacted, these regions still harbor important clues for drug development and the conservation of biocultural diversity within their remaining plant cultures [6].

This study defines weeds as noncultivated associated plants in farmland ecosystems that possess local utilization value, including those occurring in agricultural and disturbed habitats. In traditional agricultural systems, weeds are key biological components that perform irreplaceable ecological service functions. Indirectly, they enhance crop resilience, control pests and diseases, remediate soil pollution, conserve water, maintain soil fertility, and preserve biodiversity [7-13]. Directly, they provide raw materials such as medicinal herbs, food, feed, and green manure [3, 14-17]. As a result, weeds serve as important resources for communities to adapt to environmental changes, contributing to the healthy and sustainable development of terrace ecosystems. Weeds are an important source of indigenous pharmacopoeias [18], appearing more frequently in pharmacopoeias than other plants [19]. These “field-side pharmacies” provide valuable life-saving medicines [3, 20-24].

As a globally important agricultural heritage system (GIAHS), the Longsheng Terraces in Guangxi, China, are renowned not only for their unique rice-farming landscapes but also for their distinctive value due to their weed resource management model, which is based on traditional ecological knowledge. This traditional knowledge of weed utilization plays a key role in maintaining the sustainable management of ecosystems. It not only provides profound insights into the relationships between organisms and the environment but also closely connects humans with nature through unique value systems and beliefs, forming dynamically balanced ecological management wisdom [25, 26]. The uniqueness of Longsheng Terraces lies in their "weed–crop–culture" synergistic system: ethnic minorities such as the Zhuang, Yao, and Dong have long held in-depth understanding and practices regarding the medicinal value of various plants, forming a unique medical culture. For example, the Yao people's Pangtong medicinal bath (an intangible cultural heritage of Guangxi) makes extensive use of farmland weeds [27]. However, traditional weed knowledge is facing a severe crisis of intergenerational discontinuity due to factors such as the reduction of medicinal plant resources, replacement by modern medicine, and cultural cognitive gaps [28-31].

Research on important agricultural cultural heritage sites in China has achieved remarkable results, but the focus has focused mainly on areas such as resources and industrialization, value and protection systems, and connections with rural revitalization [32-34], with few studies involving the biodiversity of important components of agricultural cultural heritage and related traditional knowledge. Without systematic research and evaluation, valuable medicinal weed resources in biodiversity hotspots such as Longsheng may disappear due to improper management.

Therefore, this study aims to (1) systematically record and evaluate weed resources and related traditional knowledge in the Longsheng Terraces and quantify their utilization value; (2) analyze the differences in weed utilization knowledge among the Zhuang, Yao, and Dong ethnic groups to provide a basis for targeted protection and sustainable management; (3) Given that Longsheng is a renowned tourist destination with a large number of visitors, this study evaluates whether tourism development has impacted traditional weed utilization practices; and (4) explore the positive role of alien invasive plants in supporting local livelihoods to provide an indigenous wisdom perspective for the resource-based utilization of invasive species and ecological risk management. This work provides not only a rescue record of traditional endangered knowledge but also a key scientific basis for understanding the biocultural diversity of GIAHS sites and exploring the synergistic protection of the sustainable utilization of weed resources and farmland biodiversity.

2 Methods

2.1 Study area

Longsheng multiethnic Autonomous County (25°29′–26°12′N, 109°43′–110°21′E) is located in the mountainous northern part of Guilin, Guangxi, China (Figure 1). Geographically, it lies at the ecotone between karst landforms and the Nanling

Mountains, with its iconic terraced landscapes distributed across steep slopes (300–1100 m above sea level), forming a vertically mosaic system characterized by "forests atop ridges and terraces on mid-slopes". The area features a mid-subtropical monsoon climate, with an annual average temperature of 18.2°C and annual precipitation of 1500 mm; the significant diurnal temperature variation creates a superior habitat for medicinal plants and characteristic crops. Primary forests cover 82% of the region, playing a pivotal role in water conservation and biodiversity maintenance.

As a GIAHS and a "Best Tourism Village" recognized by the United Nations World Tourism Organization, the Longsheng Terraces boast a 2300-year history of adaptive farming. The core area spans over 5000 mu, comanaged by the Zhuang, Yao, and Dong ethnic groups (the county's total registered population is 171,800, with rural residents accounting for 78.75%). This region offers an ideal model for exploring the coupling relationships among agricultural biodiversity, traditional ecological knowledge, and tourism-driven economic transformation—with a specific focus on traditional utilization practices related to weed resources.

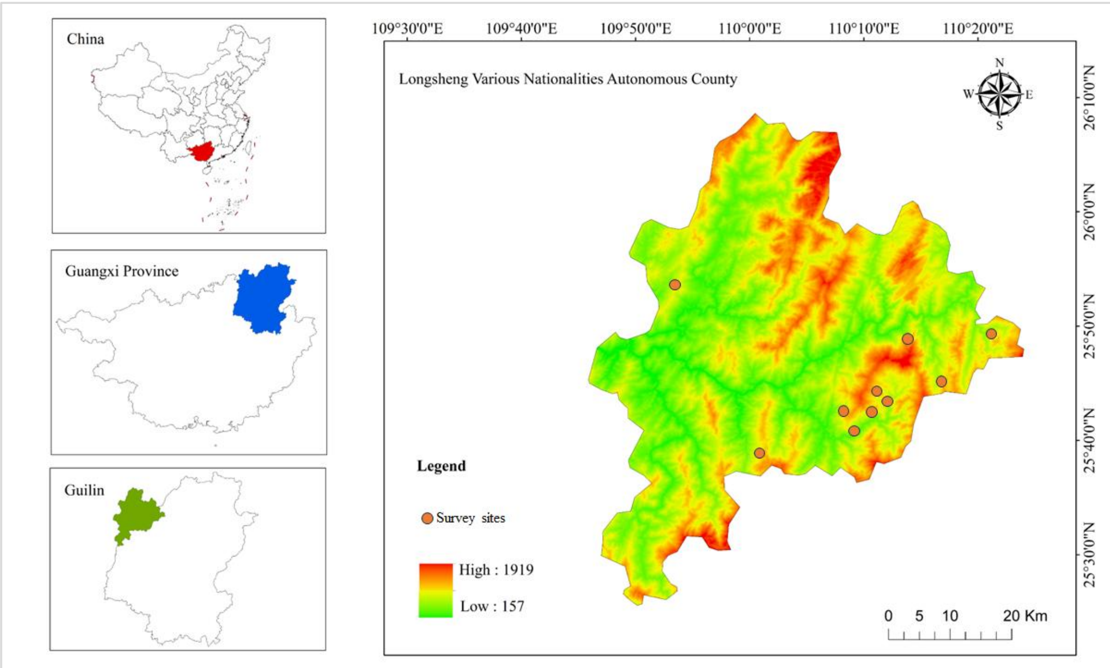

Figure 1 Locations of the 10 locations of Longsheng in China selected as study sites

2.2 Survey and Sample Collection

Field surveys were conducted at 10 sites within the Longsheng terrace system in July 2020 (Table 1), covering 11 types of typical habitats, including paddy field ridges, areas around houses, land for growing *Icacina oliviformis*, fallow fields, spider flower fields, monk fruit fields, polygonatum fields, peanut field ridges, corn field ridges, bletilla fields, and passion fruit fields. In accordance with the guidelines of the *Convention on Biological Diversity* (CBD), prior to the survey, research objectives were explained to community leaders and informants to obtain permission for cooperation, and official collaboration was established with the Agriculture and Rural

Bureau of Longsheng County to ensure that the collection of TEK (traditional ecological knowledge) adheres to the ethical norms of the *International Society of Ethnobiology* (2008). The survey was divided into three stages (Figure 2): (1) A preliminary survey of weed diversity was conducted along field ridges, with systematic collection of vascular plant samples; (2) Using the snowball sampling method combined with recommendations from the local government, key informants were recruited: a total of 36 individuals (14 males and 22 females), including members of the Zhuang (11 people, 72.7% aged ≥ 60 years), Yao (16 people, 81.25% aged ≥ 60 years), and Dong (9 people, 100% aged ≥ 60 years) ethnic groups; (3) Data collection: ① Key informants were clearly informed of the connotation of the term “farmland weeds”; ② Local names, uses, utilized parts, preparation methods, and frequency of weed utilization were recorded through semistructured interviews, with respondents given the option to answer voluntarily; ③ Interpreters (proficient in Mandarin, dialect, and ethnic minority languages) provided real-time translation and recording of plant names; and ④All mentioned species were identified by plant taxonomists on the basis of living specimens or images, voucher specimens were deposited in the Weed Herbarium of Nanjing Agricultural University, and image records were maintained for species without physical specimens.

Table 1 Study sites in the Longsheng Terraces, GIAHS

Ethnic Group	**Study Site**	**Tourist Attraction**	**Species Number of Weeds**	**Habitat**
Dong	Diling Village	No	76	Paddy field ridges Areas around houses Land for growing *Icacina oliviformis* Fallow fields Spider flower fields Monk fruit fields Polygonatum fields Peanut field ridges Corn field ridges Bletilla fields Passion fruit fields
Yao	Huangluo Yao Village	Yes	25	
	Jinkeng Terraces (Dazhai)	Yes	46	
	Jinkeng Terraces (Xiaozhai)	No	46	
	Buni Terraces	Yes	38	
	Jianxin Village, Chenglin Village, Shangmeng Village	No	105	
Zhuang	Pingan Zhuang Village	Yes	84	
	Jinjiang Village	No	59	

Figure 2 Panoramic views of the Longsheng terraces and pictures taken during the research

2.3 Statistical analysis

Quantitative ethnobotanical indices, including frequency of citation (FC), index of informant consensus (F_{ic}), use value (UV), relative importance (RI), similarity coefficient (S), and t tests, were used for data analyses.

2.3.1 Frequency of citations (FC):

To assess the importance of specific species, this study employed the frequency of citation (FC), one of the simplest and most widely used indices. This index ranges from 0 to 1: it equals 0 when no informants recognize the species as valuable and 1 when all informants mention the species, although such a scenario is rarely observed.

$$\mathrm{FC} = \frac{N_p}{N_i}$$

To assess the relative importance of each species, the total use value (UV) was calculated as follows:

$$\mathrm{UV} = \frac{\sqrt{U}}{N_i}$$

N_p: the number of informants who mention the particular use of the species

N_i: the number of all informants

U: the number of uses mentioned for each species.

2.3.2 Index of informant consensus (F_{ic}):

F_{ic} is an indicator of how many informants agree with a specific plant use of a particular category. F_{ic} is calculated via the following formula.

$$F_{ic} = \frac{N_{ur} - N_t}{N_{ur} - 1}$$

N_{ur}: the number of use reports in each category

N_t: the number of taxa used

2.3.3 Relative importance (RI):

The RI index theoretically varies from 0 when no one mentions any use of the plant to 1 when the plant was the most frequently mentioned as useful and in the maximum number of use categories.

$$\mathrm{RIs} = \frac{\mathrm{RFCs(max)} + \mathrm{RNUs(max)}}{2}$$

$RFC_{s(max)}$: the relative frequency of citations over the maximum.

$$\mathrm{RFCs(max)} = \frac{\mathrm{FCs}}{\max\mathrm{(FC)}}$$

$RNU_{s(max)}$: the relative number of use categories over the maximum.

$$\mathrm{RNUs(max)} = \frac{\mathrm{NUs}}{\max\mathrm{(NU)}}$$

2.3.4 Similarity coefficient (S):

The similarity coefficient (S) of valuable plant species among the three ethnic groups was calculated via the following formula:

$$\mathrm{S} = \frac{2c}{(a + b)}$$

where a and b represent the species used by two ethnic groups, and c represents the common species in both ethnic groups.

2.3.5 T tests:

T tests were used to examine the impact of sex on the reported knowledge of weeds and the influence of tourism on the utilization rate of weeds.

3 Results

3.1 Diversity and Taxonomic Characteristics of Weed Species

In this study, a weed survey was conducted in 11 types of habitats within the Longsheng terrace system in Guangxi (Figure 3), and a total of 189 vascular plant species belonging to 49 families were identified. Among them, the paddy field ridges had the highest weed diversity, with 148 recorded species, followed by the areas around houses, Glycosmis fields, and fallow fields, each with more than 50 species. Among the 189 weed species, 49 (accounting for 25.9%) were endowed with traditional utilization value by local ethnic groups (Appendix A). The dominant families included Polygonaceae (7 species, 14.29%), Asteraceae (5 species, 10.20%), and Lamiaceae (3 species, 6.12%) (Figure 4). Notably, the study revealed 6 invasive plant species, including Category 1 invasive species (highest risk level), namely, *Phytolacca americana*, *Bidens pilosa*, *Anredera cordifolia*, and *Erigeron annuus*; Category 3 invasive species (managed risk), namely, *Talinum paniculatum*; and the species to be observed, namely, *Plantago asiatica*.

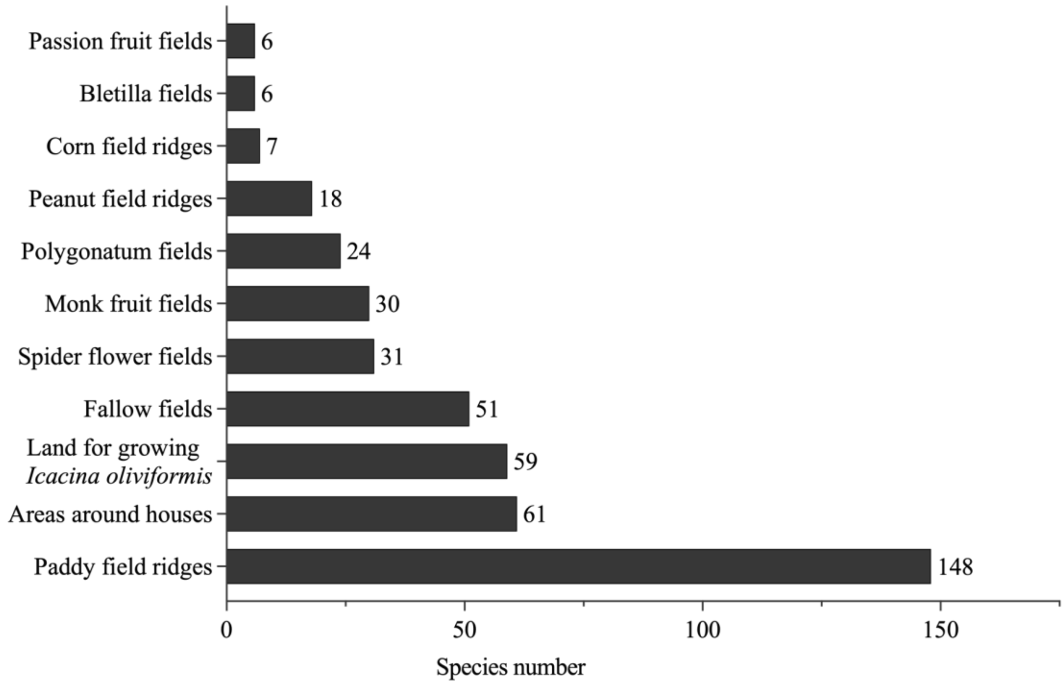

Figure 3 Numbers of weed species in different habitats of the Longsheng terrace

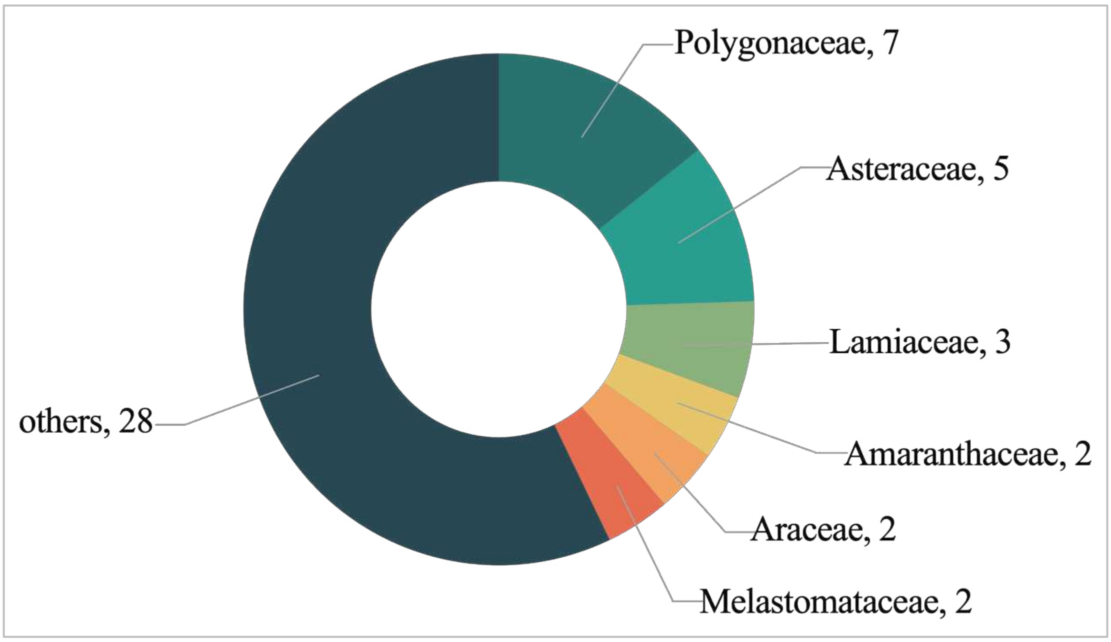

Figure 4 Numbers of weed plant species in different plant families

3.2 Types of Resource Utilization of Weeds

According to ethnobotanical surveys, 49 weed species have clear practical value, and their utilization strategies show significant preferences: traditional Chinese medicine (TCM) is dominant, followed by edible use, with forage and tool use accounting for relatively low proportions. This reflects the concentration of weed utilization directions—centered on medicinal and edible purposes—while also embodying the local emphasis on the medicinal value of weeds, the influence of TCM culture, and the integration of traditional dietary culture with natural resources. The specific classifications are as follows:

(1) TCM use: A total of 41 species (accounting for 81.6%) involved in the treatment of 36 types of diseases, covering common ailments such as coryza, snake bites, and rheumatism, were used. The usage methods include external application (e.g., mashing and applying), soaking in medicinal wine, and internal administration (e.g., decoction). For example, the whole plant of *Bidens pilosa* can be used to treat rheumatism and coryza, and *Lobelia chinensis* can be used to treat snake bite and edema, reflecting the role of weeds in the traditional medical system.

(2) Edible use: A total of 12 species (accounting for 24.5%), including wild vegetables (e.g., tender leaves of *Erigeron annuus* blanched and then cold mixed) and wild fruits (e.g., fruits of *Actinidia chinensis*). Among them, 7 species (accounting for 58.3%) have medicinal value, which is characteristic of the "homology of medicine and food". For example, the above-ground parts of *Houttuynia cordata* can not only be eaten cold as a dish but also assist in treating respiratory infections, demonstrating the versatility and utilization efficiency of weed resources.

(3) Forage use: A total of 6 species (accounting for 12.2%), all of which are used by the Yao people as supplementary pig feed. The main parts used are the above-ground parts (5 species). Among them, 4 species, *Colocasia esculenta*, *Polygonum nepalense*, *Murdannia triquetra*, and *Polygonum chinense*, need to be chopped and boiled to reduce toxins and improve palatability, whereas *Erigeron annuus* and *Phytolacca americana* can be fed directly, reflecting the local practical awareness of feed safety.

(4) Tool use: A total of 2 species (accounting for 4.1%). For example, the Dong people use the stem bark of *Boehmeria nivea* to weave fishing nets, and the tough natural fibers in its stem bark endow the tools with good durability. The Yao and Dong people mashed the leaves of *Polygonum hydropiper* and used the natural anesthetic substances released to catch the fish. These practices reflect the material support role of weeds in traditional livelihoods.

In terms of the plant parts used, 13 categories are involved, including the whole plant, above-ground part, tender leaf, leaf, root, rhizome, fruit, tuber, tender stem, seed, petiole, flower, and bark. The results revealed that whole plants (26.09%), aboveground parts (18.48%), roots (16.30%), and leaves (13.04%) were the main parts used, accounting for more than 73% of the total. This not only reflects the practical wisdom of efficiently obtaining plant biomass via traditional local utilization but also reflects the concentration of resource utilization. In addition, the utilization of parts such as tender leaves (8.70%) and fruits (5.43%) is also common, revealing an adaptive strategy for multidimensional and refined utilization of weed resources.

3.2.1 Analysis of the Medicinal Potential of Weeds and Consensus on Traditional Knowledge

In medicinal plant research, the index of informant consensus (Fic) reflects the degree of consensus among respondents regarding the uses of specific plants. Among the 49 weed species with practical value in this study, 83.7% (41 species) are utilized in traditional medicine, covering the treatment of 36 types of diseases. Among these, 8 disease categories—female metrorrhagia (severe), tonifying the kidney, furuncle, leukorrhea, removing leeches from the nasal cavity, rhinitis, fracture, and pulmonary tuberculosis—were mentioned only once and were thus excluded from the Fic calculation. Analysis of the Fic values for the remaining 28 disease categories revealed that 14 corresponded to a single plant species, resulting in a constant Fic value of 1.00. Additionally, 6 disease categories exhibit a high degree of knowledge consensus (Fic > 0.80), indicating that the associated utilization knowledge is widely recognized within the community, including the following:

Coryza (F_{ic}=0.92, *Bidens pilosa*, *Osmunda japonica*), snake bite (F_{ic}=0.92, *Lobelia chinensis*, *Viola philippica*), fever (F_{ic}=0.86, involving *Polygonum hydropiper, Glechoma longituba*, *Rotala rotundifolia*, *Eleusine indica*), diarrhea (F_{ic}=0.83, involving *Viola philippica*, *Reynoutria japonica*), hemostasis (F_{ic}=0.83, involving *Boehmeria nivea*, *Blechnum orientale*, *Melastoma dodecandrum*, *Rubus rosaefolius*, *Odontosoria chusana*), and rheumatism (F_{ic}=0.81, involving *Lygodium microphyllum*, *Bidens pilosa*, *Ranunculus sieboldii*, *Lycopodium japonicum*, *Polygonum capitatum*).

A comparison with the *Pharmacopoeia of the People's Republic of China* [35] revealed that 29 of the 41 medicinal weed species in this study were not included in the pharmacopoeia, indicating significant development potential (Appendix A). For example, the whole plant of *Cayratia japonica* mashed for external application can treat fractures, and when used internally, it can treat pulmonary tuberculosis; the flowers of *Iris japonica* decocted for internal use can alleviate pharyngalgia with swelling and gastralgia; the whole plant of *Grangea maderaspatana* decocted for internal use can treat hepatitis, etc. These unrecorded medicinal uses provide new research clues for expanding medicinal plant resources.

In addition, among the 14 plant species included in the *Pharmacopoeia of the People's Republic of China*, 9 traditional uses of 6 weed species remain unrecorded (Table 2). Specifically, the decoction of the above-ground parts of *Juncus effusus* can treat edema; the rhizome of *Fagopyrum dibotrys* applied externally can relieve leukorrhea symptoms; and the mashed whole plant of *Plantago asiatica* applied externally can treat traumatic injuries, etc. These supplementary effects offer new directions for developing the efficacy of known medicinal plants.

Table 2 Unrecorded uses of plants documented in the *Pharmacopoeia of the People's Republic of China*

SN	Plant species	Plant parts used	Ailment category	Application mode	UV
1	*Grangea maderaspatana*	Above ground part (Zhuang) Whole plant (Yao)	Edema	Decocted in water for internal use	0.08
2	*Fagopyrum dibotrys*	Root, Stem	Pharyngalgia with swelling, Gastralgia (Zhuang, Yao)	Decocted in water for internal use	0.08
			Leukorrhea (Zhuang)	Decocted in water for external use	
3	*Reynoutria japonica*	Root	Diarrhea	Decocted in water for internal use	0.06
4	*Achyranthes bidentata*	Whole plant	Dysentery	Decocted in water for internal use	0.06
5	*Viola philippica*	Whole plant	Diarrhea	Decocted in water for external use	0.07
			Dysentery	Triturated for external use	

6	*Plantago asiatica*	Whole plant	Traumatic injuries	Triturated or external use (Zhuang) Decocted in water for external use (Yao)	0.13

3.2.2 Edible Value and Utilization Characteristics of Weeds

Surveys revealed that among the 12 edible weed species, leaves (4 species, accounting for 33.3%), aboveground parts (2 species, accounting for 16.7%), and roots (2 species, accounting for 16.7%) were the main edible organs (Table 3). For example, the leaves of *Anredera cordifolia* can be stir-fried for consumption and are rich in protein and fiber; the roots of *Achyranthes longifolia* can be stewed with meat for consumption. In terms of processing methods, 3 species (accounting for 25%) can be eaten raw directly, such as the fruits of *Actinidia chinensis*; another 9 species (accounting for 75%) need to be cooked. For example, the leaves of *Centella asiatica* can be used to make soup. Cooking can degrade the secondary metabolites they contain and improve taste.

Notably, among these edible weeds, 7 species (accounting for 58.3%) also have medicinal effects. For example, the leaves of *Centella asiatica*, when stir-fried, are not only a vegetable with a unique flavor, but the triterpenoids they contain can also promote wound healing; the whole plant of *Eleusine indica* used in soup can clear heat and promote diuresis, and the flavonoids it contains endow it with therapeutic effects through the diet. This characteristic of "homology of medicine and food" provides natural materials for the development of functional foods.

Table 3 Plants and traditional knowledge of food

Plant species	Application mode	Use part	Plant species	Application mode	Use part
Actinidia chin ensis	Eating directly	Fruit (Zhuang, Yao, Dong)	*Dichroceph ala integrifo lia*	Eaten raw	Seed (Yao)
Centella asiat ica	Boiled into soup, Stir-fried	Leaf (Zhuang, Yao)	*Eleusine ind ica*	Cooked into soup	Whole plant (Dong)
Phytolacca a mericana	Chopped up and then cooked thoroughly Stewed with pig's feet	Leaf (Yao) Root (Dong)	*Erigeron an nuus*	Blanched and made into a cold dish	Leaf (Yao)
Achyranthes l ongifolia	Stewed with Polygala fallax, pork, and chicken	Root (Yao)	*Anredera co rdifolia*	Eaten after stir-fried	Leaf (Yao)
Talinum panic ulatum	Cooked into soup	Root (Yao, Dong)	*Perilla frute scens*	Cooked and eaten with duck	Leaf (Yao)

Hydrocotyle s ibthorpioides	Stri-fries with eggs	Tender leaf (Dong)	*Houttuynia cordata*	Cold mixed	Above-ground part (Yao)

3.2.3 Exploring the Potential of Weeds as Forage

The six weed species used as pig feed in this study were recorded through interviews with Yao informants, and these weeds were used locally as supplementary feed for pigs.

In terms of the plant parts utilized, the above-ground parts are the main feeding parts, involving 5 weed species, accounting for 83.3% of the total. The only exception is *Erigeron annuus*, whose main utilized part is the leaves. This is because the stem fibers of *Erigeron annuus* are coarse and hard, with extremely poor palatability, making it difficult for pigs to consume.

In terms of processing methods, 4 out of the 6 weed species (66.7%) require cooking treatment: the above-ground parts of taro, *Polygonum nepalense*, *Polygonum chinense*, and *Murdannia triquetra* need to be chopped first and then boiled. This process destroys the toxic components therein while improving the palatability of the feed. In contrast, *Erigeron annuus* and *Phytolacca americana* can be fed directly without additional processing.

3.3 Utilization value and relative importance of weeds in Longsheng terraces

This study quantitatively evaluated the comprehensive utilization value of weeds through the analysis of use value (UV) and relative importance (RI).

The results of UV analysis revealed that the UV values of the 49 weed species ranged from 0.04 to 0.14. The five species with the highest UV values were *Polygonum hydropiper* (0.14), *Plantago asiatica* (0.13), *Lygodium microphyllum* (0.12), *Actinidia chinensis* (0.11), and *Boehmeria nivea* (0.11). Specifically, *Polygonum hydropiper* can be used to treat dysentery, fever, and anesthetized fish; *Plantago asiatica* can be used to clear heat, detoxify, treat fever, promote diuresis, and cure traumatic injuries; *Lygodium microphyllum* has medicinal value for treating rheumatism and cutaneous pruritus with pain and alleviating blood circulation stagnation in elderly individuals; and *Actinidia chinensis* can be used for edible purposes. *Boehmeria nivea* has both medicinal functions and weaving uses. These characteristics fully reflect the comprehensive value of weeds in terms of their livelihood aspects, such as food, medicine, and tools.

Species with high relative importance (RIs) include *Phytolacca americana* (RI=0.75), *Polygonum hydropiper* (RI=0.67), *Plantago asiatica* (RI=0.67), and *Erigeron annuus* (RI=0.59). Among them, *Phytolacca americana* stands out in both its breadth of uses and citation frequency due to its functions in medicine (for treating edema), forage (pig feed), and food (tender stems and leaves stewed with meat), making it one of the weed species with high comprehensive value locally.

3.4. Differences in Weed Utilization Strategies and Used Parts among Different Ethnic Groups

This study recorded 49 weed species with traditional utilization value in the Longsheng Terraces. The Zhuang, Dong, and Yao ethnic groups presented significant differences in their ecological adaptation strategies and cultural practices regarding weed utilization (Figure 5).

The Zhuang ethnic group utilized 22 weed species, among which 20 are medicinal plants, forming distinct emergency external treatment methods that mainly target scenarios such as traumatic injuries, snake bites, hemostasis, and detoxification, with simple and efficient application methods. For example, *Viola philippica* is exclusively used by the Zhuang people; when ground into a paste for external application, it can detoxify snake venom and treat diarrhea and dysentery. The tender leaves of *Odontosoria chusana* are chewed and applied externally to achieve immediate hemostasis. The juice of *Scutellaria barbata* is used externally to treat traumatic injuries. The medicinal methods of these plants are mostly external application of mashed juice or external washing with a decoction, avoiding complex processing. There are few edible weeds, with only *Centella asiatica* and *Actinidia chinensis*.

The Dong ethnic group's utilization of medicinal plants is centered on the core characteristic of "living by water, homology of medicine and food", which is closely related to their fishing livelihood, with a particular emphasis on the homology of medicine and food. Among the 15 medicinal plants, 4 also have food uses, accounting for 26.7% of the conversion of medicinal plants into daily food ingredients. Owing to its strong toughness, the stem bark of *Boehmeria nivea* is woven into fishing nets, which serve as a fishing tool. Moreover, the Dong people discovered the anesthetic effect of *Polygonum hydropiper* leaves during fishing, which not only is used to improve fishing efficiency but also has medicinal value for treating fever, forming a closed-loop ecological wisdom of "using its tools to treat its injuries". For lower back pain, a common condition among those engaged in fishing due to frequent bending, Dong people use mashed leaves of *Sambucus javanica* soaked in wine for consumption. In addition, practices such as *Hydrocotyle sibthorpioides* frying eggs to treat gastralgia, *Phytolacca americana*, which uses pigs' feet as tonics, and *Talinum paniculatum*, which is used in soup to nourish the body and treat scalp pruritus, all reflect the tradition of combining medicine and food.

The Yao ethnic group utilized the most abundant weed species (34 species) with the most diverse uses, covering medicine, food, forage, and tools. Among them, medicinal plants are dominant (24 species), and their traditional knowledge in the field of trauma treatment is particularly rich, with 14 medicinal plants used externally. For example, *Glechoma longituba* is stir-fried, mashed, soaked in rice-washing water, heated on a pot lid, and can be applied externally to treat fever or used for scraping therapy to treat traumatic injuries; mashed *Boehmeria nivea* is used externally to treat traumatic injuries and external hemostasis; and *Polygonum chinense* soaked in wine and applied externally can treat traumatic injuries, and these plants can all be used for medicinal baths. In addition to medicinal use, the Yao people also use 6 weed species, namely, *Phytolacca americana*, *Polygonum chinense*, and *Polygonum nepalense,* as forage. The steep terrain limits crop cultivation, prompting them to "replace grain with grass" by developing forage plants. Moreover, the use of fruits of *Rhus chinensis* to remove leeches from the nasal cavity and the use of *Polygonum hydropiper* to anesthetize fish for fishing are adaptations to the terrace living environment.

Among the 41 medicinal weed species and 66 usage methods used in this study, the whole plant used for medicine accounted for 33.3%. This not only reflects that the active ingredients of some medicinal plants may be widely distributed in different parts, such as roots, stems, and leaves but also embodies the practical wisdom of maximizing the utilization of herbal resources. Another 18.2% of the usage methods involve leaves, and 16.7% involve roots. The utilization of edible weeds is based mainly on leaves, accounting for 41.2%, followed by roots (23.5%) and fruits (17.6%). Owing to their large biomass, easy access, convenient collection, and strong regenerability, weeds are used as forage for almost all the above-ground parts. Notably, the utilization of specialized parts (such as the Dong people taking the stem bark of *Boehmeria nivea* to weave nets and using its roots for treating rheumatism) further highlights the ecological wisdom of matching functions with structures.

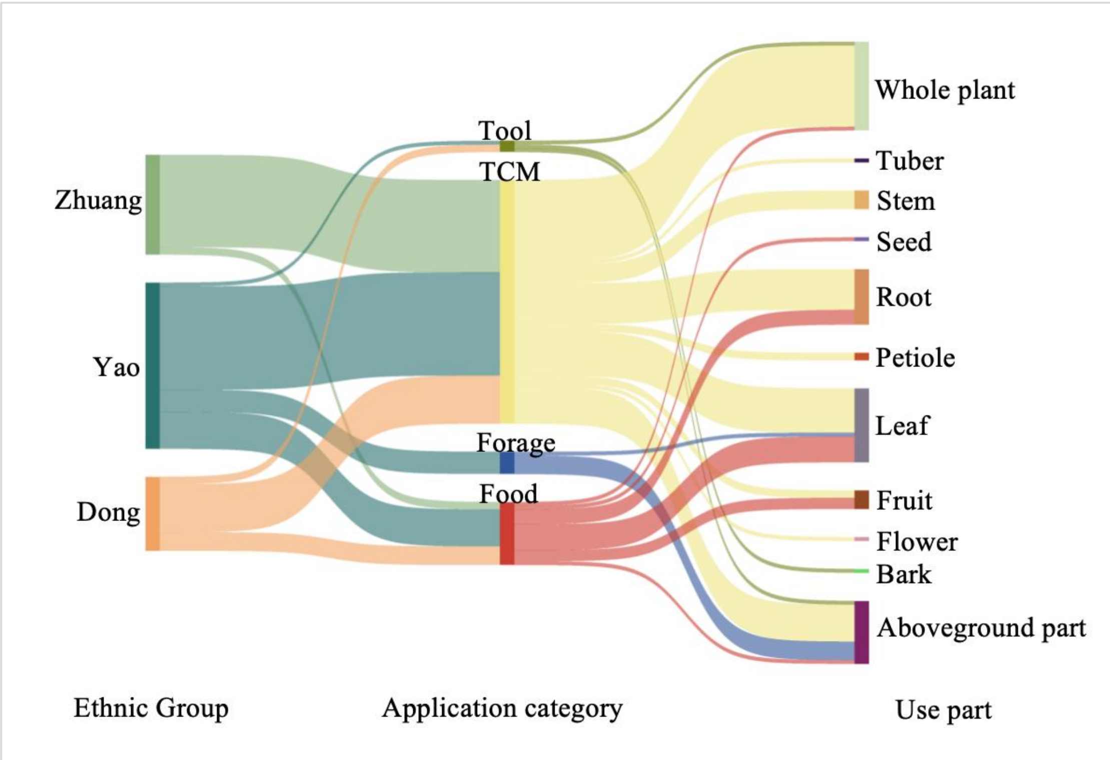

Figure 5 Ethnic differences in weed application categories and use parts

3.5. Relationships among weed species utilized by different ethnic groups

Similarity coefficient analysis further quantified these differences. The similarity in weed utilization between the Zhuang and Yao ethnic groups was the highest (S=36.36%), with 11 plant species used in common. The similarity between the Yao and Dong ethnic groups was the next highest (S=32.00%), sharing 10 plant species, most of which had broad-spectrum first-aid functions (e.g., *Plantago asiatica* for treating traumatic injuries, *Polygonum hydropiper* for fever). The similarity between the Zhuang and Dong ethnic groups was the lowest (S=10.81%), with only 4 shared plant species, all of which are commonly used by all three ethnic groups (Figure 6).

Significant differences also existed at the functional level: the Yao people were the only ethnic group that used weeds as forage and retained the tradition of using *Polygonum hydropiper* leaves for fishing. The Dong people not only used *Polygonum hydropiper* leaves to anesthetize fish but also featured the use of *Boehmeria nivea* stem bark for weaving fishing nets. These differences are closely related to the livelihood patterns (e.g., Yao's breeding industry and Dong's fishing industry) and cultural traditions of each ethnic group.

There are 4 "universal weeds" commonly utilized by the three ethnic groups, whose functions are focused mainly on medicinal and edible uses. (1) *Plantago asiatica* (FC=0.61): The whole plant is used for medicinal purposes. All three ethnic groups use it as a decoction for internal use to clear heat and detoxify. The Zhuang and Yao ethnic groups also apply it externally to treat traumatic injuries, and the Yao people additionally use it for diuresis. (2) *Polygonum hydropiper* (FC=0.61): The medicinal parts vary among ethnic groups—the Zhuang uses the whole plant, the Yao uses the leaves, and the Dong uses the above-ground parts. Its effects include treating fever, reducing swelling, relieving pain, curing traumatic injuries, and addressing dysentery. Moreover, the Yao and Dong ethnic groups also use it to anesthetize fish. (3) *Lygodium microphyllum* (FC=0.44): The above-ground parts are used for medicinal purposes. The Zhuang and Yao ethnic groups use it to treat rheumatism and cutaneous pruritus with pain, and the Yao people additionally use it to improve blood circulation disorders in elderly individuals. (4) *Actinidia chinensis* (FC=0.47): Its fruits are a wild resource commonly consumed by all three ethnic groups. These four "universal weeds" also had the highest FC values, reflecting the importance of these plants.

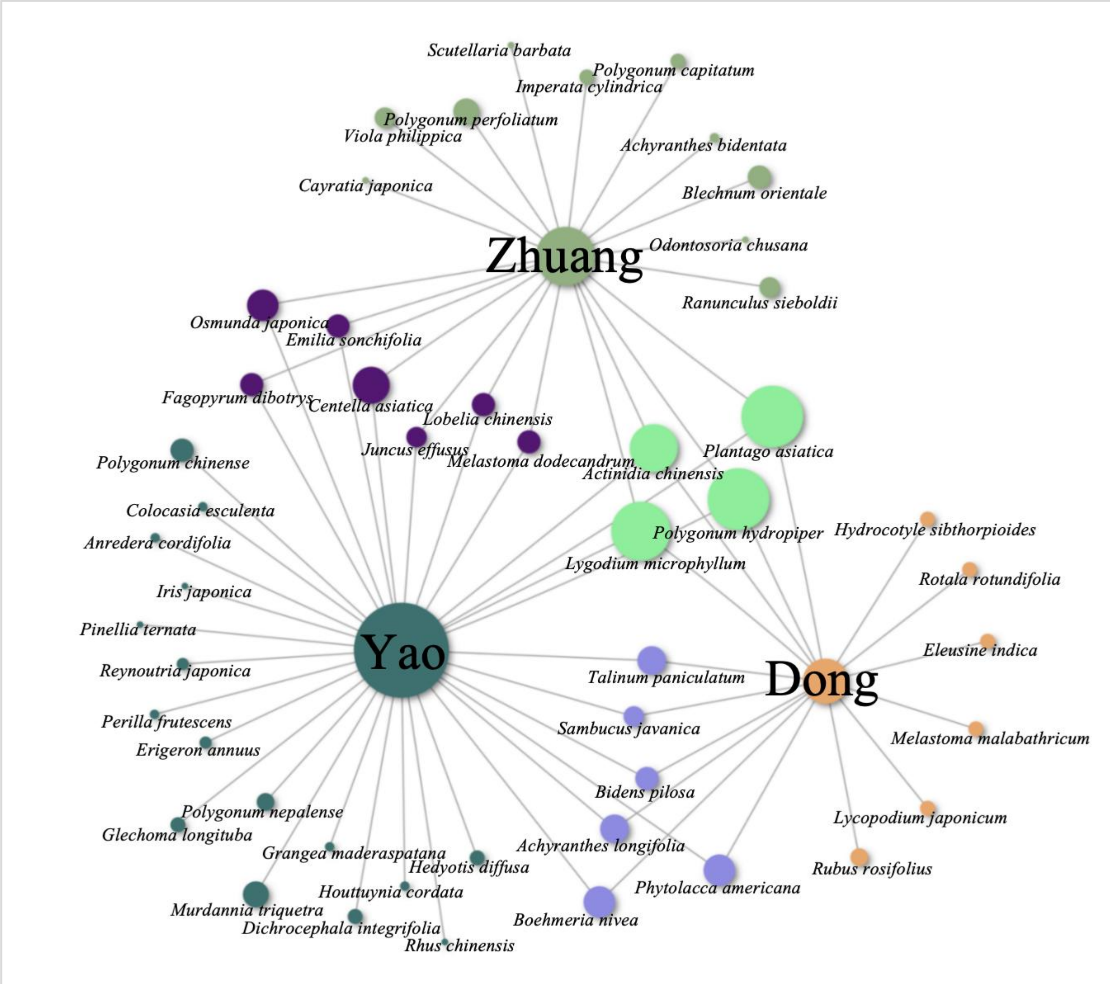

Figure 6 Network analysis diagram of plant use among the Zhuang, Yao, and Dong ethnic groups in Longsheng Terrace

3.6 Impact of Age and Tourism on Weed Utilization

Traditional knowledge regarding weed utilization shows an intergenerational declining trend, with respondents over 60 years old having significantly more knowledge reserves than younger groups do. The results of the t test indicate that there is no significant gender difference in knowledge mastery (*P=0.8968*), suggesting that the inheritance of weed utilization knowledge in the Longsheng terrace community does not exhibit an obvious gender bias.

The study revealed that tourism activities have not "dissolved" the traditional wisdom of local weed utilization. Although Longsheng is a popular tourist destination, the results of t test reveal that there is almost no significant difference in weed utilization rates between tourist areas and nontourist areas (*P=0.4236*). This result deviates from expectations, and the speculated reasons may be as follows: tourists' dietary needs are met mainly through farm stays, whereas local villagers still maintain their traditional dependence on weeds, such as the use of weeds to treat diseases and feed livestock. In other words, tourism activities have not replaced villagers' traditional demand for weeds, thus allowing the utilization pattern of weeds to remain stable.

4 Discussion

4.1 Ethnic Practices and Cultural Adaptation of Weeds in Longsheng Terraces

This study recorded 49 weed species with traditional utilization value in Longsheng Terraces (Appendix A), among which 83.7% (41 species) are used in traditional medicine, involving the treatment of 36 types of diseases. This result further confirms the core role of weeds in supporting the traditional medical system of agricultural communities and echoes the conclusion that "weeds are an important source of ethnic medicine" across regions [18, 36]. Notably, 27 plant species found in this study have not been included in the *Pharmacopoeia of the People's Republic of China*, and even for those already included in the pharmacopoeia, 9 uses of 6 plant species have not been recorded. This indicates that the traditional knowledge of various ethnic groups in Longsheng contains many unexplored medicinal resources, which is consistent with the rule that new medicinal plant species are continuously discovered through ongoing ethnobotanical surveys [37-39]. Moreover, the preference for medicinal plants is dominated by the whole plant (33.3%), whereas nonmedicinal parts are almost all above-ground parts, with some specialized parts also utilized. This shows that local people pursue both the maximization of resource efficiency and the optimization of functions, which together constitute the sustainable collection ethics of the terrace community.

The differences in the utilization of core medicinal plants among the Zhuang, Yao, and Dong ethnic groups resulted from the long-term interactions between their cultural traditions in specific ecological environments and natural conditions. This practice provides a vivid case for understanding the coevolution of "disease-plant-culture":

(1) From the perspective of Zhuang people's practices, their weed utilization features the characteristic of "first aid in mountain forests". The 10 unique weed species that are exclusively used by the Zhuang people are all medicinal, and most have traditional uses that target specific diseases. This has enabled the Zhuang people to form a knowledge system of "specific weeds for specific treatments" in the herbal treatment of certain diseases, which is in sharp contrast to the Dong people's "homology of medicine and food" model. This reflects the different explorations of the medicinal value of plants by different cultures within the same geographical region.

(2) Dong people live mostly in high-altitude terraces. The cold and humid environment gives rise to the need to treat fever, rheumatism, and nourishment. The limited cultivated land has prompted them to develop wild food resources (such as tender leaves and rhizomes), thus forming the "homology of medicine and food" survival strategy.

(3) Yao people's diverse use of medicinal plants (a total of 24 species, mainly for medicinal purposes) is closely related to their unique "Pangtong medicinal bath" culture.

The "Pangtong medicinal bath" is a living custom and health care method inherited by the Yao people for thousands of years. For example, the Yao people include *Achyranthes longifolia*, *Lygodium microphyllum*, *Sambucus chinensis*, *Glechoma longituba*, *Melastoma malabathricum* and other plants in the medicinal bath formula. These herbs exert anti-inflammatory effects through transdermal absorption, addressing the high incidence of rheumatism caused by high humidity and heavy fog in mountain-dwelling environments [40]. In addition to rheumatism, problems such as skin inflammation caused by mosquito bites in mountain-dwelling environments and muscle soreness after labor are also alleviated through the use of medicinal baths with different herbal combinations, resulting in a pattern of utilizing medicinal plant diversity that far exceeds that of other ethnic groups.

The cultural traditions of each ethnic group have transformed and functionally adapted local resources according to their needs. The "external application-oriented" utilization model commonly adopted by the three ethnic groups is an active adaptation to the common health threats in mountainous areas.

In terms of the correlation between plant multifunctionality and relative importance (RI), the high RIs of *Phytolacca americana* (RI=0.75), *Polygonum hydropiper* (RI=0.67), and *Plantago asiatica* (RI=0.67) are directly related to their composite values. Taking *Phytolacca americana* as an example, its aboveground parts can be used as pig feed, its tender leaves can be used to treat edema, its leaves can be chopped and cooked for consumption by the Yao people, and its roots can be used by the Dong people for stewing meat. This "one weed with multiple effects" utilization model not only improves resource utilization efficiency but also strengthens the memory and inheritance of medicinal efficacy knowledge through daily livelihood practices. Similarly, *Polygonum hydropiper* (RI=0.67) has functions such as treating fever, dysentery, and traumatic injuries; reducing swelling; relieving pain; and anesthetizing fish. *Plantago asiatica* (RI=0.67) covers uses such as external application for traumatic injuries and internal use for clearing heat and detoxifying as well as promoting diuresis.

Network analysis and similarity coefficients quantify knowledge sharing and isolation among ethnic groups. The similarity of medicinal efficacy knowledge between the Zhuang and Yao ethnic groups reaches 36.36% (higher than the 10.81% between the Zhuang and Dong ethnic groups), and most of the shared knowledge involves broad-spectrum first-aid functions, reflecting the common risks in mountainous environments (trauma, heat-related syndromes). This relatively high similarity may stem from the convenience of medicinal material exchange caused by geographical proximity (e.g., *Fagopyrum dibotrys* is used by both ethnic groups to treat gastralgia). In contrast, owing to their larger area of *Icacina oliviformis* cultivation land, the Dong ethnic group has developed distinctive herbal knowledge targeting damp-heat syndromes (such as the localized use of *Bidens pilosa*).

4.2 Traditional Consensus on Medicinal Efficacy and Potential for Modern Verification

The traditional uses of core medicinal plants and modern pharmacological research can provide a dual pathway for drug development and the scientific recognition of traditional knowledge.

For some plants that have received support from modern research, the traditional uses recorded in this study are highly consistent with their pharmacological activities. For example, Zhuang people use the above-ground parts of *Lygodium microphyllum* to treat rheumatism (Fic=0.81). This traditional practice is highly consistent with findings from modern research: components such as quercetin, kaempferol, trifolin, pyroglutamic acid, arachidonic acid, and rutin contained in *Lygodium microphyllum* have been proven to possess antioxidant, antibacterial, and anti-inflammatory activities, thus confirming the scientificity of traditional usage [41]. Another example is *Phytolacca americana*, which is used by both the Yao and Dong ethnic groups. The Yao people chop its tender stems, leaves, and above-ground parts to make soup for treating edema, whereas the Dong people stew its roots with pig feet for nourishment and health preservation. Although this plant contains toxic components such as phytolaccines and requires strict control of dosage, modern studies have shown that its extracts exhibit significant antibiosis, antitumor, antioxidant, antiviral, anti-inflammatory, toxicological, and molluskicidal effects [42], which provides an important research entry point for analyzing the local traditional experience in balancing "toxicity and medicinal efficacy" (such as the processing methods used by the Yao people).

In addition to the 27 medicinal plant species not included in the *Pharmacopoeia of the People's Republic of China*, among the 14 medicinal plant species that have been included, 9 traditional uses of 6 weed species have not been recorded (Table 2). For example, (1) the Zhuang people (UV=0.08) use the above-ground parts of *Juncus effusus*, and the Yao people use its whole plant to treat edema, whereas the Pharmacopoeia records only its ability to clear heart fires. The traditional use of this plant by the Zhuang and Yao ethnic groups in Longsheng for treating edema suggests that the plant may contain specific components that target edema, which is consistent with the functions of the isolated compounds that can regulate estrogen and have anti-inflammatory activities [43]. (2) Both the Zhuang and Yao ethnic groups use the rhizome of *Fagopyrum dibotrys* decocted in water for internal use to treat pharyngalgia with swelling and gastralgia; the Zhuang people use its decoction for external application to treat leukorrhea. However, the Pharmacopoeia only records its effects of clearing heat, detoxifying, draining pus and removing blood stasis; notably, the traditional experience of Zhuang people using the rhizome of *Fagopyrum dibotrys* externally to treat leukorrhea provides a beneficial complement to the conclusion of modern studies that its rhizome has anti-inflammatory and antibacterial activities [44].

(3) According to the *Pharmacopoeia of the People's Republic of China*, the roots and stems of *Reynoutria japonica* (UV=0.06) promote diuresis to alleviate jaundice, clear heat and detoxify, dissipate blood stasis to relieve pain, relieve cough and reduce phlegm, and through phytochemical and pharmacological analysis, it is considered a potential natural agent for treating digestive system diseases [45]. The roots of the three ethnic groups in Longsheng have long been decocted in water for internal use to treat diarrhea, and this practice provides folk experiential support for the application of its pharmacological effects. (4) In the Pharmacopoeia, *Achyranthes bidentata* (UV=0.06) is only used as a medicine with its roots, and its effects include promoting blood circulation to remove blood stasis, unblocking the meridians, tonifying the liver and kidneys, strengthening muscles and bones, promoting diuresis and treating stranguria, and guiding blood to descend; however, the three ethnic groups in Longsheng have supplemented its usage of being decocted in water for internal use to treat dysentery. Previous studies have confirmed that *Achyranthes bidentata* polysaccharides can improve the intestinal morphology and microbial community structure of chickens [46], and the practice of the ethnic groups in Longsheng applying these polysaccharides to humans suggests that they may have similar regulatory effects on the human body. (5) The whole plant of *Viola philippica* (UV=0.07) is recorded in the Pharmacopoeia to clear heat, detoxify, cool blood and reduce swelling, while the people of Longsheng use its decoction for external application to treat diarrhea or mash it for external application to treat dysentery. The anti-diarrhea effect of its congener *Viola canescens* has been verified [47], which provides a direction for exploring the active components of *Viola philippica* against diarrhea and dysentery. (6) The whole plant of *Plantago asiatica* (UV=0.13) is recorded in the Pharmacopoeia to clear heat, promote diuresis, treat stranguria, eliminate phlegm, cool blood, and detoxify; the Zhuang people have supplemented the usage of mashing it for external application to treat traumatic injuries, and the Yao people use its decoction for external application to treat traumatic injuries. Like *Viola philippica*, compounds with wound healing-promoting and anti-inflammatory activities have been isolated from its congener *Plantago subulata* [48], which echoes the usage of *Plantago asiatica* in ethnic medicine. The 9 uses of these 6 weeds that are not recorded in the pharmacopoeia alone are sufficient to reflect the value of traditional medicinal weeds in Longsheng, and the importance of the remaining 27 medicinal plant species not included in the *Pharmacopoeia of the People's Republic of China* is self-evident, as they contain more abundant active medicinal compounds and can be called untapped treasure houses of natural medicines.

The core medicinal plants (such as *Phytolacca americana*, *Polygonum hydropiper*, *Plantago asiatica*, and *Erigeron annuus*) identified in this study through relative importance (RI) and an index of informant consensus (F_{ic}) screening not only demonstrate their medicinal value through significant quantitative indicators but also embody the practical wisdom formed by local ethnic groups in the long-term process of adapting to the environment. In terms of knowledge consensus, the associations between diseases corresponding to high Fic values (>0.8) (coryza, snake bite, fever, diarrhea, hemostasis, and rheumatism) and core plants have a clear logic of ecological adaptation. For example, Longsheng Terraces feature a mountainous and humid environment, where rheumatism (Fic=0.81) is a prevalent disease. *Lygodium microphyllum* (aboveground parts), as a core species for treating such conditions, is utilized by all three ethnic groups, with its frequency of citation (FC) and consensus ranking among the highest across the three groups. This consensus is not accidental but rather a "therapeutic effect–environment" matching scheme screened out by the community through intergenerational practices. For example, the anti-inflammatory components (such as quercetin) in *Lygodium microphyllum* are highly compatible with exogenous diseases in humid environments [41]. The knowledge of the medicinal efficacy of such high-Fic plants is essentially the result of the coevolution of "disease-plant-culture".

This "farmland-edge pharmacy" model provides low-cost healthcare strategies for rural communities, particularly those that play a significant role in areas lacking modern medical resources [24]. However, with the reduction in the number of medicinal plants and the intergenerational disruption of traditional knowledge, these resources face the risk of loss. As FAO warned, global agricultural biodiversity is disappearing at an alarming rate [5]. Therefore, there is an urgent need to systematically evaluate the medicinal potential of these weeds by combining ethnobotanical and molecular biological methods and to simultaneously protect the species and their associated traditional knowledge through the establishment of "cultural–ecological" protected areas [49].

4.4 Resource utilization of invasive plants: Implications for ecological management

Among the 49 weed species with traditional utilization value, 6 are invasive plants, including 4 Category 1 invasive species (highest risk level), such as *Phytolacca americana* and *Erigeron annuus*. They have high relative importance (RI) values (0.75 and 0.59, respectively) because of their multiple functions, such as medicinal, edible, and forage uses. This finding challenges the one-sided view that "invasive species are merely ecological threats" and supports the perspective that "invasive species may have cultural and practical value in local contexts" [50]. These conflicting findings on invasive plants require detailed research on the TEK of human populations that coexist with invasive plants to understand the balance between positive and negative impacts [51].

The Yao people's practice of using them as pig feed not only inhibits their spread through manual collection but also enhances the economic efficiency of ecological control through the "medicinal-forage" value chain. For example, after the tender stems and leaves of *Phytolacca americana* are fed to pigs, their trace toxic components can increase their disease resistance. This traditional wisdom of "using poison to attack poison” provides a low-cost solution for the resource-based management of invasive species. Compared with chemical control (such as soil pollution caused by the abuse of glyphosate), such models are more sustainable at agricultural heritage sites such as Longsheng Terraces.

Moreover, the potential for industrialization of the medicinal efficacy of these plants is worthy of attention: the effects of *Plantago asiatica* (UV=0.13) in treating traumatic injuries and clearing heat and detoxifying can be developed into portable medicine packs for mountainous areas; the multiple uses of *Phytolacca americana*, *Erigeron annuus*, and *Talinum paniculatum* (UV=0.09, 0.06, 0.10) make them suitable for creating “homology of medicine and food” products. A community-led cooperative model can convert traditional knowledge into economic benefits, which in turn feeds back into its protection—this is exactly the practical path of “utilization promoting protection” [52].

4.5 Intergenerational crisis and conservation strategies for TEK

The results of linear regression indicate an intergenerational decline in weed-related knowledge, with the understanding of the medicinal efficacy of core medicinal plants being the most severely lost among young groups; thus, urgent targeted protection is needed. The root causes of the crisis include replacement by modern medicine (e.g., commercial cold medicines replacing *Bidens pilosa* and *Osmunda japonica*), reduced field practices due to urbanization, and the weakening of traditional education systems [24, 30] The elderly over 60 years of age, as “living knowledge repositories”, have demonstrated the experience-dependent nature of TEK through their advantages [30]. The gender-neutral inheritance (P=0.8968) reflects the equality in knowledge distribution within Longsheng communities, but it cannot offset the substitution effect of modernization (e.g., popularization of Western medicine, industrialization of feed). Without establishing a community-led participatory protection mechanism, the wisdom of terrace weeds may face the risk of “de-ecologization” [53].

Conservation strategies need to balance cultural identity and practical value: (1) Establish a “medicinal efficacy knowledge database”: Record elders’ experiences in identifying, processing, and combining core plants (such as controlling the decoction time of *Fagopyrum dibotrys* rhizomes) through short videos, and develop a mobile recognition system combined with AR technology to lower the learning threshold for young people; (2) Integrate into local education: Offer “Terrace Herb Courses” in primary and secondary schools in Longsheng, using common plants like *Plantago asiatica* and *Polygonum hydropiper* as cases, and integrate medicinal efficacy knowledge with biology and chemistry courses (e.g., testing the relationship between the pH value of *Lygodium microphyllum* and its anti-inflammatory properties); (3) Promote community participatory protection: Relying on the intangible cultural heritage project of “Pangtong medicinal bath”, organize Yao physicians to teach apprentices and pass on their skills, while standardizing the collection quantity of core plants (e.g., setting an annual harvesting quota for *Phytolacca americana*) to ensure resource sustainability and simultaneously protect species and their associated traditional knowledge through the establishment of “cultural-ecological” protected areas [49].

Future research can focus on two directions: multiomics studies (genomics + metabolomics) of core plants to analyze the molecular mechanisms underlying the unique medicinal effects of plants such as *Juncus effusus* and cross-cultural comparisons of medicinal efficacy knowledge among different ethnic groups, such as whether the differences in the usage of *Polygonum hydropiper* between the Zhuang and Yao ethnic groups are related to genetic polymorphisms.

5 Conclusion

Weeds in the Longsheng Terraces of Guangxi are resources with unique value embedded in globally important agricultural heritage systems. Through ethnobotanical and weed science methods, this study revealed that among 189 local weed species, 49 have been endowed with traditional utilization value, covering multiple functions, such as medicinal, edible, forage, and tool material uses. These functions embody the traditional wisdom of “homology of medicine and food” and efficient resource utilization. Among them, core species such as *Phytolacca americana*, *Polygonum hydropiper*, and *Plantago asiatica* have become the focus of local utilization due to their prominent comprehensive value. In the Longsheng area, all ethnic groups primarily use weeds for medicinal purposes, while the Yao people’s unique utilization of forage weeds, the Zhuang people’s distinctive knowledge of medicinal plants, and the Dong people’s traditional use of weeds for fishing constitute the distinctive characteristics of each ethnic group. There are differences in utilization knowledge among ethnic groups: the Zhuang and Yao peoples are more similar, whereas the difference between the Zhuang and Dong peoples is more obvious. Notably, traditional knowledge has a significant intergenerational decreasing trend, and tourism development has not had a significant effect on the local weed utilization rate. These weeds and the traditional knowledge they carry not only involve the crystallization of wisdom for addressing local survival needs but also provide important references for biodiversity conservation, traditional knowledge inheritance, and sustainable agricultural development at global agricultural cultural heritage sites. Protecting them means safeguarding the precious experience of long-term coexistence between humans and nature.

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Acknowledgments

Special thanks to Yunbiao Liao and Caiai Nong for their assistance with contact and translation. Gratitude was also extended to Shi Qi to help with the field surveys. Many thanks to the 36 informants from Longsheng County.

Funding

Support for this study was provided through grants from the Fundamental Research Funds for the Central Universities (Grant No. KYXJ202006), GEF-Building Sustainability into PA Reforms to Conserve Globally Significant Biodiversity in China(GEF No. 9461), the National Natural Science Foundation of China (Grant No.

31600254), and Agricultural Research Funding from the Ministry of Agriculture and Rural Affairs of China (Survey on Occurrence, Damage and Spread Risk of Alien Invasive Species in Agriculture (HYJG22103).

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Contributions

LYJ was responsible for the conception, design, and methodology formulation of the study; LYJ and HRC jointly undertook the field survey work; LYJ and HRC collaborated to complete plant identification; MWL, ZY, and ZJR were in charge of data analysis; MWL and ZY took on the writing task; LHO was responsible for resource acquisition and liaison matters, and together with LYJ, oversaw the review and finalization of the paper.

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Ethics declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Supplementary Information

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