In-situ Conservation of Traditional Vegetable Diversity in Wa Homegardens in Southwestern Yunnan, China

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Research Article

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Abstract

Background: Homegardens are recognized as in-situ conservation sources of germplasm diversity to overcome homogenous germplasm problems in the industrial agriculture system; it is crucial to understand how smallholders manage their homegardens to maintain traditional genetic resources. Wa is a long-dwelling ethnic group living mainly in southwest Yunnan, China.

Traditional vegetables in homegardens management are still central to farmers’ livelihoods in Wa villages. We surveyed traditional vegetables in Wa homegardens and analyzed the factors conserving traditional vegetables in the homegardens management.

Methods: The methods used in this work included semi-structured interviews, questionnaires, and field surveys. A total of 60 households through purposive sampling in three townships, 6 villages were surveyed. We documented ethnobotanical information on local name, edible methods, edible parts of traditional vegetables maintained in Wa homegardens. Plant species cultivated in Wa homegardens were identified according to Flora of China.

Results: Fifty-five traditional vegetable varieties and 36 hybrid vegetable varieties in the homegardens were recorded. Among all the villages, $23 \pm 6$ (average $\pm$ S.D.) traditional vegetable varieties per homegarden and $9 \pm 3$ (average $\pm$ S.D.) introduced vegetable varieties per homegarden were recorded. 78% of households choose to store the local seeds themselves, with a further 9% of households’ seed supplies coming from neighbors and relatives, other 13% of households choose to purchase local seeds in the markets. In 83% of families, the female head holds the main responsibility for decision making for traditional vegetables planted in homegardens; in 10% of families were male head household to take responsibility for decision-making, and a small percentage which is 2% is determined by the elderly. 5% of families will make decisions jointly between both male and female household heads.

Conclusions: This study demonstrated that rich traditional germplasm diversity is harbored in the Wa homegardens because of Wa communities’ unique culture and traditional knowledge, which is practiced daily using homegrown food plants. Local vegetable seed saving and sharing systems can help maintain the germplasm diversity in the Wa community’s homegardens. Wa homegardens can be a practical solution to protect the traditional germplasm diversity and maintain a lifestyle with traditional culture.

Background

Traditional vegetables are cultivated varieties arising through a long history of selection and cultivation in places like homegardens. 'Traditional’ vegetables are defined as those ‘indigenous or exotic species which, due to prolonged use, have become part of the culture of a community[1]. As the world’s population continues to grow, high malnutrition rates, insufficient energy sources, and a lack of essential nutrients, like vitamins, continue to be of serious concern [2]. The urgent need for food security and nutrition requires dietary diversity, particularly vegetables, for health [3, 4]. [2]Traditional vegetables have considerable commercial value and high market potential to contribute the household income [5].
However, traditional vegetables as a valuable source for food and nutritional security are underutilized and under-represented in the global conservation system for plant genetic resources [6–8]. Due to the expansion of the global market economy and modernization of agriculture, high yield hybrid vegetables have become more popular and valued. However, the diversity of traditional vegetables are threatened with extinction [9, 10].

Homegardens are recognized as a source of high vegetable germplasm diversity, which can be essential to overcome food-security problems, such as loss of food sources from rapidly spreading diseases associated with homogenous germplasm in the industrial agriculture system [11–13]. Homegardens possess many attributes to make economic, social, and ecological contributions to sustainability. Homegardens provide edible vegetables, medicinal plants, ornamental plants, firewood crops, and fodder without negatively causing the resource shortages for self-sufficiency and social values underpinning and contributing to cultural diversity [14, 15]. [17, 18] Furthermore, traditional homegardens are more sustainable and adapted to local demands by planting traditional varieties and using traditional management knowledge [16, 17].

The diversity in homegardens can be affected by the interactions with spatial, environmental, demographic, social, economic, and cultural factors to influence agricultural practices management. Diversity in homegardens is influenced by the size of communities, ethnicity of residents and geographical position away from the town [18]. Also, elevation, location, homegarden size, distance to market, additional land ownership (outside the homegardens) and livestock ownership are significant predictors of crop diversity [19]. Besides, a household’s family structure is associated with the diversity of plants of homegardens [20]. Ancestor worship and dietary culture could be the vital reasons for farmers to keeping and cultivated local vegetables [21]. The roles of traditional knowledge to protect genetic diversity have been acknowledged [22–24], and it has much potential to help design more effective conservation for agrobiodiversity, especially for traditional vegetables [25]. Gender is also another factor that influences the crop diversity in homegardens [26], previous study has shown that the awareness of the importance of organic vegetables planted in the homegardens has been increased by women [27].

China has a long history of traditional vegetable cultivation in homegardens, maintaining this vegetable cultivation [28, 29]. Studies have shown homegardens can be a source of germplasm bank for the conservation of local varieties [30–32]. [35] In southwest China, homegardens are small-sized agroecosystems and provide an on-farm conservation strategy consistent with household socio-economic characteristics [33–36]. Wa people is one of the 55 ethnic minorities in China. Wa people mainly inhabit the mountain areas called “Wa mountains” in the southwest of Yunnan. The Wa people speak the Wa language and do not have written words in history. The Wa villages are located on the hillside, and the traditional houses were built with thatch, bamboo, and timber. Each house has a fire pit inside to cook food and keep the house warm. Their staple foods are rice, corn, and buckwheat. The traditional belief of Wa people is animism, and they hold nature worship, ancestor worship, animal and plant worship [37]. The Wa mainly lived on abundant plant resources in the mountains and forests near the villages; they practiced swidden agriculture, hunting, and gathering activities. Due to their long history
of interacting with the plant resources around the living environment and crop farming practices, Wa people have developed various dietary cultures and traditional specialties[21, 38].

This study demonstrates traditional vegetable diversity and the factors of Wa households conserving traditional vegetable resources in the homegardens in Wa areas. We address three key questions: (1) What traditional vegetable varieties do the households prefer to plant in their homegardens? (2) who does decision-making for homegarden management in the household? Moreover, (3) Why do households continually plant traditional vegetables in their homegardens? We argue that Wa homegarden management is a promising approach for conserving traditional vegetable resources to keep dietary diversity and self-sufficiency.

**Methods**

**Research area**

The research area lies in the mountainous region of the southern part of the Nu Mountains at the border with Myanmar in the southwest Yunnan province of China, located between the west of Lancang River and the east Salween River (Fig. 1). The region embraces a diverse ethnic composition, including Wa, Lahu, Dai, and 31 other ethnic minorities. This area, traditionally known as the “Wa Mountains”, straddles the tropic of Cancer and has a subtropical climate with mild weather conditions. Affected by the Indian Ocean's warm and wet airflow, rainfall is relatively abundant. The climate is also affected by the three-dimensional characteristics of the topography in this mountainous region [38]. Cangyuan County is located between 98°52'- 99° 43'E, and 23°04'- 23° 30'N. Cangyuan belongs to the subtropical monsoon climate with a mild and wet climate. The average annual sunshine hours are 1862.5 hours. The annual average temperature is 17.7°C, and the annual average rainfall is 1747.2mm. Ximeng County is located between 99°18'- 99° 43'E and 22° 25' -22° 57'N. It belongs to a subtropical marine monsoonal climate, affected by the warm and humid southwest of the Bay of Bengal. The annual average temperature is 15.3°C, and the average annual rainfall is 2758mm, which is the highest in Yunnan province. The highest altitude in this territory is 2458.9 meters, and the minimum altitude is 590 meters. Due to this climate, the vegetation in those two counties is plentiful and diverse, with 37% of the forest coverage rate.

**Sampling and data collection**

Data were collected from May 2015, December 2015, May 2017, and December 2019 in six villages in Cangyuan Wa Autonomous county and Ximeng Wa Autonomous County. Dazhai village, Xiaozhai village and Banjing village are in Zhongke Town, Ximeng county. Yangluo village is in Mengsuo town, Ximeng county. Heling and Paipa villages are in Nuoliang town, Cangyuan county (Table 1). The six representative villages are mainly inhabited by Wa ethnic groups, located far from the county centre, and they were selected through discussions with local elders and village heads in an initial reconnaissance visit [39]. With the help of local farmers, agricultural bureau, and professional agricultural technology
staff from the agricultural vegetable station, 60 participants (52 males and 8 females) were sampled through a purposive sample approach [40], following the village heads’ advice to identify the key informants. The interviewed households accounted for 10% of total households in each village. For reference, the interviewees’ consent is based on households’ availability and interest.

| Village          | Ximeng County | Cangyuan County |
|------------------|---------------|-----------------|
| Zhongke town     |               |                 |
| Dazhai           | 99°36’ E, 22°47’ N |                 |
| Xiaozhai         | 99°36’ E, 22°47’ N |                 |
| Banjing          | 99°36’ E, 22°43’ N |                 |
| Yangluo          | 99°40’ E, 22°39’ N |                 |
| Heling           | 99°19’ E, 23°12’ N |                 |
| Papai            | 99°22’ E, 23°18’ N |                 |

Table 1
Characterization of six Wa villages

The 60 households were considered for both individual interviews and garden inventories. For the individual interview, we collected the socio-demographic information of respondents, including age, gender, and education level were recorded [41] (Table 12). Following the age categorization, 46.67% of the informants were young people (21–40 years old), 45.00% were middle-aged (41–60 years old) and the remaining 8.33% were the elderly (age ≥ 60 years old). 86.67% of informants were male. Regarding education level, 5.00% were uneducated, 51.67% attended primary school, 38.33% attended middle-high school, and 5% attended high school or more.

We defined the “traditional” vegetables should be the heirloom crops, local and culturally adopted, and handed down from generation to generation [1]. And the introduced or exotic vegetables are the vegetables being planted in recent 10 years. Homegardens inventories were conducted to identify the traditional vegetable and introduced vegetables planted in the homegardens [39]. The semi-structured interview included documentation of local names, Wa names, edible parts, edible methods of the traditional vegetables they planted in the homegardens [24, 35]. Structured questionnaire forms were assigned to participants and consisted of three main parts. The first question aimed to determine the characteristics of homegardens including size and cultivated varieties. In the second part, seed management and sourcing, self-consumption from homegardens, and the gender of the responsibility for homegarden management were considered. In the last parts, the threats and conservation issues were
identified. The nomenclature of all plants reported in our study follows the *Flora of China*. Traditional vegetable variety resources are jointly identified by local farmers, agricultural bureau, and agricultural vegetable station professional agricultural technology staff. Data obtained were triangulated to ensure reliability and validity [42].

Table 2  
Sociodemographic characteristics of participants

| Category | Gender | Age   | Education level |
|----------|--------|-------|-----------------|
|          |        | 21–40 | 41–59 | ≥ 60 | Illiteracy | Primary School | Middle school | High school |
| Dazhai   | 10     | 0     | 5     | 3    | 2    | 0   | 4   | 6   | 0 |
| Xiaozhai | 6      | 4     | 6     | 4    | 0    | 1   | 7   | 2   | 0 |
| Banjing  | 8      | 2     | 4     | 5    | 1    | 2   | 5   | 3   | 0 |
| Yangluo  | 10     | 0     | 3     | 6    | 1    | 0   | 6   | 4   | 0 |
| Heling   | 10     | 0     | 6     | 4    | 0    | 0   | 4   | 4   | 2 |
| Papai    | 8      | 2     | 4     | 5    | 1    | 0   | 5   | 4   | 1 |
| Quantity | 52     | 8     | 28    | 27   | 5    | 3   | 31  | 23  | 3 |
| Proportion (%) | 86.67 | 13.33 | 46.67 | 45.00 | 8.33 | 5.00 | 51.67 | 38.33 | 5.00 |

Data analysis

Replies from participants were organized according to vegetables, management, and factors from a thematic analysis of the interviews [43]. Those included why traditional vegetable resources are continually planted in the homegardens; several themes encompassing social and cultural changes emerged from this analysis. Traditional vegetable information collected from 60 respondents was counted to identify the most important varieties in homegardens. Vegetables were counted as distinguishable units rather than as species or varieties [1].

Relative frequency of citation (RFC):

$$RFC = \frac{FCs}{N}$$

This parameter refers to the ratio of the number of respondents who mention a particular traditional vegetable cultivar (i.e., the frequency of citation, FC) to the number of all respondents participating in the survey (N). The larger the RFC, the more important and valuable the traditional vegetable is in the homegardens [44, 45].
Result

Diversity of traditional vegetables in Wa homegardens

A total of 91 vegetable varieties were recorded from the six villages, 55 traditional vegetable varieties, belonging to 11 families and 25 genera, were recorded in the homegardens (Table 3). Out of the total traditional vegetable varieties, the largest number of traditional vegetables belonged to Cucurbitaceae (10 varieties, 18.18%), Solanaceae (10 varieties, 18.18%), Brassicaceae (7 varieties, 12.73%), and Liliaceae (7 varieties, 12.73%) (Fig. 2). And other 36 introduced vegetables were investigated in the study area. Among all the villages, 23 ± 6 (average ± S.D.) traditional vegetable varieties per homegarden and 9 ± 3 (average ± S.D.) introduced vegetable varieties per homegarden were analyzed. Villages from Dazhai, Xiaozhai, Banjing, Yangluo, Heling, and Papai cultivated more in traditional vegetables than in introduced vegetables (Fig. 3).

The RFC value calculated in this study ranged from 0.02 to 1. For each traditional vegetable variety, the higher the RFC value, the more frequently it was planted by local Wa villagers in the homegardens, and the more important and valuable it was in the Wa community. The most frequent vegetable varieties encountered in the homegardens were Allium fistulosum, Allium tuberosum, Amaranthus paniculatus, Brassica chinensis, Capsicum frutescens, Nepeta cataria, and Sechium edule. These 7 traditional vegetables cultivated by 100% of the households are essential plants in homegardens for edible use. For example, Amaranthus paniculatus has been widely planted in Wa homegardens owing to the feature of drought resistance, tolerance to barren soil, high yield, and no plant diseases or insect pests. Allium fistulosum, Nepeta cataria, Allium tuberosum, and Capsicum frutescens are used as spices in traditional food, which reflected that Wa households are selecting and planting local spicy vegetables, to be used as a seasoning, in the homegardens.
Table 3
Traditional vegetables and their uses in Wa homegardens

| Scientific name          | Local name | Wa name      | Family   | Edible parts | Edible methods | RFC |
|--------------------------|------------|--------------|----------|--------------|----------------|-----|
| *Allium chinense*        | Jiao tou   | Gong de mo   | Liliaceae| Bulb         | Spice          | 0.38|
| *Allium fistulosum*      | Pake da cong | De mo       | Liliaceae| Whole plant  | Spice          | 0.12|
| *Allium fistulosum*      | Xiao xiang cong | De mo a mu | Liliaceae| Whole plant  | Spice          | 1.00|
| *Allium sativum*         | Bai pi suan | De ha       | Liliaceae| Bulb         | Spice          | 0.53|
| *Allium sativum*         | Yongguang da suan | De ha din | Liliaceae| Bulb         | Spice          | 0.05|
| *Allium hookeri*         | Pie cai    | De ga       | Liliaceae| Root, flower | Spice          | 0.62|
| *Allium tuberosum*       | Xi ye jiu cai | De ga bie te | Liliaceae| Leaf         | Fry            | 1.00|
| *Amaranthus paniculatus* | Yi mi cai  |             | Amaranthaceae| Tender leaf and stalk | Fry, Boil | 1.00|
| *Benincasa hispida*      | Lao mian dong gua | Bie lan   | Cucurbitaceae| Fruit | Fry          | 0.48|
| *Benincasa hispida*      | Yuesong dong gua |             | Cucurbitaceae| Fruit | Fry          | 0.40|
| *Brassica chinensis*     | Zi qing cai |             | Brassicaceae| Leaf, stalk | Fry, Boil      | 1.00|
| *Brassica chinensis*     | Da qing cai | Di ke lao te | Brassicaceae| Leaf, stalk | Fry, Boil, Pickling | 0.48|
| *Brassica chinensis*     | Wa qing cai |             | Brassicaceae| Leaf, stalk | Pickling       | 0.90|
| *Brassica chinensis*     | Yuan qing cai | Di ke lao | Brassicaceae| Leaf | Pickling      | 0.82|
| *Brassica pekinensis*    | Pake bai cai | Di ke lao ben | Brassicaceae| Leaf, stalk | Fry, Boil      | 0.47|
| *Brassica pekinensis*    | Nangui bai cai |             | Brassicaceae| Leaf, stalk | Fry, Boil      | 0.28|

* cultivated and wild species
| Scientific name                  | Local name         | Wa name       | Family        | Edible parts | Edible methods | RFC  |
|---------------------------------|--------------------|---------------|---------------|--------------|----------------|------|
| *Capsicum annuum*               | Chao tian jiao      | Solanaceae    | Fruit         | Spice        | 0.63           |      |
| *Capsicum annuum*               | Xiaozhai la jiao    | Solanaceae    | Fruit         | Spice        | 0.22           |      |
| *Capsicum annuum*               | Talang la jiao      | Solanaceae    | Fruit         | Spice        | 0.02           |      |
| *Capsicum frutescens*           | Xiao mi la meng xiao| Solanaceae    | Fruit         | Spice        | 1.00           |      |
| *Capsicum frutescens*           | Bai pi xiao meng he bie te | Solanaceae | Fruit         | Spice        | 0.77           |      |
| *Capsicum frutescens*           | Lao shu la meng he bing | Solanaceae | Fruit         | Spice        | 0.02           |      |
| *Capsicum frutescens cv. Shuanlaense* | Shuan shuan la jiao | Solanaceae | Fruit         | Spice        | 0.02           |      |
| *Colocasia esculenta*           | Zi yu Gi ao         | Araceae       | Corm          | Fry, Soup    | 0.05           |      |
| *Colocasia esculenta*           | Banshuai yu tou     | Araceae       | Corm          | Fry          | 0.38           |      |
| *Colocasia esculenta*           | Di shui yu bui*     | Araceae       | Leaf, stalk   | Soup, Spice  | 0.90           |      |
| *Colocasia esculenta*           | Naka da ma yu       | Araceae       | Corm          | Soup         | 0.02           |      |
| *Coriandrum sativum*            | Xi ye yan sui       | Apiaceae      | Tender leaf and stalk | Boil, Salad, Spice | 0.85 |      |
| *Cucumis sativus*               | Di huang gua Gai    | Cucurbitaceae | Fruit         | Salad        | 0.95           |      |
| *Cucurbita moschata*            | Jin gua             | Cucurbitaceae | Fruit, tender leaf, flower | Fry | 0.28 |      |
| *Cucurbita moschata*            | Lao mian nan gua    | Cucurbitaceae | Fruit, tender leaf, flower | Fry | 0.22 |      |
| *Cucurbita moschata*            | Xiao nan gua        | Cucurbitaceae | Fruit, tender leaf, flower | Fry | 0.55 |      |

* cultivated and wild species
| Scientific name         | Local name | Wa name   | Family          | Edible parts | Edible methods | RFC  |
|-------------------------|------------|----------|-----------------|--------------|----------------|------|
| *Dioscorea batatas*    | Zi shan yao | Dioscoreaceae | Tuber          | Boil         | 0.03           |
| *Dioscorea batatas*    | Shan yao   | Dioscoreaceae | Tuber          | Boil         | 0.65           |
| *Dioscorea batatas*    | Xi shan yao | Dioscoreaceae | Tuber          | Boil         | 0.32           |
| *Foeniculum vulgare*   | Hui xiang   | Apiaceae | Whole plant     | Spice        | 0.03           |
| *Lagenaria siceraria*  | Hu lu      | Cucurbitaceae | Tender leaf   | Fry          | 0.07           |
| *Luffa cylindrica*     | Si gua     | Cucurbitaceae | Tender fruit  | Fry          | 0.27           |
| *Lycopersicon esculentum* | Xiao fan qie | Solanaceae | Fruit          | Salad        | 0.35           |
| *Eryngium foetidum*    | A Wa yan sui | Apiaceae | Whole plant, tender leaf and stem | Spice | 0.30           |
| *Mentha haplocalyx*    | Bo he*      | Lamiaceae | Tender stem tip, leaf | Spice, Fry | 0.45           |
| *Momordica charantia*  | Menge ku gua | Cucurbitaceae | Fruit          | Fry, Salad   | 0.02           |
| *Nepeta cataria*       | Jing jie   | Lamiaceae | Tender leaf    | Spice        | 1.00           |
| *Pachyrhizus erosus*   | Hong shu   | Leguminosae | Bulb           | Fry          | 0.05           |
| *Perilla frutescens*   | Bai su     | Lamiaceae | Leaf, stalk    | Spice        | 0.02           |
| *Perilla frutescens*   | Hei su      | Lamiaceae | Leaf, stalk    | Spice, Salad | 0.02           |
| *Pisum sativum*        | Lao zhai wan dou | Leguminosae | Seed         | Fry          | 0.23           |
| *Pisum sativum*        | Wangya wan dou | Leguminosae | Seed         | Fry          | 0.20           |
| *Pisum sativum*        | Hong wan dou | Leguminosae | Seed         | Fry          | 0.17           |

* cultivated and wild species
| Scientific name         | Local name | Wa name | Family          | Edible parts   | Edible methods | RFC |
|------------------------|------------|---------|-----------------|----------------|----------------|-----|
| *Raphanus sativus*    | Bai luo bo | Meng bie te | Brassicaceae     | Root, leaf | Pickling          | 0.03 |
| *Sechium edule*       | Fo shou gua |                 | Cucurbitaceae | Tender stem tip, flower, fruit | Fry | 1.00 |
| *Solanum melongena*  | Bai qie | Solanaceae | Fruit | Fry | 0.23 |
| *Solanum melongena*  | Zi qie | Solanaceae | Fruit | Fry | 0.67 |
| *Vigna unguiculata* | Dou jiao | Bai | Leguminosae | Tender pod | Fry | 0.55 |
| *Zingiber officinale* | Huang jiang Si gei | Zingiberaceae | Root stock | Spice | 0.90 |
| *cultivated and wild species*

The edible methods for traditional vegetables are various, including fry, boil, salad, or spicy seasoning. Those traditional edible methods objectively require Wa gardeners to grow more vegetables to meet daily dietary needs. Among all the recorded 55 traditional vegetable cultivars, the edible plant parts of traditional vegetables were divided into nine categories: fruit, leaf, stalk, bulb, flower, seed, root, whole plant, and pod (Table 4). Fruits (20 species, 28.17%), mainly in the Cucurbitaceae and Solanaceae families, are the most commonly used plant parts for nutrition. For 19 species (26.76%), the tender leaf is the part for edible usage by Wa people. Households used tender leaves of traditional vegetables in multiple cooking methods, such as seasoning, frying, boiling, and salad. For five species (7.04%) of 55 cultivars, traditional food needs to use the flower as edible parts. This phenomenon showed that the anthophagy (flower-eating) culture is rich and diverse among Wa villagers.
Traditional vegetables planted in homegardens were used mostly for self-consumption and fulfilling the owners’ needs. The number of households who cultivated vegetables in homegardens for self-consumption was relatively high (Fig. 4). Thirty-three out of 60 households which accounted for 55% of households use 80%-100% of their vegetables. 13% of households have achieved self-sufficiency in the proportion of 50%-80% of their cultivated vegetables in the homegardens. 15% of households are self-sufficient in percentages of 20%-50% of cultivated vegetables in the homegardens. Only 17% of 10 households use 0–20% of their cultivated vegetables in the homegardens. Vegetables planted in homegardens were used mostly for self-consumption and to fulfill the needs of the owners. Traditional vegetables are primarily used for the household’s diet but are increasingly being used to generate cash income for several families. According to the interviewees, sometimes the surplus from the consumption would be sold to increase supplementary income for the families.

### Seed sourcing and management

The storage and protection of seeds are an essential part of the traditional knowledge related to crops. Traditional seeding and breeding methods can promote the protection and inheritance of local vegetable germplasm resources. Among all the traditional vegetable seeds sources, about 78% of the total 60 household depend on maintaining and storing the local seeds themselves, with a further 9% of households’ seed supplies coming from neighbors and relatives. 13% of households choose to purchase local seeds in the traditional markets (Fig. 5). According to the interviews, households in Wa villages primarily use local storage methods to conserve the seeds of traditional vegetables planted in their homegardens the next year. Local seed storage practices are simple. The seeds will be hung above the
fireplace where households cook the meals every day. The purpose of this action is to keep the seeds directly in a dry and ventilated place to prevent mildew and to prevent predation from insects. The selection of crop seeds for saving is based on colour, food quality, resistance to environmental stress, yield, and so on. Because of the simple breeding and selection methods of seeds, traditional vegetable landraces such as melons, beans, and peppers, which are easily harvested, are better preserved.

Seed exchange system occur within the villages and seeds are also exchanged outside Wa communities. When a household plants vegetable that have excellent characters such as color, quality or resistance to insects, neighbors, and relatives can ask for an exchange with their local crop seeds. In this way, local people have a positive, regular and reciprocal exchange seed system in the local areas. Excellent local vegetable landraces are selected from generation to generation, which is conducive to the preservation and development of traditional vegetables. The exchange between villages and towns occurs through traditional markets—farmers sell local traditional vegetable seeds in traditional markets. About 13% of households purchase local seeds in the traditional markets. Some farmers sell local traditional vegetable seeds, which are selected with better quality and set the price themselves. Like many of the local communities, seed exchange is not the main mechanism for seed acquisition in the Wa communities, with most seeds coming from each households’ own storage systems. In that context, it is not surprising that, although active, the traditional seed exchange methods are fragmented and decentralized.

The exchange between villages and towns occurs through traditional markets—farmers sell local traditional vegetable seeds in traditional markets held for a long time. However, while the local family’s economic conditions gradually improved, seed management for traditional vegetables has been under threat of loss. Local farmers started to stop preserving traditional seeds and choose to go to the seed stores to buy modern hybrid seeds. Unlike in the villages’ traditional market, seed stores in the agriculture market now only provide modern hybrid-seeds for farmers. One of the seed dealers said: “Farmers now prefer to buy modern seed because of the high production when they have enough money.” (Interview, 16th December 2015). This development will increase the homogeneity of vegetables planted in homegardens, consisting primarily of modern hybrid varieties of vegetables in the future. Meanwhile, from interviews we gathered that approximately 80% of the modern hybrid varieties of vegetable seeds could not be retained and sown. Farmers continuously have to buy new varieties of vegetable seeds frequently every year. This cycle's consequence is that local farmers lose the traditions of seed selection and breeding of vegetables in their homegardens unconsciously without realizing it.

**Gender relation for homegardens management**

In the study areas, 83% of families were female household heads who have the right to make decisions about what kinds of vegetables will be planted in the homegardens. Male household heads account for 10% responsible for decision-making, and a small percentage which is 2% is determined by the elderly. 5% families will make decisions jointly between both male and female household heads. When it comes to seed selection and breeding, female households take more responsibility (88%). Male household heads
account for only 10% of those responsible for the management of the gardens, less that for making decisions (8%). (Fig. 6). The proportion of male household heads involved in garden management and with responsibility for distribution of vegetable varieties, and for preservation and cultivation, is smaller than the female household head.

**Factors influence traditional vegetables and relevant traditional knowledge in the homegardens**

The participants addressed five main factors for continued cultivation and selection of traditional vegetables in the homegardens: good taste (73.33%), honoring their ancestors through maintaining their traditions (46.67%), low cost (16.67%), low planting requirements (10.00%), and cultural festivals (1.67%) (Fig. 7).

Good taste is the fundamental reason for Wa villagers to keep planting traditional vegetables and preserving traditional knowledge in homegarden management. In Wa villages’ view, traditional vegetables commonly have a more robust flavor than the modern hybrid ones, which is the main reason for traditional vegetables being used in their daily meals. Besides, Wa farmers believed that many traditional vegetable varieties have adapted to local soil and climatic conditions over these millennia of cultivation and have superior traits or good palatability.

Nearly half of the respondents believed that keeping planting traditional vegetables is critical to honor and respect their ancestors. Wa people have ancestor-worship consciousness; they value the traditional vegetable varieties germplasm as wealthy cultivated through generations and generations back to their ancestors.

16.67% and 10.00% Wa villagers, respectively, choose low planting costs and requirements because they will not give up planting traditional vegetables in the homegardens. For example, *Allium fistulosum* has a strong pungent spicy taste and a high resistance to disease and is easily cultivated. These features help Wa villagers save the workforce and financial resources for managing their vegetable gardens. Local people also prefer to grow traditional varieties using their seed and without fertilizers in their homegardens. Even though the modern hybrid vegetables can bring higher production, in the meantime they would have to continuously spend more money for vegetable seeds and fertilizer on the market. Resource input and outcomes are not proportional in such small systems; one of the farmers said:

“The traditional vegetables are easier to manage in homegardens, we don’t need to spend too much time on pest control and fertilization with traditional vegetables, but as for modern vegetable varieties, they are easily threatened by pests and diseases, and we need to spend time spraying pesticides and applying chemical fertilizers to achieve high yields. It’s not always worth the effort.” (Interview, 3rd August 2015)

1.67% of the respondents mentioned that culture and festivals make traditional vegetables vital in Wa custom. Although these traditional vegetables only account for a small proportion, each has its unique
characteristics and should not be ignored. For instance, Wa people have the custom of eating *Brassica chinensis* as a traditional dish during the New Year to bless the whole family for the coming year. *Colocasia esculenta* (Di shui yu) and *Eryngium foetidum* (A Wa yan sui) are the essential seasonings due to a particular taste for traditional Wa dish “chicken rice porridge” which is a cultural custom for Wa families to host guest and celebrate festivals.

**Discussion**

Our study demonstrated a great diversity of traditional vegetables in Wa homegardens represented by a total of 91 vegetable varieties. [38, 42]55 traditional varieties were maintained in homegardens. The local community has a wide variety of choices and uses of vegetables from many families and different genera in the homegardens. Such diversity reflects both the rich germplasm biodiversity cultivated by Wa households and the complexity of traditional dietary habits in the Wa community. Wa homegardens provide households with fresh, diverse vegetable supplies, improving their self-sufficiency capacity while conserving in-situ genetic diversity. The homegardens’ locations are closed next to the households’ houses, and this closing distance allows Wa families to plant and pick-up vegetables more accessible.

The preservation and sustainable use of traditional crop germplasm resources is the basis for ensuring the inheritance of relevant ethnic and cultural practices [46]. Dietary diversity is significant factor for Wa people to keep cultivating high diversity of vegetables in their homegardens. Wa people’s culinary culture require mixing a lot of vegetables and meat to make the dishes delicious and nutritious, which fostered traditional knowledge of various edible methods for edible parts. Demand for traditional dishes keeps some essential vegetable varieties preserved well. For example, they prefer to eat a traditional dish, Chicken Rice Porridge, which is made by using fennel, tabasco pepper, mint, garlic, spring onion, cilantro, *Allium hookeri*, chicken and rice. This dish is served when hosting guests and friends to show great respect, reflecting the cultural links between people and high crop diversity in the Wa society. Also, the preference of “spicy food” custom maintains pepper varieties in the homegardens over history. For pepper varieties in this region, seven varieties have been found in the homegardens.

The pursuit for health also promotes the diversity of vegetables used by Wa people. The traditional knowledge of health care through a daily diet rich in vegetables is important [47]. The daily Wa diet thus provides multiple functions, including nutrition supply and health care knowledge. For example, the tender leaf of *Acanthopanax trifoliatus*, which is “Daex giam” in Wa language, is usually used as a salad or traditional sauce “Sapie”, and it has an appetizing medical function. It shows that local people have a comprehensive and in-depth understanding of plant resources’ choice and have rich traditional knowledge of using traditional vegetables. [52][53]

Seed systems are an essential part for enhancing community resilience as seed security has several direct links to food security[48, 49]. The circulation of seed among farmers is central to agrobiodiversity conservation and dynamics [50]. Local seed supply enables local reproduction of the seed by farmers themselves, using local seed selection, production and conditioning practices [51]. All of these practices
depend on the ongoing transmission of traditional knowledge about seeds across generations. Local Wa people have a positive, regular, and reciprocal exchange seed system in the local areas. Excellent local vegetable varieties are selected from generation to generation, conducive to preserving and developing traditional vegetables. The seed exchange is not the primary mechanism for seed acquisition in the Wa communities, with most seed coming from each households’ storage systems. In that context, it is not surprising that, although active, traditional seed exchange methods are fragmented and decentralized.

Homegardens are generally managed by an individual or a couple of family members, mainly the female heads of households. And women in one study were found to be aware of home-garden conservation to conserve the agro-biodiversity of homegardens.[52]. [59, 60]In the families of this study, women are generally responsible for planting and managing vegetables, selecting breeding and breeding, and the knowledge of traditional vegetable cultivation and retention is well preserved among female groups. Women in the Wa family are mainly responsible for the cultivation of vegetables in homegarden management. These findings add weight to previous studies that have identified the significant positive influence of women on the use, management and conservation of biodiversity through their roles in seed selection, seed saving and use of wild plants for food and medicines [53, 54].

Nevertheless, rapid economic and social changes and the penetration of foreign cultures are challenging the ongoing maintenance of traditional vegetables. The respondents mentioned that economy has developed rapidly in recent years, and the income of farmers has increased notably. This opportunity for higher wages pulls farmers towards urban labor and large-scale rural agricultural development has significantly reduced the rural labor force. Instead of being satisfied with the self-sufficient traditional agricultural-production lifestyle, more and more young people choose to go out to work or engage in other industries, which results in the gradual decline of cultivation of traditional. More and more households choose to plant introduced vegetables for higher yield compared to traditional vegetables. Either of these will result in the gradual disappearance of a large number of traditional vegetable varieties [55].

**Conclusions**

High traditional vegetable diversity which is a total of 55 traditional vegetable varieties was found in the homegardens. This study proves that high traditional vegetable diversity is maintained grown in homegardens by households in the rural villages in Wa communities in southwestern China. The continued planting and use of traditional vegetables from diverse seed sources in homegardens contribute to germplasm diversity conservation. Households in homegardens maintain and protect the diversity of traditional vegetables through their seed management systems, both saving and exchanging seeds. The cultural preference for a high vegetable diet among the Wa people plays a positive role in the protection and utilization of traditional vegetable resources—which are better tasty were kept being cultivated in homegardens. Our results reinforce the shreds of evidence that maintaining homegardens can be a practical in-situ conservation solution to protect traditional resources. Policymakers should take homegardens into land planning consideration for rural communities to keep the small-scale agriculture functioning and support encourage farmers to keep homegardens for
agrobiodiversity in-situ conservation, protection of traditional varieties, and traditional knowledge held by ethnic people in the local and communities.

**Declarations**

**Ethics approval and consent to participate**

All informants gave verbal consent for the information they provided to be shared for academic purposes only, in accordance with the ethical standards adopted by the International Society of Ethnobiology (2008).

**Consent for publication**

Not applicable.

**Availability of data and materials**

All data generated or analyzed during this study are included in this published article.

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**Conflict of Interest**

The authors declare that they have no conflict of interest.

**Authors’ contributions**

Hua Shao as the principal researcher conducted the field research and data analysis and drafted the manuscript. Dr. Dayuan Xue and Dr. Jingbiao Yang as supervisors initiated and provided oversight to the study and input in its planning and provided the ethic and cultural advice based on his rich experience and knowledge. Dr. Rosemary Hill revised the English. Dayuan Xue, Jingbiao Yang and Rosemary Hill carefully revised the manuscript. All authors reviewed and approved the final manuscript.

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References

1. Keller GB, Mndiga H, Maass BL. Diversity and genetic erosion of traditional vegetables in Tanzania from the farmer's point of view. Plant Genet Resour, 2005, 3(3): 400-413. http://doi.org/10.1079/PGR200594.

2. Keatinge JDH, Yang RY, Hughes JD, Easdown WJ, Holmer R. The importance of vegetables in ensuring both food and nutritional security in attainment of the Millennium Development Goals. Food Secur, 2011, 3(4): 491-501. http://doi.org/10.1007/s12571-011-0150-3.

3. FAO, IFAD, UNICEF, WFP and WHO, The state of food security and nutrition in the world 2018. building climate resilience for food security and nutrition. Rome: FAO, 2018.

4. Slavin JL, Lloyd B. Health benefits of fruits and vegetables. Adv Nutr, 2012, 3(4): 506-516. http://doi.org/10.3945/an.112.002154.

5. Chagomoka T, Afari-Sefa V, Pitoro R. Value chain analysis of traditional vegetables from Malawi and Mozambique. Int Food and Agribus Man, 2014, 17(4): 59-85.

6. Ebert AW. Potential of underutilized traditional vegetables and legume crops to contribute to food and nutritional security, income and more sustainable production systems. Sustainability, 2014, 6(1): 319-335. http://doi.org/10.3390/su6010319.

7. Odhav B, Beekrum S, Akula U, Bajinath H. Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa. J Food Compos Anal, 2007, 20(5): 430-435. http://doi.org/10.1016/j.jfca.2006.04.015.

8. Maroyi A. Potential role of traditional vegetables in household food security: A case study from Zimbabwe. Afr J Agr Res, 2011, 6(26): http://doi.org/10.5897/ajar11.335.

9. Huai HY, Xu W, Wen GJ, Bai WR. Comparison of the homegardens of eight cultural groups in Jinping County, Southwest China. Econ Bot, 2011, 65(4): 345-355. http://doi.org/10.1007/s12231-011-9172-1.

10. Solberg SØ, Seta-Waken P, Paul T, Palaniappan G, Iramu E. Patterns in the conservation and use of traditional vegetables from the New Guinean biodiversity hotspot. Agroecol Sust Food, 2018, 42(1-13. http://doi.org/10.1080/21683565.2018.1489932.

11. Galluzzi G, Eyzaguirre P, Negri V. Home gardens: neglected hotspots of agro-biodiversity and cultural diversity. Biodivers conserv, 2010, 19(13): 3635-3654. http://doi.org/10.1007/s10531-010-9919-5.

12. Whitney CW, Tabuti JRS, Hensel Q, Yeh CH, Gebauer J, Luedeling E. Homegardens and the future of food and nutrition security in southwest Uganda. Agr Syst, 2017, 154(133-144. http://doi.org/10.1016/j.agsy.2017.03.009.

13. Rammohan A, Pritchard B, Dibley M. Home gardens as a predictor of enhanced dietary diversity and food security in rural Myanmar. BMC Public Health, 2019, 19(1): http://doi.org/10.1186/s12889-019-
14. Das T, Das AK. Conservation of plant diversity in rural homegardens with cultural and geographical variation in three districts of Barak Valley, Northeast India. Econ Bot, 2015, 69(1): 57-71. http://doi.org/10.1007/s12231-015-9299-6.

15. Díaz-Reviriego I, González-Segura L, Fernández-Llamazares Á, Howard PL, Molina JL, Reyes-García V. Social organization influences the exchange and species richness of medicinal plants in Amazonian homegardens. Ecol Soc, 2016, 21(1): http://doi.org/10.5751/ES-07944-210101.

16. Alayón-Gamboa JA, Gurri-García FD. Home garden production and energetic sustainability in Calakmul, Campeche, Mexico. Hum Ecol, 2007, 36(3): 395-407. http://doi.org/10.1007/s10745-007-9151-4.

17. Idohou R, Fandohan B, Salako VK, Kassa B, Gbédomon RC, Yédomonhan H, Glélè Kakaï RL, Assogbadjo AE. Biodiversity conservation in home gardens: traditional knowledge, use patterns and implications for management. International Journal of Biodiversity Science, Ecosystem Services & Management, 2014, 10(2): 89-100. http://doi.org/10.1080/21513732.2014.910554.

18. Perrault-Archambault M, Coomes OT. Distribution of Agrobiodiversity in Home Gardens along the Corrientes River, Peruvian Amazon. Econ Bot, 2008, 62(2): 109. http://doi.org/10.1007/s12231-008-9010-2.

19. Whitney CW, Luedeling E, Tabuti JRS, Nyamukuru A, Hensel O, Gebauer J, Kehlenbeck K. Crop diversity in homegardens of southwest Uganda and its importance for rural livelihoods. Agr Hum Values, 2018, 35(2): 399-424. http://doi.org/10.1007/s10460-017-9835-3.

20. Buchmann C. Cuban Home Gardens and Their Role in Social–Ecological Resilience. Hum Ecol, 2009, 37(6): 705. http://doi.org/10.1007/s10745-009-9283-9.

21. Shao H, Xue DY. Influence of traditional Wa culture on vegetable germplasm diversity in Yunnan Province. Biodiversity Science, 2017, 25(1): 36-40. http://doi.org/10.17520/biods.2016324.

22. Altieri MA, Merrick L. In situ conservation of crop genetic resources through maintenance of traditional farming systems. Econ Bot, 1987, 41(1): 86-96.

23. Xue DY, Guo L. On protection and benefit-sharing of genetic resources and associated traditional knowledge in the ethnic areas of China. Resources Science, 2009, 31(6): 919-925.

24. Ma Y, Luo B, Zhu Q, Ma D, Wen Q, Feng J, Xue D. Changes in traditional ecological knowledge of forage plants in immigrant villages of Ningxia, China. J Ethnobiol and Ethnomed, 2019, 15(1): 65. http://doi.org/10.1186/s13002-019-0333-0.

25. Dweba TP, Mearns MA. Conserving indigenous knowledge as the key to the current and future use of traditional vegetables. International Journal of Information Management, 2011, 31(6): 564-571. http://doi.org/10.1016/j.ijinfomgt.2011.02.009.

26. Reyes-García V, Vila S, Aceituno-Mata L, Calvet-Mir L, Garnatje T, Jesch A, Lastra JJ, Parada M, Rigat M, Valles J, Pardo-de-Santayana M. Gendered homegardens: a study in three mountain areas of the Iberian Peninsula. Econ Bot, 2010, 64(3): 235-247. http://doi.org/10.1007/s12231-010-9124-1.
27. Cody K. Community gardens and the making of organic subjects: a case study from the Peruvian Andes. Agr Hum Values, 2018, 36(1): 105-116. http://doi.org/10.1007/s10460-018-9895-z.

28. Cui JY, Fu YN, Guo HJ, Chen AG. Study on Household-based Agrobiodiversity Assessment (HHABA) of Homegarden in Daka, Xishuangbanna, Yunnan. ACTA Botanica Yunnanica, 2000, S1: 81-90.

29. Clarke LW, Li LT, Jenerette GD, Yu ZR. Drivers of plant biodiversity and ecosystem service production in home gardens across the Beijing Municipality of China. Urban Ecosyst, 2014, 17(3): 741-760. http://doi.org/10.1007/s11252-014-0351-6.

30. Huai HY, Hamilton A. Characteristics and functions of traditional homegardens: a review. Frontiers of Biology in China, 2008, 4(2): 151-157. http://doi.org/10.1007/s11515-008-0103-1.

31. Pei SJ, Hamilton AC, Yang LX, Huai HY, Yang ZW, Gao F, Zhang QX. Conservation and development through medicinal plants: a case study from Ludian (Northwest Yunnan, China) and presentation of a general model. Biodivers conserv, 2010, 19(9): 2619-2636. http://doi.org/10.1007/s10531-010-9862-5.

32. Zhu MJ, Luo BS, La B, Chen RJ, Liu FG, Long CL. Homegarden agroecosystems managed by Salar people on Qinghai-Tibet Plateau. J Ethnobioland Ethnomed, 2021, 17(1): http://doi.org/10.1186/s13002-021-00448-x.

33. Fu YN, Guo HJ, Chen AG, Cui JY. Household differentiation and on-farm conservation of biodiversity by indigenous households in Xishuangbanna, China. Biodivers conserv, 2006, 15(8): 2687-2703. http://doi.org/10.1007/s10531-005-6318-4.

34. Wang JR, Long CL. Ethnobotanical study of traditional edible plants of Jinuo nationality. ACTA Botanica Yunnanica, 1995, 17(2): 161-168.

35. Yang LX, Ahmed S, Stepp JR, Mi K, Zhao Y, Ma J, Liang C, Pei S, Huai H, Xu G, Hamilton AC, Yang Z-w, Xue D. Comparative homegarden medical ethnobotany of Naxi healers and farmers in Northwestern Yunnan, China. J Ethnobioland Ethnomed, 2014, 10(1): 6. http://doi.org/10.1186/1746-4269-10-6.

36. Shen S, Xu G, Li D, Clements DR, Zhang F, Jin G, Wu J, Wei P, Lin S, Xue D. Agrobiodiversity and in situ conservation in ethnic minority communities of Xishuangbanna in Yunnan Province, Southwest China. J Ethnobioland Ethnomed, 2017, 13(1): http://doi.org/10.1186/s13002-017-0158-7.

37. Wang KJ. On traditional ecology culture of Wa nationality. Journal of Honghe University, 2008, 6(4): 22-25,34.

38. Liu CY, Du F, Wang J, Guo SP, Xi ZP, Leng TX. Ethnobotanical survey of wild food plants used by Wa people in Cangyuan county of Yunnan province. Journal of West China Forestry Science, 2012, 41(5): 42-49. http://doi.org/10.16473/j.cnki.xblykx1972.2012.05.001.

39. Uprety Y, Poudel RC, Shrestha KK, Rajbhandary S, Tiwari NN, Shrestha UB, Asselin H. Diversity of use and local knowledge of wild edible plant resources in Nepal. J Ethnobioland Ethnomed, 2012, 8(1): 16. http://doi.org/10.1186/1746-4269-8-16.

40. Tongco MDC. Purposive sampling as a tool for informant selection. Ethnobotany Research and Applications, 2007, 5, 147-158.
41. Gbedomon RC, Fandohan AB, Salako VK, Idohou AFR, Kakaii RG, Assogbadjo AE. Factors affecting home gardens ownership, diversity and structure: a case study from Benin. J Ethnobiol and Ethnomed, 2015, 11(56): http://doi.org/10.1186/s13002-015-0041-3.

42. Jick TD. Mixing qualitative and quantitative methods: Triangulation in action. Administrative Science Quarterly, 1979, 24(4): 602-611.

43. Creswell JW, Poth CN. Qualitative inquiry and research design: choosing among five approaches. Sage publications, 2017.

44. Vitalini S, Iriti M, Puricelli C, Ciuchi D, Segale A, Fico G. Traditional knowledge on medicinal and food plants used in Val San Giacomo (Sondrio, Italy)—An alpine ethnobotanical study. J Ethnopharmacol, 2013, 145(2): 517-529. http://doi.org/10.1016/j.jep.2012.11.024.

45. Tardío J, Pardo-de-Santayana M. Cultural importance indices: a comparative analysis based on the useful wild plants of Southern Cantabria (Northern Spain). Econ Bot, 2008, 62(1): 24-39. http://doi.org/10.1007/s12231-007-9004-5.

46. Liu HM, Xu ZF, Xu YK, Wang JX. Practice of conserving plant diversity through traditional beliefs: a case study in Xishuangbanna, southwest China. Biodivers conserv, 2002, 11(4): 705-713. http://doi.org/10.1023/A:1015532230442.

47. Chen M, Qu Y, Liu BL, Ye F. A study on the health care methods of homology of medicine and food of Wa people. Chinese Journal of Ethnomedicine and Ethnopharmacy, 2018, 27(18): 1-3.

48. Aguilar-Støen M, Moe SR, Camargo-Ricalde SL. Home Gardens Sustain Crop Diversity and Improve Farm Resilience in Candelaria Loxicha, Oaxaca, Mexico. Hum Ecol, 2008, 37(1): 55-77. http://doi.org/10.1007/s10745-008-9197-y.

49. Abizaid C, Coomes OT, Perrault-Archambault M. Seed sharing in Amazonian indigenous rain forest communities: a social network analysis in three Achuar villages, Peru. Hum Ecol, 2016, 44(5): 577-594. http://doi.org/10.1007/s10745-016-9852-7.

50. Pautasso M, Aistara G, Barnaud A, Caillon S, Clouvel P, Coomes OT, Delêtre M, Demeulenaere E, De Santis P, Döring T, Eloy L, Emperaire L, Garine E, Goldringer I, Jarvis D, Joly Hl, Leclerc C, Louafi S, Martin P, Massol F, McGuire S, McKey D, Padoch C, Soler C, Thomas M, Tramontini S. Seed exchange networks for agrobiodiversity conservation. A review. Agron Sustain Dev, 2013, 33(1): 151-175. http://doi.org/10.1007/s13593-012-0089-6.

51. Almekinders CJM, Louwaars NP, de Bruijn GH. Local seed systems and their importance for an improved seed supply in developing countries. Euphytica, 1994, 78(3): 207-216. http://doi.org/10.1007/bf00027519.

52. Akhter S, Alamgir M, Sohel MSI, Rana MP, Ahmed SJM, Chowdhury MSH. The role of women in traditional farming systems as practiced in homegardens: a case study in Sylhet Sadar Upazila, Bangladesh. Trop Conserv Sci, 2010, 3(1): 17-30. http://doi.org/10.1177/194008291000300103.

53. Rocheleau DE. Gender and biodiversity: A feminist political ecology perspective. IDS bulletin, 1995, 26(1): 9-16. http://doi.org/10.1111/j.1759-5436.1995.mp26001002.x.
54. Momsen JH. Gender and biodiversity: a new approach to linking environment and development. Geogr Compass, 2007, 1(2): 149-162. http://doi.org/10.1111/j.1749-8198.2007.00011.x.

55. Yang YH, Bai KY, Jarvis D, Long CL. Xishuangbanna cucumber landraces and associated traditional knowledge. Biodiversity Science, 2019, 27(7): 743-748. http://doi.org/10.17520/biods.2019108.

**Figures**

![Map of Wa areas in China](image)

**Figure 1**

Geographic location of the study villages in Wa areas in China

Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.
Figure 2

The taxonomic families with traditional vegetable varieties recorded in the home gardens.

- Mean no. of traditional vegetables per home garden
- Mean no. of introduced vegetables per home garden
- Mean no. of vegetables per home garden
Figure 3

Portrait of vegetable diversity in six Wa villages

![Bar Chart: The self-consumption proportion of vegetables in home gardens]

Figure 4

The proportion of total vegetables consumed sourced from home gardens

![Pie Chart: All by themselves - 78%, From neighbors and relatives - 13%, Local market - 8%]
Figure 5

Proportion of households' source of traditional vegetable seed supply

Figure 6

Responsibility for preservation and cultivation of traditional vegetables in home gardens (proportion/head of household)
Figure 7

Factors for keeping growing traditional vegetables perceived by Wa respondents