Agrobiodiversity and in situ conservation in ethnic minority communities of Xishuangbanna in Yunnan Province, Southwest China

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Abstract

Background: Xishuangbanna of Yunnan Province, southwest of China belongs to a global biodiversity and cultural hotspot. Agrobiodiversity plays an essential role in local livelihoods and traditional culture in the region. However, preliminary studies suggest that diversity of crop plants and livestock species is declining. We hypothesized that agrobiodiversity and traditional means of preserving agrobiodiversity are threatened because of changes in government policy in favor of commercial plantations, land use change and changes in traditional agricultural practices. We investigated whether or not agrobiodiversity was declining, the specific causes, and signs of active biodiversity conservation practices in ethnic minority communities of Xishuangbanna which could form the basis for extensive in situ conservation programmes.

Methods: A series of field studies to document trends in agrobiodiversity were conducted in different ethnic minority communities in Menghai County, Mengla County and Jinghong City of Xishuangbanna of Yunnan Province, southwest of China between July 2015 and February 2016. Data was obtained through the use of semi-structured questionnaires, field observation and participatory rural appraisal (PRA) tools. A total of 360 ethnic households provided information on current status, functions, characteristics, changes, and threatened factors of farming crop and livestock resources. Some measures for in situ conservation of agricultural biological resources were also researched using PRA methods.

Results: Two hundred twenty-six crop varieties belonging to 31 families, 71 genera and 101 species were identified in Xishuangbanna, which included 83 vegetable crops, 77 food crops, 24 spice crops, 22 fruit crops, 13 cash crops, 6 oil crops, and 1 cloth crop, respectively. There were 15 livestock varieties, belonging to 6 major species: cattle, pigs, goats, chickens, ducks, and geese. Different crop and livestock resources had their own characteristics, functions and threatened factors. Since 2002, agroecosystem, crop diversity and livestock diversity have declined greatly over the Xishuangbanna region as a whole under implementation of the Sloping Land Conversion Program (SLCP). Swidden agriculture was completely eliminated under this program and gradually replaced by large land areas devoted to rubber, tea and banana plantations. Villager numbers engaging in farming production and population of crops and livestock were greatly decreased, particularly in terms of production of local traditional varieties. However, some in situ conservation measures such as seeds preservation, planting of traditional crops and raising livestock have played an important role in local agrobiodiversity conservation.

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Background

Biodiversity is the material foundation of human survival and development and also is an important symbol to measure the environmental quality status and degree of ecological civilization in a region or a country. Biodiversity refers to the sum total of different animals, plants and organisms living on Earth and includes species and genetic diversity, as well as the variety of habitats and ecosystems where they live [1, 2]. Biodiversity functions to provide direct and beneficial products to human, regulation of climate and environment, formation of unique cultures, and other functions [3].

Agrobiodiversity plays a significant part in global biodiversity system [4]. The maintenance of agrobiodiversity is extremely important for production of food and other agricultural products, as well as for human development, including food security, nutrition and means for improving livelihood. Agrobiodiversity is the general term for all organisms related to food and agricultural production and can be demonstrated to be an important means of meeting human health and development goals [5, 6]. Promotion of agrobiodiversity involves utilization of species, germplasm conservation, utilization of resource management, and agricultural ecological environment protection. Farmers and agricultural producers are the main managers of agrobiodiversity and have abundant knowledge of biodiversity management and maintenance. Agriculture contributes to conservation and sustainable use of biodiversity, but it is also an important driving force for loss of biodiversity [6, 7]. However, currently agrobiodiversity and related traditional knowledge are often neglected and easily lost because of biological invasion, the advent of new crop varieties and the application of technology related to the production of transgenic organisms.

Xishuangbanna is a multinational region, which harbors much of the cultural diversity and biodiversity of China [8]. Swidden agriculture is central to local livelihood, agrobiodiversity and traditional culture in Xishuangbanna [7]. Widely known as the “Animal and Plant Kingdom”, Xishuangbanna is rich in animal and plant species resources. There are over 4669 vascular plant species, 700 species of higher animals and 1500 species of insects [8]. The number of these species makes up 21%, 40.3% and 15% of the total of Yunnan, or 13% 24% and 6% of that of China, respectively [8–10]. Moreover, there were more than 577 cultivated plant species in Xishuangbanna before 2011 [11]. However, in recent years, with rapid economic development and changing national policy, agricultural ecosystems and agrobiodiversity in the region face tremendous challenges.

We hypothesized that agrobiodiversity and traditional means of preserving agrobiodiversity are threatened by changes in government policies, land use change and abandonment of traditional agricultural practices. Therefore, our objective was to investigate whether there were indications that agrobiodiversity was in decline, and how much it has declined. Furthermore, we examined the role of in situ conservation via ethnic minorities in Menghai County, Mengla County and Jinchong City in Xishuangbanna from July 2015 to February 2016. Through a survey we sought to investigate what measures might provide for conservation of local biodiversity and traditional culture in Xishuangbanna.

Methods

Study area

Xishuangbanna Dai Autonomous Prefecture is situated in the south end of Yunnan Province, southwest China, between 99° 56′-101° 50′E and 21° 08′-22° 36′N. To the west and east, it borders Jiangcheng County and Puer City, and to the northwest, it shares a border with Lancang County in Yunnan Province, and shares a boundary of 1069 km with Myanmar and Laos in the southeast, south and southwest. The total area is 19,223 km² of which 95% is mountainous area. The elevation ranges from 477-2429 m, and annual average temperature is around 15-22 °C with an annual rainfall of 1138.6-2431.5 mm [7]. The region is inhabited by 13 ethnic groups, dominated by Dai people, supplemented by Han, Hani, Yi, Lahu, Bulang, Jinuo, Yao, Miao, Bai, Hui, Wa, and Zhuang people. Due to special geographical location, complicated terrain and superior climates, there are abundant agricultural biological resources and traditional culture [7, 12–14].

Conclusion: Abundant agricultural resources and agrobiodiversity are critical to the local livelihood and maintenance of traditional culture in Xishuangbanna. However, agrobiodiversity and related traditional culture have been greatly impacted by implementation of the SLCP since 2002. Therefore, in future conservation of agrobiodiversity, incorporating some sustainable protection measures based in local communities such as convening seed exchange fairs, conserving traditional varieties in permanent plots, making a visual documentary of indigenous cultivation, and providing traditional agricultural products to tourists should be carefully considered and adopted.

Keywords: Xishuangbanna, Agrobiodiversity, Diversity change, In situ conservation, Ethnic minority
Methods
The main aims of the study were to investigate indicators of agrobiodiversity decline and to examine the role of in situ conservation via ethnic minorities in Xishuangbanna. According to elevation and minority differences, a total of 24 ethnic minority villages of 11 townships in Menghai County, Mengla County and Jinghong City of Xishuangbanna were selected. The elevation range was 538-1660 m and ethnic groups included Dai, Hani, Lahu, Yao, Yi, Jinuo, Bulang, Miao, and Han.

Based on the selected villages, field data collection was undertaken using questionnaires, interviews, group discussions, key informants, observations, and participatory rural appraisal/rapid rural appraisal (PRA/RRA) from July 2015 to February 2016. Information gathered included: village name, ethnic groups, population, farming calendar, land area, and livestock. General information collected at the household level, included social and economic situation, the respondent’s basic situation and agricultural practices were supported by a survey using a questionnaire sampling 360 households during a field survey. This relatively large sample size enabled us to assess common trends despite some differences in terminology among respondents, taking care to account for nomenclature differences between different localities. Household information included: crop cultivation (crop type, origin, grow area, yield, function, purpose, problems, and conservation means) and animal production (herd size, function, purpose, problems, and conservation methods). Participatory Rural Appraisal (PRA) [15, 16] and ethnobotanical and anthropological methods [17, 18] were used to facilitate participation of local villagers in extraction and analysis of agrobiodiversity and related traditional agricultural knowledge in the field. Interviews were conducted individually and collectively, taking into consideration gender and age differences. Household samples were selected at random in 24 ethnic villages of 360 households in Menghai County, Mengla County and Jinghong City.

Data analysis
All primary data and sources were captured and analyzed with qualitative and quantitative methods and tools. In some cases like agrobiodiversity trends, qualitative comparisons were more appropriate than quantitative comparisons. Field data was entered in Microsoft Excel and analysed with the Statistical Package for Social Scientist (SPSS). Quantitative data was analyzed by using descriptive statistics through calculating frequency, percentage, means, and tables to present the outputs.

Results
Community farming calendar
Agricultural production was the most important production activity in rural communities of Xishuangbanna, and each year villagers spent a lot of time on cultivation, management and harvest of food crops and cash crops (Table 1). Due to high temperatures and adequate rainfall, crops could be grown over 2-3 seasons per year. Vegetables especially could be cultivated and harvested at any time because of faster growth rates and shorter growth periods. The cultivation time of crops for local villagers was usually influenced by market demand and cash crop types. Rubber tree tapping (March to November) and tea collection (February to October) were the main farming activities. Corn and vegetables could be cultivated at any time throughout the year, but winter corn and vegetables were mainly sown in January. Upland rice was generally sown in March, paddy rice was sown from May to June, and fall corn was sown from April to May (Table 1).

| Month   | Farming activities and traditional customs activities                                      |
|---------|------------------------------------------------------------------------------------------------|
| January | Winter corn management, weeding and fertilizing, sweet corn harvest, vegetable and peanut sowing, house building, wedding, tea weeding but not fertilizing, sugarcane harvest, *Amomum villosum* weeding and old branch and leaf cutting |
| February| Spring tea collection, fresh corn harvest, rubber tree weeding and fertilizing, sugarcane harvest, *Amomum villosum* weeding and old branch and leaf cutting |
| March   | Tea collection, rubber tree tapping, upland rice sowing and weeding, sugarcane harvest        |
| April   | Tea collection, corn sowing, rubber tree tapping, winter corn harvest, sugarcane harvest        |
| May     | Tea collection, corn sowing, rubber tree tapping, winter corn harvest, paddy rice seedling and transplanting, upland rice harvest |
| June    | Tea collection, rubber tree tapping, paddy rice seedling and transplanting, upland rice harvest |
| July    | Tea collection, rubber tree tapping, wild mushroom collection                                |
| August  | Tea collection, rubber tree tapping, wild mushroom collection, *Amomum villosum* collection  |
| September| Tea collection, corn harvest, rubber tree tapping, paddy rice collection                      |
| October | Tea collection, rubber tree tapping, paddy rice collection, vegetable sowing, sweet corn sowing, sugarcane leaf cutting |
| November| Winter corn harvest, wedding, fuel wood collection, house building, sugarcane leaf cutting    |
| December| Winter corn harvest, wedding, fuel wood collection, house building, sugarcane harvest, vegetable and potato sowing |
Livestock was also an important farming activity. All households raised large and small livestock (cattle, goats, pigs, chickens, ducks, and geese), and family members spent considerable time on animal husbandry. There were no special grasslands in Xishuangbanna, so cattle and goats were mainly herded to wastelands and mountains jointly owned by several households but pigs were pen-raised. Poultry such as chickens, ducks and geese were freely grazed near villagers’ houses.

Agrobiodiversity

Crop genetic resources and functions

There were 226 crop varieties belonging to 31 families, 71 genera and 101 species grown in Xishuangbanna (Table 2). The paddy rice (23 varieties) and corn (23 varieties) had the greatest number of varieties, followed by upland rice (21 varieties). There were 165 local crop varieties and 61 imported crop varieties, accounting for 73% and 27% of all crop varieties grown, respectively. Of the 226 crop varieties grown, there were 83 vegetable crops, 77 food crops, 24 spice crops, 22 fruit crops, 13 cash crops, 6 oil crops, and 1 cloth crop (Table 2).

Corn and rice were the main food crops, and were utilized both for human consumption and livestock fodder. Corn included 10 local varieties and 13 new varieties and was mainly used for livestock fodder grain (66.3%), followed by alcohol production (25.4%) and human consumption (7.1%), and was rarely for market sale (1.2%) (Table 3). Local villagers primarily consume corn made into an alcoholic drink, but do consume some fresh corn directly. In the region, there were 7 local varieties and 16 new imported varieties of paddy rice and 21 local varieties and no new imported varieties for upland rice. Almost all rice (90.6%) grown by local farmers was used for household consumption. Only a small amount of rice was used for alcohol production (5.8%) and market sale (3.6%) (Table 3).

Vegetables grown included 68 local varieties and 15 new imported varieties, which were mainly used for livestock fodder (50.4%) and household consumption (42.5%), and rarely for market sale. Spices grown included 22 local varieties and 2 new imported varieties, of which most were consumed by households (97.5%) and little for market sale (2.5%). The six oil crops (92.5%) and one cloth crop (100%) were mainly grown for household consumption. Fruit crops were grown for human consumption (60.4%) and market sales (39.6%). Most of the cash crops were introduced by local government and mainly grown for cash sales (78.4%) with a small amount grown for human consumption (21.6%) (Table 3).

Livestock genetic resources and functions

There were 15 livestock varieties, belonging to six major species in Xishuangbanna (Table 4). Animals raised included cattle, goats, pigs, chickens, ducks, and geese. Most cattle raised were yellow cattle and buffalo, both of which were local varieties. Yellow cattle were mainly used for transporting goods, including maize, rice and fodder collected in swidden land, and buffalo mostly used for plowing. The other uses of yellow cattle and buffalo included providing manure, labour, household consumption, and cash (Table 5). Cattle were never used to produce milk and rarely killed for household consumption, rather they tended to be consumed at big events such as funerals, weddings and religious activities in the village. Cattle manure was essential to maintain good agricultural yields. Usually, cattle served as a store of value (a valuable disposable asset) and were rarely sold, and when they were sold, it was not usually a planned transaction. Because of the high labour requirements of raising cattle, they were often owned and raised jointly by many households in wastelands and mountains. Goats provided manure, were sold or saved as store of value, and their meat was consumed at home. Goat faeces were highly valued as a fertilizer, and were said to have a better effect than pig or cattle manure. Goats required a household member to herd them full-time because they run quickly.

Pigs raised included two local varieties (Donggua pig and small ear pig) and three new imported varieties (Landrace pig, Durloc pig and Shuanghui pig). Generally, new imported pigs grown faster, were more easily raised, and reduced more fodder grain than traditional varieties. However, they were less flavorful and had lower nutrient levels and fetched a lower market price. A local pig took about at least one year to reach consumable size, but a newly import pig just required 3-6 months. The primary function of pigs was for household consumption. Pigs were also slaughtered for funerals, weddings, house building, rituals, and religious activities. When penned, pig manure contributed to the compost that was put on corn and vegetable fields. Pigs are rarely sold and piglets were given away to friends and relatives as gifts.

Chickens were raised by almost every household and numbers changed rapidly because a household may raise many large and small chickens at any one time. Chickens raised includes two local varieties (Chahua chicken and cultivated chicken) and two new imported varieties (Fighting chicken and Waidi chicken). Compared to traditional varieties, new imported chickens usually grew faster, were more easily raised, fattier, and heavier. However, they were less flavorful and had lower nutrient content and fetched a lower market price. A chicken took about six months to reach a saleable and consumable size. Chickens were easily sold in the village and can be converted quickly into small amounts of cash to be used for buying daily necessities. In addition to cash sales, chickens can be exchanged for wine, grain, piglets, and
| Family          | Scientific name   | Local variety | Imported variety | Resource type | Cultivation status                                                                 | Main characteristics and uses                                      |
|-----------------|-------------------|---------------|------------------|---------------|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| Amaranthaceae   | Amaranthus tricolor| 2             | 0                | Vegetable     | Some households and little land area per household                                   | Annual, green or red color, human consumption                         |
|                 | Spinacia oleracea  | 1             | 0                | Vegetable     | Some households and little land area per household                                   | Annual, human consumption, sale                                      |
| Amaryllidaceae  | Allium fistulosum  | 1             | 1                | Spice         | For local variety, many households and little land area per household                | For local variety, small root, short length, spicy, more fragrant, human consumption, sale |
|                 | Allium sativum     | 1             | 1                | Spice         | For local variety, many households and little land area per household                | For local variety, small root, short length, spicy, more fragrant, human consumption, sale |
|                 | Allium tuberosum   | 1             | 0                | Spice         | A lot of households and little land area per household                                | Tall and thin plant, human consumption, prickles                      |
| Anacardiaceae   | Mangifera indica   | 2             | 0                | Fruit         | Many households and little land area per household                                    | Perennial, good tasty, more fragrant, human consumption, sale         |
| Apiaceae        | Apium graveolens   | 2             | 0                | Vegetable     | A lot of households and middle land area per household                               | Good tasty, human consumption, sale                                  |
|                 | Coriandrum sativum | 1             | 0                | Spice         | A lot of households and little land area per household                                | Good tasty, human consumption, oil making                             |
|                 | Daucus carota subsp. sativus | 1 | 0  | Vegetable | Few households and little land area per household                                   | Short root, human consumption, sale                                 |
|                 | Eryngium foetidum  | 1             | 0                | Spice         | Some households and little land area per household                                  | Human consumption                                                    |
|                 | Foeniculum vulgare  | 1             | 1                | Vegetable     | For local variety, some households and little land area per household                | For local variety, grow fast, good fragrant, human consumption, seeds for medicine |
|                 |                   |               |                  |               | For imported variety, some households and little land area per household            | For imported variety, grow slow, human consumption, seeds for medicine |
| Araceae         | Amorphophallus albus | 1         | 0                | Vegetable     | Some households and little land area per household                                  | Perennial, small root, human consumption, sale                       |
|                 | Amorphophallus krausei | 1    | 0                | Vegetable     | Some households and little land area per household                                  | Perennial, small root, human consumption, sale                       |
|                 | Amorphophallus yuloensis | 1 | 0  | Vegetable | Some households and little land area per household                                  | Perennial, small root, human consumption, sale                       |
|                 | Amorphophallus yunnanensis | 1 | 0  | Vegetable | Some households and little land area per household                                  | Perennial, small root, human consumption, sale                       |
|                 | Colocasia esculenta | 1             | 0                | Vegetable     | Some households and little land area per household                                  | Perennial, small root, human consumption, fodder                     |
|                 | Colocasia gigantea  | 1             | 0                | Vegetable     | Some households and little land area per household                                  | Perennial, big root, human consumption, fodder                       |
| Asteraceae      | Glebionis coronaria | 1             | 0                | Vegetable     | Some households and little land area per household                                  | High yield, human consumption                                       |
|                 | Helianthus annuus  | 3             | 0                | Oil           | Some households or no households and middle land area per household                  | Low yield, drought resistance, barren resistance, snacks, making oil |
|                 | Lactuca sativa     | 0             | 1                | Vegetable     | Many households and little land area per household                                   | Perennial, high yield, human consumption, fodder, sale               |
| Brassicaceae    | Brassica juncea    | 3             | 0                | Vegetable     | Many households and little land area per household                                   | Low yield, good tasty, fodder, prickles, human consumption           |
|                 | Brassica oleracea var. capitata | 1 | 1  | Vegetable | For local variety, a lot of households and little land area per household            | For local variety, low yield, more sweet, prickles, human consumption |
|                 |                   |               |                  |               | For imported variety, few households and little land area per household              | For imported variety, high yield, human consumption, fodder          |
Table 2 Summary of type and characteristics of crops in Xishuangbanna (Continued)

| Family              | Species                  | Type  | Count | Description                                                                 |
|---------------------|--------------------------|-------|-------|-----------------------------------------------------------------------------|
| Brassica rapa       | subsp. chinensis         | Vegetable | 1     | For local variety, a lot of households and little land area per household   |
|                     |                          |       |       | For imported variety, a lot of households and little land area per household |
|                    |                          |       |       | For local variety, low yield, good tasty, small length and leaf, human consumption |
|                    |                          |       |       | For imported variety, high yield, high length and big leaf, human consumption, fodder |
| Brassica rapa       | subsp. pekinensis        | Vegetable | 2     | Many households and large land area per household                           |
| Raphanus sativus    |                          | Vegetable | 1     | For local variety, few households and little land area per household         |
|                     |                          |       |       | For imported variety, a lot of households and little land area per household |
| Bromeliaceae        | Ananas comosus           | Fruit | 1     | Few households and little land area per household                           |
| Caricaceae          | Carica papaya            | Fruit | 1     | Many households and little land area per household                          |
| Bromeliaceae        | Ipomoea batatas          | Vegetable | 2     | For local variety, some households and little land area per household        |
|                     |                          |       |       | For imported variety, few households and large land area per household       |
| Convolvulaceae      | Ipomoea aquatica         | Vegetable | 1     | For local variety, some households and little land area per household        |
|                     |                          |       |       | For imported variety, few households and large land area per household       |
|                     |                          |       |       | Extension by government since 2004, 2-3 m height, sale                       |
| Convolvulaceae      | Ipomoea batatas          | Vegetable | 2     | For local variety, some households and little land area per household        |
|                     |                          |       |       | For imported variety, few households and large land area per household       |
| Cucurbitaceae       | Benincasa hispida        | Vegetable | 2     | For local variety, a lot of households and large area per household          |
|                     |                          |       |       | For imported variety, few households and little land area per household      |
| Citrullus lanatus   |                          | Fruit | 0     | Few households and large land area per household                            |
| Cucurbitaceae       | Cucumis hystrix          | Vegetable | 1     | Few households and little land area per household                           |
|                     |                          |       |       | Prostrating, high yield, more sweet, human consumption, sale                |
| Cucurbitaceae       | Cucumis melo             | Vegetable | 1     | Few households and little land area per household                           |
|                     |                          |       |       | Climbing, middle yield, more sweet, human consumption, sale                 |
| Cucurbitaceae       | Cucumis sativus          | Vegetable | 2     | For local variety, some households and little land area per household        |
|                     |                          |       |       | For imported variety, a few households and little land area per household    |
|                     |                          |       |       | For local variety, no thorn, short, prostrating or climbing, low or high yield, more sweet, human consumption, sale |
|                     |                          |       |       | For imported variety, thorn, long, climbing, high yield, human consumption, sale |
| Cucurbita moschata  |                          | Vegetable | 4     | For local variety, some households or no households and little land area per household, or few households and large land area per household |
|                     |                          |       |       | For imported variety, many households and large land area per household      |
|                     |                          |       |       | For local variety, different shape, low yield, more sweet, fodder, human consumption, sale |
|                     |                          |       |       | For imported variety, high yield, fodder, human consumption, sale           |
| Lagenaria sicenaria |                          | Vegetable | 3     | Some households and little land area per household or few households and large land area per household |
|                     |                          |       |       | Different yield, making cucurbit flute, human consumption, sale, fodder, making bailer |
| Luffa aegyiaca      |                          | Vegetable | 2     | A lot of households and little land area per household                      |
|                     |                          |       |       | Middle and high yield, good tasty, human consumption, washing dishes        |

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| Family          | Genus               | Type  | Characteristics                                                                 |
|-----------------|---------------------|-------|---------------------------------------------------------------------------------|
| **Momordica**   | charantia           | 1     | 1 Vegetable                                                                   |
|                 |                     |       | For local variety, few households and little land area per household            |
|                 |                     |       | For imported variety, few households and large land area per household          |
|                 |                     |       | For local variety, low yield, more bitter, human consumption, sale             |
|                 |                     |       | For imported variety, high yield, less bitter, sale, human consumption         |
| **Sechium**     | edule               | 1     | 0 Vegetable                                                                   |
|                 |                     |       | Many households and little land area per household                              |
|                 |                     |       | Climbing, disease resistance, better tasty and more pretty fruit in winter,    |
|                 |                     |       | human consumption, sale                                                       |
| **Dioscoreaceae**| **Dioscorea**       | 2     | 0 Vegetable                                                                   |
|                 | esculenta           |       | Some households and little land area per household                             |
|                 |                     |       | Perennial, low yield, small and middle root, human consumption                |
| **Dioscorea**   | opposita            | 2     | 0 Vegetable                                                                   |
| **Euphorbiaceae**| **Hevea**           | 0     | 1 Cash                                                                        |
|                 | brasiliensis        |       | A lot of households and large land area per household                          |
| **Fabaceae**    | **Arachis**         | 2     | 1 Oil                                                                         |
|                 | hypogaea            |       | For local variety, some households and little land area per household          |
|                 |                     |       | For imported variety, few households and little land area per household        |
|                 | **Glycine**         | 2     | 0 Vegetable                                                                   |
| **Lablab**      | purpureu            | 2     | 0 Vegetable                                                                   |
| **Phaseolus**   | coccineus           | 2     | 0 Vegetable                                                                   |
| **Phaseolus**   | vulgaris            | 3     | 0 Vegetable                                                                   |
| **Pisum**       | sativum             | 1     | 1 Vegetable                                                                   |
| **Psophocarpus**| tetragonolobus      | 2     | 0 Vegetable                                                                   |
| **Senegalia**   | pennata             | 1     | 0 Vegetable                                                                   |
| **Vicia**       | faba                | 1     | 0 Vegetable                                                                   |
| **Vigna**       | angularis           | 1     | 0 Vegetable                                                                   |
| **Vigna**       | radiata             | 1     | 0 Vegetable                                                                   |
| **Vigna**       | sinensis            | 0     | 1 Vegetable                                                                   |
| **Vigna**       | umbellata           | 1     | 0 Vegetable                                                                   |
| **Vigna**       | unguiculata         | 0     | 2 Vegetable                                                                   |
| **Lamiaceae**   | Agastache rugosa    | 1     | 0 Spice                                                                       |

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| Family         | Genus                  | Type | Yield Characteristics | Uses                                      |
|----------------|------------------------|------|-----------------------|-------------------------------------------|
| Elsholtzia     | kachinensis            | Spice| A lot of households and little land area per household | Human consumption, sale                   |
| Mentha         | haplocalyx             | Spice| A lot of households and little land area per household | Human consumption, sale                   |
| Ocimum         | basilicum              | Spice| A lot of households and little land area per household | Good tasty, good smell, human consumption, sale |
| Perilla        | frutescens             | Spice| Few households and little land area per household       | Low yield, more fragrant, human consumption |
| Pogostemon     | cablin                 | Spice| Some households and little land area per household      | Low yield, more fragrant, human consumption |
| Moraceae       | Artocarpus heterophyllus| Fruit| A lot of households and little land area per household | Perennial, good smell, human consumption, sale |
| Musaceae       | Musa acuminata         | Fruit| For local variety, many households and little land area per household | For local variety, little fruit, low yield, human consumption, fodder, sale For imported variety, large fruit, high yield, human consumption, fodder, sale |
| Musaceae       | Musa basjoo            | Fruit| A lot of households and little land area per household | Leaf for multi-purposes, human consumption, fodder, sale |
| Myrtaceae      | Psidium guajava        | Fruit| Many households and little land area per household       | Perennial, sweet, human consumption, sale |
| Passifloraceae | Passiflora caerulea    | Fruit| Many households and little land area per household       | Perennial, good smell, human consumption |
| Pedaliaceae    | Sesamum indicum        | Spice| Few households or no households and little land area per household | Good tasty, making oil, human consumption |
| Poaceae        | Coix lachryma-jobi     | Food | Few households or not household and large land area per household | Middle and high yield, good tasty, good smell, suitable for high altitude, human consumption, making wine, fodder, sale |
| Cymbopogon     | citratus               | Spice| A lot of households and little land area per household | Perennial, spice for chicken and pork cooking |
| Oryza sativa   |                        | Food | For local variety, a few households and little land area per household | For local variety, good tasty, good smell, low yield, suitable for high altitude, human consumption, disease resistance, barren tolerance, sale For imported variety, suitable for low and middle altitude, high yield, human consumption, sale |
| Oryza sativa var. spontanea |            | Food | A few households and little land area or large land area per household | Good tasty, good smell, low yield, suitable for high altitude, human consumption, disease resistance, barren tolerance |
| Saccharum      | officinarum            | Cash | A lot of households and large land area per household   | Imported since 1992, making sugar, sale, few human consumption |
| Sorghum        | bicolor                | Food | Few households or not household and large land area per household | Middle yield, good tasty, good smell, fodder, human consumption, making wine, making broom, washing dishes, dying cloth |
| Triticum       | aestivum               | Food | For local variety, no households per household           | For local variety, low yield, good tasty, human consumption, making wine For imported variety, high yield, less tasty, just for fodder |
| Zea mays       |                        | Food | For local variety, a few households or no households and little land area per household | For local variety, good tasty, low yield, suitable for high altitude, barren resistance, disease resistance, fodder, making wine, human consumption, sale |
| Family          | Species                  | Yield | Use                                      | Yield | Use                                      |
|-----------------|--------------------------|-------|------------------------------------------|-------|------------------------------------------|
| Polygonaceae    | *Fagopyrum tataricum*    | 2     | Food                                     | 0     | Few households and large land area per household |
| Ranunculaceae   | *Anemone vitifolia*      | 1     | Cloth                                    | 0     | No households                            |
| Rhamnaceae      | *Ziziphus mauritiana*    | 0     | Fruit                                    | 1     | Few households and large land area per household |
| Rosaceae        | *Prunus persica*         | 2     | Fruit                                    | 0     | Few households and little land area per household |
|                 | *Prunus salicina*        | 1     | Fruit                                    | 0     | Some households and little land area per household |
| Rubiaceae       | *Coffea arabica*         | 0     | Cash                                     | 1     | Some households and large land area per household |
|                 | *Coffea libericosa*      | 0     | Cash                                     | 1     | Some households and large land area per household |
| Rutaceae        | *Citrus grandis*         | 1     | Fruit                                    | 0     | Some households and land area per household |
|                 | *Citrus limon*           | 2     | Fruit                                    | 0     | Some households and little land area per household |
|                 | *Citrus medica*          | 1     | Fruit                                    | 0     | Some households and little land area per household |
|                 | *Citrus medica var. sarcodactylis* | 1 | Fruit                                    | 0     | Few households and little land area per household |
|                 | *Citrus reticulata*      | 1     | Fruit                                    | 0     | Some households and land area per household |
| Solanaceae      | *Capsicum annuum*        | 2     | Spice                                    | 0     | Many households and little land area per household |
|                 | *Capsicum frutescens*    | 1     | Spice                                    | 0     | Many households and little land area per household |
|                 | *Nicotiana tabacum*      | 0     | Cash                                     | 2     | No households                            |
|                 | *Solanum betaceum*       | 1     | Vegetable                                | 0     | A few households and little land area per household |
|                 | *Solanum etuberosum*     | 2     | Vegetable                                | 0     | A few households and middle land area per household |
|                 | *Solanum lycopersicum*   | 1     | Vegetable                                | 1     | For local variety, some households and little land area per household |
|                 |                          |       |                                          |       | For imported variety, some households and a large land area per household |
|                 |                          |       |                                          |       | For imported variety, high yield, human consumption, sale |
|                 | *Solanum melongena*      | 1     | Vegetable                                | 0     | Many households and little land area per household |
|                 |                          |       |                                          |       | Middle yield, human consumption |
| Theaceae        | *Camellia sinensis*      | 3     | Cash                                    | 0     | A lot of households and large land area per household |
| Zingiberaceae   | *Amomum vilosum*         | 0     | Cash                                    | 1     | A lot households and large land area per household |
|                 | *Curcuma longa*          | 1     | Spice                                    | 0     | Some households and little land area per household |
|                 | *Zingiber officinale*    | 2     | Spice                                    | 0     | A lot of households and middle land area per household |
|                 |                          |       |                                          |       | Perennial, yellow root, human consumption, sale |
Agrobiodiversity changes

Changes of crop diversity

According to field surveys, agricultural farming systems and crop diversity in Xishuangbanna have changed greatly. In order to support livelihood development and ecological protection of ethnic minority areas in Yunnan, national and provincial governments have issued a series of policies, such as poverty alleviation, forest conversion and agricultural technology extension. In 2002, the Sloping Land Conversion Program (SLCP) was implemented in Xishuangbanna. Apart from retaining paddy rice fields, permanent cultivation fields and vegetable gardens, almost all rotational fields (swidden) and some arable land were incorporated in the conversion program.

Villagers who took part in the program would be provided with grain subsidies or cash for five to eight years. However, they were required to plant trees and some cash crops and ecological crops (rubber, tea and bamboo) as the swidden lands were converted. The implementation of the SLCP has achieved great success in economic, environment and ecological terms. Household income from cash subsidies and from cultivation of cash crops in converted swidden lands was quickly increased. Land degradation was reduced, natural and artificial vegetative cover was increased and soil and water loss was reduced. However, this program brought traditional cultivation to an end, threatened survival and continuity of crop species diversity and traditional culture in Xishuangbanna. Since the implementation of the SLCP, agricultural land use and diversity of crop varieties have decreased. In 2002, the cultivated area under swidden agriculture accounted for 58% of all cropland, but now swidden cultivation is almost completely eliminated.

Traditional crop varieties, especially some upland rice and sticky corn have been lost. Many traditional crops disappeared because the yields were lower when planted in permanent fields rather than in swiddens. Moreover, as household income from cash subsidies and from cultivation of cash crops in converted swidden lands improved livelihoods, food crops were neglected by local villagers, especially cultivation and conservation of old varieties.

Every year, local agricultural technology service sectors would introduce different new crop varieties and technology in Xishuangbanna. At the beginning of implementation, to encourage local villagers to grow these species, local governments adopted a series of favorable incentives, such as providing free seed, chemical fertilizers, herbicides, and plastic sheeting. New crops had generally higher yield and faster growth than local crops and new technologies were more convenient and reduced labour, so these new crops were easily accepted and used by villagers. The main new crop varieties were maize, rice and vegetables, and new technologies were comprised of plastic sheeting, auxin, herbicide, and pesticides. With these promotions, local agricultural production has become more and more dependent on these technologies.

Many villagers reflected that new varieties were usually higher yield but were less flavorful, of lower nutritional value, preferred more fertile soil, and less resistant to diseases compared to traditional varieties. Some traditional crops, such as sticky maize and sticky rice, play an essential role in local traditional rituals such as traditional festivals, ancestor worship and religious activities. Therefore, in addition to planting a large area of new corn varieties to feed livestock, some villagers also devoted a small area to old varieties for household consumption, exchange and rarely sale.

Table 3: Function of different crops in Xishuangbanna

| Crop type | Eating (%) | Making alcohol (%) | Sale (%) | Fodder (%) | Others (%) |
|-----------|------------|--------------------|----------|------------|------------|
| Maize     | 7.1        | 25.4               | 1.2      | 66.3       | 0          |
| Rice      | 90.6       | 5.8                | 3.6      | 0          | 0          |
| Vegetable | 42.5       | 0                  | 7.1      | 50.4       | 0          |
| Spice     | 97.5       | 0                  | 2.5      | 0          | 0          |
| Cash      | 21.6       | 0                  | 78.4     | 0          | 0          |
| Oil crop  | 92.5       | 0                  | 7.5      | 0          | 0          |
| Fruit     | 60.4       | 0                  | 39.6     | 0          | 0          |
| Cloth     | 0          | 0                  | 0        | 0          | 100        |

Changes in livestock diversity

The number and variety of livestock resources have greatly declined in Xishuangbanna. Some livestock used in transport such as horses and mules were no longer used.

Other items. They were also frequently given as gifts between relatives and friends. Fighting chickens originated from Myanmar and Thailand and were mainly used for cockfighting. A small number of households also raised ducks and geese for household consumption, exchange and rarely sale.
Table 4 Summary of type and characteristics of livestock in Xishuangbanna

| Name          | Origin     | Population | Feed                      | Uses and function                                      | Other characteristics                                                                 |
|---------------|------------|------------|---------------------------|--------------------------------------------------------|----------------------------------------------------------------------------------------|
| Yellow cattle | Local      | Reduced    | No stall-raising          | Transport, manure, meat, sale, exchange, store of value | Various appearance colors, small size, no produce milk                                 |
| Buffalo       | Local      | Reduced    | No stall-raising          | Plowing, manure, meat, sale, exchange, store of value   | Black and white colors, big size, no produce milk, plowing before and now instead of plowing machine, many household raised jointly |
| Goat          | Local      | Reduced    | No stall-raising          | Consumption, manure, meat, sale, store of value         | Various appearance colors, small size, fast running                                    |
| Donggua pig   | Local      | Reduced in low elevation, increased in middle and high elevation | No stall-raising before and pen-raising now | Consumption, manure, meat, lard, gifts, exchange, savings, sale | Small size and small ear, slow growth, more 1 year raising, 50-70 kg, high price, high nutritional value, good tasty, more fodder grain, few diseases |
| Small ear pig | Local      | Reduced in low elevation, increased in middle and high elevation | No stall-raising before and pen-raising now | Consumption, manure, meat, lard, gifts, exchange, savings, sale | Small size and small ear, slow growth, more 1-2 year raising, 70-80 kg, high price, high nutritional value, good tasty, more fodder grain, few diseases |
| Landrace pig  | Imported   | Reduced    | No stall-raising before and pen-raising now | Consumption, manure, meat, lard, savings, sale | Big size and big ear, fast growth, 3-5 months raising, 150-200 kg, low price, fattier, low nutritional value, low tasty, few disease |
| Duroc pig     | Imported   | Steady     | No stall-raising before and pen-raising now | Consumption, manure, meat, lard, savings, sale | Big size and big ear, fast growth, 3-5 months raising, 150-200 kg, low price, fattier, low nutritional value, low tasty, few disease |
| Shuanghui pig | Imported   | Reduced    | No stall-raising before and pen-raising now | Consumption, manure, meat, lard, savings, sale | Big size and big ear, fast growth, 3-5 months raising, 150-200 kg, low price, fattier, low nutritional value, low tasty, few disease |
| Chahua chicken| Local      | Steady     | No stall-raising          | Consumption, sale, exchange, gifts, meat, eggs          | Small size and small feet, slow growth, 1 year raising, 1 kg, high price, more eggs, high nutritional value, high tasty, more hard bones, few diseases |
| Cultivated chicken | Local | Increased | No stall-raising          | Consumption, sale, exchange, gifts, meat, eggs          | Medium size, fast growth, 6 months raising, 1-3 kg, high price, more eggs, high nutritional value, high tasty, few diseases |
| Fighting chicken | Imported | Reduced | No stall-raising          | Cockfighting game                                      | Long feet, cockfighting game on Thursday and Friday                                      |
| Waidi chicken | Imported   | Reduced    | No stall-raising          | Consumption, sale, exchange, gifts, meat, eggs          | Big size, fast growth, 3-5 months raising, 2-5 kg, low price, low tasty, fattier          |
| Drought duck  | Local      | Reduced    | No stall-raising          | Consumption, sale, exchange, gifts, meat, eggs          | Small size, low growth, 6 months raising, 2-4 kg, high price, good tasty                |
| Water duck    | Local      | Reduced    | No stall-raising          | Consumption, sale, exchange, gifts, meat, eggs          | Big size, fast growth, 3-5 months, 3-4 kg, low price, low tasty                         |
| Goose         | Imported   | Reduced    | No stall-raising          | Consumption, sale, exchange, gifts, meat, eggs          | Big size, fast growth, 6-7 months raising, 5-6 kg, medium tasty                         |

employed by local communities. In order to improve local livestock breeds and promote local animal husbandry production, some new livestock breeds, especially pigs and chickens were often introduced by local governments. Hybridization of either pigs or chickens has resulted in the erosion of local varieties. Most yellow cattle, buffalo and goats were still from traditional varieties, but their populations were in decline. This was because many herding places have gradually been replaced by a large area plantation of economic crops such as tea, rubber, bamboo, and banana. Moreover, with a lack of special grasslands, villagers had no incentive to put more labour and material resources to herd livestock. Currently, there were very few cattle and goats raised in low altitude areas. Although there were some villagers raising a large number of cattle and goats at
In situ conservation of agrobiodiversity

Crops conservation Currently, the protection of crop diversity has not received enough attention by relevant interest groups in Xishuangbanna. Most of crops were usually used as the food supply in many communities. Some crops (such as sticky rice and sticky corn) had important significance for traditional rituals, but were rarely used for market sale, so many villagers did not think they had special protection value. Villagers and communities consciously or unconsciously protected crops through two ways, via preserved seeds or via planted crops. The main method of storing crop seeds was to put them on the fireplace in a residence. This method served to dry crop seeds and prevent insect damage. In addition, most families had an independent grain house to preserve crop seeds. After returning swidden to forest, some villagers still kept crop seeds but did not continue to plant them. Villagers thought that many crop seeds could only be stored for 1-3 years, but some may be preserved for 8 years.

The survey found that a lot of villagers planted a small land area or some villagers grew a large area of traditional crop varieties. In low altitudes, villagers usually planted a large area of new varieties of crops and very small land traditional crop varieties. However, if communities were close to market or had access to vehicles, villagers might plant a large area of old varieties, especially traditional vegetables for market sale. At high altitudes, many villagers mainly planted new varieties, but because more land was available, they also planted old varieties on some of the available land. While rubber and banana crops were at relatively young stages, villagers tended to grow old varieties such as upland rice, corn and vegetable simultaneously on the plantations.

Livestock conservation

Villagers kept livestock through breeding of traditional varieties. Livestock such as yellow cattle, buffalo and goats were all local traditional breeds. Before the SLCP, these livestock were not stall-raised and were freely grazed by individual family, but now due to increased land in cash crops, many households grazed jointly. At low altitudes, only a small number of villagers raised a few cattle and goats, but at high altitudes a small number of villagers raised larger numbers. Pigs were freely grazed before the SLCP and now were pen-raised in pigsties. Local villagers preferred traditional pork, so at middle and high altitudes, most families raised several Donggua pigs and small ear pigs. In some communities, some villages established special places to breed old varieties for market sale. Chickens were the main source of meat raised by villagers. Local villagers preferred to breed traditional chicken varieties such as Chahua chicken and cultivated chicken. Almost all families raised ducks before the SLCP, but subsequently only a small number of villagers raised a large number of ducks and geese for sale.

Discussion and recommendations

For many agricultural people inhabited in upland mountainous regions, swidden agriculture is an integral part of not only natural-resources management and genetic-resources conservation, but also of ethnic identity and bio-cultural heritage [6, 7]. In areas rich with natural biodiversity, the persistence of swidden cultivation is mostly seen as a ‘problem’ that obstructs the achievement of conservation objectives, and policies originating from a forest-conservation perspective often seek to eradicate swidden
agriculture. However, traditional rotational shifting cultivation contributes to the maintenance of diversity of both crop and animal genetic resources, and these play important roles in maintaining cultural identity [6].

Xishuangbanna is one of the ethnic minority areas in Yunnan Province and swidden agriculture is central to agrobiodiversity, livelihoods and traditional culture there [7]. Because of the location of Xishuangbanna neighboring Laos, Myanmar and Vietnam, some crop varieties are likely to be unique to the region. Some studies reported that there were more than 577 cultivated plants in Xishuangbanna before 2011 and most of them were related to swidden agricultural practice [7, 11, 12, 19, 20]. There were over 100 varieties of upland rice in swidden fields among just a few Hani and Lahu communities in Xishuangbanna before 1996 [7]. Genetic diversity, variety diversity and species diversity of agricultural resources in Xishuangbanna have declined and some crop varieties have even disappeared. First of all, land in agricultural production was decreased greatly because most swidden land was replaced by rubber, tea, banana, coffee, bamboo, and pine. Secondly, plantation style crops tend to towards monocultures and most food crops are new varieties. Finally, local traditional crop varieties, area over which they are planted, and the number of villagers cultivating them are gradually reduced.

For any ethnic group engaged in agriculture, agricultural production is a core part of the ethnic culture [6]. In Xishuangbanna, traditional agriculture is an important part culture feature for ethnic minorities such as Dai, Hani, Yi, Yao, Bulang, and Lahu. Traditional agriculture, food culture, other cultural aspects, traditional ecological knowledge, religion, and the concept of the universe are highly interrelated [12]. Along with implementation of the SLCP and livelihood development, many younger villagers lost interest in traditional culture, and were unwilling to return to traditional practices for agricultural production.

Besides in situ conservation, through sustainable uses, including techniques developed for propagation, cultivation, on farm and off farm management, new variety breeding, and scientific studies are also important protection measures for agrobiodiversity [21]. In many mountain areas, local food security is mostly dependent on conservation of agricultural biological resources and plant resources, so in situ conservation measures by local farmers are very important [22]. Stemming from our discussions with local villagers and relevant government agencies, we recommend the following conservation measures:

1) Promote consensus among different stakeholders on the value of agrobiodiversity conservation: This research found that new imported varieties of crops and livestock were widely accepted by local villagers, technicians and officials but there needs to be a way to alleviate the contradiction between traditional variety conservation and new variety extension. Many personnel promoting agricultural technology and many villagers have not recognized the importance of traditional agricultural biological resources, so it is necessary to implement a series of exchange meetings and other communication to promote consensus among different stakeholders on the value of agrobiodiversity conservation.

2) Encourage households to conserve traditional varieties in permanent plots: The advantages of traditional variety conservation through individual household cultivation may be realized by ensuring local villagers can take personal ownership of germplasm resources and publically participate in biodiversity conservation promotion [6]. However, some traditional low yielding varieties are not protected effectively, so it may be more feasible to utilize collective community farmland to conserve traditional crops in these cases. At the local farming system level, each household could contribute to land, seeds and the labour force. Each village could decide on participation, seed and labour contributions and how to distribute outputs.

3) Convene seed exchange fairs among farmers: Crop diversity can be enhanced by facilitating seed exchange among farmers [23]. Many households believe that other farmers are retaining traditional-crop seeds and expect that if, in the future, they want to plant these crops, they will be able to obtain seeds through seed exchanges [6, 24, 25]. In fact, information on traditional crop conservation is rarely exchanged among different communities. In order to raise awareness of traditional crop conservation for villagers and local township government, some traditional cultural-exchange meetings should be convened in different communities. During seed fairs, villagers could bring traditional seed varieties and exchange knowledge about seeds, as well as exchanging the germplasm itself. The fairs could also provide an opportunity for local government officials to understand the range and characteristics of traditional seed varieties and their current conservation status. Meanwhile, in order to improve farmers’ awareness and encourage them to protect older varieties, special competitions and prizes should be designated in various categories, such as traditional crop-variety preservation, traditional food making, song and dance, and traditional costume making [6].

4) Make a visual documentary of the indigenous knowledge related to cultivation: Considering the cultural significance and abundance of traditional
knowledge of various traditional resources, it is necessary to record the status, distribution, use and management, and cultural values of some agricultural biological resources, by using a digital video camera [6]. When the video is completed, an ethnic language version can be used to educate school children about traditional agriculture and related culture. Chinese language version may also be useful to support dialogue with policymakers in the future. The video documentary format is conducive to improve understanding of environment and minority culture for the younger generation. Moreover, local traditional knowledge is also recorded and preserved with this method.

5) Provide traditional agricultural products to tourists: The feasibility of developing processed products using traditional crop varieties for sale to tourists can be explored as a means to promote agrobiodiversity conservation [6]. Local government agencies could help villagers and communities to establish some tourism centres. These centres can organize local villagers to grow traditional crops, raise traditional livestock, collect wild medicines and cash plants, and make traditional costumes for markets. Traditional seeds, crop products, livestock products, traditional handicrafts, and traditional cultural shows would help educate and entertain tourists. This is regarded as a very important strategy for strengthening the linkage among agrobiodiversity conservation, preservation of traditional culture and livelihood development [6].

6) Ex situ conservation of agrobiodiversity: For rare and endangered agricultural crop and animal species in ethnic minority regions, ex situ conservation is another feasible strategy for agrobiodiversity conservation and may be particularly appropriate for certain crop or livestock varieties. Ex situ conservation could include seed banks/germplasm banks, zoos and botanical gardens [21]. In addition to preserving endangered species, ex situ conservation also provides good sources of crop and livestock materials for research as well as providing additional sources of these materials for farmers if needed.

Conclusion
Xishuangbanna is a multinational region considered to be a global biodiversity and cultural hotspot. The study found that there are abundant farming crop and livestock resources and that agrobiodiversity is central to local livelihood and traditional culture in Xishuangbanna. However, due to rapid economic development and land use changes, especially under implementation of the SLCP since 2002, local agrobiodiversity and related traditional culture have suffered losses and faced tremendous challenges. Some traditional crop and livestock resources have declined and some have even disappeared. In situ conservation measures such as preserved seeds, planted crops and livestock are very important methods for conserving local agrobiodiversity but need to be enhanced in Xishuangbanna. Thus in future conservation of agrobiodiversity, sustainable protection measures based in local communities should be considered and adopted.

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SCS, JWY and DYX designed the study; SCS, GFX, DYL, FDZ, GMJ, PFW, and SL performed the field studies; SCS and DRC analyzed the data and drafted the manuscript. All authors read and approved the final manuscript.

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