MANAGING AGRICULTURAL RESOURCES FOR BIODIVERSITY CONSERVATION

Case Study Yunnan, Southwest China

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A Study Commissioned

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Summary

Yunnan Province of southwest China, like much of the rest of the region, is dominated by rugged mountainous topography, climatic variability and biological diversity, and is populated by diverse cultural minority groups. Historically, these cultural minorities have practiced shifting cultivation, which depends on clearing native forests to plant agricultural crops. A rich agrodiversity at levels of crop species and varieties, plant species in agricultural fields and diversified ecosystems have been developed and conserved through agricultural systems by small farmers for their economy demands and their livelihood. Development projects, commercial exploitation and increasing demands have led to the displacement of the rice swiddens by rubber, tea, coffee, fruit, sugarcane and other commercial crops. This leads to not only a problems in loss of biodiversity but also changes in agrobiodiversity at levels of crop species and varieties, and indeed at the ecosystem level as hundreds of species planted in cycling shifting cultivation fields are transformed into permanent cultivation of monocultures.

For lacking of accurate scientific data and information, especially in the form of a national or regional agrobiodiversity, made it difficult to get a clear picture of the current status of agrobiodiversity management, and consequently to set rational priorities for action. Some findings have shown that agricultural activities and economic development do not necessarily eliminate biodiversity. On the contrary, some practices may enhance biodiversity while supplying food and other products to necessary for the livelihood of local farmers.

China starts with the formulation of its national action plan of biodiversity conservation in early 1990s, which was finalized and officially released by the State Council. And agrobiodiversity has been mentioned in the programme. But, there are not specific policies developed on development and conservation of agrobiodiversity to meet directly farmer’s livelihood and sustainable agriculture.

1. Impact of agricultural production systems in this region on the conservation and use of biodiversity

Agriculture can be viewed as supportive of biodiversity conservation, since the same places that produce our food and other living essentials also hold the great richness of life. This biodiversity plays an important role in agricultural processes. Agriculture forms a powerful basis for personal, experiential development of a profound meaning and connection to a setting or landscape (Lockwood, 1999). Furthermore, the wide diversification of crops and agricultural ecosystems created and experimented with small farmers may be the source of sustainable agriculture in the future (Brookfield and Padoch, 1994). The population continues to grow and commercial exploitation and increasing demands force more pressures on this diversity and knowledge.

China is considered internationally as one of the megadiversity countries in the world, where the number of species, as a whole, make up about one tenth of the total number of species of the world (Chen, 1992). Secondly, China with its ancient civilization and a history of several millennia has a wide variety of agriculture systems. Many important crops originated here, such as soybean, rice, barley, tea, apples, etc. Besides these, there are many wild-related species and ancestral forms of cultivated plants, such as wild soybean, wild barley and wild rice. Thirdly, seven percent of the world's cropland of China has to support 22% of the global population. Therefore, agrobiodiversity play a vital role in agricultural production and livelihood. However, China is a vast country with complex topogeography and climate. It crosses frigid, temperate and tropical zones from north to south. The agrobiodiversity management is spatially highly variable. The case study focuses on Yunnan, a southwest province of China.

1.1. Study area and its biodiversity

Yunnan is a frontier province in southwest of China, situated between $21^0$8'32" to $29^0$15'8" north latitude and $97^0$31'39" to $106^0$11'47" east longitude. It encompasses an area of 394,000 square kilometers, covering 4.1 % of China's territory. It borders on Guizhou province and Guangxi Zhuang Autonomous Region in the east, Sichuan province to the north, Tibetan Autonomous Region of China in the northwest, Myanmar in the west and both Laos and Vietnam in the south.

Yunnan encompasses a wide rangs of environments, including tropical and subtropical rainforest, temperate uplands and cool highlands of Hengduan and Gaoligong Mountains of the Himalayan range. It boasts the largest variety of plants in China and is known as the "Kingdom of Flora". Of the approximately 30,000 species of higher plants found in China, Yunnan claims 274 families, 2,076 genera and 17,000 species. In addition, there are 2,100 species of ornamental plants, of which over 1,500 are floriferous (Guo and Long, 1998). Quite a few are rare and endemic to Yunnan.

Because of its unique climate and geographical environment, Yunnan is also home to a wide variety of wildlife. This remarkable animal kingdom makes its home in a wide range of environments, ranging from frigid, temperate to tropical climates and includes 1,737 species of vertebrates and more than 10,000 species of insects. Among the vertebrates, there are 300 species of mammals, 793 birds, 143 reptiles, 102 amphibians and 366 freshwater fish. In the fish category alone, 5 families, 40 genera and 249 species are endemic to Yunnan. Many effects have been made to conserve this huge diversity. Forty-three nature reserves have been established in Yunnan at national and provincial levels since 1958 (see Annex 1). In recent years, more nature reserves have been established at the prefecture and country levels. The total conservation area is now up to 1.95 million ha. Among them, both the Xishuangbanna Nature Reserve and Guoligoing Nature Reserve are members of MAB-UNESCO. Tens of plants have been listed in the state red book for conservation. A further 46 species of animals and birds are listed as state-protected and another 154 species are under second-grade protection.

1.2. Agriculture systems in Yunnan

Yunnan Province of China, like much of the rest of the region, is dominated by rugged mountainous topography, and populated by diverse cultural minority groups. Approximately 94% of the total area is mountainous and hilly terrain, with river valleys comprising the remaining 6% and most suitable for agriculture. By the end of 1999, Yunnan's population had reached 41.92 million, of which more than 13.95 million are ethic minorities. Of the 55 minority groups in China, 51 can be found in Yunnan. Twenty-five ethnic minority groups live in compact communities, with a population more than 5,000 respectively. Of these minority groups, 15 are indigenous to Yunnan, ranking it as the first in China in terms of number of indigenous ethnic minority groups. These include: Bai, Hani, Dai, Lisu, Wa, Lahu, Naxi, Jingpo, Bulang, Pumi, Nu, Deang, Dulong and Jinuo.

Historically, these cultural minorities have practiced shifting cultivation, which depends on clearing native forests to plant agricultural crops, especially in the mountainous tropical and subtropical areas, and shifting cultivation is still the most important production method for the people among mountainous groups. For example, in Xishuangbanna, a south prefecture of Yunnan, it is estimated that swidden cultivation produces food for up to 20% of the people and swidden cultivation fields make up about 46,000 ha, which is 37.85% of the total farming land of the prefecture.

There are rich crop diversities -- the number of species and varieties in farmer activities of shifting cultivation. The main crop is upland rice and maize, but hundreds of other secondary crops such as fruits, medicines and vegetables are interplanted for their livelihood, include sweet potato, pea, soybean, buckwheat, millet, sorghum, cowpea, chile pepper, peanut, ginger, cotton, melon, tobacco, egg plant and so on. More crop varieties have been used in agriculture systems. However, these diversities have been rapidly diminished during the past 30 years as few cultivators (hybrid and

breeding cultivators) occupy an increasing larger area. This leads to not only a problems in loss of biodiversity but also changes in agrobiodiversity at levels of crop species and varieties, and indeed at the ecosystem level as hundreds of species planted in cycling shifting cultivation fields are transformed into permanent cultivation of monocultures.

Yunnan experience of cash cropping and intensification of agriculture, alternatives to shifting cultivation is instructive. Tea plantation is a traditional commercial product for the mountainous cultural groups. Rubber plantation started since the middle of 1970s by state farm and extensively developed by individual family since the early of 1980s. Rapid development of economy and individual land policy has provided opportunities to further diversify cash cropping. Coffee, sugarcane, passionfruit, Pomelom, citrus and Chinese cardamom has been rapidly extended since 1990s.

1.3 Impact of agricultural systems on use of biodiversity

The most agricultural practices have exploited a broad ecological and biophysical system both for the purpose of subsistence and commercial production. A range of activities in this area includes mainly shifting cultivation, forest products collection, and cultivation under native forests, permanent agriculture and cash crop plantation. The management system depended on all cultural groups' religion before 1949. Since then community ownership has appeared. After implementation of household responsibility system since early 1980s, farmers received lands for household cultivation. The decision-making system was totally shifted from collective quota system, village-based community system to individual farmers.

The expansion of agriculture has caused disruption of natural systems. Major environmental effects include:

- Reduction of natural forests
- Loss of species
- Loss of agrobiodiversity
- Conflicts between community and nature reserve
- Land degradation

2. Status and trends of key aspects of agrobiodibersity

For the rich diversity of natural environment, biodiversity and nationality culture, this forms the great agrobiodiversity of Yunnan. Every nationality utilizes rich biological resource directly to satisfy its development demand of food, medicine, construction and culture, as well as arts during its development progress. Correspondingly, every nationality summarizes and develops knowledge and technique of utilizing biological resource and constantly forms systemic knowledge and technique of utilizing and

managing biological resource. The most valuable practice is to develop great deal of crop varieties through domestication based on natural species, as well as to develop great deal of traditional artificial ecosystems. All these are important origin of developing sustainable agriculture of Yunnan, even of China and of the world in future. Although agrodiversity is a new systemic and holistic concept that similar to biodiversity, the local people have begun to use and practice it a long time ago.

2.1. Farmer creativity in harnessing crop diversity

Production of agricultural crops dominates Yunnan's economy, in part because of its frontier location, difficult access to the rest of China, mountainous topography, poor rural development, its rich natural biodiversity, and the diversity of cultural minority groups that farm its slopes. It contains a great repository of agricultural knowledge, developed through long creativity and experimentation with crops by smallholder farmers.

Crop diversity in agricultural systems, being affected by both human selection (e.g. taste, value) and natural selection from the surrounding environment (e.g. soil type, climate, disease), involves the conservation of local crop cultivars (or landraces) with the active participation of farmers. Agricultural varieties embody enrichment of gene diversity of natural species by develop traditional new variety of every crop through long time selecting and breeding deliberately based on utilizing some kind of species to improve its quality or to improve its yield. On the other hand, crop genetic resources are passed from generation to generation of farmers and are subject to different natural and human selection pressures. Farmers make decisions in planting, managing, harvesting and processing their crops that affect the genetic diversity of the crop populations. Over time a farmer may modify the genetic structure of a population by selecting for plants with preferred agromorphological characteristics. Farmers make decisions on how much of each crop variety to plant each year, the percentage of seed or germplasm to save from their own stock and the percentage to buy or exchange from other sources. Each of these decisions, which can affect the genetic diversity of cultivars, is linked to a complex set of environmental and socioeconomic influences on the farmer.

Yunnan is the richest area in crop variety diversity in China. Upland rice, wet rice, orchid, tea, and all kind of fruits are typical crop variety diversity in Yunnan. Many of these crops, such as rice (*Oryza sativa*), tea and lithi, originated from this area. Yunnan is regarded as one of origins of most crop varieties in Asian, such as *Oryza sativa* L., tea, etc. Most of agricultural variety resources have disappeared relative to generalizing of modern agricultural technique and crossbreed varieties. Most of variety resources are relative to culture, livelihood habit, and ecological environment of different nationality. Conservation of agricultural variety diversity has been to be one of pressing tasks of biodiversity conservation of Yunnan. Main agricultural crop varieties include (Guo and Long, 1998; Dai, 1994):

Oryza

In China, only Yunnan and Hainan provinces originate of 3 wild rice species, *Oryza Rufipogon, O. Officinalis* and *O. Meyeriana* in China. *Oryza Rufipogon* (2n=24, AA) characteristics of big and ringent stachys, athericerous grain and pilose glume, and average length of its grain of 0.7 to 0.9 cm. It can be divided into three types of red, white and semi-domestic type according to arista characteristics. *O. Officinalis* (2n=24, CC) characteristics of pilose glume, big and ringent stachys. Average length of its grain is 0.5 to 0.6 cm and average length of its arista doesn't beyond 2.0cm. It doesn't have type differentiation. *O. Meyeriana* (2n=24) characteristic of glabrous glume, beardless grain and twigless stachys, as well as with tuberculum. It is insensitive to length of light and has the widest distribution. It has been found in 102 places of 18 counties.

There are three characters of cultivated oryza in Yunnan. Firstly, most varieties have anthocyanin. The secondly, most varieties are glutinous, and most are fragrant glutinous. Finally, most are nude husk varieties. There are rich excellent germplasm resources of oryza varieties in Yunnan. For example, varieties of *Xiaobaigu* of Kunming and *Xintanheigu* of Lijiang have strong cold resistance that is regarded as the strongest cold resistance variety up to now. The length of stachys is 40 cm of *Haogelao*, one of big stachys varieties and there are over 300 grains per stachys. There are 50 g per thousands grain of *Haobuka*, one of big grain varieties. Rice cooked from *Haomusi*, one of soft varieties characterized by seldom getting hard when cool, not easy to getting sour, and being esculent whenever it's hot or cold.

Results of esterase isozyme research have also proved diversity of oryza variety resource in Yunnan. Gammarayspectrums of esterase isozyme of both cultivated oryza and common wild oryza in Yunnan are the richest and there are many common grounds. On the other hand, there is great difference of gammarayspectrums of esterase isozyme between verruca wild oryza and officinal wild oryza. Analysis result of karyotype also proved its diversity. For example, two-bit trabant found from two varieties of *Laocaogu* of Jiangchen and *Sanpangqishilong* are different from common oryza karyotype.

Triticum

There are 4 varieties and 1 sub-variety of triticum in Yunnan, common triticum (2n=42,AABBDD), dense stachys triticum (2n=28, AABB), conic triticum (2n=28,AABB), hard grain triticum, and sub-variety of Yunnan triticum (2n=42, AABBDD).

Main characters of common triticum are awny or beardless, short arista, red and white of glume and seed. There are 349 varieties of common triticum found in Yunnan and which is 89% of local variety in Yunnan. They always distribute with altitude of 300 to 3400 meters. Common triticum can be divided into three types of common type, orbicular glume multiflorous type and quasi-dense stachys type. Dense stachys

triticum mainly distribute in mountainous with altitude of 1700 to 3100 meters. The length of stachys is 5 to 7 cm. The color of its husk is red, white and black. There are 13 mutations of dense stachys triticum. Conic triticum mainly distribute in plain with altitude of 1100 to 2700 meters and there are 21 varieties are found in Yunnan. Sub-variety of Yunnan triticum is called iron husk triticum and is particular of Yunnan province. It distributes in 13 counties along Mekong River and Lujian River with altitude of 1500 to 2500 meters. There are several colors of husk, such as red, white, white husk with black side, black husk with white bottom and white husk with black fleck etc. There are 16 mutations of sub-variety of Yunnan triticum.

Hordeum

There are 1 variety of *H. Vulgare* L. and two sub varieties of both multi-arris and double-arris in Yunnan. Multi-arris sub variety distributes widely between E 98-104°, N 21-28° with altitude of 550 to 3,600 meters. Multi-arris sub variety can be divided into two types, one is hully and another is nude. There are 104 varieties of hully and 58 varieties of nude. Double-arris sub variety only distributes in Baoshan, Lulan, Luoping and Zhaotong etc with altitude of 1,600 to 1,900 meters. There are 19 varieties and 60 mutations of double-arris sub variety.

Zea

Zea mays is also the most productive food crop besides rice in Yunnan, There are big cultivation area and wide range, as well as many variety resource. 1863 varieties have been collected from most counties of Yunnan except 15 remote counties.

According to its grain character, Zea can be divided into 6 types. The percentage sequence of variety quantity of different type is hard grain type taked 59.1%, medial type 17.5%, waxiness type 15.6%, horse-tooth type 6.8%, dissilient type 0.9% and sweet type 0.17%. Zea variety of Yunnan is dominated by hard grain type as it is not easy to be wormy to be kept with plenty stratum corneum. According to grain color of variety, zea of Yunnan are dominated by white grain type of 44.5% of variety quantity and yellow grain type of 42.6%, other are dark-purple type of 3.9%, versicolor type of 2.6% and rare blood-streak type. According to mature time, zea varieties of Yunnan are dominant by media maturing type of 37.2% of variety quantity and media-late maturing type of 33.4%. There are litter early maturing type or late maturing type. Growth duration of the earliest variety is less one hundred days and the latest variety is over one hundred days. Most varieties of zea of Yunnan are single stachys and some varieties are double stachys. In addition, there are 3 to 5 stachys varieties, such as multi-stachys of Menghai and even 12 stachys variety, such as rare *Siluluo* of Menghai. The height of grain is different among different variety of zea. According to grain weight, zea variety is dominated by middle grain type that takes about 65% of all varieties as its kernel weight 251-300 g. Small grain type as its kernel weights below 250 g takes 25%. Big grain type as its kernel weights beyond 351 g takes 10%. For instance, kernel weight of Guizhou big white variety of Zhenxiong weights 504.8 g and Ruidian variety of Tengchong weights 560 g.

Fagopyrum

There are 9 varieties and mutations of wild fagopyrum found in Yunnan. They are golden fagopyrum (*F. Cymosum*), rock fagopyrum (*F. Gilesili*), thin cauli wild fagopyrum (*F. gracilipes*), tooth-alar wild fagopyrum (*F. Gracilipes var. odontopterum*), small wild fagopyrum (*F. leptopodum*), sparse stachys small fagopyrum(*F. leptopodum var. grossii*), linear leaf wild fagopyrum (*F. sineare*), bolting fagopyrum (*F. statice*) and hard twig ten thousand-year fagopyrum (*F. urophyllim*). There are several shapes of root of all varieties, such as perennial cloggy root, globular root and annual fiber. There is difference of plant shape among different varieties. For example, the height of hard twig ten-thousand-year fagopyrum is close to 2 meters with perennial brawny stem. On the other hand, the plant of linear leaf fagopyrum is annual thin and procumbent.

There are rich variety of cultivated fagopyrum and can be divided into two types in Yunnan. One is bitter type and another sweet type. Bitter type (*F. tataricum*) is anemophilous. The colors of flower are white and green. The shape of flower has two kinds, one is long androecium with short gynoecia, another is androecium as same long as gynoecia. There are 81 varieties of bitter type collected, from which 24 varieties have elliptic fruit and 57 varieties have trinal arris fruit. There are 80 varieties of bitter type without arris pterigota except one varieties. Kernel weight of *Tangqiao* of Wenshang is 24.9 g. On the other hand, kernel weight of *xiaokuqiao* of Gongshang is 8.8 g. In addition, grain quantity of individual and height of plant are different among different varieties.

Other food crop variety resource

There are *Sorghum bicolor var. kaoliang*, *Setaria italica*, *Panicum miliaceum* and *Panicum miliaceum var. glutinosa* besides above food crops in Yunnan.

There are 198 varieties of *Sorghum bicolor var. kaoliang* collected. Although variety quantity is not so large, it still has rich variety diversity. For example, growth duration of the earliest variety is 107 days and of the latest variety is 171 days. The height of most varieties is 150 to 350 cm. There are 2 varieties which height below 150 cm and 2 varieties which height over 350 cm. The biggest kernel weight is 28 g of black variety of Lijian. The smallest kernel weight is 5.5 g only of local variety of Guannan of Yunnan that is the smallest variety in China too. The average content of crude protein is 11.26 % of all varieties of China. There are 7 varieties' content of crude protein is over 14 % and 3 varieties' over 15 %. The biggest content of crude protein is 15.92 % of a local variety of Funing. At the same time, it is the second biggest variety of China, next to the biggest variety of small red variety of Leimong. In addition, there is rich difference of tannic content of variety resource of Yunnan.

97 varieties of *Setaria italica* have been collected. Varieties of *Setaria italica* of Yunnan mainly distribute in warm area and mountainous coombe. Its seed are used to

make alcohol and its stem is used as fodder for animal by local nationality. Most varieties have long growth duration and long spined chaeto. Height of plant is different among all varieties. Variety of Yunnan is typical late maturing small grain of south. Content of axunge and lysine of variety of Yunnan are higher than that of variety of Shangxi, main origin of *Setaria italica* thus variety resource of Yunnan have high worth in area of heredity and breeding.

Six varieties of *Panicum miliaceum* have been collected and sent to bank in Yunnan. *Panicum miliaceum* is annual or perennial herb of Gramineae and mainly used as fodder. Its seed is used to make alcohol and as fodder of fowl. All varieties have strong applanate glabrous strict stem and strong root. The height of all varieties is 93 to 124 cm and plant is resistant to leaning over. There are 6 to 11 effective tillering per individual. The shape of leaf is long acerosus and the length of leaf is 11 to 23 cm. There are 7 to 12 flowers per stachys. Maturing seed looks like chicken claw. Kernel weight is 2.2 to 3.4 g of *Panicum miliaceum* and its growth duration is 131 to 144 days.

Six varieties of *Panicum miliaceum var. glutinosa* have been collected and sent to bank in Yunnan. It is annual herb of Gramineae. It mainly distributes in seacoast of Dulongjian River of Gongshang of Lujiang river coombe, as well as in nationality resident are of river valley of low-grade temperature of northern Gaoligong Mountain. The stem of these six varieties is erective. The height of plant is 109 to 147 cm and the length of stachys is 28 to 41 cm. Maturing seed is glossiness and has hard smooth glumelle and hard smooth inferior palea. The grains are yellow, red and white. Kernel weight is 4.6 to 6.9 g and its growth duration is 90 to 106 days.

2.2. Species diversity in agriculture

The number of species in farmers' cultivation activities and the number of domesticated and semi-domesticated species used by farmers reflect not only the richness of natural biodiversity, but also farmer knowledge in managing for their benefit. Biological resources development has been put in the second economy strategies in Yunnan after tourism development.

The main biological resources have been catalogued as follows (Wu, 1990):

- Agricultural crops and variety: estimated about 10,000 agricultural crops and varieties in Yunnan.
- Oil plant resource: including edible and industry types; about 300 species, mainly tree species; 388 rape varieties.
- Vegetable: more than 100 species and varieties.
- Fruit: more than 1,000 species and varieties, belonging to 43 families and 74 genera.
- Special cash crops: including tobacco, sugarcane, tea and rubber in Yunnan.

- Timber species: More than 10,000 wild timber species, but less than 80 species domesticated.
- Aromatic plant: about 365 species belonging 69 families; 246 species with high development value.
- Chinese medicine/plant: estimated 1,000 species of important medicine plants, about 70 percent of total species in China; about 360 species in market or industry process.
- Mushrooms: estimated 270 species, about 75 percent of total species in China.
- Flowers and decoration plants: the leading flower and decoration plant production base in China; estimated 2,500 species.
- Protein plants: including edible, industry and medicine types; about 180 species.
- Fiber plants: about 160 species.
- Tree resins species: mainly for industry use in Yunnan.

The species, patterns and processes utilized by farmers in Yunnan vary greatly between cultural minority groups and geographic areas. As a point of illustration, a total of 315 species belonging to 219 genera and 85 families have been recorded as planted in homegardens of Dai group in Xishuangbannan prefecture (Yu et al, 1985). This richness of plants grown in Dai homegardens makes an important contribution to their livelihood (Guo and Long, 1998). Fu et al (2000b) investigates species diversity of different land management patterns of Daka, Xishuangbanna with methods of agricultural diversity assessment. The results show that the percentage of agricultural species diversity varies among utilization and management of different land resource. For example, there are 40 species in a $400m^2$ quarter of community forest and of which local smallholder farmer as building wood, fuel wood and medicine mainly utilizes 35 species.

2.3. Agroecosystem diversity

Agriculture in Yunnan, particularly mountainous areas, is usually classified as shifting cultivation, but in fact, small farmers practice many kinds of agriculture, especially after their settlement in a fixed location. No group retains exactly the same agricultural practices as ancestors did. Many types of cultivated lands and artificial ecosystems have been developed. For example, 220 different agroforestry combinations have been catalogued in south Yunnan (Guo and Padoch, 1995).

Agrodiversity of Yunnan is formed with base of rich natural biodiversity and nationality diversity, as well as society evolution diversity of different nationality of Yunnan. Effective conservation of agrodiversity will save technique and knowledge, as well as civilization of utilization and alteration of nature developed by human for thousands of years.

3. Approaches to the conservation and management of component of agrobiodiversity, in national agricultural plans and in provincial biodiversity strategies

Since 1950's, large-scaled surveys on Chinese flora and fauna were sponsored by the Chinese Academy of Sciences (CAS) and then followed by many colleges, universities and institutions. The surveys covered nearly the whole country including Yunnan province. The Environmental Law, Forest Law, The Wildlife Protection Law, National Natural Reserve Regulation, Soil and Water Conservation Law and other related legislations have been issued for preserving species and their habitats. And a series of regulations have been issues by both central and local governments (see Annex 2). Endangered species conservation and research work started in the 1950's. China Plant Red Data Book: Rare and Endangered Plants published in 1992, which contains in the first version 388 species of endangered and rare plants. Some exiting research projects related agrobiodiversity have been undergone during the recent years.

3.1 Pollinators

There are not specific policies developed on pollinator resources conservation in Yunnan, except nature reserve conservation and endangered and rare plants protection. Forty-three nature reserves have been established in Yunnan at national and provincial levels since 1958. In recent years, fifty-seven nature reserves have been established at the prefecture and country levels. The total conservation area is now up to 1.95 million. The first version 388 species of endangered and rare plants in China Plant Red Data Book, most are distributed in Yunnan. For example, there are 15 tree species, of first class protection among 37 tree species in China.

3.2 Soil biodiversity

Soils in Yunnan usually have clay textures and are deep, highly leached, weathered, and acidic. These Ultisols (US taxonomy) are common in tropical and subtropical areas. Ultisols are distinctive for their deep red color (produced by intense oxidation of iron oxides) and so denoted as “red soil” in the Chinese soil classification. Yunnan is in technically active and geologically unstable uplands. Furthermore, the total area general under intensive agricultural use, predominantly for rice cultivation in river basin and for shifting cultivation and cash crop plantations in steep mountains. Hence, due to environmental and human influences, sediments are exposed and transported, resulting in high erosion rates.

Efforts to combat erosion and develop soil diversity are making some progress. According to Yunnan Government Soil and Water Conservation Regulation published in July 1994, it prohibits cultivation of slopes steeper than 25%. The Yunnan Soil

Conservation Services, at its headquarters in the capital of Kunming, attempts to formal act soil conservation programmes. These are usually planned at a local scale for agricultural and soil conservation technical serves.

3.3 Biodiversity that provides mitigation of pests and diseases

There are not specific policies developed on biodiversity that provides mitigation of pests and diseases.

Attempted solutions to the problems caused by modern agriculture, such as the overuse of fertilizers and pesticides, are usually expensive and often lead to new problems. Zhu and his colleagues (2000) from Yunnan agricultural University have used the traditional rice varieties interplanting with hybrids rice to mitigate fungal rice blast. The National Plan Committee of China has pay much attention to this research findings, and will fund to extend this technique into 8 provinces of south China in the following years.

3.4 Crop genetic resources

Considerable effects to survey crop diversity have been made by Xishuangbannan Tropical Botanical Garden, CAS, Kunming Institute of Botany, CAS, Yunnan Agriculture Bureau, and Yunnan Academy of Agricultural Sciences since 1950s. For example, Yunnan Academy of Agricultural Sciences has organized four times investigation on a large scale from 1978 to 1981. All these works provide important information of research and conservation of variety diversity of Yunnan.

3.5 Diversity at the landscape level

A special national project (Protection of Natural Forests) has been launched to protect the forests, especially natural forests and community ownership forests since 1998. The project in Yunnan contents the following major components:

- To stop logging in the forestry farms.
- To develop forests as commonweal forests.
- To execute strict protection of natural forests in Yunnan.
- To change the production line of a group of major forest enterprises and support them to channel economic diversification.
- To reduce the fallow land by setting up or improving the agricultural facilities including irrigation, paddy field and terraced land.
- To clear and move the illegal settlements in the state forests.

3.6 Wild biodiversity in agro-ecosystems

Forest Law in China has preserved wild biodiversity in agro-ecosystems. The follow-up action needs to be emphasized.

3.7 Traditional knowledge of agrobiodiversity

Biodiversity in agricultural systems involves the active participation of farmers. The knowledge is passed from generation to generation of farmers and is subject to

different natural and human selection pressures. Environmental, biological, cultural and socioeconomic factors influence a farmer's decision to manage this diversity. However, there is little study involved, such as indigenous crop management, crops intercropping and so on.

3.8. Agrobiodiversity management at the field level by farmers

To better understand agrobiodiversity management by farmers, a field work has been undertaken to evaluate development and conservation of plant diversity within the agricultural practices of Baka and Daka villages, 60 km east of Jinghong, the capital of Xishuangbanna prefecture, south Yunnan since 1998. Agrodiversity methodology, especially household based agriobiodiversity assessment has been used in this case study (Brookfield and Stocking, 1999; Guo et al, 2000).

Baka is a village in Jinuo Township, Xishuangbanna prefecture, with an elevation of 560-1,150 m. In 1971, six households moved to the present village site from the old village located about ten km away. This relocation was prompted by rapid population growth and poor transportation at the old village. Another six households moved to the village what is now a national nature reserve. A further 30 households moved from the old village in 1972. There are currently 56 families and 319 people in Baka, including 143 males and 125 females. The Jinuo community is the smallest of the total 55 cultural minority groups in China. They have lived in the Jinuo Mountains for generations, primarily as shifting cultivators. Chinese cardamom (*Amomum villosum*) is a medicine cash crop grown by small-scale producers in the humid lowland tropics. It is often grown under the canopy of natural forests. It is very popular in Baka and has been a major source of income since the 1980s (Guan et al, 1995).

Daka is a Hani village in Menglun Township, Mengla County, Xishuangbanna prefecture. Hani is the second largest group in Yunnan. The village is located on the mid-slopes of a mountain at an elevation of 540-1,100 m. The village was originally located nearby Huiban village, about seven km away. In 1966, some people moved out and established Daka village at its present site. Fifty-six families and 319 people now live in Daka, include 153 males and 166 females.

In the study area, the climate is a monsoon climate with an average annual rainfall of 1,500 mm, 82% of which falls between May and October. The annual mean relative humidity is 83%. The mean annual temperature is 21.5°C, ≥10°C accumulated temperatures is 7,811°C.

Tables 1 and 2 show the land uses in both study villages. In Baka, there is a total of 2,600 *mu* land (Note: 1 ha = 15 mu). Landscapes are comprised of a patchwork of community forests, crop plantations, and paddy fields besides traditional shifting cultivation. Despite economic development and population increases, Jinuo still practice the old 'slash-and–burn' or shifting cultivation method of farming this mountainous area. But rates, magnitudes and technologies have changed greatly.

Shifting cultivation land accounts for 53.8% of the entire village area, but this figure is decreasing as cash plantations expand in response to farmers' need for permanent income. Traditionally, the fallow period in this area was 13 years, but has now shortened to 3-5 years due to land-use pressures. Furthermore, more "effective" agricultural techniques have been adopted, such as beginning to plough the land during the second or third cropping years. Thus, greater production benefits can be achieved in a shorter time frame.

There is both more shifting cultivation and wet rice terraces per person in Daka, as compared to Baka. Secondly, agricultural land is more gently sloped in Daka. Daka has 220 *mu* of wet rice terraces. A single crop of rice is planted yearly, with watermelon planted in most of some fields as a winter crop. The major income comes from the rubber plantations in Daka. Forty-seven households have begun to earn income from rubber sales, and the average income per household is about 5,000 Yuan yr^{-1} (Note: 1US$ = 8.23 Yuan). *Amonum villosum* planted under community forests provides the second largest source of cash income.

Upland rice is the main crop in shifting cultivation fields, with annual yields of 400-700 kg/mu. Other crops, such as cotton, soybean, and groundnut are often intercropped with upland rice. The number of crops and varieties planted in swidden fields has decreased greatly in this region. In this study, field inventories and householders interviews were conducted on upland rice diversity in Baka. We recorded local names of upland rice varieties, and later collected data on their sowing time, type, shape, and other characteristics.

Twenty varieties of upland rice are grown in Baka (see Annex 3). These varieties can be classified according to i) sowing time (early, middle and later); ii) variety (non-glutinous and glutinous); iii) color (red, white, and mixed); and iv) most suitable temperature (cold resistant, heat-resistant and broadly tolerant) (Fu and Chen, 1999). There are two reasons why this village is planting such a diversity of rice varieties. One is that the altitude of the village shifting cultivation fields ranges from 550 to 1050 m. Secondly; new varieties are easily introduced into this village since it is now near the road.

In Baka, some varieties are planted more widely than others due to three main factors are: variation in natural conditions, mainly temperature, at different altitudes, differences in the economic situation among households, and differences in soil fertility.

The biggest change in the landscape is the expansion of cash crop plantations, including rubber, passionfruit, pomelon, litchi and tea. Agroforestry systems are widely practiced as an alternative to shifting cultivation. They can be classified into indigenous practices and more recent innovations. They have different productive aims and components. Table 3 shows the main agroforestry practices in Baka and

their characteristics.

With changing land use in this village and its impact on biological resources, farmers have changed their management strategies. For example, fuelwood used to be collected when fallowed fields were opened for cultivation. A survey of 60 percent of Baka households showed that 34.5 percent of fuelwood consumed now comes from fuelwood plantations, 14.5 percent from community forests, 44.2 percent from household forests, and 6.7 percent from the nature reserve (see Table 4). The kinds and quality of firewood in Baka have also changed over time (see Table 5) (Zeng et al, 2000).

Daka village site is located on steeper slopes. Homegardens have been more developed than in Baka, and assist to preserve agricultural species. Nine homegardens were sampled in Daka. The results showed great variation in plant species richness between sampled homegardens. Furthermore, hierarchical agglomerative analysis of the results indicated that plant community similarity between different households was low. The species-household curve of homegardens showed that the minimum sampling percentage was 15% based on the fit and assessment of model curve S=a+blnB (Cui et al, 2000). The survey found 165 plant species, 124 genera in the sampled plots of which were being utilized by local households.

There are more species maintained under the less intensive land use prevalent in Daka. Eleven 10×10 m quadrants of different land management systems were established in Daka and nine in Baka. Four 1×1m sub-quadrants were established in the corners of each quadrant to investigate the individual number of undergrowth species. The survey of plants utilized under different land management systems was undertaken at the same time. We found 73 families, 139 genera and 179 species distributed in the total of 0.1 ha of quadrants sampled under different land management systems in Daka (Annex 4). And 70 families, 146 genera and 166 species were distributed in the total of 0.08 ha of quadrants sampled under different land management systems in Baka (Annex 5). Cosmopolitan families, such as Compositae and Papiloinaceae, account for about 20% of total species recorded in Daka and Baka (Fu et al, 2000a). The percentage of tropical and subtropical families in different land management systems was comparatively lower than for a native tropical rainforest (see Table 6).

Compared with the complex canopy structure of tropical rainforest, canopy structure of different land management patterns was simple. Furthermore, some layers disappeared entirely from some land management patterns. Lianas, for example, disappeared in 45% of all quadrants in Daka, and 44% in Baka. Land management had reduced biodiversity through simplification of the canopy. Comparison of canopy layers and life forms indicated that there were fewer plant species distributed under the tree layer, although there were higher volumes of biomass in the managed land. Use of trees for construction wood and fuelwood has led to the disappearance of those best suited for those purposes (Fu et al, 2000b).

There were great variations in the diversity indices recorded in different land management systems. In Daka, the species richness index varied from 0.02 in paddy fields to 0.26 in community forests, while the agro-species richness index varied from 0.03 in reservoir dike to 0.75 in community forests. This indicates that conversion of natural forest into agricultural fields has greatly reduced biodiversity. In Baka, the species richness index varied from 0.04 in upland fields to 0.28 in plantations under natural forest. The agro-species richness index varied from 0.04 in orchards to 0.52 in home gardens. This shows that simple-artificial plantation and particularly slash-and-burn agriculture had greatly reduced biodiversity. On the other hand, the natural forest had conserved much more biodiversity. The Whittaker index varied from 0.58 to1 in Daka, and 0.63 to 1 in Baka. This reflects that there were differences in species composition between land management patterns (Fu et al, 2000a). Correspondingly, there were considerable variations in Jaccard's coefficient index between the different land management patterns. The index varied from 0 to 0.26 in Daka, and 0 to 0.23 in Baka. This variation within the diversity shows that different land management patterns contain different species composition, and hence lead to different succession processes.

The case studies demonstrate that a rich plant diversity has been persevered within farming systems, but with great variation between land management systems and the two study villages. With the high population pressures in Baka village, agricultural diversity may decline as land use intensifies. Daka, with its lower population density, has been more successful in preserving plant species within its farming systems. Dynamics of these changes and agricultural practices that would enable biodiversity conservation will be imperative if agriculture is to be sustainable in the future.

4. Policies, regulatory mechanisms and the implications of agricultural development plans on agrobiodiversity management

A number of laws and regulations concerning biodiversity in various aspects were further announced since 1980s and 1990s. China starts with the formulation of its national action plan of biodiversity conservation in early 1990s, which was finalized and officially released by the State Council. And agrobiodiversity has been mentioned in the programme. But, there are not specific policies developed on development and conservation of agrobiodiversity to meet directly farmer's livelihood and sustainable agriculture.

4.1 Agrobiodiversity management changes under socio-economic development

In China, all land belongs to the government. Farmers formerly managed their resources and lands and worked together under a system of community land ownership. At that time, agro-production was allocated according to labour input. Agrobiodiversity management was less diverse, as each community planted essentially the same crops on their community farmlands. After launching of " Household Production Contract System" of land reform in 1982, land use rights were allocated to individual households in agricultural areas. Land tenure has changed dramatically since that time. Smallholder farmers now manage most land types, such as community forests, upland fields, wet rice terraces, cash crop plantations and homegardens. Smallholder farmers have many options to manage their land, which may include by using multiple crops and different cultivation systems.

Two examples from PLEC's demonstration site at Baihualing village, Baoshan City of west Yunnan show how agrobiodiversity has changed based on resources and options available to farmers. Mr. Li Dayi (Yi) is a farmer with expertise in breeding and cultivation of timber trees. In 1982, he was allocated two ha of uplands from the community for corn cultivation. He has begun to plant a native timber tree (*Phoebe puwenensis*, propagating the seedlings by himself) and other timber trees since 1983. At present, his allocated land is covered by timber trees and other cash crops (*Ammomum vilosum,* etc.). Another example can be cited from another natural village in the same administrative village. Mr. Wu Chao-ming is expert in integrated land use. Since he has a big family, his household was allocated a big area of uplands in 1982. He began to plant the uplands (about one ha) with tree crops, such as chestnut (local cultivator), walnut, Chinese fir, *Toona ciliate* and so on since 1983. Our survey found 20 cultivated plants and more than 60 wild plants managed in his orchard. Some new cash crops with high market value have been introduced into his upland fields in recent years, e.g., *Ammomum kravanh,* which has been managed under agroforestry system. Walnut and/or chestnut have been intercropped with understory crops. He used his homegarden to propagate different kinds of seedlings, both for himself and other farmers. Table 7 shows species diversity within homegardens in this village. Species richness and number of useful species in homegarden vary significantly among households. Our survey found high species diversity in the homegardens, ranging from 34 to 85 in the sampled homegardens. The number of useful species ranged from 13 to 62, representing 38% to 73% of total species found in home gardens. Many useful wild species and semi-cultivated species are found in those homegardens.

4.2 Household income and its relation to agrobiodiversity

As shown in Table 8, the annual cash income of those households with diverse sources of income is generally higher than that of other households with fewer sources. This data is derived from PLEC's demonstration village, in Gaoligongshan area. This suggests that farmers who manage more varieties of crops (crop endowment, including cash crops) can obtain more cash income (financial endowment). But cash

income of most households still largely comes from traditional cash crops, sugarcane and grain in this region. About half of annual household cash income comes from these two crops. Sugarcane is the leading cash income source, accounting for 36.15% of total income. Sugarcane prices have decreased in recent years in response to international and domestic market demands. Local government controls the planting area and price of sugarcane. Cash income of those households depending only on sugarcane has seriously decreased in recent years. Most of these farmers are forced to seek off-farm work to supplement their income. Livestock, mainly breeding pigs, is also an important source of cash income, accounting for 15.1% of total household income. The most important findings here are that the households can obtain more sustainable cash incomes if they grow a diversity of crops and/or manage their land under agroforestry systems. According to our interviews, the cash income from agroforestry systems has been increasing yearly. For example, about 15% of annual cash income in Mr. Wu Chaoming's household comes from fruit trees with other crops grown as an understory.

4.3 Gaoligongshan Farmers' Association for Biodiversity Conservation

The Gaoligongshan Farmers' Association for Biodiversity Conservation was established in 1995. It is the first NGO for environmental protection in China. It is an association of self-organization, self-management, self-development and self-service by its member of farmers. Its principle objective is to balance the relationship between biodiversity (mainly agrobiodiversity) conservation and sustainable rural development. It also opens channels between government departments and farmers, as well as donor projects and farmers. Membership of the Association has been as high as 108, of which ten are women. The Association has organized yearly training workshops on agrobiodiversity development, useful rural knowledge and biodiversity conservation. During training activities, farmers learn skills on grafting, pruning, dealing with plant diseases and insect pests, and other practical agricultural skills.

In recent years, the Association has begun to identify and organize expert farmers to demonstrate agrobiodiversiy. It is well known that farmers are principle actors in the management of agrobiodiversity. Farmers frequently have rich skills in planting, grafting, pruning, breeding and other agroforestry techniques. Once a farmer has been identified as expert farmer, he or she is invited to lecture at training events organized by the Association. Cross-visits by farmer trainees to expert farmer are also sometimes organized. One example is Mr. Chen, an expert in rice variety selection and cultivation. Two years ago, he began cultivating a high quality rice variety instead of the hybrid that he had formerly planted. Now, increasing number of farmers are cultivating this rice variety because of its superior quality and market value.

5. Constraints to the use of sound policies and practices

Since the adoption of the policy of reform and opening up in 1978, Yunnan has under gone rapid economic and social development. Yunnan has gone through great changes and substantially increased its economic strength, with an economic growth rate of about 10 % for past 10 years. This change has led to diverse industrial cash crops, but loss in nature forests, ecosystems and agrobiodiversity managed by the small farmer. This trend includes:

- Growth of industrial plantations
- Decline in swidden cultivation
- Decrease in agroecosystem diversity
- Devolution of agricultural decision making from state to household

6. Examples of best practice

6.1 Upland rice intercropping with crops

In the fallow field, the main crop is upland rice and maize, but hundreds of other secondary crops such as fruits, medicines and vegetables are interplanted for their livelihood, include sweet potato, pea, soybean, buckwheat, millet, sorghum, cowpea, chile pepper, peanut, ginger, cotton, melon, tobacco, egg plant and so on. More crops and their varieties have been developed in agriculture systems

6.2 Agroforestry systems and development and conservation of biodiversity

Small-scale producers have largely practiced complex agroforestry systems. The system supports not only higher levels of crops but also more biological diversity and soil diversity (Chen, 1992).

6.3 Domesticated crops from fallow forest to homegarden field by small farmer

Smallholder usually collects both seeds and seedlings from fallow forest to homegarden, leading the shift from wild species to cultivated or semi-domesticated. There are two kinds of utilized species are usually transferred from fallow forest to homegarden. One is there are little quantity in fallow forest; another is smallholder great demand of whose species. For example, smallholder earns cash income U.S. $68.2/ household annually from fallow forest from 1998 to 2000 of Daka, Yunnan, SW China. Smallholder uses 79 species in fallow forest and 124 species in homegarden respectively. 22 species in homegarden are transferred from fallow forest. There is great difference of plant transfer from fallow forest to homegarden among different smallholder. The indigenous knowledge of plant transfer is valuable to development potential for human being.

6.4 Cash crop cultivation under forests

As a method of forest resource management, the cultivation of cash crops under tropical forest has practiced for hundreds of years. And it is increasingly popular in tropical areas of Yunnan. Some of them such as tea, *Calamus spp*. and *Baphicacanthus cusia* have been planted under natural forest for a long time by the indigenous minority nationalities, i.e. Jinuo, Hani. Others are more recent, and include *Amomum villosum*, A. tso-ko, and A. kravanh. At the beginning of the 1970s, A. villosum (a Chinese or Indo-Chinese species of cardamom, usually known as Chinese Cardamom and a member of the family of *Zingiberaceae*) was newly introduced to this area. A. villosum is an important tropical medicinal plant with high value. Nowadays there are more than 3,700 hectares of A. villosum in Xishuangbanna, which has been one of the largest growing areas of A. villosum in China. In Jinuo district, in the area administered from Jinghong city, there are more than 15,270 mu (about 1016 hectares, one ha = 15 mu) of A. Villosum and the annual product is 81 .5 tons, which is one-fourth of the whole country's total. A. villosum has become the major cash income source of the local people because of its high value. But more than 3000 mu of this A. villosum are being cultivated in Xishuangbanna natural Reserve, some even planted very close to the core zone of the reserve. A. villosum has been cultivated on a large scale before the ecological and social effects of this kind of cultivation are well known.

7. Results and lessons learned

Institutional and Administrative issues

Until now, Chinese Academy of Sciences, Yunnan Academy of Agricultural Sciences, environment and agriculture sections of Yunnan Government, universities and institutions have engaged partially in agrobiodiversity research and management. There is a need to form an institutional structure to coordinate agrobiodiversity development and conservation. At the national level, the State Environmental Protection Administration (SEPA) was designated as the lead agency in coordinating and monitoring biodiversity conservation and in implementing the CBD. Accordingly, SEPA had key responsibility for developing the NBAP and in its implementation.

Technical issues

For lacking of accurate scientific data and information, especially in the form of a national or regional agrobiodiversity, made it difficult to get a clear picture of the current status of agrobiodiversity management, and consequently to set rational priorities for action. Preliminary findings have shown that agricultural activities and economic development do not necessarily eliminate biodiversity. On the contrary, some practices may enhance biodiversity while supplying food and other products to necessary for the livelihood of local farmers. However, the social-economic

influences on agrobiodiversity are quite complex. There is urgent need (i) to understand land use change system and the impact of this change on agrobiodiversity, (ii) to document biodiversity conservation through agrobiodiversity practices, and (iii) to research on the relation between farmer's livelihood and biodiversity, especially the great gape between farmer's poverty and rich biodiversity.

8. Guidelines or policies that have resulted from this experience

The development and conservation of agrobiodiversity in agricultural systems is essential for a range of agronomic, economic and environmental reasons. Agrobiodiversity should be developed to support the livelihoods and wellbeing of local people, but wile still conserving traditional biodiversity resources. To some extent, a balance between agricultural production and biodiversity conservation must be struck. There is an urgent need to document changes in agrobiodiversity and trends induced by shifting cultivation and other alternative land use practices. The case studies demonstrate that rich plant diversity has been persevered within farming systems, but with great variation between land management systems, villages and even householders. With the high population pressures, agricultural diversity may decline as land use intensifies. With its lower population density, it has been more successful in preserving plant species within its farming systems. Dynamics of these changes and agricultural practices that would enable biodiversity conservation will be imperative if agriculture is to be sustainable in the future.

Agrobiodiversity is a new field of study. There remains insufficient data and objective information to alter public perception and policy until now. Future effects should pay more attention to training and education. More research is needed on existing strategies for on-farm conservation of agricultural diversity, especially indigenous systems that are able to meet agriculture production, maintain soil quality and conserve biodiversity.

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Table1. Overview of land use at Baka study site

Land-use stage	Field type	Area (mu*)	Percentage (%)
Reserved forests	Water source forest	300	11.5
	Holy hill	3	0.1
Cultivated lands	Fallow	1,400	53.8
	Paddy field	80	3.1
Crop gardens	*Hevea brasiliensis* plantations	633	24.3
	A*momum villosum* plantations	294	11.3
	Passiflora caerulea plantations	200	7.7
	Camellia sinensis plantations	25	1.0
	Cassia siamea plantations	55	2.1
Rusty fields	Rusty field	100	3.8
Homegardens	Homegarden	10	0.4
Number of field types		11	
Total area		2,600	100

* 15 mu = 1ha

Table 2. Overview of land use at Daka study site

Land-use stage	Field type	Area (mu*)	Percentage (%)
Reserved forests	Water source forest	400	3.7
	Holy hill	100	0.9
	Scenic forest	100	0.9
	Community forest	4,000	36.7
Cultivated lands	Fallow	950	8.7
	Paddy field	295	2.7
Crop gardens	*Hevea brasiliensis* plantations	2,800	25.7
	Amomum villosum plantations	250	2.3
	Passiflora caerulea plantations	750	6.9
	Camellia sinensis plantations	5	0.1
	Cassia siamea plantations	40	0.4
	Citrus grandis plantations	40	0.4
Water	Stew	5	0.1
Rusty field	Rusty field	1,100	10.1
Homegarden	Home-garden	75	0.7
Number of field types		15	
Total area		10,910	100

* 15 mu = 1 ha

Table 3. Categorization and description of agroforestry systems in Baka

Categories	Models	When appeared	Key components	Characteristics	Product purposes
Indigenous practices	Burn & slash	Long history	Forest, cereal staples, vegetables	Rational system of crops and forest	Mainly for subsistence use and some exchange
	Forest farming	Long history	Forest, *Camelia sinensis var, assamica*	Economic perennials planted under forests	
	Taungya	Since 1970	*Cassia siamea, Gossypium hirsutum,* agricultural crops, etc.	Learnt from Dai people	
	Home garden	Since settlement	Vegetables, fruit trees, *Jatropha curcas*, etc.	Improve microclimate	
Present practices	Taungya	Since 1970s	Rubber trees, agricultural crop, vegetables, tea tree, etc.	Simultaneous systems.	For both home use and sale
	Forest farming	Since 1970s	Forest, Chinese cardamom	Alternative to growing tea under forest	
	Passion fruit crops	Since 1993	*Passiflora cearulea*, economic trees, agricultural crops	Provides combination of short- and long-tern benifits	
	multi-storied orchard	Since 1980s	Fruit orchards	Long-term benefit (simultaneous systems)	

Table 4. Fuelwood species and sources in Baka village

Fuelwood species	Volume harvested (m^3)				Timber volume (m^3)	Percentage (%)
	Plantation	Community forest	Household forest	Nature reserve		
*Cassia siam*ea	28.6				28.6	34.5
Epiprinus siletanus		6.5	9.7	1.3	17.5	21.2
Pometia tomentosa		5.5	5.5	2.5	13.5	16.4
Schima wallichii			0.3		0.3	0.3
Bauhinia acuminata			2.0		2.0	2.4
Toona ciliate.			2.0		2.0	2.4
Wend landia			2.2	0.3	2.5	3.0
Anthocephalus chinensis, *Melia azedarch, Albixia Lucidior, etc.*			14.8	1.5	16.3	19.7
Percentage of origin	34.5	14.5	44.2	6.7		

Total households: 61; Sampled households: 36; Interviewed people: 268

Table 5. Changes in fuelwood species and quality over time in Baka village

Period	Main fuelwood species	Quality (%)			Source				
		High	Medium	Low	Community forest	Fallow field	Household forest	Plantation	Nature reserve
Before 1980	• *Epiprinus siletanus* • *Csatanopsis fleuryi* • *Lithocarpus fenestratus* • *Lithocaepus tomentosa* • etc.	100			60	40			
1980 – early 1990s	• *Epiprinus siletanus* • *Pometia tomentosa* • *Schima wallichii* • *Bauhinia acuminata* • *Toona ciliate* • etc.	70	30		45	25	20	10	
Post 1990s	• *Cassia siamea Epiprinus siletanus* • *Pometia tomentosa* • *Schima wallichii* • *Bauhinia acuminata* • etc.	73	8	19	15		44	35	8

Table 6. Comparison of dominant plant families inventoried tropical rainforests and different fields at Daka and Baka

No.	Tropical rainforest in Xishuangbanna				Different land management systems							
					In Daka				In Baka			
	Family	Type*	Genera	Species	Family	Type*	Genera	Species	Family	Type*	Genera	Species
1	Rubiaceae	S	17	29	Euphorbiaceae	S	13	18	Compositae	T	13	16
2	Euphorbiaceae	S	10	25	Compositae	T	11	12	Euphorbiaceae	S	12	13
3	Lauraceae	S	10	25	Gramineae	O	10	12	Papillionaceae	O	7	8
4	Moraceae	S	4	18	Rubiaceae	S	10	12	Gramineae	O	7	8
5	Annonaceae	T	7	13	Papillionaceae	O	9	11	Rutaceae	S	4	6
6	Meliaceae	S	8	11	Lauraceae	S	3	6	Rubiaceae	S	6	6
7	Myrainaceae	S	4	11	Myrsinaceae	S	3	6	Moraceae	S	5	5
8	Fagaceae	W	3	11	Fagaceae	W	3	5	Acanthaceae	S	4	5
9	Papillionaceae	O	5	10	Meliaceae	S	5	5	Araceae	S	4	5
10	Araceae	S	5	10	Anacardiaceae	S	5	5	Menispermaceae	S	3	4

*T=tropical family; S=subtropical family; W=temperate family; O=cosmopolitan family

Table 7. Species inventories in sampled house gardens at Baihualing village

Farmer	Sample No.	Total Species	Timbers	Fruits	Tree Vegetables	Vegetables	Condiments	Medicines	Fodders	Ornamentals	Grasses	Border Plants
Peng Xueli	G1	85	2	16	3	22	4	5	4	6	8	15
Peng Dafan	G2	52	2	2	3	21	2	4	2	0	11	5
Yang Zhixue	G3-A	40	0	7	1	8	1	1	1	0	16	5
	G3-B	39	0	0	0	13	2	0	1	0	14	9
Wu Chaoming	G4A	75	0	10	3	23	3	5	2	8	16	5
	G4B	34	1	5	1	4	0	0	2	0	11	10
Xiong Weirong	G5	50	2	2	0	13	0	1	1	0	20	11
Duan Zhaoqi	G6	73	1	6	1	18	2	4	3	0	30	8
Zhang Mingshu	G7-A	36	(Winter seasonal garden)			13	0	0	1	0	13	9
	G7-B	44	0	6	0	11	1	1	0	2	13	10
Liu Zhanwei	G8A	51	1	8	1	18	3	2	2	0	11	5
	G8B	46	1	4	0	13	1	3	2	4	13	5
Hu Jixue	G9	76	1	4	1	16	3	5	3	4	23	16
Zhang Pincai	G10	56	2	5	0	21	2	2	2	1	16	5

Table 8. Sources of income (Yuan *) in sampled households in the year of 1999 at Hanlong village

Farmer	Livestock	Chestnut	Walnut	Sugarcane	Coffee	Vegetables	Grains	Off farm income	Transportation	Total
Wu Chaoming	4,000	1,800	1,440	7,500	900		1,950	2,800	8,000	28,390
Liu Zhanwei	2,800		60	3,400	100	150	3,400	300		10,210
Duan Zhaoqi			30	2,040		20		220		2,310
Hu Jixue	800		600	2,000	640	60				4,100
Peng Dafan	1,900		300	3,600	1,000	120	1,200	600		8,720
Zhang Pincai			99	2,000						2,099
Xiong Weirong	700		1,000	4,000		200	1,850	1,200		8,950
Yang Zhixue		90	60	3,200		340	2,000	5,300	2,000	12,990
Zhang Mingshu	1,000			2,200		105				3,305
Peng Xueli	4,200			4,200	1,250		1,200	3,000		13,850
Yang Fujun	1,260			2,600			500	5,000		9,360
Yang Zhishun	600	40		600						1,240
Yang Guolian	600			400			725	3,000		4,725
Hu Yixing			600	3,000			315			3,915
Ynag Zhiguang	2,728		250	2,040			700	800		6,518
He Gengming	200	150	1,650		200			260		2,460
Xiong Weirshen	1,386			3,500		10	240			5,136
Liu Shaofeng	300	150		200		150		700		1,500
Liu Shaohua				3,000			215	600		3,815

Tang Zhenggui	1,800		10	2,910			326	2,700		7,764
Liu Yingze				600		50	5,120	3,260		9,030
Hou Jinfu				3,000		100	400			3,500
Dong Xinguang			300	1,000			180	100		1,580
Xiong Weirun	135		150				600	1,590		2,475
Tang Yongjian			150							150
Yang Fuqiang	800		200	3,000	250		1,180	180		5,610
Dong Debao				400		100	450	2,400		3,350
Total	25,209	2,230	6,899	60,390	4,340	1,405	22,551	34,010	10,000	167,034
%	15,10	1.33	4.13	36.15	2.60	0.84	13.50	20.36	5.99	100

* 1 US$ = 8.23 Yuan

Annex 1. National and provincial nature reserves in Yunnan, southwest China

Level	Name	Location	Area (ha)	Protected ecosystems	Started year	Staff (no.)
State	1. Xishuangbanna	Jinghong, Mengla, Menghai.	241,776	Tropical & south sub - tropical rainforest	1958	218
	2. Gao Li Gong Shan Mountain	Bao Shan, Teng Chong, Lu shui	123,900	Vertical distribution of subtropical & boreal forest ecosystems	1981	89
	3. Ai Lao Shan Mountain	Jing Dong, Zhen Yuan, Xing Ping , Chu Xiong , Shuang Bai	50,360	Humid broadleaf evergreen forest on middle mountain sub-tropical area	1981	54
	4. White Horse Snow	De Qing	190,144	Subalpine mountain, coniferous forest with Yunnan snub-nosed monkey	1981	40
	5. Cangshan Mountaion & Erhai Lake	Da Li , Yang Bi	79,700	Glacial trace, forest and plateau lake ecosystem	1981	5
	6. Nan Guen He	Chang Yuan	6,983	Tropical forest contains *Elphas maximus*	1980	51
Province	1. Long shan Mountain	Meng Lian	54	*Dracacna cochinensis* forest	1986	4
	2. Tong Bi	Ying Jiang , Long Chuan , Rui Li	34158	Guan tropical forest	1986	31
	3. Fen Shui Ling	Jing Ping	10,760	Mountain land moss broadleaf forest	1986	45
	4. Da Wei Shan Mountain	Ping Bian , He Kou	15,365	Tropical and sub-tropical broadleaf forest	1986	24
	5. Lao Jun Shan Mountain	Ma Guan	4,509	Monsoon broadleaf evergreen forest	1986	9
	6. Huang Lian Shan Mountain	Lu Chun	13,935	Monsoon broadleaf evergreen forest	1983	23
	7. Lai Yang He	Si Mao	7,035	Tropical & sub – tropical broadleaf forest	1986	9
	8. Da Xue Shan Mountain	Yong De	15,786	Humid broadleaf evergreen forest on middle mountain in sub-tropical area	1986	21
	9. Xiao Qiao Gou	Xi Chou	1,893	Monsoon broadleaf evergreen forest contains magnolias	1986	11
	10. Wei Yuan Jiang	Jing Gu	7,653	Reserve of *Pinus kesiya* varieties	1983	26
	11. Wu Liang Shan Mountain	Jing Dong	23,355	Humid broadleaf evergreen forest on middle mountain in subtropical area	?	?
	12. Diao Lin Shan Mountain	Lu Feng	613	Semi – humid broadleaf evergreen forest	1984	14
	13. Shi Ba Lian Shan Mountain	Fu Yuan	1,212	Wild tea forest	1986	6
	14. Pu Du He	Lu Quan	11	*Cycas panzhihuaensis* forest	1984	--
	15. Jia Che	Hui Ze	8,282	Reserve of *Pinus armandii* varieties	1984	5

16. Tian Chi	Yun Long	6,630	Resource of *Pinus yunanensis* varieties	1983	8
17. San Jiang Kou	Yong Shen	680	Upland humid broadleaf evergreen forest	1984	5
18. Hai Zi Ping	Yi Liang , Wei Xin	2,782	Bamboo (*Phyllostachys pudescens & Qiongzhuea tumidinoda*) forest	1984	12
19.Yao Shan	Qiao Jia	10,215	Medical plants	1984	8
20. Yu Long Snow Mountain	Li Jiang	25,996	Vertical distribution of subalpine forest	1984	14
21. Ha Ba Snow Mountain	Zhong Dian	21,908	Boreal coniferous forest aciculishilvae ecosystem	1984	13
22. Nu Jiang	Gong shan , Fu Gong	375,433	Diversified subalpine forest	1986	52
23. Lu Gu Lake	Ning Lang	8,133	Precious aquatic biological resources	1986	20
24. Bi Ta Hai Lake	Zhong Dian	14,181	Plateau lake and forest landscape	1984	11
25. Na Po Hai	Zhong Dian	2,400	Ecosystem used by *Crus nigricollis* and other overwintering waterfowls	1984	4
26. Ji Zu Shan Mountain	Bin Chuan, He Qing	10,760	Buddhism shrine and semi-humid broadleaf evergreen forest	1984	57
27. Dian Chi Lake	Kunming	292,000	Famous scenic beauty , verified forest with special Yunnan feature	1981	18
28. Stone Forest	Lu Nan	8,433	high cliffs dominated karst geomorphic landscape	1981	91
29. Da Long Dong	Zhao Tong	134	Water source and nearby foret	1981	12
30. Jing Guang Temple	Yong Ping	9,584	Semi - humid broad leaf evergreen forest	1980	5
31. Zi Xi Shan	Chu Xiong	16,000	Ancient camellia, *Pinus yunanensis var . tenuifolia*	1982	10
32. Lin Cang Snow Mountain	Lin Cang , Yun Xian	17,887	Subtropical broadleaf evergreen forest and warm temperate coniferous forest	1983	10
33. Guan Yin Shan Mountain	Yuan Yang	16,406	Monsoon broadleaf evergreen forest	1988	49
34. Jiao Zi shan Mountain	Kunming , dong chuan	1,704	Subalpine broadleaf evergreen forest and mountain coniferous forest aciculishivae	1992	--
35. Da Bao Shan Mountain	Zhao Tong	19,200	Habitat for *Crus nigricollis* and other overwintering waterfowls	1990	12
36. Black necked cranes	Hui Ze	6,800	Eco - environment for crus nigricollis and other overwintering waterfowls	1990	--
37. Na Ban He	Jing Hong	26,067	Topical & south sub - tropical forest	1991	30
38. Mei Shu Chuan	Jin Ning	580	Stratum trace	1988	10
39. Song Hua Ba	Song Ming	63,000	Water source sheltering forest	1981	3

	40. Wu Liang Shan Mountain	Nan Jian	6,702	Humid broadleaf evergreen forest on middle mountain in subtropical area with migrating birds	1990	5
	41. Amu Mountain	Hong He County	14,756	Broadleaf evergreen forest	1981	44
	42. Da Zhong Shan Mountain	Nan Hua	4,838	Forest with migrating birds	1984	30
	43. Xiao Hei Shan Mountain	Long ling	6,293	Humid broadleaf evergreen forest on middle mountain in subtropical area, contains *Cyathea brunoniana*	1995	--

Annex 2: Lists of laws and programmes issued by Chinese government related to biodiversity Conservation

National Laws

Forest Law
Wildlife Protection Law
Agriculture Law
Water and Soil Conservation Law
Environment Law
Land Management Law

Administration Regulations and Programmes

Voluntary Plant Tree Programme
Native Reserve Regulation
Forest Log and Recover Programme
Forest Fire Regulation
Seed Regulation
Wildlife Conservation Regulation
Wild Plant Conservation Regulation
Forestry Station Programme
Land Use Regulation
Herb Resources Regulation

Annex 3. Diversity of upland rice varieties in Baka (Fu and Chen, 1999)

No.	Local name	Sowing time	Type	Shape	Shell color	Grain color	Taste	Yield	Temperature (resistant to)	Fertility of soil	Frequency
1	landigu	middle	G	small and thin	red	white	bad and hard	low	cold	poor	few
2	luoli	early	G	medium and round	red	red	good	high	hot	fertile	many
3	hejieba	middle	G	medium and round	white	red	bad	high	cold and hot	poor	more
4	liandaogu	early	G	thin and long	white	white	Good, soft and fragrant	middle	cold	fertile	few
5	diancui	early	G	medium and round	white	white	hard	middle	cold	fertile	few
6	bailuogu	late	Ng	long and large	white	white	good	high	cold and hot	fertile	many
7	maogu	late	G	round and small	black	red	best and fragrant	middle	colder	poor	fewer
8	huagu	late	G	round and small	purple with white	red	best and fragrant	middle	colder	poor	fewer
9	mowanggu	early	G	round and large	white	white	best, fragrant and soft	high	hot	fertile	few
10	changgu	late	G	thin and long, medium	white	white	good and fragrant	low	cold	fertile	fewest
11	sequoluo	early	G	thin and long	white	white	good, soft and fragrant	low	cold	fertile	few
12	manyagu	late	G	large and long	purple with yellow	white	bad and hard	high	cold	fertile	many
13	hebeng	middle	G	largest and round	purple with yellow	white	good and fragrant	middle	cold	fertile	many
14	gulala	latest	Ng	thin and long	black	black	good, soft and fragrant	lowest	cold	fertile	few
15	xiahong	middle	G	long and medium	white	red	bad and hard	high	cold	poor	few
16	dahong	middle	G	long, large with short awn	white	red	bad and coarse	high	cold	poor	few
17	xihong	middle	G	long and small	white	red	bad, hard and coarse	high	cold and hot	poor	more
18	anene	late	Ng	long and large	yellow	red	good	high	hot	fertile	many
19	langu	late	G	long and large	red	white	good, soft and fragrant	high	cold	fertile	few
20	ximongu	late	G	large and round	purple with white	white	good, hard and fragrant	high	hot	fertile	few

Annex 4. Inventory of plants found on agricultural fields of Daka

Family	Scientific name	Life form	Utility purpose	Utility part	No. sample distributed
Selaginellaceae	Selaginella delicatula	herb			9
Equisetaceae	Hippochaete debilis	herb	medicine	all parts	8
Lygodiaceae	Lygodium japonicum	climber	medicine, vegetable	all parts, young leaf	1, 2, 3, 4, 6,
Dicksoniaceae	Cibotium borometz	herb	medicine, vegetable	root	1
Adiantaceae	Adiantum capillus	herb	edible	fruit	8
Aspidiaceae	Tectaria fengii	herb			10
Marsileaceae	Marsilea quadrifolia	herb			7
Gnetaceae	Gnatum montanum	climber			1, 5
Lauraceae	Litsea euosma	tree			5
	Litsea glutinosa	tree			2
	Litsea monopetala	tree			3, 11
	Litsea panamonja	tree			2, 3
	Machilus rufipes	tree			1
	Phoebe lanceolata	shrub			5, 10, 11
Myristicaceae	Knema erritica	tree			1, 5
Menispermaceae	Pericampylus glauca	climber	medicine	root	1, 5, 11
	Stephania delavayi	climber	medicine	root	1, 2
	Stephania hernandifolia	climber	medicine	root	1, 3, 4
Piperaceae	Piper spirei	herb			5
Capparidaceae	Capparis fohaiensis	shrub			4, 6
	Stixis suaviolens	climber			1, 6
Xanthophyliaceae	Xanthophyllum siamensis	tree	vegetable	young leaf	1
Crassulaceae	Bryophyllum pinnatum	herb	medicine	leaf	7
Polygonaceae	Polygonum chinensis	herb			8
Amaranthaceae	Achyranthes bidentata	herb			11
Passifloraceae	Passiflora caerulea	climber	fruit	fruit	3, 7
Cucurbitaceae	Zehneria javanica	climber	medicine	root□seed	1
Theaceae	Camellia sinensis	shrub	drink	leaf	7, 11
	Eurya groffii	shrub			2, 3
	Schima wallichii	tree	wood	timber	2
Myrtaceae	Psidium guajava	shrub	fruit	fruit	4, 6, 11
	Syzygium cumini	tree	fruit	fruit	11
	Syzygium latilimbum	tree			10
	Syzygium szemaoense	tree	fruit	fruit	1, 4, 5, 11
Lecythidaceae	Barringtonia macrostachya	tree			1
Melastomaceae	Melastoma affine	shrub	ornamental	flower	3
	Osbeckia paludosa	shrub			2
Rhizophoraceae	Carallia brachiata	tree			
	Pellacalyx yunnanensis	tree			10
Hypericaceae	Cratoxylon cochinchinensis	shrub	medicine	young leaf	2, 3, 5
	Hyporicum wightianum	herb	medicine	all parts	9

Annex 4. (Cont.)

Family	Scientific name	Life form	Utility purpose	Utility part	No. sample distributed
Guttiferae	Garcinia cowa	tree	fruit	fruit	11
Tiliaceae	Microcos nervosa	tree	fruit	fruit	4, 5, 6, 11
Sterculiaceae	Helicteres angustifolia	shrub	medicine	root	6
	Helicteres viscida	shrub			1, 3
	Pterospermum menglunense	tree			10
	Sterculia lanceolata	shrub	edible	fruit	1, 6
Malvaceae	Sida acuta	herb	broom	all parts	6, 9
	Sida szechuensis	herb	medicine	root	6, 7, 11
Malpighiaceae	Aspidopterys obcordata	climber	medicine	all parts	1
Euphorbiaceae	Aporusa yunnanensis	tree			1, 2, 3, 4, 5, 6, 11
	Baccaurea ramiflora	tree	fruit	fruit	11
	Bridenia insulana	tree			10
	Cleidion spiciflorum	tree			10
	Cleistanthus sumatranus	tree			10
	Croton argyratus	tree			3, 11
	Croton caudatus	shrub			1
	Croton kongensis	tree			1
	Flueggea virosa	shrub	medicine	root	6
	Glochidion arborescens	shrub	medicine	root	1, 2
	Glochidion puberum	shrub			2
	Hevea brasiliensis	tree	trmt	juice	4, 7
	Macaranga denticulata	tree			2, 5
	Mallotus macrostachys	tree			6
	Phyllanthus emblica	tree	fruit, medicine	fruit□bark	3, 6
	Phyllanthus urinaria	herb	medicine	all parts	4, 11
	Sapium discolor	shrub	wood	timber	2
	Trigonostemon thyrsoideum	shrub			10
Mimosaceae	Acacia intsia	climber	vegetable	young leaf	7
	Adenanthera pavonina	tree			1, 11
	Albizia lucidior	tree	washing hair	leaf	6, 7
	Cylindrokelupha yunnanensis	tree			1
Caesalpiniaceae	Cassia laevigata	herb	medicine	all parts	6
	Cassia siamea	tree	fuel	stem	6
	Tamarindus indica	tree	fruit	fruit	7
Papilionaceae	Abrus pulchellus	herb			2
	Atylosia mollis	climber			2
	Campylotropis pinatorum	herb			3
	Clitoria mariana	climber			1, 5
	Crotalaria albida	herb	medicine	all parts	9
	Indigofera zollingeriana	herb			9
	Millettia leptobotrya	tree	medicine	root	1, 5, 6
	Millettia pachycarpa	tree			5
	Nicolsonia oblata	shrub			9

Annex 4. (Cont.)

Family	Scientific name	Life form	Utility purpose	Utility part	No. sample distributed
	Tadehagi triquetrum	shrub	drink	leaf	2
	Uraria crinita	herb			5, 9
Fagaceae	Castanopsis carlesii	tree			1
	Castanopsis echinocarpa	tree	wood	timber	2
	Castanopsis indica	tree	edible	fruit	2, 5, 11
	Cyclobalanopsis kerrii	tree	wood	timber	1
	Quercus acutissima	tree	wood	timber	2
Ulmaceae	Aphananthe cuspidata	tree			10
	Gironniera subaequalis	tree			5
Moraceae	Broussonetia papyrifera	tree	fodder, fibre	young leaf, bark	7
	Ficus hirta	shrub			1, 2, 5
Urticaceae	Elatostema acuminatum	herb			10
	Pilea cordifolia	herb			10
Celastraceae	Celastrus monospermus	climber			1, 5
	Celastrus paniculatus	climber	vegetable	young leaf	2
Cardiopteridaeae	Peripterygium quinquelobum	climber			11
Vitaceae	Cissus repens	climber			5
Rutaceae	Cirtus maxima	tree	fruit	fruit	7
	Euodia lepta	shrub	medicine	root	1, 2, 11
	Euodia simplicifolia	shrub	condiment, medicine	fruit	2
	Zanthoxylum nitidum	climber	medicine	root	5
Meliaceae	Aphanamixis polystachya	tree	wood	timber	5
	Chisocheton siamensis	tree	wood	timber	5
	Toona sinensis	tree	wood, vegetable	timber, young leaf	7
	Trichilia connaroidis	tree	medicine	root	1, 3, 11
Sapindaceae	Pometia tomentosa	tree	wood	timber	10
Anacardiaceae	Choerospondias axillaris	tree	fruit	fruit	5
	Mangigera indica	tree	fruit	fruit	5, 7
	Rhus chinensis	shrub	medicine, condiment	root, fruit	2
	Spondias pinnata	tree	condiment, medicine	fruit	5
	Toxicodendron succedaneum	shrub			1
Juglandaceae	Engelhardtia dpicata	tree			2, 5
Alangiaceae	Alangium barbatum	tree	medicine	root	5
Araliaceae	Acanthopanax trifoliatus	shrub			2
	Aralia armata	tree			1
	Heteropanax fragrans	shrub			5
Umbellieferae	Eryngium foetidum	herb	condiment	all parts	4
Sapotaceae	Lucuma nervosa	tree	fruit	fruit	7
Myrsinaceae	Ardisia japonica	shrub			4, 11
	Embelia laeta	climber	fruit	fruit	5
	Embelia ribes	climber	fruit	fruit	3
	Measa indica	shrub	medicine	root	2, 11

Annex 4. (Cont.)

Family	Scientific name	Life form	Utility purpose	Utility part	No. sample distributed
Loganiaceae	Gelsemium elegans	climber	medicine	root	2
Oleaceae	Jasminum wangii	climber			1
	Olea rosea	tree			7
Apocynaceae	Parabarium linearicarpum	herb	condiment	young leaf	5
	Parabarium spireanum	climber			2
	Parabarium tournieri	climber	medicine	root	2, 5
	Winchia calophylla	tree	medicine, wood	leaf□bark, timber	1, 10
Asclepiadaceae	Streptocaulon griffithii	herb			3, 4, 6
Rubiaceae	Canthium parvifoliam	shrub			2, 3, 4, 5, 6, 11
	Chesalia curviflora	herb	medicine	root	5
	Geophila herbacea	herb			4, 5
	Hedyotis diffusa	herb	medicine	all parts	9
	Lasianthus hookeri	shrub			10
	Mussaenda elongata	shrub			1, 2
	Mussaenda hossei	shrub			1
	Psychotyia calocarpa	shrub			5
	Psychotyia henryi	shrub			1
	Randia acuminatissima	shrub			1, 5
	Rubia cordifolia	herb			2, 3, 9, 11
	Wendlandia wallichii	tree			2
Compositae	Ageratum conyzoides	herb			3, 11
	Bidens pilosa	herb	medicine	all parts	9
	Camchaya loloana	herb			3
	Crassocephalum crepidioides	herb	fodder	all parts	3, 8
	Dichrocephala integrifolia	herb	medicine	all parts	9
	Eupatorium coelesticum	herb			2, 9, 11
	Eupatorium odoratum	herb			2, 3, 4, 5, 6, 11
	Grangea maderaspatana	herb			9
	Spilanthes paniculata	herb	medicine	all parts	8
	Synedrella nudiflora	herb			7
	Tithonia diversifolia	herb			6
	Vernonia esculenta	herb	medicine	bark	1, 2
Solanaceae	Solanum myriacanthum	shrub			4
	Solanum verbacifolium	shrub	power material	stem	6
Convolvulaceae	Dichondra repens	herb	medicine, vegetable	all parts	9
Bignoniaceae	Dolichandrone stipulata	tree			6
Acanthaceae	Baphicacanthus cusia	herb	medicine	all parts	4, 6
	Phlogacanthus curviflorus	shrub	medicine	all parts	5
	Pseudoranthemum palatiferum	herb	medicine	root	5, 10
Verbenaceae	Callicarpa bodinieri	shrub			11
	Garrettia siamensis	shrub			5
	Tectona grandis	tree	wood	timber	3

Annex 4. (Cont.)

Family	Scientific name	Life form	Utility purpose	Utility part	No. sample distributed
Commelinaceae	Amischotolype hispida	herb			4, 5, 10
Musaceae	Musa sapientum	herb	fodder	bark	7
Zingiberaceae	Alpinia blepharocalyx	herb	medicine, condiment	fruit, root	5
	Amomum villosum	herb	medicine	fruit	10
Liliaceae	Reineckea carnea	herb			2
	Tupistra chinensis	herb			10
Smilacaceae	Smilax hypoglauca	climber			1
	Smilax indica	climber			2
Araceae	Aglaonema pierreanum	herb			5
Dioscoreaceae	Dioscorea alata	climber			2
Pandanaceae	Pandanus tectorius	herb			5
Hypoxidaceae	Curculigo orchioides	herb	medicine	all parts	4
Cyperaceae	Cyperus cuspidatus	herb			8, 9
Gramineae	Phyllostachys nigra	herb			5
	Cynodon dactylon	shrub			9
	Digitaria ciliaris	herb			2, 5
	Eragrostis pilosa	herb			3, 7, 11
	Imperata cylindrica	herb			3
	Oryza sativa	herb	foodgrain	seed	8
	Oryza sativa	herb	foodgrain	seed	3
	Paspalum conjugatum	herb			7, 8, 9
	Setaria glauca	herb			3
	Thysanolaena maxima	herb	vegetable	flower	1, 2

Annex 5. Inventory of plants found on agricultural fields of Baka

Family	Scientific name	Life form	Utility purpose	Utility part	No. of sample distributed
Selaginellaceae	Selaginella refer	herb	medicine	all parts	2, 5
Angiopteridaceae	Angiopteris latemarginata	herb	medicine	leaf	5
Lygodiaceae	Lygodium japonicum	climber	medicine, vegetable	all parts, young leaf	2, 3, 6, 7
Aspidiaceae	Tectaria fengii	herb			5
Annonaceae	Mitrephora wangii	tree	wood	timber	5,
	Polyalthia cerasoides	shrub			5
Lauraceae	Litsea euosma	tree			2
	Litsea monopetala	tree			7
	Machilus salicina	tree			3
Myristicaceae	Horsfieldia tetratepala	tree			5
Menispermaceae	Diploclisia glaucescens	climber	medicine	root	5
	Parabaena sagittata	climber			3
	Stephania delavayi	climber			6
	Stephania hernandifolia	climber			3
Piperaceae	Piper spirei	climber	medicine	all parts	3
Capparidaceae	Stixis suaviolens	climber			7
Cruciferae	Rorippa dubia	herb	vegetable	young leaf	9
Portulacaceae	Portulaca oleracea	herb	vegetable	young leaf	1, 9
Amaranthaceae	Achyranthes aspera	herb	medicine	all parts	3, 5, 6,
	Amaranthus spinosus	herb			9
	Amaranthus tricolor	herb			2
Oxalidaceae	Oxalis corniculata	herb			2, 9
Lythraceae	Lagestriemia tomntosa	tree	wood	timber	3, 7
Passifloraceae	Passiflora caerulea	climber	fruit	fruit	2
Cucurbitaceae	Gynostemma pentaphylla	climber	medicine	all parts	5
	Thladiantha cordifolia	climber			6
Begoniaceae	Begonia cathayana	herb			5
Theaceae	Camellia sinensis	tree	drink	leaf	4
	Schima wallichii	tree			6
Myrtaceae	Psidium guajava	tree	fruit	fruit	7
	Syzygium cumini	tree			3
Combretaceae	Terminalia bellirica	tree	wood	timber	5
Hypericaceae	Cratoxylon cochinchinensis	tree	wood	timber	7
Sterculiaceae	Byttneria grandifolia	climber			5
	Helicteres viscida	shrub	medicine	all parts	6
	Sterculia lanceolata	shrub			5
Bombacaceae	Bombax ceiba	tree			6
Malvaceae	Sida acuta	shrub	broom	all parts	3, 6, 7
	Sida szechuensis	shrub			3, 6, 7
Euphorbiaceae	Aporusa yunnanensis	shrub			3, 6

Annex 5. (Cont.)

Family	Scientific name	Life form	Utility purpose	Utility part	No. of sample distributed
	Baccaurea ramiflora	tree	fruit	fruit	5
	Bridenia insulana	climber			7
	Croton kongensis	shrub			5
	Euphorbia hirta	herb			1, 2, 6, 9
	Flueggea virosa	shrub			7
	Glochidion sphaerogynum	shrub			3, 5, 7
	Hevea brasiliensis	tree			2
	Lasiococca comberi	tree			5
	Mallotus macrostachys	tree			7
	Mallotus philippinensis	tree			5
	Phyllanthus urinaria	herb			2, 6
	Trigonostemon thyrsoideum	shrub			5
Rosaceae	Duchesnea indica	herb			3
	Prunus persica	tree	fruit	fruit	1
Mimosaceae	Acacia farnesiana	shrub			3, 5
	Acacia intsia	climber	vegetable	young leaf	5, 8
	Albizia lucidior	tree			3, 7
	Albizia odoratissima	tree			7
Caesalpiniaceae	Bauhinia viridiscens	tree	vegetable	flower	3
	Cassia siamea	tree			7
	Tamarindus indica	tree			4, 8
Papilionaceae	Dalbergia pinnata	tree			3
	Flemingia macrophylla	shrub			7
	Millettia pachycarpa	tree			5
	Millettia pulchra	tree			5
	Nicolsonia oblata	shrub			6
	Pueraria lobata	climber	cord	bine	6, 7
	Tadehagi triquetrum	shrub			7
	Uraria lagopodioides	herb			1
Ulmaceae	Aphananthe cuspidata	tree			3
Moraceae	Artocarpus heterophylla	tree	fruit	fruit	8
	Broussonetia papyrifera	tree			8
	Cudrania fruticosa	climber			5
	Ficus semicordata	tree			7
	Morus alba	tree			9
Urticaceae	Pilea melastomoides	herb			5
Celastraceae	Celastrus monospermus	climber			5
	Celastrus paniculatus	climber	vegetable	young leaf	7
Vitaceae	Cissus adnata	climber			3
	Leea crispa	shrub			5
	Tetrastigma lenticelatum	climber			3, 5

Annex 5. (Cont.)

Family	Scientific name	Life form	Utility purpose	Utility part	No. of sample distributed
Rutaceae	Boenninghausenia albiflore	herb			2
	Citrus aurantiflolia	shrub	fruit	fruit	4
	Cirtus maxima	tree			4, 8
	Cirtus reticulata	tree			8
	Clausena lenis	shrub			3
	Micromelum falcatum	climber			3
Burseraceae	Garuga floribunda	tree	wood	timber	5
Meliaceae	Dysoxylum excelsum	tree	wood	timber	5
Sapinindaceae	Pometia tomentosa	tree	wood	timber	7
Anacardiaceae	Mangigera indica	tree	fruit	fruit	4, 8
	Mangigera sylvatica	tree			5, 7, 8
Alangiaceae	Alangium chinensis	tree			8
Araliaceae	Heteropanax fragrans	tree			8
Umbellieferae	Coruandrum sativum	climber	condiment	leaf	3
	Eryngium foetidum	climber			2, 3
Myrsinaceae	Ardisia depressa	shrub			3, 7
	Measa indica	shrub	medicine	root	3, 7
Oleaceae	Jasminum coarctatum	climber			3
Apocynaceae	Epigynum auritum	climber			5, 7
	Winchia calophylla	tree	medicine	bark	3
Asclepiadaceae	Marsdenia tinctoria	climber			5
Rubiaceae	Canthium parvifoliam	shrub			7
	Hedyotis diffusa	climber			2, 9
	Morinda umbellata	climber			7
	Mussaenda hossei	shrub			3, 5
	Psychotyia calocarpa	shrub			5
	Rubia cordifolia	herb			6
Caprifoliaceae	Sambucus chinensis	herb			5
Compositae	Ageratum conyzoides	herb			1, 2, 3, 6, 9
	Bidens pilosa	herb			4, 6
	Conyza canadensis	herb			1, 6
	Crassocephalum crepidioides	herb	fodder	all parts	3
	Dichrocephala integrifolia	herb			8
	Enydra fluctuans	herb			9
	Eupatorium coelesticum	herb			3, 6
	Eupatorium odoratum	herb			1, 2, 3, 5, 6, 7, 9
	Grangea maderaspatana	herb			9
	Gynura procumbens	herb			9
	Sphaeranthus africanus	herb			6
	Sphaeranthus senegalensis	herb			9
	Spilanthes callimorpha	herb			1, 2, 6
	Spilanthes paniculata	herb			1, 5, 9
	Tithonia diversifolia	herb			8

Annex 5. (Cont.)

Family	Scientific name	Life form	Utility purpose	Utility part	No. of sample distributed
	Xanthium sibiricum	herb			9
Lobeliaceae	Pratis nummularia	herb			9
Solanaceae	Solanum indicum	shrub			3
	Solanum verbacifolium	tree	power material	stem	8
Convolvulaceae	Ipomoea aquatica	climber			1
Bignoniaceae	Oroxylum indicum	tree	vegetable	fruit	1, 6
	Stereospermum colais	tree			7
Acanthaceae	Baphicacanthus cusia	herb	medicine	all parts	5, 7
	Dipliptera riparia	herb			3
	Pseudoranthemum malaccense	shrub			5
	Pseudoranthemum palatiferum	shrub			3, 5
	Thunbergia grandiflora	climber			7
Verbenaceae	Callicarpa rubella	shrub	medicine	root	3
Labiatae	Colebrooker oppositifolia	shrub			7, 8
	Elsholtzia blanda	herb	medicine	all parts	2
	Microtoena patchouli	herb			3
Commelinaceae	Amischotolype hispida	herb			5
Bromeliaceae	Ananas comosus	herb	fruit	fruit	4
Zingiberaceae	Amomum villosum	herb	medicine	fruit	5
Marantaceae	Phrynium capitatum	herb	wrap	leaf	5
Liliaceae	Aloe vera	herb	medicine	all parts	8
Smilacaceae	Smilax indica	climber			3
Araceae	Homalomena occulta	herb	medicine	stem	5
	Pothos chinensis	climber			5
	Rhaphidophora decursiva	climber			5
	Rhaphidophora megaphylla	climber			5
	Typhonium diverdifolium	herb			2, 6
Amaryllidaceae	Crinum asiaticum	herb	ornamental	flower	8
Iridaceae	Belamcanda chinensis	herb	medicine	root	8
Dioscoreaceae	Dioscorea alata	climber	foodgrain	root	2, 7
Taccaceae	Tacca chantrieri	climber	medicine	root	5
Cyperaceae	Cyperus cuspidatus	herb			1, 9
	Cyperus rotundus	herb			2, 3
	Mariscus sumatranus	herb			2
Gramineae	Cymbopogon citratus	herb	condiment	leaf	8
	Cynodon dactylon	herb			7
	Digitaria ciliaris	herb			5
	Eragrostis pilosa	herb			3, 5, 6, 7
	Oryza sativa	herb	foodgrain	seed	9
	Oryza sativa	herb	foodgrain	seed	1
	Paspalum conjugatum	herb			3, 6, 9
	Sorghum vulgare	herb	foodgrain	seed	1