Traditional Agroforestry Systems: One Type of Globally Important Agricultural Heritage Systems

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Abstract: As one kind of land use practice, traditional agroforestry systems already have a long history of hundreds of years in practice and still play a significant role in the world today, especially in tropical and subtropical areas. In this era of globalization and food security, more and more governments and non-governmental organizations are paying attention to traditional agroforestry systems because of their economic, ecological and socio-culture benefits. These benefits are also in accord with the characteristics of Globally Important Agricultural Heritage Systems (GIAHS). So far, four typical traditional agroforestry systems from five countries have been designated as GIAHS. These traditional agroforestry systems have rich agricultural and associated biodiversity, multiple ecosystem services and precious socio-culture values at a regional and global level. Although traditional agroforestry systems are confronted with many threats and challenges, such as population growth, migration, market impact, climate change and so on, as long as governments and non-governmental organizations, local communities and smallholders can cooperate with each other, traditional agroforestry systems will be effectively protected and will remain in the future a sustainable global land use practice.

Key words: traditional agroforestry systems; GIAHS; agro-biological diversity; ecosystem services; socio-culture

1 Introduction

Agroforestry is an old land use practice worldwide which has shown strong resilience and robustness over centuries (Atangana et al. 2013). Until the late 1970s, with the explosive growth of population, excessive consumption of resources and increasing damage of the global environment, people have begun to reflect on and explore sustainable land use practices and agriculture development patterns (Li and Nai 1994). As an ancient and existing form of land use today, the international scientific community has begun to embrace the potentials of agroforestry and to recognize agroforestry as a sustainable practice in the trend of sustainable development because of its ecological, economic and social attributes (Nair and Garrity 2012). Recently, scientists have conducted in-depth and comprehensive studies to form an interdisciplinary approach to the agroforestry system of land use.

As an important traditional land use practice, agroforestry was undoubtedly recognized as an indispensable Globally Important Agricultural Heritage Systems (GIAHS) type because of its high levels of biodiversity, traditional knowledge systems, livelihood guarantee and diversified traditional cultures. On the occasion of GIAHS project designations in the last ten years, this paper focuses on the current authorized GIAHS pilots which belong to the agroforestry type and analytically describe them from the perspective of the GIAHS. Currently there are many problems facing traditional agroforestry systems, and this paper tries to put forward some suggestions to deal with them.

2 A brief introduction to traditional agroforestry and GIAHS

2.1 Agroforestry systems

Agroforestry is a kind of land use systems in which woody
perennials (trees, shrubs, palms, bamboo, etc.) are grown on the same piece of land with herbaceous plants and/ or animals, either in specific spatial arrangements or in a time sequence in which there are both ecological and economic interactions between the trees and non-tree components (Beets 1989). For centuries, agroforestry has been artfully practiced throughout the world, especially in the developing countries of the tropics (Nair 1993). Up to now, it is estimated that almost half the world’s agricultural lands have at least a 10 percent tree cover, suggesting that agroforestry is widespread and critical to the livelihoods of millions of people (Buttoud 2013).

As an ingenious dynamic land use system, agroforestry integrates trees with crops, livestock or others deliberately on the same land unit according to special local conditions. Owing to its complexity and specificity, there are different classifications of agroforestry based on vegetation components, functions, levels of management input and environmental conditions and ecological suitability (Atangana et al. 2013). In general, agroforestry can be classified into four groups based on the nature of these components: (i) agri-silviculture, which includes crops and trees; (ii) silvo-pastoral that consist of pastures or animals and trees; (iii) agri-silvo-pastoral that comprise crops, pastures or animals and trees; and (iv) other systems that are based on trees (Nair 1985, 1993).

Traditional agroforestry models are the crystallization of the wisdom of human beings over hundreds of years, many of which are practiced in difficult natural resource conditions with local people’s ingenious ideas. It has enormous benefits not only in the provision of food for local people, but also for the multiple ecological services and socio-cultural values it provides for the global system. The details we can see from Fig. 1.

As one of the most widespread land use systems, agroforestry is practiced by different nations around the world, no matter weather in tropical or in temperate regions. According to a global survey by The International Center for Research in Agroforestry (ICRAF) (Nijhoff and Junk 1983), the predominant traditional agroforestry systems are rich and diverse as shown below in Table 1.

### 2.2 Globally Important Agricultural Heritage Systems (GIAHS)

In the contemporary context of “global change” in an ecological sense (Walker et al. 1999), and “globalization” in an economic context (Daly and Cobb 1989; Dragun and Tisdell 1999), it is urgent to explore, protect and develop highly functional traditional agriculture to cope with environmental uncertainties that modern agriculture has created. Globally Important Agricultural Heritage Systems (GIAHS) was conceptualized and introduced during the World Summit on Sustainable Development (WSSD) in 2002. The Food and Agriculture Organization of the United Nations (FAO) defined GIAHS as “Remarkable land use systems and landscapes which are rich in biological diversity evolving from the co-adaptation of a rural community with its environment and its needs and aspirations for sustainable development”. GIAHS are characterized by a combination of significant agricultural biodiversity and associated biodiversity, outstanding landscape, resilient ecosystems and valuable socio-cultural heritage.

The outstanding features of GIAHS can be summarized in terms of their relevance to global concerns addressing sustainable development and ecosystems management and their cultural and agricultural heritage value. There are five criteria that represent the totality of functionalities, goods and services provided by the system which are: (i) food and livelihood security; (ii) biodiversity and ecosystem function; (iii) knowledge systems and adapted technologies; (iv) culture, value systems and social organizations; and (v) remarkable landscapes, land and water resources management features.

Later the GIAHS idea was registered by the Partnerships for Sustainable Development that operates under the Commission on Sustainable Development (CSD) in 2004. The overall goal of the partnership is to identify, support and safeguard GIAHS, through catalyzing and establishing a long-term program to support such systems and enhance global, national and local benefits derived through their dynamic conservation, sustainable management and enhanced viability (Kitalyi et al. 2013).

### 2.3 Relationship between traditional agroforestry and GIAHS

Traditional agroforestry not only plays a significant role in food security and poverty alleviation, but also contributes to the ecology and environment, as well as the socio-culture in a local region. These characteristics highly conform to the criteria of GIAHS, so traditional agroforestry is
undoubtedly viewed as an important GIAHS type. We can see the correspondence between traditional agroforestry and GIAHS based on the five criteria of GIAHS. In addition, we generalize the main characteristics of traditional agroforestry and classify them into three aspects: agricultural and associated biodiversity, multiple ecosystem services and valuable socio-culture as shown below in Fig. 2.

To date, GIAHS have been established in 31 pilot sites globally. Four of these sites belong to the typical agroforestry type (Table 2). There are still many potential traditional agroforestry systems that can be approved as a GIAHS, such as those in East Kalimantan and Butitingui in Indonesia; the highlands of Rwanda and Uganda; Titicaca in Peru; Kayapo in Brazil and so on.

3 The traditional agroforestry: one type of GIAHS

Traditional agroforestry can bring many benefits which are conforming to the characteristics of GIAHS. As the Fig. 2 shows, there are some corresponding relationship between

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**Table 1** Predominant traditional agroforestry systems in different geographic regions of the world.

<table>
<thead>
<tr>
<th>Geographic region</th>
<th>Predominant traditional agroforestry systems</th>
</tr>
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<tbody>
<tr>
<td>S.E. Asia</td>
<td>Intercropping in plantation crops; Live fences; Shelterbelts; Taungya; Shifting cultivation systems; Commercial/Fruit trees among crops</td>
</tr>
<tr>
<td>S. Asia</td>
<td>Various forms of shifting cultivation; Commercial/Fruit trees among crops; Taungya; Live fences; Shelterbelts</td>
</tr>
<tr>
<td>Mediterranean &amp; Middle East</td>
<td>Olive + cereals; Trees for sand dune reclamation; “Huertas”-small plots irrigated crops + fruit trees; Aromatic, medicinal and fruit trees with crops in pastures</td>
</tr>
<tr>
<td>Eastern, Central &amp; Humid West Africa</td>
<td>Plantation crops (oil palm/rubber) and root crops complex; Coffee + banana; Mixed perennial crops; Gum arabic + millet; Shifting cultivation/bush fallow systems; Taungya</td>
</tr>
<tr>
<td>Arid and Semi-Arid West Africa</td>
<td>Use of trees on farmlands for protective role (windbreaks, dune fixation); Productive + protective role of trees on farms (A. ibida/Leucaena + agric, crops systems); Gum arabic + food crops</td>
</tr>
<tr>
<td>American Tropics</td>
<td>Trees in perennial cash crops (coffee, cacao, tea); live fences; Windbreaks and shelterbelts; Taungya; Shifting cultivation</td>
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</tbody>
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**Table 2** The four authorized agroforestry GIAHS pilots in the world (2014).

<table>
<thead>
<tr>
<th>System</th>
<th>Country</th>
<th>Approval date</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghout and Gafsa oases</td>
<td>Algeria, Tunisia</td>
<td>2005</td>
<td>Agrisilvicultural</td>
</tr>
<tr>
<td>Shimbwe Juu Kihamba Agro-forestry</td>
<td>Tanzania</td>
<td>2008</td>
<td>Agrisilvicultural</td>
</tr>
<tr>
<td>Oases systems in the Atlas Mountains</td>
<td>Morocco</td>
<td>2011</td>
<td>Agrisilvicultural</td>
</tr>
<tr>
<td>Kunisaki Peninsula Usa integrated forestry, agriculture and fishery system</td>
<td>Japan</td>
<td>2013</td>
<td>Agrosilvofishery</td>
</tr>
</tbody>
</table>

Source: adapted from Nijhoff and Junk (1983).
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3.1 A biodiversity perspective on traditional agroforestry systems

Biodiversity is vital in sustaining human life and the ecological health of our planet, but the loss of biodiversity is becoming more and more severe (MA 2005). The current extinction rate is much greater than during any of the “Big Five” mass extinctions, and the current rate is estimated to be as much as 140,000 species per year, which is caused by climate change, human activities such as hunting, invasive species introductions, land use change and so on. One of the key characteristics of a GIAHS is the emphasis on protecting the agricultural and associated biodiversity.

The need to conserve biodiversity is receiving considerable attention worldwide. In this respect, traditional agroforestry systems can play an important role. The mechanisms that agroforestry contribute to biodiversity have been studied by many authors (Schroth et al. 2004; McNeely 2004; Harvey et al. 2006). In general, the following may be the reasons for maintaining biodiversity: (i) the various components (trees, crops, livestock, etc.) of agroforestry combine and interact in spatial or sequential ways, creating rich ecological niches to content the survival conditions of diversified species on the same land unit; (ii) when the agroforestry system fulfills its eco-balance in the complex and heterogeneous land unit, it is favorable to preserve germplasm of sensitive species; (iii) the structure of agroforestry is more similar to the forest than monoculture agriculture, and is often viewed as an ecological buffer and a more productive alternative than agriculture; (iv) from a landscape perspective, the land unit of agroforestry managed by different smallholders can be viewed as many matrixes. These agroforestry matrixes provide connectivity by creating corridors between remnants of habitat that support the integrity of these habitats and the conservation of local species; (v) agroforestry provides other ecosystem services such as microclimate regulation, nutrition recycling, erosion control and water recharge, thereby preventing the destruction and degradation of habitat and maintaining a healthy ecosystem for the survival of floral and faunal species.

The four traditional agroforestry systems that are designated as GIAHS sites all have a rich agricultural and associated biodiversity (Table 3). These systems also have many endemic species which is not only important to the local, but are also significant at the global level. Taking Kihamba agrisilviculture in Shimbwe Juu Village, Tanzania as a case, the system is characterized by the unique feature of a multilayered vegetation structure similar to a tropical montane forest which is composed of four vegetation layers. The uppermost layer is formed by sparsely spaced trees which provide shade, medicine, fodder, fruits, firewood and timber. Under this layer more than 15 varieties of bananas are grown. Under the bananas there are coffee shrubs and under these, vegetables of variable species including climbers. This multilayer system maximizes the use of limited land and provides for nutritionally diverse food all the year round for local populations.
Table 3 The agricultural and associated biodiversity in agroforestry in the GIAHS pilots (2014).

<table>
<thead>
<tr>
<th>System</th>
<th>Agricultural biodiversity</th>
<th>Associated Biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghout system</td>
<td>100 date varieties, several local varieties of vegetables, beans, medicinal plants, fruit trees and shrubs; sheep (Rahali, breed Timahdite) goats (Rahali), cattle (local breed and crossbreeding), camels (local breed and crossbreeds), poultry (local breed and crossbreeds).</td>
<td>Migratory birds, Gazelle (Gazellacuvieri), Fennec (Vulpeszerda)</td>
</tr>
<tr>
<td>Gafsa oases</td>
<td>50 date varieties, a large number of varieties of fruit trees (pear, apple, plum, peach, mulberry, apricot, olive, citrus, etc.), vine, fruits (cucumber, melon, zucchini) vegetables (parsley, celery, spinach, and cabbage), roots and bulbs, pulses, aromatics, cereals, fodder and ornamental plants.</td>
<td>Migratory birds, Gazelle (Gazellacuvieri), Fennec (Vulpeszerda)</td>
</tr>
<tr>
<td>Shimbwe Juu</td>
<td>Crops such as coffee, coconut, banana, cassava, yams, taros, beans, potatoes, maize, ginger, turmeric, pineapple, cashew, jackfruit, tamarind and mango.</td>
<td>Livestock such as dairy cows, buffalos, goats, sheep, pigs and poultry</td>
</tr>
<tr>
<td>Kihamba Agroforestry system</td>
<td>Rich diversity of crops, vegetables, endemic breeds, as well as fruit species, forage and wild graminae, aromatic and medicinal plants and other herbs. 53 different species of cultivated vegetables: 7 types of cereals, 7 types of beans, 11 gardening crops, 9 spices, 13 fruits and 6 wood products. Livestock: sheep, goats, cattle, camels and poultry (local breed and crossbreeding)</td>
<td>445 plant species including 135 endemic species</td>
</tr>
<tr>
<td>Oases system in Atlas Mountains</td>
<td>Rich diversity of plants, creatures. Shiitake, Shichitoui, Mitori bean, Oben kaki persimmon</td>
<td>Among plants, 145 genus and 975 species of vascular plants; Extremely wide variety of creatures, such as Japanese Bitterling, Akaza, Kabohaze, Kabutogani; 32 species of reptiles and amphibians; 259 bird species</td>
</tr>
<tr>
<td>Kunisaki Peninsula Usa integrated forestry, agriculture and fisheries system</td>
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3.2 An ingenious system with multiple ecosystem services

Besides the maintenance of biodiversity, the provisioning services to support the livelihood of local people are also vital among the characteristics of GIAHS, as well as some other ecosystem services such as carbon sequestration, soil conservation, and water and air purification. It has been well recognized that traditional agroforestry systems can provide these services and benefits on a sustained basis (Garrett and McGraw 2000; Garrity 2004; Williams-Guillén et al. 2008; Nair et al. 2009).

The most fundamental function that agroforestry systems supply is that of production which includes not only food, fodder and biofuels that can maintain the subsistence of local people, but even some kinds of cash crops and animals that can adapt to a more commercially orientated economy. In the Ghout and Gafsa oases systems for example, which have been developed over millennia, the date palm is dominant being intertwined with other trees and crops. These ancient systems produce a surprising variety of fruits and vegetables, cereals and forages, medicinal and aromatic plants, as well as some livestock. In the Kihamba system, it started with irrigated banana intercropped with other annuals and widely spaced shade trees. It is estimated that the system supplies 1/4 to 1/3 of the fuel wood requirements of a family (Fernandes et al. 1984). In the 1880s, coffee was introduced to the system which had a positive integration, thus increasing the cash income of many farm households.

With the increasing attention to global climate change, the function of traditional agroforestry systems to act as a carbon sink is becoming more and more emphasized. Many researches have shown that agroforestry systems have the potential to sequestrate carbon (Schoeneberger 2009; Kumar and Nair 2011). In general, carbon can be absorbed through physical and biological functions and stored in the plants and soils. Agroforestry systems often have a larger biomass than monoculture and thereby have a bigger carbon stock, especially in the tropics (Sharrow and Ismail 2004; Kirby and Potvin 2007). The Kihamba system has a high potential for sequestrating carbon.

Traditional agroforestry systems can play a remarkable role in soil productivity. On the one hand, it is favorable to maintain soil fertility and keep nutrient cycling (Nair and Latt 1997; Young 1997; Buck et al. 1998; Schroth and Sinclair 2003). This is because these woody perennials in the system have more extensive and deeper roots than herbaceous plants and thus have the potential to capture and recycle larger amount of available nutrients (Nair 1993). On the other hand, due to the physical fixation of the woody roots, erosion control and soil stabilization can be accomplished. In this way, the surface soil can be conserved well, especially on the slopes of mountain regions. In
the Oases system of the Atlas Mountains, the practice of mixed farming (crop and tree association) and crop rotation contribute highly to the improvement of soil fertility and soil conservation.

Traditional agroforestry systems also contribute to improved air and water quality. In the system, vegetation plays a buffer reaction that can filter the airstreams of particulates by removing dust, bad odor and microbial constituents (Tyndall and Colletti 2007). In addition, agroforestry systems can ensure water quality. One reason is that the system uses less nitrogen and phosphorous fertilizer and pesticides than conventional agriculture and thus decreases the flow of chemical pollution into the rivers. The system can also reduce the velocity of runoff and promote infiltration, sediment deposition and retention because of its rich vegetation cover (Udawatta et al. 2002; Anderson et al. 2009). In the four GIAHS sites, fertilizers and pesticides are seldom used and have both good air and water quality.

Some traditional agroforestry systems have magnificently attractive landscapes because these systems are often developed on the mountain sides or around the oasis. In addition, these constituents of systems also have multiple structures that create beautiful scenery. So, some traditional agroforestry regions are viewed as famous sightseeing districts. For example, Kunisaki Peninsula Usa integrated forestry, agriculture and fisheries system was created in a near-circular shape around Mt. Futago. The landscape is recognized for its excellent visual and natural capital value and consequently this area was registered as a Nationally Important Cultural Landscape in 2010.

3.3 Valuable human assets in terms of distinct local social-culture

Socio-culture is also an indispensable characteristic of a GIAHS which is the cornerstone to sustain the development of the system. In general, traditional agroforestry systems include many factors such as land tenure, labor requirements, tree and water management, all of which require local knowledge and organization. This human system is symbolized in food, folk and festival culture. Traditional agroforestry systems usually have an ingenious social management system based on an understanding of local special natural conditions such as local micro climates, topography, soil conditions and peculiarities and so on. In the process of formation of the system, people gradually form a local culture that adapts well to the ecology. Therefore, society and culture of the system connect and interact with each other tightly, which maintains the sustainable development of the whole system (Fuller and Min 2013).

Taking Kunisaki Peninsula Usa integrated forestry, agriculture and fisheries system as a case, the system has distinctive socio-culture characteristics. The area is comprised mainly of the circular shaped peninsula in the center, extending out to the southern edge of the Seto Inland Sea and mainly comprised of deep valleys. Meanwhile, the soil is highly porous volcanic soil. So the limited conditions are the deficiency of land and water in this region. According to the special natural conditions, local people constructed about 1200 small scale ponds and many canals to reserve and distribute the limited water resources for production such as rice, Shiitou and Shiitake mushrooms. There is a series of Sawtooth Oak forest management protocols to cultivate Shiitake and conserve water. In addition, there are many festivals pertinent to agriculture such as Shujo-onie, Otaue, Doburoku and a unique food culture such as Dango-jiru, Kenchin-jiru, Imokiri, Mitori- okowa and Ureshino.

4 The threats and strategies for traditional agroforestry systems

4.1 Threats of traditional agroforestry systems

With rapid development in globalization, liberalization of international trade and commerce advances in technology, the traditional agroforestry systems are confronted with many threats. Although threats always are different in various systems, they are mainly from common aspects such as policy, population, the market system and land use changes. This is illustrated according to the four GIAHS sites.

As for traditional agroforestry systems, policies from the government can have a huge impact on smallholders. However, these regions still lack good policies currently which include two aspects. One is some existing policies impede and constrain the development of agroforestry; the other is there are not enough aggressive policies to promote and stimulate the development of agroforestry. For example, agroforestry management is long-term investment; however, the rights of land tenure and trees ownership are not clear which will discourage people from continuing agroforestry. In some places, complicated taxation frameworks restrict agroforestry development. Lack of coordination among different sectors can also have adverse impacts on the development or maintenance of agroforestry systems.

In recent years, there is the phenomenon where the young generation from the GIAHS sites migrates out to the other places. The situation is becoming so severe that it will cause the disappearance of the traditional agroforestry that will help to sustain agroforestry systems in the future. When no people participate in production activities, the knowledge, technology and culture will all disappear. In addition, due to the increasing population in some places, it causes negative consequences. The first is the expansion of agricultural land into forested and hilly areas resulting in land degradation from soil erosion and deforestation; the second is the fragmentation of land that cannot support the effective management of agroforestry.

The smallholders of traditional agroforestry management cannot always have enough information and a clear understanding of the market. This may lead to poor actions
and loss of economic benefits. For instance, in the 1990s, due to the decline of the crop price and the increase in pests and diseases in the Kihamba system, there was a sharp decline in productivity and profitability. Some farmers could not make ends meet and cut down the trees to sell for timber. This led to land degradation and the whole cycle of decline.

4.2 The future of agroforestry as one of the GIAHS types in the world

Although traditional agroforestry systems are confronted with many threats and challenges, it is still noticeable that more and more governments and non-government organizations are paying much more attention to these systems in the world. For instance, ICRAF was established in 1978 with the goal of initiating and assisting the generation and dissemination of appropriate agroforestry technologies for resource-poor farmers and other land users. The GIAHS designation was initiated by FAO in 2002 whose goal is to establish a long-term program to support systems like agroforestry and enhance their global, national and local benefits derived through their dynamic conservation, sustainable management and the enhanced viability of the system. The way to the future for traditional agroforestry systems is positive despite the daunting challenges on the way. The following measures to protect and develop traditional agroforestry systems are suggested:

(1) As an important model of GIAHS, we should continue to improve and enlarge the impact of traditional agroforestry systems through the policies and programs of governments and non-governmental organizations. For some traditional agroforestry systems in danger, local governments should actively declare GIAHS-type designation to protect and promote sustainable development.

(2) Policy, regulation and the institutional context play a significant role affecting the smallholders of traditional agroforestry systems. It is not sufficient to guarantee the maintenance by farmers without policy. There are so many concrete policies which are very important in traditional agroforestry management such as land tenure, stakeholder input, appropriate technologies and extension services, private and public partnerships and so on that we cannot list all of them. However, it is worth noting that when the government enacts a policy, it should be oriented towards creating favorable conditions for traditional agroforestry systems and in this way meet the goals of poverty alleviation, food security and sustainable development of natural resources.

(3) For smallholders of traditional agroforestry management, ensuring their own food security and enhancing incomes are the most important factors that they concerned about. In this aspect, governments should think about more channels to provide incentives to farmers. On the other hand, governments should explore multiple means to increase the income of farmers. For example, traditional agroforestry systems can provide ecosystem services especially in climate mitigation, and as there is a tendency in the world to promote carbon sequestrated in agroforestry systems these could be sold in carbon credit markets. This is a way to support labor intensive practices. Payment of ecosystem services (PES) can be a measure executed in traditional agroforestry systems. Base on the unique folk custom, dietary habits, attractive landscapes and so on, eco-tourism should also be encouraged to develop income sources in some of the traditional agroforestry regions.

(4) Community groups should play an important role in creating a bridge between farmers and governments, as well as between region and global institutions. Among the younger generation, fewer people are engaged in agroforestry management. Traditional knowledge and technology should be protected and recorded swiftly by local community authorities. In addition, local communities should vigorously publicize the precious value of traditional agroforestry systems and thus enhance the pride and protection consciousness of local farmers and their families.

To protect and develop traditional agroforestry systems still has a long way to go and the connection with GIAHS is a good approach for these systems. We sincerely call for more countries which have ingenious traditional agroforestry systems to actively declare GIAHS pilot sites and thus bring more ecological and income benefits for more people in the world.

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