Effects of Traditional Ecological Knowledge on the Drought-resistant Mechanisms of the Hani Rice Terraces System

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Abstract: The Hani Rice Terraces System is one of the Globally Important Agricultural Heritage Systems (GIAHS) sites which can successfully resist extreme droughts. The reason is not only that the forests and terraces have the important function of water conservation, which provide and conserve adequate water resources for this complex ecosystem, but also that Hani traditional ecological knowledge plays an important role in the drought-resistance process. In this paper, drought-resistant mechanisms of the Hani Rice Terraces System have been analyzed first, then Hani traditional ecological knowledge has been analyzed based on a comprehensive literature review, a questionnaire survey and key informant interviews. The results show that the Hani nationality has developed knowledge of water management techniques, including water conserving construction, water allocation and ditch management. The Hani people are also highly conscious of water resources protection. There is a good deal of forest resource management knowledge and worship of forests, which have effectively helped in protecting the forest ecological system. In the reclamation and maintenance of Hani terraced fields, the Hani people have developed a series of farming systems, which have effectively protected the terrace ecosystem. Through analyzing this knowledge of water management, forest resource management and Hani terraced fields management, our paper confirms the important role that traditional ecological knowledge plays in maintaining stability of the system and realizing the efficient use of water resource. This is not only helpful for preserving cultural heritage, but is vital for protecting the Hani Rice Terraces System as a whole.

Key words: Globally Important Agricultural Heritage Systems (GIAHS); Hani Rice Terraces System; drought-resistant mechanisms; traditional ecological knowledge

1 Introduction

The Hani terraces are mainly distributed along the southern part of the Honghe Ailao mountain range and are spread in four counties of Yunnan province, including Honghe, Yuanyang, Lüchun and Jinping. It is one of the foremost models of mountain ecological agriculture in the world. With the highly integrated historic culture, economy, science and aesthetics (Huang 2012; Jiao 2009), the Hani Rice Terraces System was selected as one of the national wetland parks in 2007, selected as one of the Globally Important Agricultural Heritage Systems (GIAHS) sites by FAO in June 2010, and has also been listed in the catalogue of World Cultural and Natural Heritage in 2013 (Li 2014; Yuan 2014; Koohafkan 2009; Sun 2013). Various nationalities live in the four counties, with Hani and Yi being the main minority groups. During 2009-2010, a severe drought occurred in Yunnan Province, which was a ‘once in one hundred years’ type of occurrence. Most places of Yunnan Province were severely affected by droughts.
affected, however, the Hani Rice Terraces System was only marginally affected (Bai 2013). This exceptional phenomenon has aroused the attention of scientists. It is therefore of great significance to study the drought-resistant mechanisms of the Hani Rice Terraces System.

In order to explore the drought-resistant mechanisms of the Hani Rice Terraces System, scholars have carried out a series of research projects on the water conservation capacity of natural ecosystems in this system. Water conservation functions of different forest types in Yuanyang County have been discussed by Duan Xingfeng (2011) which are based on field survey and indoor experiments. Li Yangfang (2012) has studied the water holding capacity and soil porosity of forest land, shrub land, farmland and grassland in the Yuanyang terraces by using the ‘cutting ring’ method. For studying the spatial and temporal heterogeneity of soil moisture, soil volumetric water contents (different soil depths) of forests, the Yuanyang terraces have been monitored by various soil moisture measuring instruments (Zhang 2014).

The Hani Rice Terraces System can resist dry conditions successfully not only because the forest and terrace wetland ecosystems (components of the system) have the function of water conservation, which provide and conserve the water resources for the complex ecosystem, but also that Hani traditional ecological knowledge plays an important role in resisting extreme droughts, which has effectively protected the natural ecosystems. In a word, the Hani Rice Terraces System can successfully resist an extreme drought as the result of the harmonious development of natural ecosystems and national traditional culture (Sun 2012). Until now, the water conservation function of the Hani Rice Terraces System has only been studied quantitatively. In this paper, effects of traditional ecological knowledge will be discussed, based first on an analysis of the drought-resistant mechanisms of the Hani Rice Terraces System, which will focus on the knowledge of water management, terrace management and forest practices of the Hani people in maintaining the terraced fields system.

2 Materials and methods

2.1 Study area

Honghe County is located along the south bank of the Red River, in the southwest of the Honghe Hani and Yi Autonomous Prefecture, which is 300-1634 m above sea level (Fig. 1). It has a subtropical monsoon climate with a mean annual temperature of about 20-23°C and a mean annual precipitation of 843 mm. It is believed that in China, terraces in Honghe County are the largest in terms of scale and distribution. They are mainly concentrated in two areas; the Tasa terraces in Jiayin Town, and the Samaba terraces in Baohua Town.

The study area of this paper is the Menglong river basin with a cultivated land area of 40.11 km², forest land area of 40.11 km², grassland area of 45.73 km², and construction land area of 0.44 km². Forest land accounts for 47.5% of the area and is dominated by both coniferous and broad-leaved forests (Fig. 2). Local soil parent materials are mainly composed of red soil, yellow soil, paddy soil and red sandy soil. The Menglong river basin includes the eastern region of Baohua Town and the western region of Jiayin Town. The Tasa terraces and Samaba terraces are wholly located within this basin, where our research work was conducted.

2.2 Data collection

Field surveys with key informants were conducted during the period of July to August 2014. Information about the drought-resistant mechanisms of the Hani Rice Terraces System and traditional ecological knowledge about water resources management, forest management and terrace management was collected by key informant interviews and
by using secondary data in books, reports and papers.

3 Results and discussion

3.1 Drought-resistant mechanism of the Hani Rice Terraces System

The Hani Rice Terraces System is one of the best examples showing the wisdom of farmers in China (Fig. 3). The vertical distribution of the Forest-Village-Terrace-River ecological landscape features have been man-made in the Hani terraced landscape (Sun 2013). There are material circulations and energy flows in the four subsystems of the Hani Rice Terraces System, which are the basis of its sustainable development over time. The forest ecosystem, mainly located above an altitude of 2000 m, plays the important role of reservoir in the system, and provides the water resources for the complex ecosystem. In addition, the forest ecosystem performs various ecological functions, such as soil conservation, providing fuel wood, plant and animal products and building materials for the villages. The Hani villages are built on the mountainsides, where the climate is mild and suitable for living. It is also convenient for collecting and hunting in the forest and going down to the terraced fields for irrigation and fertilizer management. The terraces are just below the villages. They look like half artificial ecosystem with layers of terraced fields filled with water, which can provide food for the villagers and in the meantime play an integral role in soil and water conservation.

Water circulation in the Hani Rice Terraces System is the key factor to guarantee adequate supply of water for the system (Bai, 2013). Natural rainfall falls on the ground to form the surface runoff and percolates into the underground water system; surface runoff and springs flow through the forests, and then run through a cleverly designed irrigation network to the villages and then to numerous layers of horizontal terraced fields, and then finally into the river in the valley bottom. The water in the terraces and valley also evaporates and forms into clouds at the hilltops when the monsoon and the topographic conditions are suitable. The forests on the hilltops can transform the rising vapour to form dew and accumulate moisture into enough water stored in the forested hilltops, to finally form swags and creeks in the forests. That is why water supply is abundant in the Hani valleys although there are no reservoirs in the rice terraces (Fig. 4).

Through the above analysis, it can be seen that the Hani Rice Terraces System can resist an extreme drought successfully, because there is a very functional water cycle system among forest, village, terrace and river in this complex ecosystem. The typical ecological landscape of the Hani Rice Terraces provides perfect natural conditions for this water cycle. The four sub-ecosystems all play important roles in resisting the drought, especially when the rain drops move through the canopy layer, litter layer and soil layer of forests. The rainfall can be conserved effectively by forest cover, thus it can be seen that the forest ecosystem plays the role of "green reservoir" by providing water resources for this complex ecosystem. Besides, the terrace ecosystem also plays an important role in water conservation, like the forest ecosystem, the soil of which can conserve water effectively, and there is plenty of water stored in the terraced fields for rice to grow perennially.

In addition to the natural ecological system which plays the vital role in resisting drought, there is a complete set of traditional ecological knowledge playing another important part in maintaining the stability of the system and controlling the water resource circulation. Hani people have developed a series of water management protocols including water conservancy, system construction, water allocation and ditch management. The Hani people are also highly conscious of water resources protection, which effectively manages the cycle of water resource circulation in the complex ecosystem. There is also a lot of forest resources management knowledge and prescribed meanings of the plants and trees in the forests, which have also helped to protect the forest ecological system from overuse. The Hani nationality has developed a good deal of terrace management knowledge in the reclamation and maintenance of Hani terraced fields, which has effectively protected the hillside
terrace ecosystem from erosion (Fig. 5).

3.2 Traditional ecological knowledge about water resources management

The Hani people utilize and manage the local water resources in a unique, simple, economical and efficient manner. Their knowledge built up through generations of experience has provided a guarantee for the sustainable operation of the Hani terraced rice farming system. With the water crisis intensified, water shortage has evolved into one of the well-focused global environmental problems. With this backdrop, indigenous water resource management has an important role in addressing these issues. Therefore, it is of great importance to protect and learn from the Hani people’s water resources utilization and management methods.

3.2.1 Water conservancy construction

Construction of the ditches play a central role in terraced field irrigation. Water coming down from the hills has to go through ditches to reach the whole terraces. The purpose of digging the ditches is to catch flows from mountain forests and spring water seeping from mountains to irrigate terraces (Huang 2013). In addition, ditches can also deposit sediments before they enter the terraces, which can avoid continuously elevating the terrace surface due to sediment deposition and declining water-retention capacity. There is a pond about 3-5 m² in size at the inlet of each terrace constructed to deposit sediment (Fig. 6). Digging the ditches must follow strict local rules, for instance, a new ditch can no longer be dug above a ditch which has been dug already because the new one can block or capture the water.

3.2.2 Water distribution system

To enable every household access to a reasonable amount of water, the Hani people have invented a unique water allocation method with “water dividing stone” (Fig. 7) and “water dividing wood” (Fig. 8). The specific method is as follows: a wood or a stone bar is placed at the junction of the water diversion to ditches below. The wood or stone bar is carved with different size apertures for water outlets to divide and allocate certain volumes of water to flow to lower ditches. The size of the water outlet for each lower ditch is decided according to the irrigation area of the ditch, the water flow in the upper ditch, and the historical order of irrigation priority (Huang 2007). This water distribution method not only enables modest terraced water conservation, but also ensures irrigation of lower hill paddies, and has set the precedent for irrigation of mountainous regions. People are punished for
changing the wood or stone bars for getting more water into their terraces.

3.2.3 Ditch management system

3.2.3.1 Ditch management

There is a special water resources management system, i.e. ditch leadership system, in the Hani Rice Terraces area. The operator of water allocation is the ditch leader, whose first job is to dredge ditches, allocate water and solve disputes over the use of water. This position is voted on by villagers. Since the ditch leader has contributed his labour to water management, the households whose terraced fields are irrigated by the ditches must pay "ditch rice". In general, to use certain water in a ditch for irrigation of 2 to 3 mu of terraced fields, a household must pay a bucket of rice (2.8 ~ 3.0 kg) to the ditch leader. The collected ditch rice will be distributed to the ditch leaders as annual labour allowance.

3.2.3.2 Village regulations

Not only are effective management organization needed, but also fair village regulations are required for constraining villagers. Through soliciting ideas from villagers, a series of village regulations about water resource management has been formed, which has been adopted by consensus and implemented. The village regulations require that households cannot use the water from ditches without the permission of the ditch leader, and the person will be punished seriously for changing the wood or stone bar in order to get more water. The households who have violated village regulations are forbidden to use the water in the ditches to irrigate terraces.

3.2.3.3 Water management and regulation in drought and flood seasons

In the dry season, especially in April, when the Hani people are ready for transplanting rice seedlings, the ditch leader will promote efforts to dredge the ditches, strengthen management of water resources, and distribute water reasonably for satisfying the irrigation of terraced fields. In the flood season, when there is an abundance of water from precipitation and water diversion works and it is easy to form floods, the ditch leader should cut off the water to diversion works to avoid the occurrence of flooding disasters. In addition to artificially controlling water, an outlet has been made at the ridges of each terraced field where water flows from the upper layer of terraced fields to the lower layer, and Hani people have put a stone at the outlet, which can conserve the water in the terraced fields in the dry season when there is not enough water, and in the flood season, when the terraced fields are filled with plenty of water, the stone can be moved away to let the excess water flow into the lower layers of terraces, which avoids washing out terraces and terrace walls.

3.2.3.4 Water disputes

There are a few disputes on water resource allocation or water diversion works which are mostly managed by ditch leaders, while for collective ditches; there is no unified managing organization to manage the water and any disputes. Small ditches are commonly used by a few household villagers who often quarrel over the uneven use of water. Especially in the dry season, the upstream terrace allocations will affect the lower terraces on the supply and use of limited water. Disputes can usually be resolved among the villagers themselves, but disputes which cannot be resolved in this manner will be settled by ditch leaders and village heads under the ‘fair and reasonable’ conditions concept.

3.2.4 Water conservation awareness

In the minds of the Hani people, wells are pure and holy, which are the source of life and the heart of the village. Some people are asked to clean and maintain these wells, and there are some religious practices for blessing pools and wells every year. Some ponds have been dug near terraced fields for storing agricultural water which can be used for

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1 http://image.haosou.com/v?q
irrigation when there is no enough water. Furthermore, in order to make full use of water resources, domestic sewage often can be used to water trees and flowers, or be stored in the septic tank near the houses.

3.3 Traditional ecological knowledge about forest management

Forests can be looked at as the "natural reservoir" for the terraced fields and village homes. It provides an important guarantee of adequate water resources for the Ailao Mountain terraced areas, thus playing a crucial role in the stability and sustainability of local ecosystems. Forests have been protected well since there is a series of traditional ecological knowledge about forest management which has influenced Hani people deeply.

3.3.1 Classification and management of forest resources

According to different uses, forests have been classified into six major functional forest regions, such as fuelwood forest, water conservation forest and so on. Woodlands are managed by different classifications and functions, there are strict regulations about these different forests. A man who has violated rules will be punished severely. Some forest regions are sacred and inviolable, both men and livestock are not allowed to enter without permission, certainly not to cut trees and reclaim land for non-conservation purposes (Yang 2015). Forests are mainly managed by forest rangers, but natural worship and religious activities also play an important role in the respectful management of woodlands. Through the classification and management of forest resources, as well as the worship of the forest, Hani people have effectively protected the forest ecological system, guaranteed water supplies and controlled soil and water loss, which together have maintained the stability of the system.

3.3.2 Natural worship

The Hani worship of nature ultimately is embodied in the worship of the tree. Hani people respect trees as Gods, safeguarding and blessing them. They believe that cutting down trees will bring retributions. This natural worship makes the tree represent nature and is the basis of a series of religious activities worshiping the tree deity regularly, such as "Village Deity’s Day". Hani people worship trees and nature annually, with a solemn religious ceremony to express their reverence to trees and nature.

3.4 Traditional ecological knowledge about terrace management

Terrace ecosystems are one component of the Hani Rice Terraces System which plays an important role in water circulation and conservation. Landslides and terrace collapses are frequent in the steep gradients when there is torrential and prolonged rainfall in the Hani terraced area. Different measures have been taken in order to maintain the water retention of terraced fields. Terrace ridges are cleaned up before planting and after harvesting the rice. Field mud is pasted on the ridges of terraces which can increase water retention and prevent destruction by animals. In order to prevent weed growth, the ridges of terraces are repaired carefully twice a year. Mouse-holes will be blocked once they have been discovered. Plants, such as Mung beans and kidney beans, are planted on the ridges of the terraces to consolidate ridges and these leguminous plants also help in nitrogen fixation. During the rainy season, in order to ensure the safety of terraced fields and canals, all the canals are dredged to discharge excess water taking a lot of manpower and material resources. Besides, some sheds for resting have been built on the sides of the fields for managing terraces conveniently.

4 Conclusions

Key drought-resistant mechanisms of the Hani Rice Terraces System have been presented in this paper. The Hani Rice Terraces System can successfully resist the extreme drought because it is the result of the harmonious development of natural ecosystems and the use of traditional ecological knowledge. Water conservation of forests and terrace wetland ecosystems are the important prerequisites for resisting extreme droughts. In addition, the Hani people have developed a series of traditional ecological knowledge practices about water resource, forest and terrace management, which play important roles in maintaining the stability of the system and realizing the efficient use of available water resources. Through analyzing the series knowledge of water management, forest resource management and terraced fields management, this paper has identified the important role that traditional ecological knowledge played in resisting the extreme drought, the result of which is help for cultural inheritance and for protecting the Hani Rice Terraces System. In the future, we should not only strengthen the protection of the natural ecological system, but also pay attention to the inheritance of traditional culture.

The importance of traditional ecological knowledge has been identified in this paper, while, we have found some problems during investigation which are urgent to be solved. In order to make more money, young people prefer to live and work in the cities with the old and children staying in the villages. There will be no people managing the terraces and inheriting the traditional ecological knowledge in the near future without any measures to solve this problem. Low income is the key reason why the farmers do not want to manage the terraces, measures must be taken to improve their income by the government, such as improving farm subsidies and the price of rice. In addition, work about investing and collecting traditional ecological knowledge should be carried out as soon as possible (Xue 2014), and a cultural museum should be set up to display the Hani traditional ecological knowledge.
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References


