

Agro-environmental Sustainability of the Yuanyang Rice Terraces of Yunnan Province, Chinaⁱ

Sustentabilidade Agro-ambiental dos Terraços de Arroz de Yuanyang, Província de Yunnan, China

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Abstract: The Hani minority people of Yunnan Province (south-west China) have developed a complex and sustainable agro-environmental system of terraced rice paddy fields in Yuanyang (22°49'-23°19'N, 102°27'-103°13'E). The Hani people have maintained this intricate and elaborate system for over 1,300 years, with some 3,000 terraces covering about 11,000 hectares. Hence, during the Ming Dynasty (1368-1644), the Emperor awarded the Hani people the title of "*Magic Mountain Sculptors*" for "*building their ladders to Heaven*." However, geographic isolation and proximity to the, until recently, politically-sensitive border with Vietnam, has meant the Yuanyang terraces have attracted scant scientific attention. If we can understand how this system is sustained, we can learn lessons which hopefully can be applied more generally.

Keywords: cultural attitudes, Hani minority people, landscape multifunctionality, resource optimization, Yuanyang, China.

Resumo: O povo de minoria Hani, da Província de Yunnan (sudoeste da China) desenvolveu um sistema complexo e sustentável agro-ambiental de arroz, plantado em terraços em Yuanyang (22°49'-23°19'N, 102°27'-103°13'E). O povo de Hani tem mantido esse sistema intrincado e elaborado por mais de 1.300 anos, com aproximadamente 3.000 terraços cobrindo uma área de 11.000 hectares. Desta forma, durante a Dinastia Ming (1368-1644), o imperador deu ao povo de Hani o título de "Escultores da Montanha Mágica" por terem construído essas escadas para o céu. No entanto, o isolamento geográfico e a proximidade da então fronteira politicamente sensível, levou com que os terraços de Yuanyang tenha atraído a atenção científica. Se podemos compreender como esse sistema tem sido sustentável, podemos aprender lições as quais podem ser aplicadas de forma mais genérica.

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Palavras-chave: atitudes culturais, povo de minoria Hani, paisagem de multifuncionalidade, otimização de recursos, Yuanyang, China.

Introduction

“Better water comes from better trees, better paddies develop with better water, and better offspring prosper with better paddies” (Ancient song of the Hani minority people).

The Yuanyang terraces are located at 22°49'-23°19'N, 102°27'-103°13'E (Figure 1) and are extremely spectacular (Plates 1 and 2). Thus, they have been long been a magnet for photographers and tourists, evidenced by many excellent web-based photo albums. However, the remoteness from host investigative teams (Yuanyang is 326 km south of Kunming, the capital of Yunnan Province) and the former political tensions on the nearby Chinese-Vietnamese border, has meant the area has received scant scientific study.

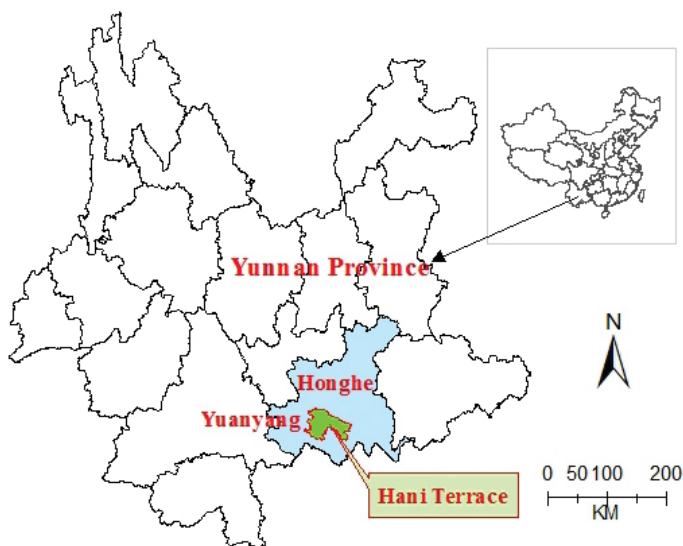


Figure 1 - Location of Yunnan Province, Honghe Prefecture, Yuanyang County and the Hani Terraces.



Plates 1 and 2 - Rice terraces of Yuanyang.

The 'Magic Mountain Sculptors'

The Hani minority are believed to have originated as the nomadic Qiang tribe, which migrated from the Qinghai-Tibetan Plateau to Yunnan Province in ~300 AD, where they developed their complex rice dominated terraces agricultural system (Wang 1999). During the Ming Dynasty (1368-1644), the Emperor awarded the Hani people the title of "Magic Mountain Sculptors" for "building their ladders to heaven." The Hani language belongs to the Tibeto-Burmese linguistic family, which adds to their distinctness from the Han Chinese majority. Generally, terrace construction commenced on lower slopes and each generation adds another terrace level to the system. Thus the oldest, as yet undated, terraces probably lie at the base of the terrace system. The research team intends to extract organic remains, especially wood, from beneath the oldest terrace. Carbon-14 dating of such buried organic material should indicate the inception of terrace building.

The environment of the Yunnan uplands is suitable for rice cultivation with an average annual sunshine of 1,670 hours and temperature of 15.4°C (Wang, 1999). The area possesses considerable water resources, with ample annual precipitation. Average annual precipitation is ~1400 mm, ranging between 1200-1500 mm on lower slopes to 1500-2000 mm on upper slopes. Most precipitation falls as summer monsoon rains between May and October. The meso-scale climate effectively retains and recycles water within the Yuanyang basin, a subcatchment of the Red River (Hong He) basin. The valley is noted for frequent fogs. Furthermore, differential late afternoon solar heating of mountain sides induces slight pressure differences, which cause upslope (anabatic) winds to transport moist airstreams from the valley base upslope. The monsoonal precipitation falls on the Ailao Mountain Range, which rises from ~1400 m above sea-level to 2940 m.

Lithology plays an important role, with upslope rocks consisting mainly of impervious metamorphic gneiss and mica-schists, which encourage runoff into the mid-slope spring lines. Furthermore, structural geology influences hydrogeological behaviour. The main valley follows a syncline structure and so the hydrological catchment is larger than the physiographic catchment, with groundwater permeating along bedding planes into the main catchment from adjacent catchments. Furthermore, deep (~50 m) pockets of weathered material act as important water storage features and springs often originate at their bases. Thus, the mid- to lower slopes possess a multitude of springs, which are the main water source for the paddy fields.

Soil survey revealed that inherent soil fertility is surprisingly low. Soil pH is typically low at pH 5-6 and cation exchange capacity (CEC) is also low, with typical values of 4-7 cmolc kg⁻¹ (Colinet *et al.*, 2011). Crop productivity is thus maintained by efficient recycling of nutrients within the system (Colinet *et al.*, 2011). Topsoils (Ap horizons) are generally clay loams and the depth of the minero-organic topsoil seems to increase in the lower, and thus older, terraces. Typically, the depths of Ap horizons are ~0.6 m in the upper terraces, ~1.0 m in the mid-level terraces and ~1.2 m in the lower terraces. This leads to the research question whether the depth of Ap horizons can be used as an indirect surrogate measure of terrace age.

The total Hani population is 1.44 million, of which 1.42 million live in Yunnan Province (2000 Census). About 12,500 Hani people live in Vietnam. In Yunnan, most Hani live in the Ailao Mountain Range, concentrating in southern Yunnan between the Red River and

Mekong River. The Hani population in the seven counties of Yuanyang, Mejian, Honghe, Yuanjiang, Jinping, Luchun and Jiangcheng accounts for 76% of the total Hani population and >50% of the local population. There are two towns and 970 villages in the 2190 km² Yuanyang County. The total population was 371,489 (late 2004), of which the Hani minority population was 326,100 (87.8%) and the agricultural population was 351,543 (94.6%).

The seven major nationalities in Yuanyang County live at different altitudes, largely in accordance with their traditions and customs. Generally, the people living on the relatively flat valley bottoms (elevation from the lowest point of Xiaohekou village at 144 m to 600 m) are mostly Dai (Tai, that is ethnically Thai) people. At the bottom of the valley side (altitude 600-1000 m) are Zhuang people. Yi people mainly live on the lower mid-section of the valley side (altitude 1000-1400 m). The Hani people mainly live at an altitude of 1400-2000 m. Higher elevations (>2000 m) are the habitat of Miao and Yao people. Normally, the Han majority live in towns or alongside the main roads.

The Hani people have a unique cultural system that reveres the land. Even the name of their main village 'Qingkou' (Catchment Gate) is connotative of their landscape ecology. The site selection of Hani villages also indicate their environmental understanding, as Hani villages are usually located on the middle and sunny mountain slopes. At the middle part of the mountain, temperatures are mild with less possibility of disease and pest damage than at the lower warmer and more humid basal slopes and less chance of animal attack (i.e. by bears) than the higher part. Normally, a Hani village is comprised of 20-50 households and the distance between two adjacent villages is ~2 km. With such small villages and their close proximity, people can efficiently manage their lands without long walks to the fields.

The Hani religion embraces polytheism and the worship of ancestors and nature. They pay particular devotion to the 'forest god,' which is perceived as the source of life-giving water. Deforestation is considered a religious violation and the Hani people actively teach their children to respect the forest. This concept significantly contributes to forest conservation and ecosystem stability. Consequently, the existing forest area in Yuanyang County is ~28,000 ha, that is 26.7% of land cover.

The Hani have developed complex agricultural systems. Rice is the dominant crop, but it is maintained with few additions of artificial fertilizers or pesticides. Complex fertigation systems provide most nutrients, especially nitrogen (N). Mixes of manure from cattle and pigs and 'night soil' are placed adjacent to channels. When needed, irrigation waters are diverted into paddy fields, inputting a N flush, especially in the early growing season. The Hani have the philosophy of dividing the rice crop into three. The upper third 'is for the people' (i.e. the crop for domestic consumption), the middle third is 'for the animals' (i.e. straw for animal consumption) and the lower third is 'for the soil' (i.e. retained as a stubble, returning nutrients to the paddy soil system and improving soil structure). Rice straw is also used for thatching the distinctive Hani 'mushroom shaped' houses.

Ancillary food production includes ducks, fish (crucian carp (*Carassius carassius*), eels and mudfish), frogs and snails. Pond weed is utilized for pig-feed. These measures provide valuable supplements to the diet and increase the nutrient loads of the perennially wet paddy fields. The nutrient budgets and aquatic ecology of this integrated water management system are under further study. In addition, bee culture provides both honey and a pollination mechanism for local crops and wild vegetables and mushrooms are harvested from the forest.

Fullen, M. A.

Increased crop genetic diversity can extend the cultivation period of a crop variety and the Yuanyang rice cultivars have considerable genetic diversity (Zhu Yongyong *et al.*, 2000). Genetic diversity and careful agronomic management means rice crop yields are high, typically 4-6 t ha⁻¹, compared with the usual 2-3 t ha⁻¹ in traditional cropping systems. Minimal artificial fertilizers and virtually no pesticides are used. The traditional rice varieties used by the Hani require less fertilizer inputs than modern varieties and are noted for their resistance to disease (Zhu Yongyong *et al.*, 2000).

Land use patterns promote soil and water conservation. Hilltops are afforested, with ~15 identified tree species, predominantly Yunnan pine (*Pinus yunnanensis*). This land use is very effective in conserving soil and water and releases high quality water from the upper to lower slopes.

Global lessons for sustainability

The combination of all these identified cultural and agro-environmental factors appear to have allowed the Yuanyang rice terrace system to remain in a sustainable state. The research team postulate that these lessons will have some applicability for agro-environmental sustainability on the global scale. Identified lessons relate to resource optimization, landscape multifunctionality and cultural attitudes. However, our understanding is far from complete. Thus, a joint Chinese-European team has established the 'Yuanyang Project' to explore, study and understand the factors which promote sustainability. The team is approaching these questions as inquisitive students, trying to understand the 'secrets' of the Hani people. Understanding and then presenting these findings should make a positive contribution to the broader development and dissemination of sustainable agricultural technology.

The ancient ballads (poetic songs) of the Hani people are highly instructional. Until recently, the Hani had no written language. These ballads were collated by Zhang Hongzhen (2010), based on meetings with the Mopi (elders of the Hani). The collated ballads consist of 121 verses and cover events throughout the four seasons. Below is a selected verse from each season.

Winter

I cut down water gourd trees,
And turned over straw ash for the need of growing buckwheat.
The leaves of water gourd trees and the straw ash are good fertilizer,
So the buckwheat surely grows well
With plump seeds.
Do remember to cultivate the field in the coming year,
No matter what a good harvest of buckwheat it is.

Spring

In the right condition raindrops beat down the withered leaves,
Trinkling the edge of the leaves like grease.
The raindrops fall on the muddy road.
Without raindrops in winter, the stream may dry up,
And is revived in March with the coming of raindrops.

The grass of Eyuecao buds gradually on the edge of the village,
Woods and grass look green by the pool.
And Wushanoao grass returns to life again.
Horses nicker in the stall,
And the fat and husky oxes grow well.

Curicao grass by the fields bud with tender leaves,
Offering succulence for the pigs,
The boar grows fatter and stronger day by day.

Summer

Hani's happy Kuzhazha Festival falls in June,
It is time for the Hani to play swing;
The swing is set by the Quifang house on the verge of the village,
And quality bamboo is used in making the swing,
Attached to the swing,
Four strong ropes are put firmly into the earth,
And the ropes are fastened together at the top,
With a pedal board being pegged at the bottom,
And a bridge-like beam being set between.

The swing is played high,
With one's arms extending like birds;
With the first swing,
Bad plants are swung out,
And good plants are swung in;
With the second swing,
Evil persons are swung out,
And pure persons are swung in;
With the third swing,
The lazy domestic animals are swung out,
And diligent ones are swung in;
Playing the swing symbolizes the bumper harvest,
And safety for every household,
As well as the prosperity of domestic animals.

Autumn

We harvest ample foods to treat hundreds of Dai people,
And hundreds of Pula people;
The men and women are engaged in endless labour,
On which their value depend.

The autumn is almost gone.
The cicada goes back to earth to rest,
And Dayue returns to earth to sleep;

Fullen, M. A.

They live in the section between the loess and black-land,
Where the thin roots in earth are used as clothes and quilts.
They have to drink dew which has fallen into the earth,
And be taken care of by Zheboranyi.

The three months of autumn have come to an end,
A round of 13 days and nights have come to an end,
And a year of 12 months has come to an end,
The three months of winter is just around the corner.

The more agriculturally-orientated ballads are being serialized in the 'Newsletter of the European Society for Soil Conservation' (ESSC), starting from Issue 2012/3. There is free and open access to ESSC Newsletters at: <http://www.essc.sk>

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Note: excellent web-based photo albums are available on the Yuanyang Terraces:

<https://www.google.co.uk/search?q=yuanyang+rice+terraces&tbm=isch&tbo=u&source=univ&sa=X&ei=GVkPU8OCG9LwhQfv3oGoCQ&ved=0CCoQsAQ&biw=1280&bih=828> (accessed 27/02/14).

<http://www.trekearth.com/gallery/Asia/China/South/Yunnan/Yuanyang/> (accessed 27/02/14).

<http://natureproducts.net/Ecotourism/rice Terraces.html> (accessed 27/02/14).

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