

Agricultural Technologies of Terraced Rice Cultivation in the Ailao Mountains, Yunnan, China

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Abstract

Along the slopes of the Ailao Mountains in Yunnan Province, Southwest China, ethnic groups such as the Hani and Yi have developed an impressive landscape of terraced paddy fields over the past several hundred years. Their intensive terraced rice cultivation stands in striking contrast to shifting cultivation, the predominant mode of agriculture in tropical mountain areas. This study aims to clarify how terraced rice cultivation has been developed and sustained over many years in the Ailao Mountains from the viewpoint of agricultural technology.

In terraced rice cultivation, considerable effort is paid to the preservation of paddy fields. In the dry season, most of the terraced paddy fields are kept inundated even when no crop is grown. This dry season irrigation helps to prevent the collapse of the terrace, in close relationship with various farming works. The long-distance channel irrigation systems maintained by local groups have secured a dry season water supply. In the wet season, on the other hand, protection of paddy fields from excess water is the major concern. Many kinds of drainage facilities can be observed both in the irrigation channel and in the terraced paddy field.

Irrigation in terraced rice cultivation is designed not only for supplying water to rice plants but has various other purposes as well. In addition to the protection of terraced paddy fields, the unique practice of year-round irrigation plays many important roles, including storing water, maintaining favorable soil conditions for rice growth and providing a habitat for various edible aquatic animals.

In conclusion, the terraced rice cultivation in the Ailao Mountains has been sustained by various types of technology, related in particular to irrigation and drainage, which have special bearing in the terraced paddy field.

Introduction

Along the slopes of the Ailao Mountains in Yunnan Province, Southwest China, ethnic groups such as the Hani and Yi have carved an impressive landscape of terraced paddy fields over the past several hundred years. Thanks to intensive terraced rice cultivation, people have formed and

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maintained communities of relatively high population density, even in a mountainous area. This stands in striking contrast to low-population density societies based on shifting cultivation, which are predominant in tropical mountain areas.

In order to sustain agricultural activities on the steep mountain slopes, it is important to preserve the farmland itself, as well as maintaining the productivity of the land. Agricultural technologies required for terraced rice cultivation differ in this sense from those for rice cultivation in the plain. Terraced rice cultivation in the Ailao Mountains has been widely studied [Mao 1991; Wang 1999; Li 2000: 1-17; Huang 2000: 85-108; Li and Chen 2000: 117-124; Bouchery 1996]. However, most of these are folklore studies that place more emphasis on the description of the Hani people's traditional culture. No empirical studies have yet been conducted to examine agricultural technologies from the agro-ecological characteristics of the terraced paddy field.

In the Ailao Mountains, various kinds of unique agricultural technologies can be observed. For example, most of the terraced paddy fields in this area are irrigated even during the fallow period when no crops are grown. This irrigation practice not only prevents farmers from growing the second crop, but also requires continuous water supply during the dry season. However, farmers adhere to this traditional irrigation practice even when they introduced improved rice varieties including the hybrid rice, which require occasional water drainage during the growing season to maximize productivity. This example closely relates to the specific technological requirement for terraced rice cultivation.

This study aims to illustrate how terraced rice cultivation has been developed and sustained over many years in the Ailao Mountains from the viewpoint of agricultural technologies, especially focusing on irrigation and drainage systems. It is also an attempt to understand the technological characteristics of the terraced rice cultivation in comparison with rice cultivation in the plain.

1. The Research Site

The Ailao Mountains consist of peaks that are mostly over 2,000 m in altitude, running northwest to southeast along the Hong River, which originates in Yunnan and flows down through Vietnam to the Gulf of Tonkin (Fig. 1). The mountain slopes are covered with yellow or brown colored clayey soils originating from metamorphic rock formed by repeated tectonic movements and magma intrusions, all beginning in the Palaeozoic Era [*Yuanyang Xianzhi Bianxie Weiyuanhui* 1990: 44]. Some researchers have pointed out that tectonic movement and volcanic activity prevent tropical soil from forming duripan and provide suitable soil for agricultural development. However, the relationship between geological conditions at the macro level and agricultural activity is not yet

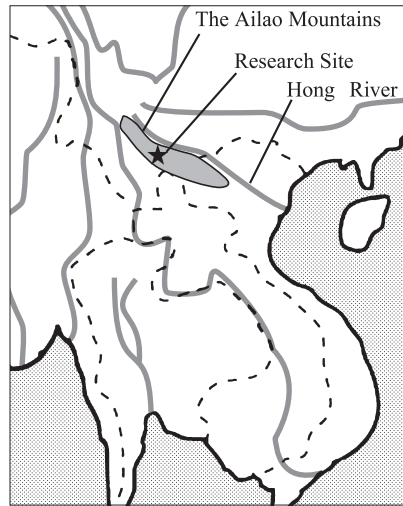


Fig. 1. The Ailao Mountains and the Research Site

fully understood. Here, I only note the importance of the clayey soil formed by the tectonic movement, which plays an important role both in water control and in farming works of the terraced rice cultivation in this area.

Weather conditions vary greatly depending on the altitude and topography. Temperature changes in the response to altitude. There is a difference of about 10°C in the yearly average temperature between Nansha town (250m in altitude) at the foot of the Mountains and Shengcun village (1,850m) on the upper slope of the mountains although these two places are only 10km apart in horizontal distance. The seasonal rainfall pattern shows the existence of two contrasting seasons: rainy season (May-October) with moist monsoon from the south and dry season (November-April) with dry monsoon from the north (see also Fig. 3). Rainfall amounts in the wet season tend to increase with the increase in the altitude, and this trend is clear especially on the north slope of the Ailao Mountains. This is a result of the southern monsoon that drops all its rain at the highest part of the mountains, with dry wind blowing down the northern slope as a foehn. During the dry season, winds blowing up from the Honghe valley form dense fog at the upper part of the Ailao Mountains. In Xingai town (1,540m in altitude), there are 180 misty days in a year [Yuanyangxian Qixiangzhan 1986].

Ample rainfall (over 1,800mm yearly) in the wet season and heavy fog in the dry season have nurtured the cloud forest that covers the highest part of the mountains (approximately higher than 1,800m in altitude). The numerous mountain streams and springs originating from the cloud forests

supply irrigation water for the terraced rice fields below the forest. Thanks to trees with abundant epiphytes on their trunks and branches, cloud forests capture plenty of moisture from the mist and serves as an excellent source of irrigation water, even during the dry season [Momose 2003]. Terraced paddy fields are distributed on slopes of 700-1,800m in altitude, with particularly high concentration at 1,200-1,800m. In the alluvial valley of the Hong River, there are terraced paddy fields cultivated by the Thai. These rice terraces are constructed on the sandy soils of much gentler slopes. There are differences in paddy fields on the mountain slopes not only in terms of physical structure of the terraces, but also in the use of agricultural technology. It can be considered that these two types of rice cultivation have different cultural backgrounds. In this paper, I discuss only the terraced rice cultivation on the mountain slope.

According to Chinese historical materials, terraced rice cultivation in this area has a history of more than 700 years.¹⁾ Major cultivators of terraced paddy fields are ethnic groups such as the Hani, Yi and Han.²⁾ Roughly speaking, the Hani cultivate terraced fields on the upper slopes, and the Yi and Han cultivate terraced fields mostly on the lower slopes.

The current field survey was conducted for approximately four months during 2002-2004 at Shanlaoqing village (with a population of 415 Yi people, organized into 83 households) in Shalatuo Township of Yuanyang County. The village is located on the southern slope of the Ailao Mountains at an elevation of about 1,640m. Data was collected through interviews and participant observation. In this paper, words in italics indicate local Yi language terms, unless otherwise stated.

2. Physical Structure of Terraced Paddy Field

In this section, a brief introduction to the physical structure of terraced paddy fields is given in order to provide the basic knowledge for further discussion of agricultural technologies.

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- 1) Many Chinese scholars believe that the rice terrace agriculture in this area dates back to the Tang era, citing a description in “*Manshu*,” a geographical report written at the end of the Tang era. According to this report, some minority ethnic groups were practicing ingenious forms of mountain farming in the southeast part of Yunnan [Li 2000:3]. However, the description lacks detailed information about the location and the ethnic groups. The reliable records about the rice terrace agriculture in this area first appeared in the Ming era, which included the description of irrigation channel construction [*Yunnanshen Luchun Xianzhi Bianxie Weiyuanhui* 1992: 261], and of opening new terraced field [*Minzhuwenti Wozhongcongshu Yunnanshen Bianji Weiyuanhui* 1982: 7-10]. An interview survey on the patronymic linkage system in a Hani village also supports the rice terrace construction in Ming era [*Minzhuwenti Wozhongcongshu Yunnanshen Bianji Weiyuanhui* 1982: 15].
 - 2) The Hani and Yi, both belong to the Tibeto-Burman language family, and are believed by Chinese scholars to have evolved from the ancient Qiang, a nomadic people who lived in Qinghai-Tibet Plateau. Their languages are very similar with regard to grammar, but are quite different in phonologically. Among them, the Hani are believed to be the first immigrants to the Ailao Mountains, although accurate date is still unknown. The Yi and Han are considered to have come during the Ming-Qing era.

Terraced paddy fields in the Ailao Mountains consist of several parts (Fig. 2). The bottom layer of the inundated enclosure is the plow layer (*aludumo*). This layer is plowed and harrowed many times in a year to prepare the soil for growing rice plants. Below the plow layer, there is the subsoil or plow pan (*agelamo*), which is an artificially compacted semi-impermeable layer. Pond water is captured between upper section (*ngebu*) of the dike and the dike wall (*ngeda*). In the Ailao Mountains, most of the dikes (*ngebu* and *ngeda*) are made of soil, but stones are used for some dikes in order to reinforce the structure when there are plenty of stones available around the construction site. Since piled stones are often covered with soil, it is difficult to distinguish from the appearance whether there are stones inside the dike. Shallow cuts (*yima*) on the dike draw water into the paddy from the irrigation channel or from the upper paddy field, and also to drain the excess water to the lower paddy field. Many of the fields have conduits (*yirudu* or *yinodu*) to drain the pond water when the field needs quick drainage before works such as sowing and transplanting. When water is stored, the inlet of the conduit at the bottom of the plow layer is stuffed with soil to prevent leakage.

An owner of a paddy field is usually considered to possess both the lower *ngebu* and upper *ngeda* adjacent to the terraced pond. This ownership unit also signifies the places that the owner can modify the terrace structure and plant vegetables freely throughout farming activities, to the extent that these activities do not affect too much of the upper terraced field production.

Terraced paddy fields in the Ailao Mountains are characterized by narrow *ngebu* (usually about 20m in width) and tall and steep *ngeda* (height varying from 1 to 5m depending on inclination of

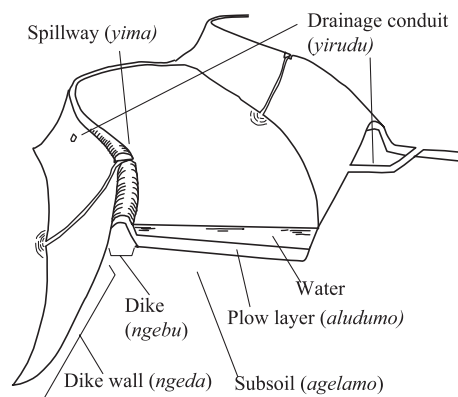


Fig. 2. Cross-section of a Terraced Paddy Field (*demi*)

*This figure shows the typical structure of the most common type of terraced paddy field (*mio*). Another type of terraced paddy field (*mifa*) has lower and narrower *ngebu* and usually no *yirudu*. Differences between these two types of field are discussed in the next section.

the construction site). This type of physical structure is possible only when plenty of clayey soils are available, which not only have high water holding capacity suited for the terrace's basement, but also become hard enough to make the terrace's dike firm. It should also be noted that such a terrace structure shows the farmer's effort to obtain a larger rice-planting area, and as described later in this paper, has been sustained by characteristic irrigation/drainage practices and farming works.

Another feature of the physical structure is a deep paddy pond enclosed by high *ngebu* (about 40 cm height). This allows farmers not only to cultivate fish, but also to store enough irrigation water for water shortage period, which will be discussed further in the following sections.

3. The Cropping Season and Year-round Irrigation

Fig. 3 shows temperature, rainfall and the rice cultivation schedule in the Shalatuo Township, where Shanlaoqing village is located. Rice is grown once a year in the wet season. Because of the high altitude, the cropping season for rice is determined by temperature rather than by rainfall patterns, considering that rice plants are often damaged by cold weather both at the beginning and at the end of the growing season. This limitation in the growing season creates a problem for the use of water resources. Irrigation water is most important for land preparation (works such as plowing, repairing dikes and harrowing) before transplanting. However, the land preparation period coincides with the low-water season of mountain streams, which are the major water sources for the

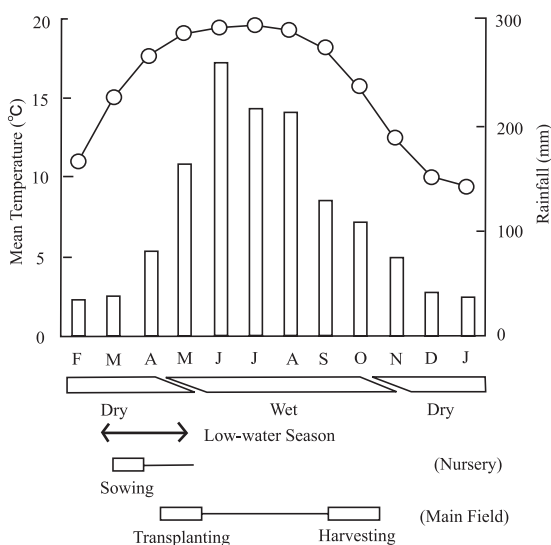


Fig. 3. Rainfall, Mean Temperature and the Rice Growing Season in the Research Site
Weather data source: [Yuanyangxian Qixiangzhan 1986]

paddy fields. As will be discussed later in this section, this imbalance is one of the factors leading to this unique irrigation practice, not to mention the construction of long-distance irrigation channel observed throughout the Ailao Mountains.

One of the most significant features of agricultural technologies in terraced rice cultivation in the Ailao Mountains is the practice of year-round irrigation. Terraced fields are irrigated and kept inundated throughout the year, even in the dry season when no crops are grown. The reasons for this practice may be summarized as follows.

- 1) To prevent water leakage or the collapse of terraced fields,
- 2) To prevent soil from becoming too hard,
- 3) To store water for farming works carried out in the low-water season,
- 4) To maintain high rice yield.

First of all, deep cracks and fissures develop in the clay soil of the paddy fields when it dries out. This leads to serious water leakage, and in more severe cases, to the collapse of terraces (*midede*). This problem is not serious for paddy fields in the plains, but is crucial for terraced paddy fields built on steep slopes where the collapse of terrace easily causes large-scale loss of farmland. The second reason is also related to soil properties. Dried clay soil is too hard to plow, and it is very difficult to mix with water. The third reason is related to the first reason. As described above, irrigation water is most needed for land preparation during the driest season of the year. If the fields were left to dry up after the harvest and were then watered again just before land preparations, the scarce water during this season would be insufficient to fill all the terraced fields suffering from severe water leakage. In fact, during the Great Leap Forward (*dayuejin* in Mandarin Chinese) (1958-1960), the local government launched a campaign to dry up the terraced fields and grow wheat during the dry season. This experiment led to severe water shortages during the land preparation period and to the collapse of many terraced fields, resulting in a great decrease in rice production [*Yuanyang Xianzhi Bianxie Weiyuanhui* 1990:122]. The fourth reason is based on farmers' answers to author's question "why do you keep your field flooded during the dry season?" The most common answer was, "if you don't irrigate, the rice yield will be very poor." This idea seems to contrast sharply with "the phenomenon of soil drying," which is widely observed in Japan. The soil drying effect refers to nitrogen mineralization that occurs when the soil is watered after being dried, and is considered to be favorable for the growth of rice. In the Ailao Mountains, however, a different reaction may have a stronger effect, leading to a decrease of the yield. More and in-depth investigation is required to clarify this mechanism.

As for the fourth reason, a kind of paddy fields called *mifa* provides a good example. *Mifa* is

a terraced paddy field that has no right to draw water from the irrigation channel during the dry season, because the field is newly opened and irrigation water of the channel was already insufficient at the time of construction (a detailed example will be given in the next section). *Mifa* can be widely observed in the Ailao Mountains. Such semi-rain-fed paddy fields, *mifa*³⁾ are distinguished from the paddy fields called *mio* that can be irrigated throughout the year. *Mifa* can be irrigated only after the completion of transplanting in all of the *mio* and the demand for irrigation water relaxes (usually end of May-early June). According to the villagers, the rice yield of *mifa* is usually smaller and more unstable than that in *mio* and the dikes of *mifa* are vulnerable to collapse during heavy rainfall. The yield (t/ha) in *mio* and *mifa* estimated by a former village head are: 2.0 and 0.8 on the upper slopes (higher than 1,650 m in altitude) and 3.0 and 1.2 on the middle slopes (1,550-1,650 m in altitude) respectively.⁴⁾ On the lower slopes (lower than 1,550 m in altitude), there are only *mio* (4.8 t/ha). The yield is high in the low altitude fields both in *mio* and *mifa*, but it is very clear that the yield in *mifa* is less than half of that in *mio* for each altitude level.

In the following part of this paper, the descriptions and discussions will mainly focus on *mio*, and the term “paddy field” will be used to mean *mio*. Differences with *mifa* will be described separately, as required. This is not only because *mio* is the dominant type of terraced paddy field in the Ailao Mountains,⁵⁾ but also because of the importance of *mio* to farmers. The villagers consider that only *mio* is a “complete” terraced paddy field and the term “*demi*” (general term for the paddy field) often refers only to *mio* in their daily conversation. The word “*mio*” is used only when they emphasize the difference with *mifa*, which they considered as “imperfect” or “inferior” paddy field.

4. Irrigation and Drainage in Shanlaoqing Village

As described above, year-round irrigation has helped maintain both the rice yield and the physical structure of the terraces. In this section, an attempt will be made to provide a comprehensive

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- 3) *Mifa* is different from what we call “rain-fed” terraced field in the following two regards. 1) *Mifa* is only socially prohibited from drawing channel water. Physically, it is possible to deliver channel water into *mifa*. 2) *Mifa* is prohibited from being irrigated only at the fallow period of rice (dry season) because the channel water is scarce. During the wet season when the rice plants are grown, it is allowed to irrigate *mifa* as long as there is enough water in the channel to irrigate older paddy fields.
- 4) It is very difficult to know the exact rice production per unit area in the village, because the villagers usually express the productivity of the paddy field as the amount of rice harvested, and they have no traditional concept to express their land area. Estimated yield used in this discussion may be inaccurate to a certain degree. However these figures show the rough trends about the relative difference in rice yield between *mio* and *mifa*.
- 5) Total area of *mio* and *mifa* in Yuanyang County in 1986 was 188,176 and 55,687 *mu* (1 *mu*=6.67a), respectively (Interview with the Deputy Chief of Yuanyang Agricultural Bureau).

description of the water control and related technologies observed in Shanlaoqing village.

4.1 Development of Irrigation Channels

The year-round irrigation, especially the requirement of dry season irrigation has encouraged the development of longer irrigation channels. In the following section, the historical processes associated with irrigation channels will be examined.

Fig. 4 shows the expansion of terraced paddy fields accompanied by irrigation channel construction in the village. According to the elderly villagers, the construction of paddy fields began in the lower slopes (at least 300 years ago). When Shanlaoqing village was founded at its present location, the water of the mountain streams near the village had already been taken by two irrigation channels of the nearby Potou village (also a Yi village but older than Shanlaoqing) to irrigate their terraced paddies. Therefore, the people in Shanlaoqing village had to take their irrigation water from sections of the streams that were lower than the water intakes of Potou village, where

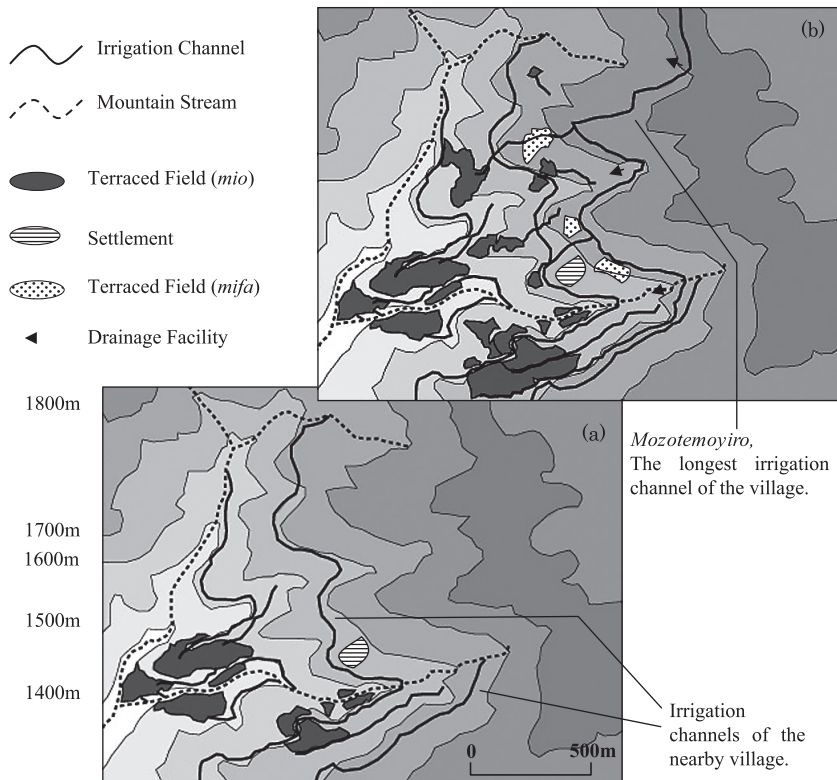


Fig. 4. Distribution of Terraced Fields and Irrigation Channels in Shanlaoqing Village before the Construction of the Mozotemoyiro Channel (a), and at the Present (b)

the remaining surface water and infiltration water welling up from the riverbed was available. Consequently, at an early stage, most terraced paddy fields in Shanlaoqing village were opened on lower slopes. Some terraced fields were opened with independent short irrigation channels that took water from small mountain streams or springs. It is supposed that when no more land or water was available for new terraced fields on the lower slopes, a 7-km irrigation channel (*mozotemoyiro*) was constructed under the leadership of the descendants of the village founder in order to expand the paddy fields on the upper slope (at an unknown date). The main water source for this irrigation channel is a stream on the upper slope of Mt. Guanyin (2,662 m) located about 5 km north of Shanlaoqing village. In addition to this, the water of numerous small streams also flows into the *mozotemoyiro* channel on the way to the village. This *mozotemoyiro* channel now irrigates about half of the total terraced paddy area in the village.

Shanlaoqing village shows the typical character of water exploitation for terraced field development in the Ailao Mountains. After making use of all the water resources available near the village, water resources in the upper watershed were exploited to enable further expansion of terraced fields through the construction of a longer irrigation channel.

During the agricultural collectivization period (1958-1979), food shortages and the prohibition of side work outside the village led the villagers to expand the paddy fields on the upper slopes. But because irrigation water from the *mozotemoyiro* channel was limited, the newly opened terraced fields became *mifa* that cannot take water from the *mozotemoyiro* channel during the dry season.

4.2 Customary Rules and Social Organization for Irrigation

For long irrigation channels such as *mozotemoyiro* channel, supply and distribution of irrigation water is managed by the principle of village social organization.

The allocation of irrigation water to fields is strictly determined by the customary rules of the village. At the major dividing points, the amount of water divided is measured by a piece of wooden weir (*yika*) with two or three (sometimes more) notched cuts. The *yika* is placed across the irrigation channel and divides the flow into different directions. Since the depth of notched cuts on a *yika* is the same, the width of the cuts is proportional to the amount of water flowing to the direction. Water redirected from the main channel flows into the branch channels, and often goes to the secondary and the tertiary branch channels. At lower levels of the channel system, simple earth weirs, instead of *yika*, are used to divide water. Irrigation water finally flows into the first (uppermost) paddy field of each household. Within the paddy fields owned by a single owner, irrigation water flows from higher to lower plot by means of spilling over through inter-plot spillways (*yima*). Irrigation water in the lowest plot then is drained out into the valley or flows to

other owner's paddy fields below.

In principle, a series of terraced paddy fields owned by a single owner has direct access to an irrigation channel in order to facilitate water management by individual owners. Such a series of paddy fields (called *mibo*) is the terminal unit of the irrigation system and also the indivisible unit for leasing the field.⁶⁾ When terraced fields are contracted out, the water rights of the fields are also transferred to the new owner. When a series of fields are divided between brothers by inheritance, the amount of irrigation water is also divided through negotiations between them, and the new channel is cut (often new *yika* is placed as well) to secure the direct water intake for each new owner's fields. When new channel cannot be constructed because of topographic restrictions, a bypass is formed using a bamboo pipe (Fig. 5).

During the low water season, the irrigation rotation (*yiba* or *yibaba*) takes place at some dividing points in order to secure the precious water supply. Irrigation water is scheduled to flow to a different owner's paddy field on a day-by-day or 12 hour-by-12 hour rotation basis. Although it is uncommon, some paddy fields are irrigated by plot-to-plot irrigation even between the paddy fields of different owners (mostly, they are brothers who inherited the fields from their parents) when it is impossible to set water dividing facilities due to topographical reasons. Water is usually allocated

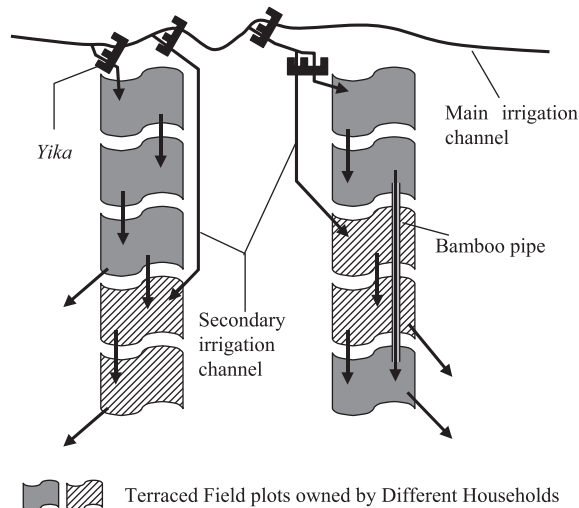


Fig. 5. Concept of Irrigation Water Distribution

6) Under the law of PR China, farmers cannot sell or buy land because the land belongs to the peasant collectives or the State. Farmers can only lease their fields.

by eye measurement of the water flow at the spillway between two owner's fields. Even in this case, irrigation rotation is implemented during the low water season. The owner of the downstream field is allowed to cut the dike of the upper field to sluice water into his fields on the day of his turn.

All the households using water from the *mozotemoyiro* channel are members of a water control group. The heads of the member households have a meeting once a year to select an irrigation headman (*yiroharapo*) usually from among the heads of households who have paddy fields downstream of the channel, where there are frequent and severe water shortages. *Yiroharapo* is responsible for the maintenance and operation of the channel. The main function of the *yiroharapo* is to patrol the channel regularly in order to make physical repairs and check whether the irrigation water is being appropriately distributed. In compensation for this work, 300 kg of unhusked rice is paid every year to the *yiroharapo*. All member households are responsible for contributing unhusked rice, depending on their water allocation.

Besides the maintenance work done by the *yiroharapo*, collective maintenance work carried out by the villagers as well. This is conducted two or more times in a year, generally once after the rice harvest, and one or more times later in the dry season.⁷⁾ The work includes dredging the channel bed and repairing the channel dike. Maintenance work after the harvest is supposed to repair dikes that were broken during the wet season, and showing the importance of storing enough irrigation water in the terrace during the dry season. Maintenance work done late in the dry season is mainly intended to supply water for land preparation and transplanting. It takes several days to clear the entire *mozotemoyiro* channel from head to end.

The water allocation practice described above is strictly practiced from the land preparation to transplanting period (from the latter half of the dry season to the beginning of wet season). In other seasons with more irrigation water, the *yika* is left unused or removed from the channel and villagers including *yiroharapo* patrol less frequently.

4.3 Drainage Technology in the Wet Season

In the abundant rains of the wet season, irrigation plays only a supplementary role. Instead, excess water becomes the major problem. The longer the channel is, the more rapidly the channel water reaches dangerous levels during heavy rain, because the flooded stream water and the overland flow join the channel at many places along its way. Simple but effective drainage facilities can be seen in the channels. At the place where the irrigation channel crosses the valley (Fig. 4), the dike

7) According to villagers, because of severe drought in the dry season, more frequent channel maintenance by all the members was needed in recent years.

is made relatively fragile, so that during heavy rain, the water rushing through the channel breaks down this part of the dike and is drained off into the valley automatically and safely. Without this mechanism, the failure of an unexpected part of the channel dike could cause a massive washout of fields located under the channel. Technologies coping with the excess water are also found in the terraced field itself. The slight inclination of the plow layer (*aludumo*) decreases water pressure on the dike and prevents the terraces from collapsing (Fig. 2). Fig. 6 shows an example of a more elaborate mechanism to drain flash flood water running down from the forest above the terraced fields. In the case of a facility the author observed in the village, the excess water is drained through more than 20 successive conduits dug under the paddy fields and flows off into the valley.

5. Farming Works in Shanlaoqing Village

The importance of irrigation and drainage for terraced rice cultivation has been discussed in the previous section. However, with the close relationship with year-round irrigation practices, the farming works of the terraced paddy fields, especially those carried out during the dry season, also play an important role in the maintenance of the physical structure of the terraced field. In this section, I describe the agricultural technologies observed in the farming works and their multifaceted role in terraced rice cultivation with special emphasis on the relationship with year-round irrigation.

Fig. 7 is a flowchart of farming works observed in the rice terrace cultivation of the village. Nearly all the farming works are carried out under flooded condition. Water is only partly drained during the transplanting, harvesting and land preparation for ease of farming works. Water is drained out

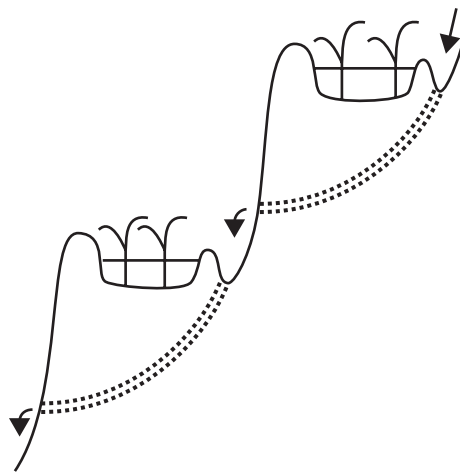


Fig. 6. Cross Section of a Drainage Facility (*Yijemutudu*)

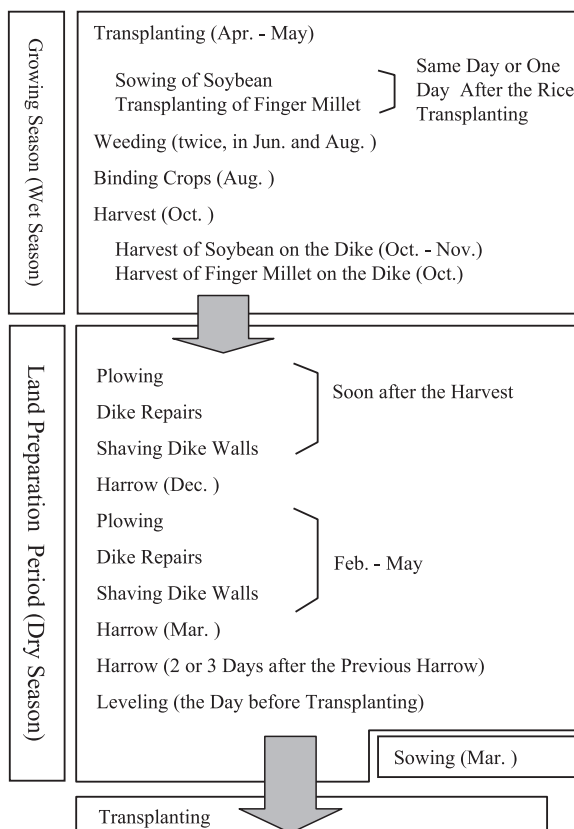


Fig. 7. Farming Works for the Terraced Paddy Fields (*mio*) in Shanlaoping Village

thoroughly only at sowing (in nursery only), but even in this case, the soil must be kept wet.

5.1 Sowing and Nursery Culture

The villagers are well aware of the coming of the rice sowing season (around early March) when they see *sopuja* trees (*Docynia indica*) bloom with white flowers. Seeds for sowing (*cheshu*) are soaked in water for two days. The seeds are then pulled up from the water and left in a plastic bag for 3-6 days. Seeds with primary root sprouts of about 0.5-1.0 cm are used for sowing. The series of tasks in nursery (*cheshumi*) preparation is carried out one month before the land preparation of the main field. The details of the land preparation in nurseries are the same as in the main field, and have been described later in this section. The only exception is that the leveling of soil surface is conducted more carefully in the nursery, using a bamboo bar or the side edge of the hoe blade, just before sowing. Each household prepares nurseries in the fields that have most fertile soils and have good access to irrigation water and drainage paths. On the lower slopes in the village, nurs-

eries are made in different fields every year to prevent declines in fertility. No manure is applied. In the fields of the upper slopes, on the other hand, suitable fields for nurseries are limited due to low fertility. Therefore, the best fields are reserved for nurseries every year, with manure (*chimo*) application about one week after sowing.⁸⁾

Immediately before sowing, the water of the nursery is drained through the spillway (*yima*) or drainage conduit (*yirudu*). The seeds are sowed by men, usually the household head. Standing on the dike, he scatters a handful of seeds evenly on the mud. Water in the nursery is controlled very carefully. For about 10 days after sowing, mud should be kept in moderately wet conditions with no standing water. After that, water level is gradually increased as the seedling grows. Even then, it is recommended to drain water during the daytime in order to promote the growth of the seedlings, but keep flooded at night in order to prevent rodent attack.

5.2 Uprooting and Transplanting

When the *sopuja* trees begin to bear edible sour fruits in the middle of April, the transplanting season comes to the village. The rice seedlings that have been grown in nursery beds (*cheshumi*) are transplanted soon after the completion of the land preparation, starting from the terraced fields on the lower slopes and proceeding towards the upper slopes. The transplanting lasts about one month until transplanting in *mifa* on the higher slope is completed. After transplanting, the water of the paddy fields is carefully controlled in order to protect the young rice seedlings from lodging (falling down flat). The water level is gradually increased as the rice grows, reaching a maximum level of 20-30 cm toward the end of June, the maximum tillering stage. Because this is just in the transition period from dry season to wet season, young seedlings that have just transplanted often suffer from drought when the onset of wet season is delayed.

5.3 Weeding and Stalk Bundling

Weeding is carried out once or twice during the growing season. Not only are weeds on the dikes and field surface pulled up (each weeding is called *gebesuta* and *depang*, respectively), but weeds on the dike wall are also hacked away (*depade*) by swinging a 2 m-long bamboo pole (*depa*). Weeding is carried out throughout all the paddy fields except for *mifa*, where the growth of weeds is slow due to infertile soil. No herbicides are applied, and pesticides are applied only when there is an outbreak of serious disease.

8) The manure is made mainly from buffalo dung, chicken droppings, pig droppings and ashes from the kitchen. They are stored in manure pits (*chimta*) of the individual household. Before use, the manure is spread in the open spaces in the village and dried for 2-3 days. Manure is applied to upland field and rice nurseries. The making and applying of manure are considered to be women's tasks.

After the rice has headed, 10 or more piles of rice stalks are tied up into one bundle to protect the plants from lodging due to strong wind or rain. This work is required only for the traditional varieties, which have longer culms and more susceptible to lodging than improved varieties.

5.4 Harvesting

During harvesting, the culms are cut off with a sickle (*bale*) about 100cm from the ear, leaving stubble 20 to 60cm from the ground. The harvested rice crops are quickly bundled and threshed on the spot. Because the terraced fields are kept flooded even in the harvest period, a boat-shaped wooden threshing implement (*jala*) is used. The farmers hold the harvested stalks over their heads and beat them down onto the threshing boat floating in the flooded rice terrace (Photo 1). The threshed rice is put into a jute bag or fertilizer bag, and carried up to the village on their shoulders. Men can carry about 60kg of rice at a time. From the furthest fields, it takes one hour to carry a rice bag up to the village.

Harvested rice crops are threshed before drying in the Ailao Mountains. There seem to be three reasons for this immediate threshing. 1) It is difficult to find the place for drying harvested crops because there is water in the field. 2) Because of high shattering habit of the traditional varieties, immediate threshing can minimize the loss of rice grain during carrying and drying. 3) Immediate threshing can reduce the labor of carrying harvested rice up to the village.

Harvested rice grains are spread over the rooftop (*toku*) of each house for drying. After drying for 2-4 days, rice grains are stored in a wooden box in the storage room. After the harvest, the terraced fields except *mifa* are kept fully inundated, but no crops are grown until transplanting takes place in the following year. During this dry season, however, various kinds of farming works take place.



Photo 1. Threshing Rice with *Jala*

5.5 Farming Works in the Dry Season

Soon after the harvest, a series of works in the dry season take place. First, the soil of the paddy fields is plowed using a buffalo. When the terraced fields are too small or too steep for buffalo, the task of turning over the soil by hoe (*tseku*) is preferred, rather than plowing. Stubbles remaining in the field are also plowed under the mud.

The terrace dikes (*ngebu*) are also repaired at this time. The inner half of the dike is broken down by foot or hoe and trampled down into mud in order to seal up the basement of the soil. Mud on the field surface is scooped up with a hoe and smeared on the dike. At the same time, the soil and weeds on the surface of the dike wall (*ngeda*) are shaved off by hoe and trampled down deep into the mud by foot (Photo 2). When the dike wall is very high (some dikes are more than 5 m in height), a 2 m-long spade (*ngedacedu*) is used to shave off the wall surface (Photo 3). The aim of this work is not only to eradicate weeds but also to destroy rodent nests. Holes made by rodents or decaying weed roots are believed by the farmers to cause water leakage or the collapse of the terraces. Approximately two months after this work is done, the paddy fields are harrowed using a buffalo.

A series of works including plowing, repairing and shaving the dike and harrowing is repeated at least twice during the dry season: once immediately after harvest and one or more times before transplanting. After the last plowing, harrowing is repeated twice followed by leveling using a bamboo rake, in preparation for transplanting. It is considered that the more times these works are repeated, the higher the yield becomes. The purpose of these repeated works in the dry season



Photo 2. Shaving the Dike Wall of a Terraced Field by Hoe



Photo 3. Shaving the Dike Wall Using a *Ngedacedu*

seems to be multifold. It is not only for making the soil soft and promoting organic decomposition by supplying oxygen to the mud, but also for sealing the bottom layer and inner side of the dike to ensure that the field can hold water effectively. Starting the works soon after the harvest suggests the importance of storing water in the terraced fields during the dry season.

The efforts to minimize the loss of precious irrigation water in the dry season can be seen in the process of these works. Among a series terraced fields owned by a single household (usually among *mibo*), dry season works start in the lowest field and then proceed to upper fields in succession. This is in contrast to farming works such as transplanting and harvesting, which proceed downward. Since works of plowing and harrowing spill over great amount of field water, operating upward can save the field water by capturing overflow in the lower fields.

These dry season works account for about 40 percent of the total requirement for labor input to rice cultivation in the village (Table 1). This shows that a large amount of labor is spent on the earth works in the dry season, in order to maintain the physical structure of the terraced fields, which provides favorable soils and sufficient water for rice growth in the wet season.

In *mifa*, on the other hand, field water dries up after harvesting and no farming works take place until irrigation is allowed again before transplanting in the next wet season. When the soil becomes slightly moist with the rain at the onset of the wet season, *mifa* is plowed with a buffalo and dike wall is shaved by hoe. The second plowing, dike repair and harrowing are carried out under flooded condition with irrigation water in the same way as *mio*. Although the series of land preparation is carried out only once a year for *mifa*, most of the villagers said that land preparation for *mifa* is more laborious than *mio*, because of its hardened soil and the existence of many cracks on the dried plow layer and dike. Despite careful maintenance, *mifa* is vulnerable to collapse due to heavy rain.

5.6 Multi-function of the Rice Terrace

Terraced paddy field is not only a place for cultivating rice but also a place for producing many kinds of supplementary foods.

In terraced paddy fields where dikes and dike walls occupy the greater portion of the total farmland area, utilization of the dike and dike wall has been highly developed. At rice transplanting, soybean is sown on the dike. Since the dike soil is renewed at least twice in a year by farming works, the soil is very fertile and produces soybean with good taste. In the village, one variety of soybean (*nebenu*) is sown especially on the dikes of paddy fields. Since this variety is only suitable for lower altitudes, seedlings of finger millet are planted on the dikes of upper paddy fields (both *mio* and *mifa*). Seedlings of finger millet are grown in upland nursery fields and are transplanted onto

Table 1. Labor Input (Man-days) and Its Percentage by Paddy Farming Stage in Shanlaoqing Village

Rice variety*	No. of terraced field cluster	Amount of rice harvested** (kg)	Labor input (man-days)										Total
			Dry season					Wet season					
			Plowing	Dike repair and shaving dike wall	Harrowing	Total	Transplanting	Weeding	Binding stalk	Harvesting	Total		
<i>Miao</i>													
I (NG)	5	3,160	14	58	20	92	31	53	6	50	232		
T (NG)	4	2,000	6	31	12	49	26	17	17	23	132		
T (G)	2	260	4	8	6	18	6	5	4	7	40		
Total (%)	11	5,420	24 (6)	97 (24)	38 (9)	159 (39)	63 (16)	75 (19)	27 (7)	80 (20)	404 (100)		
<i>Mifa</i>													
T (NG)	2	160	1.5	12.5	2	16	11	1	0	6	34		
T (G)	2	120	2	8	2	12	15	4	0	10	41		
Total (%)	4	280	3.5 (5)	20.5 (27)	4 (5)	28 (37)	26 (35)	5 (7)	0 (0)	16 (21)	75 (100)		
Total (%)	15	5,700	27.5 (6)	117.5 (25)	42 (9)	187 (39)	89 (19)	80 (17)	27 (6)	96 (20)	479 (100)		

Data was taken from four sample households having 14 clusters (an owner's fields located in a place) of terraced fields.

*T: traditional variety, I: improved variety, NG: nonglutinous, G: glutinous

**The amount of rice harvested is estimated by number of bags used for rice storage. The weight of each bag is assumed to be 40kg.

the paddy dike. In addition, the villagers often pick up many kinds of edible wild herbs grown on the dike of both terraced fields and irrigation channels. The period between May and June (one or two months after the transplanting), is considered the best season for picking these wild herbs since tender and delicious plant shoots come out in this season. Dry season farming works, described in the previous section, such as repairing the dike and shaving dike wall can create suitable soil conditions for those edible herbs to sprout each year.

In terraced fields that are kept under deep-flooded conditions on most days of the year, the villagers catch many kinds of shellfish and aquatic insects for food. Moreover, in some paddy fields, young fish are released for pisciculture during the transplanting period, and are harvested usually along with the rice. The slight inclination of the paddy field bottom, as indicated in Fig. 2, is also considered by the villagers to be suitable for pisciculture, as well as for preserving physical structure of the terrace. Flooded terraced fields also provide feeding grounds for the ducks that are raised by most of the households.

5.7 The Change in Agricultural Technologies with the Introduction of Improved Varieties

A major change in terraced rice cultivation in recent years is the rapid increase of improved rice varieties.⁹⁾ According to the author's survey conducted in 2002, only three out of 10 randomly sampled households grew improved varieties (two grew non-hybrid and one grew hybrid varieties), but in 2004, 20 out of 30 sampled households cultivated improved varieties (seven grew non-hybrid, 10 grew hybrid variety, and three grew both).

The influence of introducing improved varieties on water management seems to be limited. In order to maximize the yield potential of the improved varieties, different water management is recommended. However, the introduction of improved varieties has led to little change in the water management of terraced paddy fields. Ideally, because the seedlings of improved varieties are short, field water levels should not be high during the early parts of the growing season. Most of the villagers, however, prefer to keep the water deep enough to cultivate fish or to save irrigation water for subsequent growing season, even though deep water retards the growth of rice seedlings. In addition, when chemical fertilizer is applied, it is recommended to drain the terraced field in order to heighten the effect of fertilizer. However, very few villagers drain the fields for the same reason. The villagers also know that applying pesticide or too much chemical fertilizer at once can kill the

9) The term, 'improved variety' in this paper refers to the varieties that villagers call *zacho* (literally means 'hybrid,' borrowing from Han language). Regardless of whether they are hybrid or non-hybrid, rice varieties that have relatively short plant height with erected, dark green leaves are all called *zacho*. On the other hand, traditional varieties that have tall plant height, droopy and light green colored leaves are all called *lao pingzhong* (literally means 'old variety,' borrowing from Han language).

fish in the field, therefore, they apply them by spreading the application over several times.

It seems that the improved rice varieties have been adapted to the conventional agricultural practices, rather than having brought about drastic changes on the existing system. Again, agricultural technologies, including water management, are closely related not only to rice cultivation, but also to the physical maintenance of terraced fields and the production of supplementary food sources. The cultivation of improved varieties has been incorporated into the unique agricultural system of the terraced paddy field.

Conclusion

In conclusion, it can be pointed out that rice terrace agriculture in the Ailao Mountains has been sustained by various types of technologies related in particular to irrigation and drainage, which can be considered to be a form of technological adaptation to the local mountain environment characterized by a monsoon climate and prevalence of steep slope of clayey soil. Different from the paddy agriculture in the plains, irrigation and drainage for terraced rice cultivation are important not only for growing crops, but also for preservation of the terraced fields themselves, in close relationship with various farming works.

One of the most unique agricultural practices observed in the Ailao Mountains is year-round irrigation. It is notable that similar practices are found in other famous rice terrace areas in the world. In the Cordillera Mountains in the Philippines [Breemen *et al.* 1970; Conklin 1980] and Longsheng County in Guangxi Province of China, water are kept inundated all through the year, even though rice is grown only once a year in most of the fields. In the Kubiki hills in Niigata Prefecture, Japan, terraced fields were plowed and dikes (more than 30 cm tall) were repaired soon after the rice harvest in autumn in order to store melted snow water [Takeuchi 1974].

Behind such similarity, there are some common environmental factors peculiar to the rice terrace area. One of the factors is “steep inclination.” Prevention of collapse becomes crucial only when the terraced fields were constructed on steep slopes. Paddy fields on sloping land must be supported by their wide dikes and high dike walls. Huge amounts of work are required for repairing the terrace’s structure. Yasumuro [1998: 194] points out that crop cultivation on the paddy dike has been highly developed in terraced fields because dikes occupy a significant percentage of the farmland area.

The hydrological environment is also an influential factor in determining the technology. It is known that the catchment area for irrigation water is usually very limited in the rice terrace area, and water tends to be stored in the terraced field in case of water shortage [Tanaka and Okada

1978: 5].

Another factor is the prevalence of clayey soil. Koide [Koide 1973] indicates the relationship between the development of mountain farming and geological conditions in Japan. He points out that landslide areas have favorable conditions for terraced rice cultivation, such as prevalence of fertile, water retentive clayey soil and existence of numerous springs on the mountain slopes. Terraced paddy fields have been constructed since ancient times in such places.

Characteristic technologies that are widely observed in the rice terrace areas have been developed to adapt to such environmental conditions. On the other hand, there are also many differences in technologies among each area. Land preparation works of repeated plowing and harrowing seem to be a variation of Han agricultural technology, which probably originated from ancient upland cultivation in the north China [Watabe 1996: 78]. This contrasts sharply with the cultivation technologies in the Cordillera Mountains, where neither plow nor harrow is used. Being significantly influenced by neighboring cultures, farmers have developed the unique technologies to adapt to the specific environment.

Finally, I will discuss the contemporary issues faced by rice terrace areas. In many of the rice terraced areas, traditional agricultural practices are now being forced to change. For example, terraced paddy fields in the Cordillera Mountains were registered as a World Heritage Site by UNESCO in 1995. Consequently, many farmers have given up farming in favor of tourism-related jobs or wage labor in towns, and the collapse of abandoned terraced fields has become a major problem. In the rice terrace area of Longsheng County, since tourism development started in the 1990s, most of the terraced fields have been left to dry in the dry season because of over-logging in the water source forests and increasing water demand by hotels and restaurants. The rice terrace area of the Ailao Mountains is also not free from such changes. Accompanied by the penetration of the cash economy and tourism development, it has become increasingly difficult to continue the traditional agricultural practices that have long sustained the rice terrace agriculture. These cases remind us the two important points. One is the fact of how closely the technologies in terraced rice cultivation are related to the ecological environment of the area. The other is the fact that technologies that have sustained the terraced rice cultivation can be maintained only by the farmers' continuous action on the environment. If they stop working, terraced fields themselves will be lost.

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