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Research Paper

Indigenous Knowledge System of Agricultural Cultural Heritage: A Case Study of "Zila Tribute Rice" in Western Hunan Province, China

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Abstract: *As an important agricultural cultural heritage of China, "zila tribute rice"possesses unique indigenous knowledge, primarily comprising the "creating fields by spreading trees" technological system, irrigation system, afforestation for water conservation, and integrated knowledge systems such as "rice-fish-duck-bird-frog" co-culture. These knowledge systems are still utilized by the farmers in the heritage area, and form the foundation for ensuring sustainable local agricultural production and development. The agricultural production concepts contained within these systems offer significant insights and references for constructing a modern agricultural technology framework.*

Keywords: *zila tribute rice,creating fields by spreading trees,afforestation for water conservation,rice-fish-duck-bird-frog*

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The "*Huayuan Zila Tribute Rice Integrated Planting and Breeding System*" in Hunan province was recognized as the fourth batch of China's Important Agricultural Heritage Systems in 2017. The tribute history of "z*ila tribute rice*," widely known, spans at least over 150 years. However, the indigenous knowledge system which it embodies still needs to be deeply excavated, organized, and innovatively utilized. The core area of the "Huayuan Zila Tribute Rice Integrated Planting and Breeding System" is located along the streams of the Zila River Valley in Shilan Town, Huayuan County. It is preliminarily speculated that its cultivation began in the early Ming dynasty, with its cultivated scope gradually expanding during the early Qing dynasty, becoming essentially established by the late Qing dynasty, and has been in use till today. The construction of the "zila tribute rice" planting region adheres to the traditional Miao concept of "integrated rice and forest cultivation with coexistent fish, ducks, birds, and frogs." Through the collective wisdom of the Miao ancestors in "forest-based terraced fields" and effective transformation, they fostered an organic combination of land resource exploitation and ecological conservation, achieving overall enhancement of economic, ecological, and social benefits in the region. "Zila Tribute Rice from Huayuan" is a geographical indication product, and this integrated planting and breeding system is a gem of the Miao people's agricultural culture.

During the Ming dynasty, the tusi system and garrison commanderies were strengthened in the Tujia ethnic regions of the Wuling Mountains, incorporating many Miao villages within their jurisdictional bounds.The policies implemented by the Ming dynasty in these tusi and garrison areas, such as military farming and the submission of grain as tribute, also influenced the Miao regions, marking the advent of rice paddy cultivation in the Western Hunan Miao territory(Chen, 2018).Owing to dense forests and insufficient sunlight in the Wuling Mountain area, along with high-altitude valleys and low water temperatures, cultivating rice was not suitable. Therefore, the critical challenge for local rice cultivation was overcoming the problems of low water temperature and inadequate sunlight(Luo, 2011).

To address the ecological shortcomings, the Miao ancestors of Zila village, through a prolonged process of production practice, explored and developed a indigenous knowledge system for producing "zila tribute rice." This knowledge system mainly encompasses the cultivation of rice paddies through "tree terracing," rice field irrigation that leverages terrain and stratifies water usage, sustainable utilization of water resources through forest cultivation and water conservation, as well as the symbiotic system of rice-fish-duck-bird-frog coexistence.These systems have now become components of China's significant agricultural cultural heritage.

1. Rice paddy cultivation and management techniques based on "tree terracing".

The Miao people of Western Hunan mainly settle in the terrains of *Laershan* and *Lvdongshan* in the Wuling Mountain area, where the mountains are high, the valleys deep, and the forests dense. It's an ideal location for slash-and-burn agriculture and hunting and gathering but not fertile ground for rice paddy farming. To cultivate rice in such a geographical environment, one must either build layered terraces along the mountains like the *Hani* people of the Red River or construct dams and tiered water channels for irrigation like the *Dong* people(Luo & Liu,2013）.

The Miao people of Xiangxi live deep within the Wuling Mountain Range, an area originally characterized by marshlands with constant mountain springs and difficult-to-drain waters. To ensure the normal growth of rice, it is essential to address issues such as insufficient sunlight, low water temperature, and subsidence of cultivated land.In order to tackle this series of challenges, the Miao ancestors of Zila village underwent laborious explorations.

During the fieldwork, local Miao villagers told me that "about seven hundred years ago, Ma Da, Ma Er, and other Miao ancestors came to Zila for hunting. Their hunting dogs refused to leave Zila, and the two brothers thought that with its mountains and water, Zila was a geomantic treasure spot. So they moved here with their wives and children, and thus the village was formed" . In the legend, there is a detail that the two brothers worked together to fell pine trees and other tall trees on the hillside. They laid these logs onto the marsh's muddy ground to elevate the terrain. Subsequently, they backfilled the laid logs with sand and soil and built field ridges, gradually creating the expansive stretches of rice paddies we see today.

In order to verify the Miao folk legend of Zila village, I followed the guidance of the villagers and found a stone stele inscribed with "The Sequence of Zila Tribute Rice."子腊贡米序 The inscription on the stele reads:

"In the late Song to early Yuan period, brothers Ma Da and Ma Er, with their wives and children, journeyed through jungles from Chong Mountain, cutting through thickets for seven days and nights to reach the valleys of Zila. At that time, dense forests grew, blocking out the sunlight; wild boars swarmed the mountains, and tigers and leopards roamed in packs; rivers overflowed, and marsh mud spread far and wide. The two brothers built a cabin by cutting wood on the hillside, constructed banks with stones, channeled water to form streams, and filled the mud with pine trees, continuing their lineage through generations.Until now, Zila's wooden houses span the mountains and good fields line the rivers. The pine-mud filling technique, invented by Ma Da and Ma Er, has led to abundant pine resin and amber permeating the area. The rice from these river fields is notably fragrant and rich. By the Hongwu era of the Ming Dynasty, the Chongshan Guard's Jijiu Commandant started requisitioning Zila rice for palace tribute, a tradition that flourished through the Qianlong and Jiaqing periods."

The contents of this stele also confirm the findings from my fieldwork. At least from the early years of the Ming dynasty, the Miao people in Western Hunan started the practice of "felling pine trees to fill with mud" in order to create farmland, a tradition that has been passed down from generation to generation. Consequently, such an extent was reached that inscriptions depict a scene with "abundant pine resin and amber infiltrating the land, with rice paddies full of fragrant and oily grains". As a result, the rice produced by the Zila people had become an offering of "tribute gifts" (precious presents given in honor of the esteemed) since the Ming dynasty. It is preliminarily inferred that the "creating fields by spreading trees" practice of the Zila Miao might have a history spanning over five hundred years. The unique technique of "creating fields by spreading trees,"developed by the Miao people of Zila in Huayuan, has been continuously transmitted to this day.

In early 2017, during the fieldwork in Zila village, we coincided with the nomination of the "*Hunan Huayuan Zila Tribute Rice Composite Farming System*" as a prospective Chinese Important Agricultural Heritage System. To verify the authenticity of the villagers'legends and the records on the stele, we organized two separate excavations in collaboration with local village officials and farmer households. We conducted these digs in different areas of the paddy fields, and discovered a significant number of tree trunks at the bottom of multiple fields, thereby providing factual evidence for the documented practice of "creating fields by spreading trees" and the local legends.

The basic principle of the "creating fields by spreading trees"technique is as follows:

Firstly,by laying 1 to 3 layers of tree trunks at the bottom of the deepest silt in the marshland according to the terrain, the water level of the swamp can be raised, which facilitates the smooth drainage of water flow.

Secondly, stable gaps formed between the logs embedded in the swamp create an insulating layer beneath the rice paddies, separating the warmer water of the rice fields from the cooler currents below, ensuring a stable water temperature in the rice paddies.

Thirdly, the layered logs lead to a rise in water level, which enhances the absorption of sunlight and further increases the temperature of the water in the rice fields.

Fourthly, on top of the tree trunks, a layer of shale fragments and gravel, 30 to 40 centimeters thick, is laid first, followed by backfilling with a 30 to 50 centimeters thick layer of mixed soil consisting of smaller

grains of sand and mud. Then, a layer of 50 to 70 centimeters thick white gypsum mud is added, with a finer layer of yellow mud on the very top. The Paleozoic sandstone soils have larger particles with good aeration and water permeability, while the Mesozoic limestone soils consist of smaller particles, yielding better water retention properties. Mixing these two different types of soils in a certain proportion results in a composite soil that combines the respective advantages, creating an environment suitable for the growth of rice.

Fifthly, the upper and lower sides of the sandy soil mixed isolation layer will form relatively independent yet mutually regulating small water storage layers. This is why Zila village typically achieves relatively stable yields even in years of drought.

Sixthly, laying down tree trunks is necessary to solidify the marshy muck, thereby providing support for people and livestock to prevent sinking and facilitating cultivation.It is evident that "log-supported cultivation" is the crystallization of the wisdom of the Miao nationality's ancestors in Huayuan, a land reclamation technique deeply integrated with Miao culture. It constitutes a relatively mature knowledge system with significant practical value. Although the Miao ancestors might not have been able to articulate the scientific rationale behind this technique, it has effectively addressed the issue of low water temperature for local planting.

When clearing farmland in the hinterlands of the Wuling Mountains, it is also necessary to address the issue of insufficient sunlight for rice cultivation. In order to secure adequate water supply, farmlands can only be developed in the deep valleys of the mountains.However, due to the dense forests in the deep mountain valleys, there is not enough sunlight. Without cutting down the wooded slopes on both sides of the valley, large areas of rice fields could receive less than four hours of sunlight per day. Such brief exposure to sunlight would be insufficient for the rice grains to reach maturity. Even if the rice plants produce panicles, without sufficient sunlight, these panicles might fail to fully develop. The only solution is to cut down the surrounding trees, allowing more sunlight to reach the fields. Conveniently, the creation of these fields requires a large number of trees, which can be used to pave the bottom of the fields. Ample sunlight not only ensures vigorous growth of rice by increasing the water temperature in the paddy fields, but also benefits the land reclamation process in the Wuling mountain area, making tree cutting a doubly advantageous action.Therefore, it's evident that opening up rice fields in the Wuling mountain area is constrained by the aforementioned conditions, making large-scale land clearing impossible. The most common scenario is limited farmland peppered throughout the mountain valleys. This landscape of terraced rice fields in the canyons has thus become a unique scenic feature of rice cultivation in the Wuling mountain region.

II. Utilizing terrain and gravity: a layered rice field irrigation system

Within the knowledge system of the "zila tribute rice" agricultural cultural heritage, "log-supported cultivation" not only addresses the issues of water temperature and sunlight for rice planting but also constructs a unique irrigation system for rice fields based on the contours of mountain gullies, canyons, and the courses of streams. In the Wuling mountain region, where mountains are high and slopes are steep, valleys deeply incised, it's essential to adapt strategies according to local conditions and leverage natural terrain to develop a scientifically sound and efficient irrigation system.

The water resources of the rice fields within the "zila tribute rice" agricultural cultural heritage are managed in two parts: one involves channeling stream water into the rice fields by utilizing the natural terrain, and the other involves the stratified circulation of water from the upper to lower rice fields.

One aspect involves taking advantage of the terrain to guide stream water into the rice fields' irrigation system. This is achieved by constructing channels on the surface to form streams, setting up simple dams according to the drop in the stream to regulate water flow, and adapting the development of rice fields to local conditions. Rice fields near water sources rely on stream or river water, while those near mountains depend on spring water from slopes and natural rainfall interception. Terraced fields are developed using the natural gradient, allowing water to be channeled down in stages for irrigation.This corresponds to the irrigation system recorded in historical materials as "building stone banks and guiding water to form streams." This irrigation system, which cleverly utilizes natural terrain, not only addresses the issue of water supply for rice fields but also, to a certain extent, raises the temperature of the water used for irrigating rice, which is conducive to the growth of the crop.

In the Wuling mountain area, all major canyons and gulfs have topography that slopes downwards from high to low elevations, with ground surfaces expanding from narrow to wide. The surface water in these canyons and valleys flows from uplands to lowlands, continuously collecting water from both sides of the gullies and gradually expanding to form streams. Typically, such streams run through the middle, splitting the canyons and gullies into two halves. Without man-made design and direction, these stream waters cannot naturally flow into farmland for irrigation purposes. To cultivate rice, the local Miao people level out the terrain of the gullies according to the stream's flow and the valley's topography, creating terraced rice paddies with different drops in elevation. The size of the paddies, in turn, depends on the volume of water in the stream, which means that the stream is intercepted according to the size of the rice paddy area, creating small dams that

direct the water into the farmland to ensure a sufficient water supply for the rice.

These water-blocking dams are not intended to completely obstruct the flow, but rather to determine the depth of the dam based on the size of the developed farmland. The remaining water resources can continue to flow downstream, providing water for the farmland developed further down. In this way, a stream in a gully can be intercepted and converted into more than ten small dams. If the gully is longer, then the number of stream-blocking dams constructed will be even greater.Thus, in the valleys of the Wuling mountain area, terraced rice fields of varying sizes, shapes, and specifications have been constructed in this manner. Some rice fields are less than one fen (a Chinese unit of area where 1 fen is approximately 666.7 square meters), while others may exceed one mu (approximately 666.7 square meters) or even span several mu, all determined by the topography of the valley and the water flow of the streams.

The water flowing out of these mountain troughs is spring water, emerging from the rock layers within the mountains. The temperature of this spring water is mostly around 17°C, and some may even have lower temperatures. Such water temperatures are not suitable for the normal growth of rice (to raise the water temperature to suit the requirements of rice growth, it is possible to construct dams to retain the spring water, allowing it to warm up under the sunlight, and then diverting it into the rice paddies).During our field investigation, we also found that the diversion of stream water from the dam into the rice fields is conducted with careful consideration. To ensure that the water resources entering from the streams do not negatively affect the growth of the rice, villagers have carved out a water channel around the perimeter of the farmland. This channel is approximately 100 centimeters wide and 50 centimeters deep, allowing the water that enters the rice fields to first stagnate in this channel before flowing into the area where the rice is planted. As a result, the slowly moving stream water can be exposed to sunlight for a longer period, increasing its temperature, and ultimately reaching the water temperature necessary for the growth of the rice.

Secondly, there is the stratified return flow system in the rice paddy water areas. In the Wuling Mountain area where "zila tribute rice" is cultivated, solving the issues of water supply and temperature increase is key to the cultivation of rice. In the mountain troughs, the rice fields built at lower elevations accumulate a lot of water that cannot be completely drained. Local villagers have adopted the "tree-laying method" to prevent this undrainable cold water from overflowing upwards. This approach creates gaps between the laid trees at the bottom of the rice field, which remains constantly moist throughout the year. With the paddy fields isolated by sandy soil, two separate yet interdependent water storage layers are formed—one above the other. Consequently, a single piece of farmland essentially has two layers of irrigation water sources, each circulating independently.

In the abundant rainy season with heavy rainfall and high moisture content, and even during floods, the water from sandy fields, above will gradually infiltrate into the underlying wooden layers for storage. During prolonged droughts or periods of low rainfall, a portion of the water from beneath the sandy fields will percolate upwards, serving as a beneficial supplement for the water needed for rice growth to a certain extent, thereby alleviating drought conditions.Therefore, even in an average drought year, the cold-soaked fields of Zila village do not suffer from significant drought impact, and yield a more stable harvest compared to the water-deficient rice fields elsewhere.

During our organized field investigation, an elderly villager recalled an astonishing event where water was found spurting out from beneath the paddy while they were inserting large bamboo poles to drive ducks in the fields. At the beginning of 2017, when I participated in a village-based work team 驻村工作队 engaged in excavating trees under the fields, we also discovered water seeping out from beneath the fields, which required us to dig and bail out the water simultaneously.In one particularly low-lying rice field, the use of a water pump was even necessary to complete the task of excavating the wood from the field bottom. The situation I witnessed indirectly confirms that the water storage under the fields of Zila village is quite abundant.

Additionally, during the investigation, we discovered that before the widespread use of chemical fertilizers, which is prior to the 1980s, in order to prevent excessive cold water from seeping up from beneath the laid wood in the paddy, villagers' main source of fertilizer came from the "wood leaves," also known as "green cutting." Before the spring plowing, the shrubs and weeds on top of the rice fields are harvested and deeply buried into the field, some of which might even be placed directly above the backfilled sand and soil. This method not only supplements fertility to the paddy fields but also allows the shrubs, which are difficult to decompose quickly, to be mixed into the backfilled sand and gravel. Over time, the accumulated mix of shrubs and gravel, along with the wooden layers, creates a water barrier layer. This greatly hampers the upward seepage of cold water from below, while also reducing temperature fluctuations in the paddy field soil and keeping it as stable as possible.In summary, the stable and abundant rice production in Zila village, which has been consistently tributed year-round, relies to a certain extent on the local complex and unique paddy field irrigation system.

III. Sustainable water resource utilization system through forestry and water conservation

The "zila tribute rice" integrated farming system is an agroforestry ecological complex that efficiently utilizes soil and water resources while protecting soil and water. At the same time, it preserves the biodiversity within the system. The hillsides surrounding the rice fields are rich in vegetation and densely forested. "Miao region is mountainous and naturally suited for forestry. Apart from the lands that can be cultivated year-round, the Miao people also have experience in cultivating various economic forests. In the first year of new land reclamation, they plant oil tung trees 油桐 and tea-oil camellia trees 油茶 alongside. Grain and forest go hand in hand; the oil tung comes to maturity and blooms within three to four years. The tea-oil camellia forms a forest within five to six years. As the editor travels throughout the Miao territories under jurisdiction, one observes that tea-oil camellia, particularly in Yongshui and Guzhang, is especially abundant. Tea-oil camellia forests stretch for tens of miles... Oil tung trees are widespread, and wherever there are cliffs or steep ridges, they are densely planted with oil tung trees(Shi, 2003)." Influenced by the belief that "all things are spirited" and by the blessings of "sacred trees", the Miao people have consistently protected forest vegetation, refraining from indiscriminate logging and deforestation. In Huayuan County, there is still a wide circulation of Miao folk songs that encourage people to protect trees, and there are even extreme methods such as cursing those who cut down trees to safeguard the forests.The Miao people have a longstanding tradition of nature worship and deification, and cutting a tree would result in being looked down upon by the entire village, or even cursed. Even if no one witnesses the act, spirits are believed to be aware and might fulfill the curse, leading most to abandon the idea of cutting trees. After the state employed legal measures to close off mountains for afforestation 封山育林, local villagers became even more focused on protecting trees. They only dare to drag home trees that have been broken by heavy snow during the deep winter season for their use.

The Miao people of Zila have traditionally revered and feared the forest, which in turn has granted them the endless "wealth." The harmonious relationship between the Miao people of Zila and the forests can be characterized as "befriending the forest." For the Miao, the forest serves not just as a resource, but as a "friend" or even as "family." On one hand, the Miao revere the forest due to the mountain gods residing within it, commanding great respect, and many local taboos related to the forest are passed down among the people to regulate their behavior. On the other hand, the Miao maintain a close connection with the forest which is considered their "family." The Miao have a long history of shifting cultivation, relying on mountainous forest resources for survival throughout the extensive period of shifting cultivation, with their production and livelihood being inseparable from the forest. The forest requires continuous maintenance by the Miao, while the integrity and biodiversity of the forest ecosystem provide an inexhaustible range of natural resources essential for the Miao's survival(Luo & He, 2019).Thus, the relationship between the Miao and the forest resembles an understanding between two "old friends," interdependent on each other.

After the Miao people transitioned to settled farming, the concept of their dependent relationship with the forest continued and was elevated. The Zila Miao people divide human beings and their living environment into natural and artificial parts, which are interconnected and counterbalanced with each other, much like the two inseparable sides of a coin.And the connecting point between these two aspects is the forest. Forests play an extremely important role; it is because of forests that we have water, animals, and plants. Water irrigates the fields, which in turn produce crops; only with crops can people be fed. The animals and plants directly derived from the forest provide food for people, creating a system where the Zila Miao people regard the forest as their ally and have established a hierarchy in the utilization of natural ecological resources.

The Zila Miao people's forest-friendly land use has led to the delineation of different areas within their village such as residential zones, cultivation areas, sacred mountain forests, cemetery forests, timber and firewood zones, grazing lands, natural forest regions, and spring forest zones. This forest-centric land use philosophy has ensured that the woodlands owned by Zila village remain lush and verdant over long periods.

The watershed forests are primarily located at the headwaters of rivers and along both banks of the rivers. To this day, the sources of the rivers in Zila village are still abundant with watershed forests.Traditional customary law dictates that the trees within these water source forests cannot be cut down, as this is related to the water security of the entire village and the assurance of water for the rice fields. The Miao people of Zila believe that rivers are governed by the "water god."According to their customary law, trees in the water source forest with a diameter greater than 20 centimeters may not be felled. During my field investigation, I visited the site of the watershed forest in Zila village and observed that these forests are generally located on the cliffs along both sides of the river and in the areas where spring water emerges.The cliffs are composed of rocks, which happen to be the dwelling place of the "stone god"; as for the areas where mountain springs emerge, they are regarded by the Miao ethnicity as the "navel of the earth's life," which should not be disturbed. These areas are off-limits for tree felling and land reclamation.

The Miao people of Zila village fear offending not only the "water god" and the "stone god" but are particularly apprehensive about disrupting the "navel of the earth's life." This has led to a communal standard of behavior within the Miao settlement for the protection of the watershed forests. As a result, large areas of forest

along the banks of the water sources have been preserved, and the watershed forests remain lush throughout the year. It is such principles or folk beliefs that robustly protect the water resources of their own village, ensuring the water is safe to drink and available for the irrigation of farmland.

IV. The "rice-fish-duck-bird-frog" integrated farming system

The Miao people believe in the concept of "animism," holding that all things, including animals and plants, possess a spirit and, just like humans, need "companions." A person without companions is lonely, and so is a tree without its fellows. Everything in nature is considered kin; all things are companions, and even seen as being one with each other. Consequently, the Miao people habitually plant a variety of trees around their mountains or near their houses, and they are used to cultivating multiple species in their rice paddies. In the Miao thought, the soil and water in the rice fields form a kinship or partnership with the rice, fish, ducks, birds, frogs, and other beings, and are even seen as being one entity. Animals sharing the same space with plants are inseparable and depend on each other for survival. Should separation occur, any form of life could be affected.

Within a rice paddy, water and soil form the foundation, providing a growth environment and ample nutrients for rice, as well as a habitat for other plants and animals. Tiny insects and even microorganisms can sustain snails, fish, eels, and ducks. The life activities of fish and ducks in the water can increase the nutrient content of the water, promoting water quality activation, which is beneficial to the generation and reproduction of organisms and accelerates the decomposition of organic matter, providing sufficient fertilizer for rice growth. The foraging of fish and ducks can also help remove some weeds and insects, reducing the occurrence of rice pests and diseases. Therefore, a set of integrated planting and breeding practices, built on local knowledge and scientific management, has gradually formed: attention is paid to plant spacing when cultivating rice—it should not be planted too densely—so as to allow for the raising of fish, ducks, and other animals(Bao & Meng, 2023).

The release of fish fry is primarily focused on carp fry measuring two to three fingers in size (approximately 5 cm in length), with around a hundred or more per acre being suitable. The fish raised in the rice paddies are specially cultivated carp for paddy culture, feeding on floating zooplankton and phytoplankton. They will not attack rice roots or seedlings, nor will they prey on other wild flora and fauna that have economic value to humans; hence, they do not impact the overall production levels of the rice paddy, only forming their own capacity for output. In constructing rice paddies, the Miao people of Zila village design winding water channels around the paddies to raise the water temperature, which also serve as passages for carp activities. These channels provide ideal habitats for carps at different growth stages and pathways for them to traverse various areas of the rice fields. The released carp and ducks can undertake mid-season tilling and fertilization tasks for humans, preying on plankton to enrich the paddy soil and decrease pest incidence. This approach not only boosts rice yield but also allows the carp themselves, as by-products of the rice paddy, to directly increase revenue. Moreover, the growth period of the fish is longer than that of rice, allowing for year-round cultivation; even after rice harvest, the carp can continue to be raised in the paddies until they weigh around 1 kilo. These large carps are then the prime ingredient for the Miao to prepare delicacies such as pickled sour fish.

Before large-scale planting of rice, the Miao people of Zila village already had a tradition of catching wild ducks. During the hunting and gathering period, the Miao villagers developed a tradition of hunting wild ducks and using their down for making warm clothing and bedding. However, to domesticate wild ducks and integrate them into the "zila tribute rice" cultivation system, a series of creative labor efforts were needed.

Firstly, it was necessary to breed smaller duck species. The ducks raised in rice paddies are what the Zila Miao call "rock ducks," which are small in size, with adult ducks weighing around 1 kilogram. These diminutive rock ducks are suitable for foraging in rice fields; they eat various plants and animals that affect the growth of rice crops without damaging the rice plants and roots, serving to reduce pests and weeds for the rice. If ducks were too large, not only would they find it difficult to move through the rice fields, but they could also crush or even break the young rice plants, hindering their proper growth.

Secondly, the growth period of the ducks needed to be shortened so that they could grow quickly and leave the rice fields before the rice matured to avoid the ducks preying on the rice grains, causing loss of rice yield. During the seedling nursery and transplanting stages, ducks should be kept out of the rice fields, the size of the duck flocks reduced, or the ducks confined, and during the rice ripening season, the ducks need to be moved to fish ponds or river segments to prevent disruption of normal rice growth.

Thirdly, it was necessary to extend the egg-laying period of ducks. In the wild, ducks have a short laying period, typically only at the transition of spring to summer, and lay eggs only once a year, which is not conducive to releasing multiple batches of ducks during the rice growing period.

To this end, through long-term practice, the Miao people of Zila village selectively bred ducks with extended laying periods and practiced artificial hatching, either by using broody hens or heating with rice husks. By controlling the timing of hatching artificially, they ensured that the duck population was sufficient for multiple releases throughout the entire rice growth period.

Breeding such a variety of ducks serves multiple purposes: it not only increases the yield of duck meat

and eggs but also enhances the fertility of the rice paddies. In addition to replacing manual labor for pest control and weeding, these ducks aid in the midseason cultivation of the rice fields. The released duck flocks can also stimulate the carp in the rice paddies, encouraging them to swim about and clearing harmful organisms such as water scorpions, directly or indirectly supporting the high yield of field-raised fish.

Of course, in order to prevent ducks from harming the fish fry, the Zila Miao people are very particular about the season for releasing fry into the paddies. If the fry is small, they must be introduced into the rice paddies before transplanting the seedlings. For larger fry, they can be released about half a month after transplanting. By the time the rice begins to tiller, the fry will have grown to about 2 inches long (approximately 5 centimeters), and then it is safe to release the ducklings into the rice paddies with no harm to the young fish. In this way, rice, fish, and ducks each find their niche in harmony, ensuring a bountiful harvest.

In the "rice-fish-duck-bird-frog" integrated farming system, there are more than 20 related species of organisms. Miao rice culture not only conserves multiple species but also realizes the scientific utilization of biodiversity. The Miao have ancient teachings such as "do not harm birds in spring, and do not shed clothes in winter." As a result, a variety of birds including egrets, magpies, and sparrows inhabit the dense forests surrounding the rice paddies, and their foraging for food is an important means of pest control.

The Miao also have the traditional saying, "do not eat toads, for if you do, you'll urgently need to urinate." The elders use this fear-inducing language to prevent the younger, unaware generation from catching and eating frogs. The protected frog species thus become agricultural helpers for pest control. In this way, a rice paddy becomes a treasure trove. In addition to the human-reared rice, fish, and ducks, there is a coexistence of wild birds, frogs, eels, snails, clams, and other animals thriving in the fields, growing together. This forms a food chain network within the "zila tribute rice" agricultural cultural heritage, all of which are part of the Miao's harvest.

In the "rice-fish-duck-bird-frog" coexistence system of Zila village, rice, fish, and ducks are the main products derived from the paddy fields, while birds, frogs, eels, snails, and clams are considered by-products. However, these are not the only yields; other wild plants are also harvested by the Miao villagers. Among and around the rice paddies grow numerous wild edible plants such as water bamboo, water celery, and lotus roots. According to our field surveys, there are more than a dozen types of plants coexisting in a single paddy field. These naturally occurring wild plants in the rice fields are likewise gathered and shared among the Miao community members. More than half of these plants are consumed by people, while others serve as fodder for livestock such as pigs, cattle, and sheep.

Therefore, in Zila village, the companion plants in these paddy fields are not removed as weeds, like in other large agricultural areas, but are instead retained and carefully maintained. From this perspective, every paddy field where "zila tribute rice" grows is a small-scale ecosystem where biodiversity coexists. The role of humans is merely to harvest equitably and use moderately, ensuring that these biological species can reproduce and thrive in the rice fields for long-term continuity, thereby achieving sustainable and prolonged use by humans(Luo & Wang 2008).

The "rice-fish-duck-bird-frog" coexistence system of Zila exerts multiple benefits for the protection of biodiversity. Traditional varieties of plants and animals are developed through long-term cultivation, and their rationale and intrinsic value have withstood the test of historical development and ecological change. However, due to the impact of modern agricultural production, many are eliminated from the commodity production process because of high environmental requirements for output or low yields. The protection and research of plant and animal genetic resources hold significant value in preventing unfavorable situations caused by biological homogeneity, as well as in enhancing product quality and meeting the growing needs for a better life among the populace.

Conclusion

Traditional agricultural knowledge systems possess specific regional and ethnic cultural characteristics. They are unique agricultural landscapes formed through long-term co-evolution with their surrounding environments. Such knowledge systems are a crucial foundation for meeting local socio-economic and cultural development, as well as a vital condition for achieving sustainable development in the region. Currently, the full exploration and effective protection and utilization of the local knowledge systems of agricultural cultural heritage is not only an active measure to maintain modern agricultural systems, preserve original agricultural landscapes, and inherit agricultural culture, but it is also a fundamental requirement to protect the biodiversity of agricultural systems and to reflect the harmonious coexistence between humans and nature.

The local knowledge system of agricultural cultural heritage includes not only agricultural production experience and wisdom, that is, the technical system of farming production, but also encompasses farming beliefs, taboos, assemblies, sacrifices, etc., related to farming techniques, namely the cultural system of farming production. This system plays a crucial role in regulating social relationships within agricultural production communities and promoting harmonious rural development. Both the technological system of farming production and the cultural system of farming have significant roles as references for contemporary agricultural

development. The local knowledge system of agricultural cultural heritage primarily relies on the physicochemical interactions of crops and ecological environments, emphasizing ecological regulation and orderly production within the agricultural system. It is constructed through harmonious coexistence with the ecological environment. The ecological circulation and energy recycling systems it establishes are crucial for maintaining the stability and continuity of local agricultural ecosystems and for the development of agricultural production. These systems have extremely important implications for the construction and development of modern agricultural systems.

Annotations:
1. Informant: Shi Wanda, a 75-year-old of the Miao ethnicity from Shilan Town, Huayuan County. This field data is stored in the Folklore Archive Room of the Institute of Anthropology and Ethnology at Jishou University.
2. The stele was erected in Zila Village. The inscriptions were transcribed in 2017 and are currently housed in the Folklore Archive Room of the Institute of Anthropology and Ethnology at Jishou University.
3. Refer to "The Preface of the Zila Tribute Rice," the inscriptions were transcribed in 2017 and are currently housed in the Folklore Archive Room of the Institute of Anthropology and Ethnology at Jishou University.

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