A Study of the Qianyanzhou Mode in a Subtropical Red Soil Hilly Region of China

ZOU Jingdong¹, LIU Wenjing², WANG Jingsheng³*, WANG Tong³, LI Chao³, DING Lubin³, BAO Xiaoting²

¹. Ji’an Institute of Agricultural Sciences, Ji’an, Jiangxi 343103, China;
². School of Environment and Natural Resources Renmin University of China, Beijing 100872, China;
³. Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

Abstract: Qianyanzhou is located in the heart of Jitai Basin in Guanxi town, the county seat of Taihe county in Jiangxi province. Qianyanzhou has a subtropical humid climate and exemplifies the geographic and geomorphologic characteristics of red soil hilly regions in southern China. In the early 1980s, to control soil and water loss and problems with grain yields, Qianyanzhou’s researchers proposed an innovative, comprehensive stereoscopic agriculture development mode known as the “Qianyanzhou mode”. This mode included a forest-livestock-food ecosystem, a forest-fruit-economy ecosystem, and a land-water compound stereoscopic system, all located within a watershed. In the Qianyanzhou mode, soil and water loss were completely controlled, thereby promoting environmental conservation and economic development. The state and the society as a whole supported this mode thanks to its far-reaching social impact. In the 21st century, given new societal concerns and continuing economic development, Qianyanzhou mode has been restructured as two ecosystems of forest-fowl and planting-raising circular economies at landscape level, based on an increase in vegetation coverage from 4.3% to more than 80%. These improved modes can significantly enhance the ecosystem, reduce poverty, and promote the construction of local ecological civilization. We hope that the information in this study supports improvements to and promotion of the Qianyanzhou mode. We believe the Qianyanzhou mode can play an important role in efforts to modify the agriculture industrial structure, alleviate poverty, and construct ecological civilization.

Key words: Qianyanzhou mode; red soil hilly region; compound management

The subtropical red soil hilly region in southern China is bordered by the Ta-pieh Mountains in the north, and the Ta-pa Mountains and Wu Mountains in the south. This region is 118 × 10⁴ km², 100 × 10⁴ km² of which is mountains and hills. The region accounts for 12.3% of China’s total territory (Liang et al., 2008). Bordered on the southwest by the Yunnan-Guizhou plateau, it includes areas in western Hunan and western Guangxi. Bordered by the sea on the southeast, it also includes the middle and lower parts of Yangtze River; the middle and lower parts of Zhujiang River; and Fujian, Zhejiang, Taiwan, Hainan island, and South China Sea islands.

Qianyanzhou is situated in Taihe county, Guanxi, in Jiangxi province (115°04’01”E, 26°44’51”N, H 150 m). There are bout a thousand families live here (Leng, 1989), so its nickname is “千檐洲” (one thousand homes). Moreover, because there are three small watersheds, nine rivulets, and 81 hillocks, the region is often flooded in the rainy season; thus, it also known as “千淹洲” (water-flooded place).
1 The origin and development of Qianyanzhou station

To explore the development of the red soil hilly region, Chinese Academy of Sciences (CAS)' scientific investigation team conducted a large-scale scientific investigation in the Jitai Basin area of the southern mountainous region from 1980 to 1982. After completing the investigation, the team selected Qianyanzhou as the test site for a production experiment designed to achieve comprehensive control and exploitation (Na, 1989). In 1988, the Chinese Academy of Sciences-Jiangxi Province Qianyanzhou Experiment Station for Comprehensive Development of Natural Resources in Red Soil Hilly Area (the Qianyanzhou Station) was established by the CAS and Jiangxi Province, and affiliated with the Institute of Geographical Sciences and Natural Resources Research, CAS. In the early 1980s, forests accounted for 0.43% of Qianyanzhou’s total territory, while barren mountain areas comprised 85%. Soil erosion was a serious problem, and peasants were living in poverty. After the founding of New China, the local government established programs for reform-through-labor farms, educated youth settlements, and a state cattle farm in Qianyanzhou. However, all of these projects failed.

Based on data from scientific investigations, scientists conducted feasibility studies and proposed a novel stereoscopic agriculture comprehensive development mode, otherwise known as the Qianyanzhou mode. More specifically, by developing and controlling water resources and establishing commodity production activities on the side, scientists managed to develop coexisting forest, grassland, and pond areas so the valley slopes could cultivate crops and develop aquaculture. Eventually, livestock breeding and aquaculture were mutually beneficial, allowing for accelerated processing and the development of distribution industries (Cheng et al., 1998).

The establishment and promotion of the Qianyanzhou mode took China by storm, earning support from senior leaders and experts alike. More than 30 media organizations, including CCTV and the People’s Daily reported on it. Moreover, the mode was showcased at the “Agriculture Achievements Expo for the 50th Anniversary of the Founding of the People’s Republic of China” and incorporated into senior high school geography textbooks. Recently, it was included in the first group of ecological civilization demonstrations based in Jiangxi province. In recent years, as national ecological civilization construction has moved ahead rapidly, Qianyanzhou station has also entered a period of rapid growth. The station was eventually organized to include a “one station and four sites” research network base with headquarters in Qianyanzhou and a focus on improving the benefits of artificial forests. Qianyanzhou station has also facilitated infrastructure construction and equipment upgrades while strengthening human resources team-building and participating in many national and international projects. Qianyanzhou station has also made great progress in the study of ecosystem ecology and underground ecology, the reconstruction of low-functioning forests, and as a model for the development of business resources under forest coverage. At present, Qianyanzhou station is an important research base that has garnered international acclaim in the field of forestry and ecology in the hilly red soil region of southern China.

2 Achievements of the Qianyanzhou mode

Previously, during the 8th and 9th Five-Year Plans, Qianyanzhou Station solved problems that had hindered local and regional economic development: 1) summer and autumn drought problems, addressed through water resources management; 2) impoverished farmers and unstable growth in peasant incomes, solved by cultivating citrus fruits on slop wastelands; and 3) soil erosion, improved by major efforts to develop artificial forests and increase vegetation cover. Under such circumstance, agroforestry systems and aquatic-terrestrial complex management systems were established within a watershed, in order to control soil erosion, restore ecosystems, increase food production and boost the income of farmers. The Qianyanzhou mode includes forest-livestock-food mode, forest-fruit-economy mode, and land-water compound stereoscopic management mode.

2.1 Forest-livestock-food mode

The Qianyanzhou experimental area is located in the hill area of Jitai Basin. Its subtropical climate is warm and humid with adequate light and a long growing phase that supports rich plant resources. In the 8th Five-Year Plan, Qianyanzhou station proposed developing a forest-livestock-food mode consisting of a small watershed artificial recycling ecosystem. Forestry is the basic industry with animal husbandry as the main industry and food production as a stabilizing factor (Cheng et al., 1998). This mode realized an organic combination of forestry, animal husbandry, and food production; solved problems of subsistence, water loss, and soil erosion; and has had far-reaching social impacts.

In the early 1980s, Qianyanzhou was a region with poor forest coverage, water shortages, poor soil fertility, and low production. In addition, there was much vacant land and a single agricultural production structure (Cheng et al., 1998) as shown in Photo 1. Based on terrain and soil conditions, the forest-livestock-food mode called for the planting of Masson pine (Pinus massoniana), Chinese fir (Cunninghamia lanceolata), Slash pine (Pinus elliottii Engelm), and other arbors on infertile parts of the hill, and for planting fodder shrubs under the forest. The mode also included planting pastures or citrus on hillsides where there were better site conditions. During a three to five year period, the citrus did not bear fruit; thus, the mode adopted a fruit tree-leguminous forage intercropping model. The topography is relatively flat and open, allowing scientists to focus on turning the wasteland into fields for planting paddy, corn, peanuts, rapes, and seasonal vegetables (see Photo 2 and Photo 3).
The forest-livestock-food mode was developed in 1992 and first implemented in 1993. In that year, a total of 2.51 acres of rice were planted with a 1000-kg yield of early and late rice at an average of 398.4 kg mu⁻¹. Some other crops were also harvested, such as sesame, soybeans, corn, seeds from watermelon, and others. The output value of the planting industry was CNY 1400. Moreover, the output value of animal husbandry, including cattle, pigs, chickens, and ducks, was CNY 4765 (see Table 1).

In 1992, 60 kinds of pasture were introduced in Qianyanzhou, and after three years of experimentation, scientists had identified dozens of excellent crops that were high in nutritional value, good palatability, and suitable for growing in the hilly red soil areas of southern China, such as king grass (*Pennisetum purpureum* K. Schumach, *P. typhoideum* Rich), cocksfoot (*Dactylis glomerata* L.), dallis grass (*Paspalum dilatatum* Poir.), cilia wheatgrass (*Roegneria ciliaris* [Trin.] Nevski), napier grass (*Pennisetum purpureum*), broadleaf paspalum (*Paspalum wettsteinii* Hackel.), and setaria grass (*Setaria anceps* Stapf ex
Massey). King grass yielded 5.4 t mu⁻¹, napier grass yielded 2.7 t mu⁻¹, and tall fescue (*Festuca arundinacea* Schreb) yielded 3.0 t mu⁻¹ (Cheng et al., 1998).

In general, the stereoscopic structure of the forest-livestock-food mode initially formed a spatial stereo-structure for hilly slope and a multi-layer structure for one plot. The proportion of food crops in the production structure was reduced, and the production proportion of forestry and animal husbandry was increased. Moreover, vegetation cover improved by over 50%, and soil erosion was basically brought under control. Climate regulation and water conservation were clearly enhanced, and the application of organic fertilizer increased as well.

### 2.2 Forest-fruit-economy mode

The key to poverty eradication lies with mountain management, and the key to mountain management lies with afforestation. However, when artificial forests were developed previously in hilly areas, more attention was paid to ecosystem performance while short- and medium-term economic effects were not give sufficient consideration (Chen et al., 1998). The forest-fruit-economy mode emerged as a response that met the needs of the times. This mode emphasized combining spatial stereoscopic hierarchy and multi-series structure. Moreover, the mode promoted combining forestry with the fruit industry and medicinal materials production, developing an integrated forestry industry that included commercial forest, fruit forest, and special economic forest. Providing long-term benefits was the main goal, but the provision of short-term benefits to support long-term projects was also effective. Ultimately, this mode achieved short-, mid-, and long-term benefits.

#### 2.2.1 Commercial forest-chestnuts-commercial crops (peanuts and soybeans) mode

In the 1980s, the Chinese chestnut growing in Qianyanzhou was complex with low yields, small fruit, and scattered distribution. In 1992, the research team introduced the chestnut variety “Shaoli 18.” Saplings were planted with row spacing of 3 m × 4 m, with 55 saplings per mu. By late October 1994, the chestnuts were bearing fruit with an average basal diameter of 4.06 cm and the average height of the plants was 2.57 m. The maximum basal diameter was 5.6 cm, and the tallest plant was 3.4 m.

#### 2.2.2 Commercial forest-May-chang-Cape Jasmine mode

The horizontal bands tilted inward and holes were dug after reclamation. The planting space was 1 m × 2 m with 320 saplings per mu. May-chang (*Litsea cubeba* [Lour.] Pers.) and Cape jasmine (*Gardenia jasminoides* Ellis) were intercropped at a 1: 1 ratio. The fruit and leaf of the May-chang plant can be refined into oil whose main component is citral, which is used as a raw material in the chemical industry to synthesize vitamin A and craft violet-like fragrances (Gu and Liu, 2006). Cape jasmine is traditionally used in Chinese medicine; it protects the liver, aids the gallbladder, promotes calm, reduces swelling, stops bleeding, and so on. It can also be used in the treatment of jaundice, hepatitis, sprains, hypertension, and diabetes (Zhang et al., 2016).

#### 2.2.3 Commercial forest-broadleaf forest-medicinal materials mode

To remove weeds and brush on the hill, scientists dug a 50 cm × 50 cm × 50 cm hole in the middle of a space surrounded by four trees to grow Houpo (*Magnolia officinalis* Rehd. et Wils) and Tu-chung (*Eucomnham ulmoides*) during a rainy spring. The plants were nurtured twice per year, the soil around the trees was plowed once per year, and weeds were turned into the soil as fertilizer. After researching suitable alternatives, scientists chose the Camphor tree (*Cinnamomum camphora* [L.] Presl.) for cultivation. They implemented full reclamation in the zone area, which was about 1 m wide and deeply plowed to 30 cm. Additionally, scientists dug 30 cm × 30 cm × 30 cm holes at fixed points for an afforestation density of 1.5 m × 2.0 m. After three to four years, the roots that had sprouted in the soil layer above 20 cm below the surface were cut and this was followed by root sucker regeneration. Thereafter, the branches and leaves were cut every two to three years, and essential oils were extracted via steam distillation.

In addition, Shaoli 18 entered its peak fruit bearing period

### Table 1 Benefit accounting of agriculture, forestry and animal husbandry in the current year (1993)

<table>
<thead>
<tr>
<th>Land use type</th>
<th>Area (mu)</th>
<th>Yield</th>
<th>Income (CNY)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy field</td>
<td>6.62</td>
<td>398.4 kg mu⁻¹</td>
<td>1400.00</td>
<td>75 mu of land produced economic benefits in the short term; the average benefit was CNY 82.0 mu⁻¹.</td>
</tr>
<tr>
<td>Dry land</td>
<td>9.66</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Marshy grassland</td>
<td>15.64</td>
<td>5 pigs</td>
<td>1500.00</td>
<td></td>
</tr>
<tr>
<td>Artificial grassland</td>
<td>19.46</td>
<td>33 chickens</td>
<td>495.00</td>
<td></td>
</tr>
<tr>
<td>Artificial scrubland</td>
<td>24.04</td>
<td>40 ducks</td>
<td>520.00</td>
<td></td>
</tr>
<tr>
<td>Coniferous forest</td>
<td>29.43</td>
<td>3 cattle</td>
<td>2250.00</td>
<td></td>
</tr>
<tr>
<td>Theropencedrymion</td>
<td>86.36</td>
<td>–</td>
<td>–</td>
<td>Forests and pools produced no economic benefits in the short term (roughly a ten year period), but did produce ecological benefits.</td>
</tr>
<tr>
<td>Poold</td>
<td>21.78</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>213.00</td>
<td>–</td>
<td>6165.00</td>
<td></td>
</tr>
</tbody>
</table>
in the sixth year with an average annual output of 830 kg mu\(^{-1}\). The output was valued at about 24 CNY kg\(^{-1}\) at then current market prices, thus providing 9900 CNY mu\(^{-1}\) in annual income. May-chang entered its peak fruit bearing period in the fifth or sixth year with an average annual output of 650 kg mu\(^{-1}\)–900 kg mu\(^{-1}\). The oil yield of May-chang was 22 kg mu\(^{-1}\) to 32 kg mu\(^{-1}\) with oil yield representing 3.5% of total fruit yield. The market price of the oil was CNY 80 kg\(^{-1}\) at the time, and the output value was roughly between CNY 880 mu\(^{-1}\) and CNY 1280 mu\(^{-1}\). Moreover, if May-chang is picked at the right moment, it can also produce 150 kg mu\(^{-1}\) of fatty oil. The camellia cake oil can be used as fertilizer.

As Tu-chung matured, the annual production of fresh bark was 25 kg, equal to 11.25 kg cortex. Bark cut from the trunk can yield 100 kg of dry bark and 30 kg mu\(^{-1}\) of fresh leaves every year.

### 2.3 Land and water compound stereoscopic management mode

There is significant rainfall in the red soil hilly region of Jiangxi, but the dry and wet seasons are clearly defined. Therefore, dam impoundment offers a solution to water shortages during the dry season. The complex ecosystem is composed of water and the surrounding land. Consequently, an aquaculture industry can be developed in water areas, and farm and cash crops such as grain, pasture, and fruit can be planted on land. Some farm crop production can be processed into fodder to feed cattle, fish, pigs, chickens, ducks, and geese. Pig-biogas-fish mode is representative of the land and water compound stereoscopic management mode. This mode not only enhances the resource use rate and improves farmer incomes; it also reduces environmental pollution caused by livestock waste (Fu et al., 2004). The system includes four parts: planting, pig feeding, biogas fermentation, and fish breeding in ponds, as shown in Fig. 1.

![Fig. 1 Land and water compound stereoscopic management mode](image)

From 1983 to 1986, land use efficiency in Qianyanzhou increased from 10.9% to 75.4%. The proportion of orchards, forests, and aquiculture increased from less than 1% each of total area to 13.2%, 68.42%, and 2.4%, respectively, of total area. Barren hill and slope land areas decreased from 85.83% to 4.26%. Changes in land use patterns increased total farm revenue 15.9 fold. As a result, many people moved their farms into Qianyanzhou, the number of people rose from 31 to 156, and per-capita income grew by 3.1 times compared to 1982. Taking 1985 (the third year after development) as an example, by planting cash crops in between lines of citrus saplings, an area of 13.3 hectares had an output value of CNY 30 000 to CNY 40 000; the output value of animal husbandry and aquaculture was approximately CNY 100 000. Moreover, average per capita income reached CNY 339, calculated based on the then current population, 1.8 greater than average per capita income during the initial stage of development. During the 9th Five-Year Plan period, 38 demonstration sites to promote the Qianyanzhou mode were established in Jitai Basin with a total usable area of about 400 000 mu. These sites produced direct economic benefits of CNY 14.5 million and comprehensive benefits of CNY 202 million.

To improve the ecological environment in the red soil hilly area, improve water conservation, minimize soil erosion, and protect farmland, 123.17 hectares of barren land in Qianyanzhou, accounting for 49% of the entire region, was afforested in 1984. Consequently, soil erosion decreased from 2.82 kg m\(^{-2}\) in 1984 to 0.16 kg m\(^{-2}\) in 1992. Soil and water loss were effectively controlled (see Fig. 2).

### 3 Qianyanzhou mode in the 21st century

Qianyanzhou is located in a typical mid-subtropical region, an area with rich water and earth heat resources. After decades of comprehensive governance, the condition of the natural environment conditions has improved, the forest coverage rate has increased more than 80%, and environmental carrying capacity has obviously improved (Photo 4). Yet due to the limitations of traditional agriculture and insufficient access to new technology, the forest region also has many poor people. As such, scientists have worked to develop new techniques, provide support for new industries, and develop the forest economy so as to eradicate poverty.
Qianyanzhou mode was restructured to function as two ecosystems of forest-fowl and planting-raising circular economies at the landscape level.

3.1 Forest-fowl mode
Taihe silky fowl (*Gallus domesticus*) is a National Protection of Geographical Indications, well-known as a homologous food in Chinese medicine that has received numerous international prizes (Xie *et al.*, 2013). To fully leverage this unique resource and use its advantages to bolster economic growth, Qianyanzhou has carried out demonstration experiments to explore a forest-fowl mode focused on raising the fowl under forest cover, especially free-range silkies under Masson pine (*Pinus massoniana* Lamb.) and oiltea camellia (*Camellia oleifera* Abel.) (Photo 5 and Photo 6).

The experimental results indicate that, when silkie density is 40–50 per mu, rotational grazing and free-ranging can be realized by moving coops. This method has no significant effect on vegetation, soil, or water quality. Given the physiological and ecological characteristics of Taihe silky fowl, they can be sold after 150–180 days. The overall cost of raising a silkie is CNY 108 and the sale price is CNY 150, which yields a per silkie net profit of CNY 42. If silkies are farmed twice a year, the annual income is 3360 CNY mu⁻¹ to 4200 CNY mu⁻¹, three to four times that of farming crops.

and create income earning opportunities for local residents. Furthermore, in recent years, agricultural non-point source pollution has become China’s biggest pollution threat. Environmental pollution caused by intensive farming has restricted the construction of China’s ecological civilization. Issues with food security caused by excessive use of pesticides and fertilizers have also attracted considerable attention and have led to increased consumer demand for green foods (Yang *et al.*, 2013). Therefore, proposals for economic development and for a green production oriented recycling economic development model have been put forward.
3.2 Planting-raising circular economy mode

Hybrid paper mulberry (*Broussonetia papyrifera* L.) has a high protein and amino acid content and is fast-growing, high yielding, and drought- and barren-resistant with a strong shooting capacity that makes it suitable for mechanized cultivation and harvest (Tu, 2009). Paper mulberry is also known as protein mulberry. Because of its important economic and ecological value in providing fodder, making paper, and ecological afforestation, it has been planted in more than 20 Chinese provinces and regions. It can not only help millions of farmers to prosper, but can also improve the ecological environment of poor areas. Therefore, hybrid paper mulberry development was included in the “National Top Ten Poverty Alleviation Projects” by the Chinese Council of Poverty Alleviation Office in 2014 (Shen and Peng, 2017). Hybrid paper mulberry planting is expected to achieve “planting-feed processing-livestock farming” integration and become an important component of strategies to use the livestock industry to alleviate poverty in poor areas of rural China.

The rotation period of hybrid paper mulberry is short, producing a yield a year after planting. Once ready for cultivation, the plants can be harvested three times in the first year. After that, depending on management methods and climate characteristics, the plants can be harvested four to six times annually and can be harvested continuously for more than fifteen years. Two years after the initial harvest, plants can yield 8 t mu⁻¹ to 10 t mu⁻¹ of fresh branches each year, or about 2.5 tons of dry material. The crude protein content of fresh hybrid paper mulberry leaves ranges from 20% to 30%, 8% higher than the crude protein in alfalfa meal, and two to three times greater than that found in feed maize. Because of hybrid paper mulberry’s high protein content, it can replace soybean meal in the feed processing process (Yang et al., 2017). Hybrid paper mulberry mixed with alfalfa (*Medicago sativa* L.) and ryegrass (*Lolium multiflorum* L.) can be added to concentrated foods (such as corn) after crushing and ensilage to produce livestock feed (Chinese Agriculture Industry Hybrid Paper Mulberry Poverty Alleviation Work Leading Group, 2015). Cattle and pigs can be fed with hybrid paper mulberry feed, and earthworms can be used to decompose the animal dung (Cheng et al., 2015), after which the earthworms can be used as chicken fodder. Earthworm feces are also a high-grade fertilizer that reduce pollution caused by pesticides and present no public health hazards in food. Pig feces can be directly discharged into pools to feed fish (Lai et al., 2015); the feces also can be mixed with concentrated food to be used as fish feed after processing and fermentation (Li, 2013). At present, there are four sub-patterns of Qianyanzhou planting-breeding circulating mode as shown in Fig. 3. These patterns are still in the experimental stage, described below.

![Fig. 3 Flowchart of planting-breeding circulating mode](image-url)

3.2.1 Hybrid paper mulberry-pig-fish mode

According to the standard method of planting and managing hybrid paper mulberry in subtropical zones, after harvesting the fresh leaves, the plant can be crushed, packaged, and ensiled. Until pigs grow to about 40 kg, 30% hybrid paper mulberry can be added to feed, although the growth effect is the same as with traditional feed. Pork quality and price, however, have been found to increase by more than 10%. Each pig consumes 70 kg to 80 kg of hybrid paper mulberry feed, equivalent to saving 60 kg of grain. After fermentation, pig feces from eating hybrid paper mulberry feed can be directly discharged into pools to feed fish; alternatively, the feces can be used as fertilizer. Fresh branches and leaves also can feed fish. The whole production process balances the food chain, allows for the production of organic fodder, and reduces environmental pollution caused by livestock manure emissions.

3.2.2 Forage grass-cattle-earthworm-fruit mode

This mode is based on the planting of hybrid paper mulberry and forage grass to feed livestock, such as cattle and sheep. The plant can be used directly as feed or can be used after ensilage and fermentation. Additionally, livestock manure can be used to raise earthworms, which can then be used in the making of pharmaceuticals, or added to animal feed as protein meal or directly fed to chicken and fish. After
fermentation, goat manure can be applied directly to tilled fields. In addition, earthworm feces are a relatively good base fertilizer that can be applied directly to tilled fields or around fruit trees (Hou et al., 2003).

3.2.3 Hybrid paper mulberry-fowl-fruit mode
Harvested hybrid paper mulberry and forage grass can be used as chicken fodder after being air dried, cut short, crushed, powdered, and reduced in moisture content. When making feed, only 30% to 50% forage need be added. Furthermore, this fodder can be used to breed original Taihe silky fowl, black-haired silky fowl, yellow chickens, or partridge chickens. After fermentation, chicken manure is an organic fertilizer that can be used for fruit tree plants, such as citrus, grapefruit, and pear. Its use can also improve fruit quality and flavor.

3.2.4 Hybrid paper mulberry-paddy-duck mode
Hybrid paper mulberry, alfalfa, and ryegrass can be harvested and then crushed, ensilaged, and processed through fermentation. Next, they can be mixed with rough rice, corn, and fish meal, with concentrated food accounting for 40% to 50% of the mixture. The mixture can then be used as a supplement for ducks feeding in rice fields, thus achieving rice-duck mutualism and increasing the value of the rice paddy ecosystem.

4 Conclusions
After more than 30 years of development, the main goal of Qianyanzhou mode has changed from one of resolving water and soil loss problems and food and shelter issues to one of improving ecosystem service functions and increasing socioeconomic benefits. At present, Qianyanzhou’s forest coverage has increased from 4.3% to more than 80%, and land utilization rates have improved from 10.9% to over 90%. In the early 1990s, water and soil loss problems were basically under control and produced the earliest ten-thousand-yuan a year household in Jiangxi province. Put simply, Qianyanzhou mode has had widespread social impact.

Given new social and economic conditions and extensive demand, the prices of livestock (e.g., cow, sheep, pig, chicken, and fish) and organic foods (e.g., rice, peanut, medicinal materials, and forest-fruit) produced by the new Qianyanzhou mode are 50%–200% higher than the prices of traditional agricultural products. This mode has not only adjusted Qianyanzhou’s agricultural industrial structure, but has also brought impressive ecological, social, and economic benefits and promoted the sustainable development of local agriculture. In the near future, Qianyanzhou mode will play an important role in agriculture industrial restructuring, innovations to poverty alleviation efforts, and ecological civilization construction.

Acknowledgments
The authors appreciate all the assistance from Qianyanzhou staff, and also thank local farmers for actively taking part in all the production experiments.

References
Li S J. 2016. Pig manure feed the fish can reduce diseases and increase profits. The Farmers Consultant, 6: 24. (in Chinese)
邹敬东1, 刘文婧2, 王景升1,3, 王彤3, 李超3, 丁陆彬2, 包小婷2

1. 江西省吉安市农业科学研究所，江西吉安，343103；
2. 中国人民大学环境学院，北京，100872；
3. 中国科学院地理科学与资源研究所生态网络观测与模拟实验室，北京，100101

摘要：千烟洲位于吉泰盆地的核心地带，属亚热带湿润气候区，系我国南方红壤丘陵山地地形地貌特征的典型代表。20世纪80年代初期，为解决当地水土流失和农民口粮等问题，千烟洲的科研工作者创造性的提出了驰名中外的“丘上林草丘间塘，河谷滩地果渔粮”的千烟洲模式。其中“林—牧—粮”、“林—果—经”和“水陆复合立体经营”三个子模式基本上遏制了水土流失，实现了生态—经济双赢，获得了各界高度认同，产生了广泛的社会影响。在21世纪新的社会需求和经济背景下，千烟洲模式在森林覆盖率显著提高的生态背景下，又拓展了“林—禽”和“种—养殖循环经济”子模式，这对于提升生态系统服务功能、提前完成扶贫脱贫攻坚任务和促进当地的生态文明建设等具有重要意义。本研究综合介绍了千烟洲模式以及其在不同时期的特点。希望通过本文的介绍能够促进千烟洲模式的优化和推广，使千烟洲模式在农业产业结构调整、扶贫模式创新和引领生态文明建设等方面发挥重要的作用。

关键词：千烟洲模式；红壤丘陵区；复合经营