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Application of water resource economic management model in agricultural structure adjustment

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ABSTRACT

Taking the watershed of Nanchang city as an example, through extensive investigations, the socio-economic status, water environment status, and development status of the agricultural industry in the watershed of Nanchang city were evaluated, and the coupling relationship between industrial structure and water environment was analyzed. The dynamic simulation of agricultural industrial structure adjustment in the Nanchang city basin under the constraints of the water environment was carried out to provide scientific decision-making on water resource shortage and other issues in the Nanchang city basin and to effectively solve the problem of water resource shortage. The research results showed that under the constraints of Scheme 2, the growth rate of agricultural output was in a relatively good development process, which was 8.56% in the short term, 6.65% in the medium term, and 10.33% in the long term. It is necessary to conduct research on the agricultural industrial structure in Nanchang city, which is also conducive to the protection of the water environment.

Key words: agricultural structure adjustment, social and economic status, water resources

HIGHLIGHTS

- To play an important role in sustainable water resource development and sustainable agricultural and economic development, this article explored this issue.
- Using the method of linear programming, three different schemes were selected, the best scheme was selected, and the scheme was extended to other areas.

1. INTRODUCTION

The adjustment of agricultural structure is of great value in further optimizing agricultural structure, improving agricultural efficiency, promoting agricultural efficiency, increasing farmers' income, and improving agricultural economic benefits. The biggest contradiction in the current agricultural development of Nanchang city is as follows. A large proportion of planting occupies a dominant position. Agricultural products have a single variety, low quality, and low efficiency. The number of agricultural leading enterprises is relatively small, and the level of industrialization is relatively low. To achieve leapfrog development in agriculture in Nanchang city, the primary task is to adhere to the focus of agricultural structural adjustment and rural economic development.

This article establishes an evaluation model for the harmonious development of agricultural economy and ecological environment in the Nanchang city area, which is suitable for China's national conditions. It aims to conduct research on the harmonious development of agricultural economy and ecological environment in China at this stage. A set of effective agricultural structural adjustment strategies has been proposed to promote the sustained and rapid development of China's agriculture and rural economy, improve the level of farmers' income, and provide an important theoretical and practical basis. In theory, the method presented in this article helps to promote the quantitative and scientific development of agricultural structure analysis in Nanchang city. At the practical level, taking Nanchang city as an example, empirical research has been conducted on the current situation and existing problems of agricultural structure evolution in Nanchang city, in order to provide a certain theoretical basis for the next research work on agricultural structure evolution in the region.

Since the 1990s, China's agricultural economy has entered a period of rapid development. At the same time, there are also some problems and contradictions, the most prominent of which is the slow increase in farmers' income. To solve these contradictions, it is necessary to adjust the agricultural structure. Researchers believed that agricultural remote sensing is one of the core technologies of precision agriculture. It does not require unified management like traditional agriculture but rather considers the variability of the field for specific site management (Huang *et al.* 2018; Liu *et al.* 2023). Schmidt *et al.* (2019) collected maize roots from long-term conventional and organic managed corn tomato agricultural ecosystems and identified them as important regulatory impacts for management outcomes, helping to guide plant-based strategies to improve the productivity and sustainability of agricultural ecosystems. Levy *et al.* (2018) studied the cognitive graph of 148 sustainable agriculture thought leaders in California, and his findings were of great significance for individual and collective decision-making in sustainable agriculture, as well as other scientific and policy debates involving complex systems. Fiszbein (2022) explored the role of agricultural diversity in the development process. He utilized data from various states in the United States and utilized climate-induced changes in agricultural production patterns. He found that agricultural diversity in the mid-19th century had a positive long-term impact on population density and per capita income. During the Second Industrial Revolution, agricultural diversity promoted industrialization, manufacturing diversification, patent activities, the formation of new labor skills, and the expansion of knowledge- and skill-intensive industries. These results are consistent with the hypothesis that diversity stimulates the acquisition of new ideas and skills due to cross-departmental spillovers and complementarity. Meng *et al.* (2021) believed that with the rapid changes in global climate, agricultural systems are facing more unpredictable and harsh environmental conditions than before, leading to an impact on food production. Therefore, in order to ensure the safety and sustainability of crop production, the use of advanced nanotechnology (plant nanotechnology) in plants is of great significance. In the process of agricultural structural adjustment, farmers need to raise awareness. Their research does not reflect that the government was the leading force in agricultural structural adjustment in the past, and at the same time, they should respect the wishes of farmers.

Due to the different national conditions of each country in the world, the uneven distribution of natural resources, and significant differences in their socio-economic resources (Fang *et al.* 2023; Qiu *et al.* 2023), there are also significant differences in the content and direction of research on agricultural structural adjustment. He *et al.* (2019) believed that the rapid development of nanotechnology has promoted the transformation of traditional food and agricultural sectors, particularly the invention of intelligent and active packaging, nano-sensors, nano-pesticides, and nano-fertilizers. Hao *et al.* (2018) believed that the profitability of irrigated agriculture in arid and semi-arid regions mainly depended on the availability of water resources and the optimal planting mode in the irrigation area. Nasiri *et al.* (2018) discussed the impact of water's economic value or surplus value pricing on economic variables and water use rate. He believed that in view of the negative economic impact of these pricing policies on local agriculture, alternative policies must be adopted to offset their adverse effects. Meng *et al.* (2019) believed that with population growth and rapid socio-economic development, the excessive development of water resources has exacerbated the mismatch between water supply and demand. The replenishment time and water volume of agricultural water resources cannot reliably meet the basic needs of the ecosystem. Aghmashhadi *et al.* (2019) believed that water resource policy support systems could improve the surrounding environment. The agricultural water consumption and dam infrastructure in the Caspian Sea basin were considered essential. Tuninetti *et al.* (2019) believed that, as emphasized by water pressure indicators, agriculture in many regions has been overexploited for water resources. Gany *et al.* (2019) reviewed the reform of sustainable agricultural water management systems in the irrigation sector in 14 countries and regions. Their research did not start from a regional reality and did not reflect the issue of relying on technological progress and institutional innovation.

The main contents of agricultural structural adjustment include the variety and quality structure of agricultural products, the production structure of the agricultural sector, and the proportion of agriculture to its extended industries. This article is a multiobjective agricultural structure optimization model for the Nanchang city watershed under water resource constraints. On this basis, taking the Nanchang city basin as an example and taking water resource allocation as the starting point, a multiobjective optimization model for the agricultural structure of Nanchang city basin under water resource allocation constraints is established, and the optimal strategies under different scenarios are solved. Finally, an agricultural structure adjustment plan and ideas suitable for the economic development of Nanchang city basin are proposed. In this paper, the index of the agricultural economic system was established from the two levels of agricultural economic benefit and agricultural resource use efficiency, and the ecological environment index was established from the two levels of resource utilization and environmental carrying capacity, respectively. Under the premise of the minimum difference between agricultural water supply and demand and the highest degree of water satisfaction, the ecological benefit was taken as the focus, and economic and social benefits were taken into account. To realize the organic integration of agriculture, animal husbandry and forestry coordinate the development and promote the sustainable and innovative utilization of water resources.

2. WATER RESOURCE ECONOMIC MANAGEMENT MODEL IN AGRICULTURAL STRUCTURAL ADJUSTMENT

2.1. Water resource economic management model

The application of water resource economic management models in agricultural structural adjustment can be explored from the aspects of water resource allocation optimization, agricultural policy formulation, economic benefit assessment, and environmental impact assessment (Yuan *et al.* 2023). For a long time, the per capita share of water resources in China has been relatively small and unevenly distributed, which has become a bottleneck restricting regional economic and social development, posing a serious challenge to regional economic development in the new era. With the acceleration of China's urbanization process and the expansion of industrial scale, the demand for water in various regions and industries is rapidly increasing, leading to an increasingly prominent contradiction between the supply and demand of water resources in China. The surface soil moisture at the field scale is closely related to surface temperature and is particularly important for agricultural water resource management (Zhao 2021).

This article establishes an index for the agricultural economic system at two levels: agricultural economic benefits and the efficiency of agricultural resource utilization. The economic benefits of agriculture are influenced by multiple factors such as farmers' income, irrigation area, and multiple cropping index. In addition, as far as Nanchang city is concerned, the rapid development of animal husbandry and the increase of cash crop planting area in the planting industry have greatly promoted the agricultural economic benefits. Therefore, this paper selects the output value ratio of animal husbandry and the proportion of cash crop planting area as two indicators of the impact of agricultural structural adjustment on agricultural economic benefits. In addition, due to the widespread application of mechanical energy in agricultural production, the economic benefits of agricultural production have been significantly improved, so it is included in the evaluation index. In terms of the efficiency of agricultural resource utilization, this article selects two indicators. One is the water consumption per unit of irrigation area, and the other is the agricultural output value per unit of cultivated land area. Climate change is expected to provide important information for agricultural economic development policies, and it is expected that climate change can lead to changes in the supply of agricultural water resources (Hu 2022).

This article establishes ecological environment indices at two levels: resource utilization rate and environmental carrying capacity. Because the development of agricultural economy mainly puts pressure on soil and water resources and the environment, indicators for measuring resource and environmental quality are mainly selected from the perspectives of water and soil. Among them, the development and utilization of soil and water resources can be reflected from three aspects: agricultural water use, reclamation rate, and forest coverage rate. The environmental carrying capacity is reflected by the height of groundwater, the frequency of sandstorms, and the level of fertilizer application.

There are disharmonious factors in the development of agricultural and environmental systems. For example, the increase in effective irrigation areas within the agricultural system can improve agricultural economic benefits. In addition, with the increasing intensity of fertilizer use, agricultural economic benefits can be further improved. However, if applied in large quantities over a long period of time, coupled with unscientific fertilization, it can lead to acidification and hardening of farmland, as well as a large amount of fertilizer flowing into the water through surface and underground runoff, leading to soil and water environmental pollution (Zhang *et al.* 2021a).

It is necessary to introduce a coordinated development degree model, as the coordination degree can only reflect the coordination between the environment and the economy, and cannot reflect the overall level of development between the environment and the economy, let alone the level of coordination between the two systems. Equation (1) combines coordination with coordinated development, in order to better reflect the coordination between the agriculture (*Agr*) and the economy (*Eco*).

$$X_{\mathrm{T}} = aAgr + bEco \tag{1}$$

X_{T} represents the coefficient of coordinated development, and a and b are undetermined weights.

However, due to severe damage to the ecological environment, how to protect water resources and make reasonable use of them has increasingly become a concern in society. China is a major country with a severe shortage of water resources, and its water availability ranks at the bottom of the world.

The basic idea for strategic adjustment of agricultural structure should be as follows. One is to ensure food production as the foundation, with the goal of improving the quality of agricultural products, and with the goal of high-quality and diversified market demand. The second is to further optimize the agricultural industrial structure to better leverage the comparative advantages of the region. Resources are fully and effectively conserved, actively improving the ecological environment, and achieving equal emphasis on social, economic, and ecological benefits. The agricultural product processing industry has been actively developed to enhance the comprehensive benefits of agriculture, promote agricultural urbanization, and the development of rural agricultural industries, thereby enhancing the benefits of agriculture and rural non-agricultural industries (Banski 2018).

2.2. Agricultural structural adjustment

In the agricultural and pastoral ecotone of Nanchang city, the basic method of transforming and utilizing the land to prevent further desertification is to plant sand and soil-fixing plants through the methods of returning farmland and adapting barren mountains and wasteland to forests and grasslands, combined with soil and water conservation projects. However, in Nanchang city, water scarcity has become an important factor restricting the development of agriculture, forestry, and animal husbandry. How to scientifically manage and reasonably utilize water resources is currently an urgent problem to be solved. In Nanchang city, by appropriately returning farmland and planting suitable shrubs and weeds, the ecological environment can be restored and the tendency to drought can be reduced. On the contrary, if appropriate adjustments are not made, soil erosion is accelerated, which has the opposite effect. The most widely used scientific decision-making method is the mathematical programming method. Its essence is to express the goals, constraints, and various relationships using mathematical equations and then solve them through mathematical methods. One of the mathematical programming methods is the linear programming method, which has linear optimization objectives and constraints, and is the most mature and widely used mathematical programming algorithm at present. Linear programming is widely used in crop planting, agriculture, animal husbandry, water resources, and other fields because of its versatility and simple correctness of modeling (Kitouni *et al.* 2018; Kirkpatrick 2019). The adjustment of agricultural structure is shown in Figure 1.

There is an obvious linear relationship between the output value of agriculture and the emissions of total nitrogen, total phosphorus, and chemical oxygen demand (Equation (2)) (Coble *et al.* 2018; Zhang *et al.* 2021b):

$$w_{\mathrm{p}} = \beta + g_{\mathrm{y}}\beta \sum \gamma \tag{2}$$

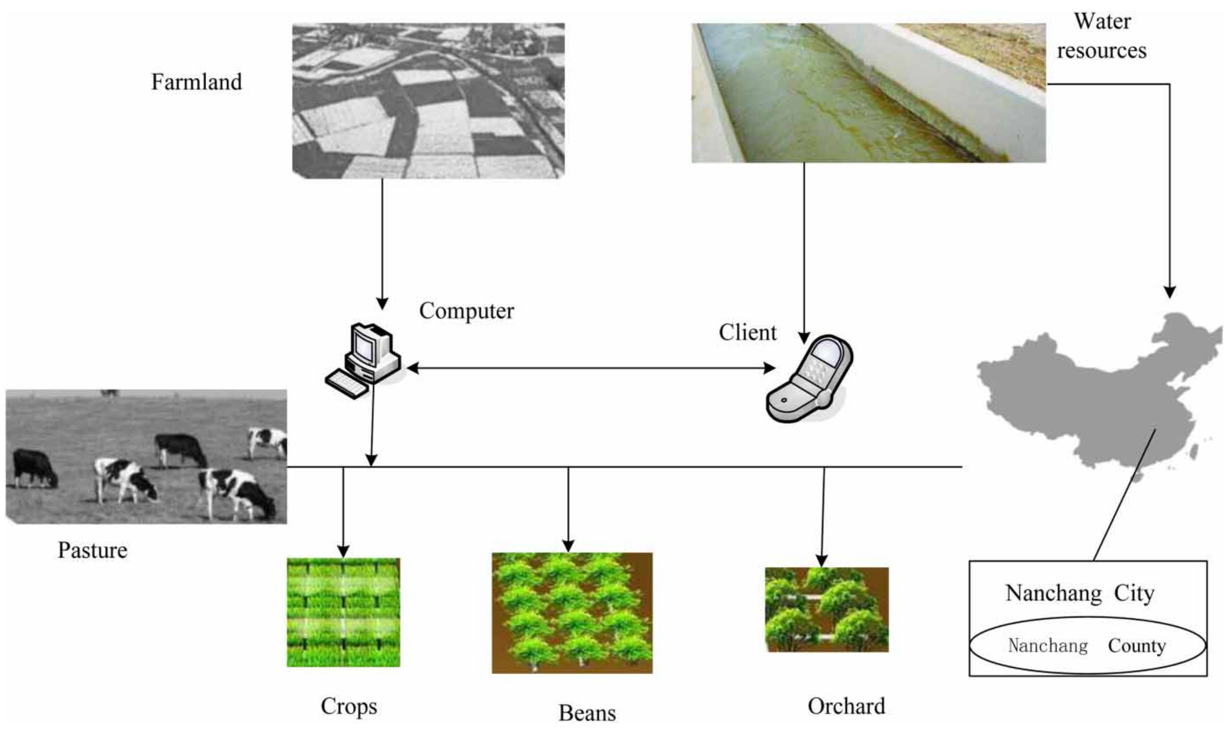

Figure 1 | Adjustment of agricultural structure.

w_p is the amount of pollutant emissions, γ is the pollutant concentration, g_y is the agricultural output, and β is the calibrated parameter.

The regression equation between agricultural industry structure (Indj) and total nitrogen emissions w_n is as follows:

$$w_n = 1.59\text{Indj} + \sum p \tag{3}$$

where p is the different values of pollutants. Reasonable optimization of agricultural structure should comprehensively consider three main factors: economic benefits, ecological benefits, and social benefits (Smith 2018; Beckman & Countryman 2021; Wu *et al.* 2023). On this basis, combined with the current problem of water scarcity, the goal of agricultural structural adjustment in Nanchang city should be to prioritize ecological benefits while minimizing the difference between agricultural water supply and demand and achieving the highest level of water satisfaction. At the same time, economic and social benefits are balanced to achieve organic integration and coordinated development of agriculture, animal husbandry, and forestry, which plays a beneficial role in the sustainable utilization of water resources.

According to the design requirements of the linear programming method, there can only be one objective function. There are two paths, one of which is to take the optimal water supply and demand state as the objective function and the other goals as constraints. The second method is to establish a comprehensive objective function. Under the existing water resource supply conditions, the objective function of minimizing agricultural water deficit is M_H:

$$M_H = \sum (p_H * x_a) \tag{4}$$

p_H is the demand for water resources, and x_a is the available amount of water resources. The maximum objective function M_z is the comprehensive indicator of agricultural water ecology and economy, which is:

$$M_z = \sum (S_z * x_a) \tag{5}$$

where S_z is the water supply situation.

Determination of output value coefficient: The determination of output value coefficient is a tedious task. Based on the data of 2021, according to the current agricultural production situation and the changes of market price index in Nanchang city, this paper conducts research and comparison on the input and output of major crops. Referring to the relevant data in recent statistical yearbooks, the output value coefficients of various main crops and livestock and poultry products have been determined.

Determination of nitrogen amount per unit of industry and nitrogen loss rate: Referring to the pollutant emission standards of livestock and poultry farming, the nitrogen production per unit area of various plant industries in the near, medium, and long term is set to be the same, and the nitrogen production per unit of animal husbandry is also the same. Moreover, the total nitrogen loss rate of the second farming method in various animal husbandry is half that of the first farming method.

There is a close relationship between agricultural structure and water environment pollution, and the optimization of agricultural structure plays a significant role in reducing agricultural pollution and protecting the water environment of river basins (Sang *et al.* 2023). By organically combining agricultural clean production with agricultural structural optimization, the emission of agricultural non-point source pollution can be significantly reduced. Under the two methods, the optimal solution for China's agricultural industrial structure adjustment is basically the same, indicating that under the same constraints, agricultural industrial structure adjustment plans with non-point sources as the core can be coordinated and satisfied. The following are some suggestions for adjusting the agricultural structure:

(1) Adjustment of planting industry structure

From the perspective of food safety, considering the low environmental pollution caused by rice cultivation and the significant impact on the ecological environment, there is still some room for growth in the current rice planting area in China. However, under the current overall protection of farmland resources in China, the increase in rice planting area is limited. The dryland crops in the Nanchang city watershed mainly include wheat, soybeans, corn, potatoes, and oil crops, but these crops have a wide distribution range and relatively simple planting patterns. At the same time, in agricultural production, there are a large number of production links, such as production links, product quality, environmental quality, etc., that need to be appropriately compressed and adjusted. Compared to this, vegetables have advantages such as high yield and good economic benefits, but due to severe outdoor pollution, key regulation is needed. The protected cultivation can not only effectively alleviate water pollution but also significantly improve the yield and benefit of vegetables. In terms of land use, there has been a shift from traditional open-field cultivation to greenhouse cultivation, which prevents direct erosion of crop root soil by rainfall and ensures the effectiveness of fertilizers (Li *et al.* 2021). Therefore, Nanchang city should vigorously develop the vegetable industry.

(2) Adjustment of animal husbandry structure

The livestock industry in the Nanchang city watershed is developing rapidly, and the number of large livestock is increasing year by year, with dairy cows growing the fastest and becoming the second largest pillar of agriculture in China, bringing large economic benefits to the watershed. However, due to the high pollution of livestock and poultry farming, it has become a key focus of regulation. In order to ensure the basic safety of agricultural and sideline product supply within the watershed, it is necessary to appropriately compress and adjust animal husbandry.

This article focuses on the industries with the largest unit emissions in China's cattle farming industry, such as cows and yellow cattle, and accelerates the implementation of 'prohibited breeding areas', 'restricted breeding areas', and 'quasi-breeding areas' by developing ecological breeding farms. The large-scale cattle farms that have been closed down and relocated within the prohibited breeding areas have been implemented through government subsidies and innovative cooperative methods to achieve ecological farming mainly focused on livestock and poultry. In relevant areas, biogas digesters have been built and livestock and poultry manure has been centrally disposed of, which not only meets the needs of residents' daily life but also prevents manure from entering the water and causing water pollution. For poultry with low pollution coefficients, it is necessary to vigorously promote them, especially in the breeding industry dominated by egg poultry.

3. RESULTS

This article takes Nanchang city as the research object to study the adjustment of agricultural industrial structure under water resource constraints, organically integrating the two, thus breaking through the principle of efficient water saving based solely on water and avoiding the adjustment of agricultural industrial structure solely based on economic benefits. (Nanchang county is under the jurisdiction of Nanchang city, and in this article, Nanchang county mainly highlights the population concentration advantage and extends it to Nanchang city, forming a sharp contrast.) In addition, the research in this article has certain theoretical significance in improving the sustainable development level of rural economy in China's water-deficient areas, and thus achieving economic development and ecological environment improvement in rural China. Through the adjustment of agricultural structure, this article can effectively utilize agricultural resources and improve agricultural production efficiency. In this process, there is a need for more technological innovation, which makes the connotation of modern agricultural technology research and development work more abundant compared to traditional research and development work. Agricultural transformation is an institutional innovation, as well as a system with higher economic efficiency and lower transaction costs.

The watershed of Nanchang city is mainly based on agriculture, which is the foundation for the survival of approximately 600,000 farmers. It is also the main source of livelihood for the local people and the main source of raw materials for local industry. The Nanchang city basin is an important area for rapid economic development in the province and a key area for western development in recent years. In terms of population in the Nanchang County watershed, in 2021, out of a total population of 297,000, there were 283,540 agricultural people (95.47%), and the actual rural labor force was 178,963. The population situation in the watershed of Nanchang city and Nanchang county in 2021 is shown in Table 1.

Table 1 | Population situation of Nanchang city and Nanchang county watershed in 2021

Number	Project	Nanchang county	Nanchang city
1	Total population (a)	297,000	596,032
2	Agricultural population (a)	283,540	320,156
3	Rural real labor force (a)	178,963	223,012
4	Proportion of agricultural population	95.47%	53.71%

According to the connotation of agricultural strategic structural adjustment, within a certain period of time and on a certain material basis, the goal is to meet the living needs of the people and meet a certain material foundation. Within a certain period of time, this structural adjustment accelerated agricultural development without affecting the development of agricultural industries. Here, the growth rate corresponds to the average value of agricultural economic development. To achieve the sustainable development of the agricultural economy, it is necessary to screen agricultural projects that can bring both good economic benefits and good economic benefits through agricultural structural adjustment. On this basis, the dynamic analysis of the benefits of agricultural production projects can better guide the adjustment of agricultural industrial structure.

Currently, it is necessary to adjust the current agricultural structure of Nanchang city. Therefore, exploring how to adjust agricultural structure to meet both ecological and economic needs in the context of limited water resources is of great practical significance for the ecological construction and farmers' income increase in Nanchang city.

In 2021, the per capita arable land in Nanchang city was only 0.56 acres, resulting in a shortage of arable land area. Compared to 2021, the grain production in 2022 increased by 54,124 tons, indicating an increase in land use density and a gradual improvement in agricultural output unit efficiency. The changes in farmland and grain yield are shown in Table 2. In addition, this article compares Nanchang and Jiujiang cities to better identify the shortcomings. This article found that in 2022, the cultivated land area in Nanchang city was 412,360 acres, while in Jiujiang city, it was 378,956 acres.

The current water use structure in Nanchang city is clearly not suitable for improving the local ecological environment, nor can it fully utilize the economic benefits of water resources. Due to the improvement of people's living standards and the efficiency of water use in non-agricultural industries, the water use for daily life and non-agricultural industries can definitely increase significantly in the future, and this growth can only come from agriculture. Therefore, the Agriculture Bureau of Nanchang city needs to reduce agricultural water use, transfer the saved water to non-agricultural industries, and increase residents' domestic water use, to improve water utilization efficiency, achieve sustainable water use and sustainable development of agriculture and animal husbandry, and achieve a 'harmonious' state of water.

The livestock breeding industry in the watershed mainly includes the breeding of large livestock such as cows and cattle, as well as pig and sheep breeding. The main breeding methods are captive breeding. Dairy farming is the central economic pillar of the region, centred around the northern region, on a large scale. Similar to dairy farming, chicken farms are also very concentrated, with southern chicken farms being the main ones. Especially for large-scale livestock farming, there is an increase yearly, while the increase in cows is relatively significant. Figure 2 shows the virtual water required to produce 1 kg of each industrial agricultural product. Furthermore, Mh, Mz, and Wp values have been compared for each product. Drought has affected water demand as well as water productivity for food production. In addition, pollutant emissions have increased by more than 17% in drought conditions.

By adjusting the economic organization of agricultural production to a certain scale, production costs can be reduced. This way, the rural labor force can be reduced, farmers' income can be higher, and the urban–rural gap can be reduced. The process of transformation and upgrading of China's agricultural industry is essentially the process of enhancing the core competitiveness of the agricultural industry. By establishing a stable agricultural land property rights system, the agricultural land property rights market has been formed. The effective operation of the rural land property rights system is an inevitable requirement for the reform of the rural land property rights system. Suitable agricultural production and operation organizations have been established, and the fields of scientific and technological applications have been expanded. At the same time, it is necessary to combine with the reform of the property rights system of agricultural enterprises to accelerate the listing and financing of agricultural enterprises and improve the efficiency of the use of agricultural capital.

At present, the nitrogen and phosphorus application levels for garlic and vegetables in the Nanchang city watershed have increased, with excessive fertilizer input and unreasonable structure. Moreover, the planting area of garlic and vegetables is

Table 2 | Changes in cultivated land and grain production status

Time (year)	Project	Cultivated land area (mu)	Grain yield (tons)
2021	Nanchang city	336,260	156,230
	Jiujiang city	302,156	310,235
2022	Nanchang city	412,360	210,354
	Jiujiang city	378,956	517,523

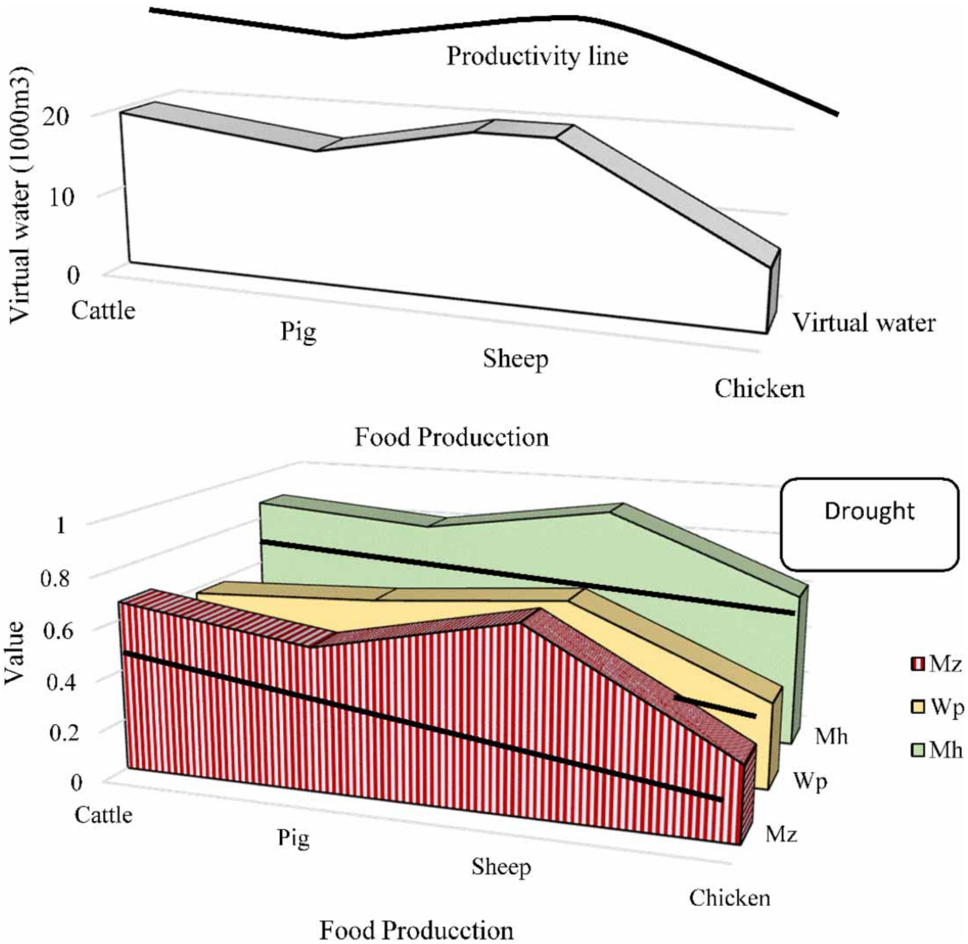

Figure 2 | Comparison of agricultural industrial productions.

showing a continuous expansion trend. Between 2021 and 2022, there was a significant increase in the use of agricultural fertilizers. The use of pesticides was 100 tons in 2021 and 123 tons in 2022. The usage of agricultural materials is shown in Table 3.

The production and inflow of pollution from pigs, cattle, and sheep into the lake are shown in Figure 3. The total nitrogen production from cattle pollution was 3,560 t/a, and the total nitrogen inflow into the lake was 1,230 t/a.

This article focuses on the coordination between agricultural economy and ecological environment, with the aim of finding out whether there is a harmonious and consistent relationship between the two, and how to make the two coordinated. The agriculture and economy of Nanchang city have developed rapidly, but at the same time, it has caused great damage to the local ecological environment. On the one hand, through the optimization and upgrading of agricultural structure, agricultural economic benefits, and resource utilization efficiency can be improved to a certain extent, and the pressure of predatory development on the environment can be improved. Second, the quality, quantity, and structure of natural resources

Table 3 | Usage of agricultural materials

Time (year)	Project	Agricultural fertilizers (tons)	Pesticide usage (tons)	Water consumption in agriculture 1,000 m^3
2021	Nanchang city	1,253	100	869
	Jiujiang city	1,423	200	1,086
2022	Nanchang city	1,354	123	1,158
	Jiujiang city	1,540	156	1,361

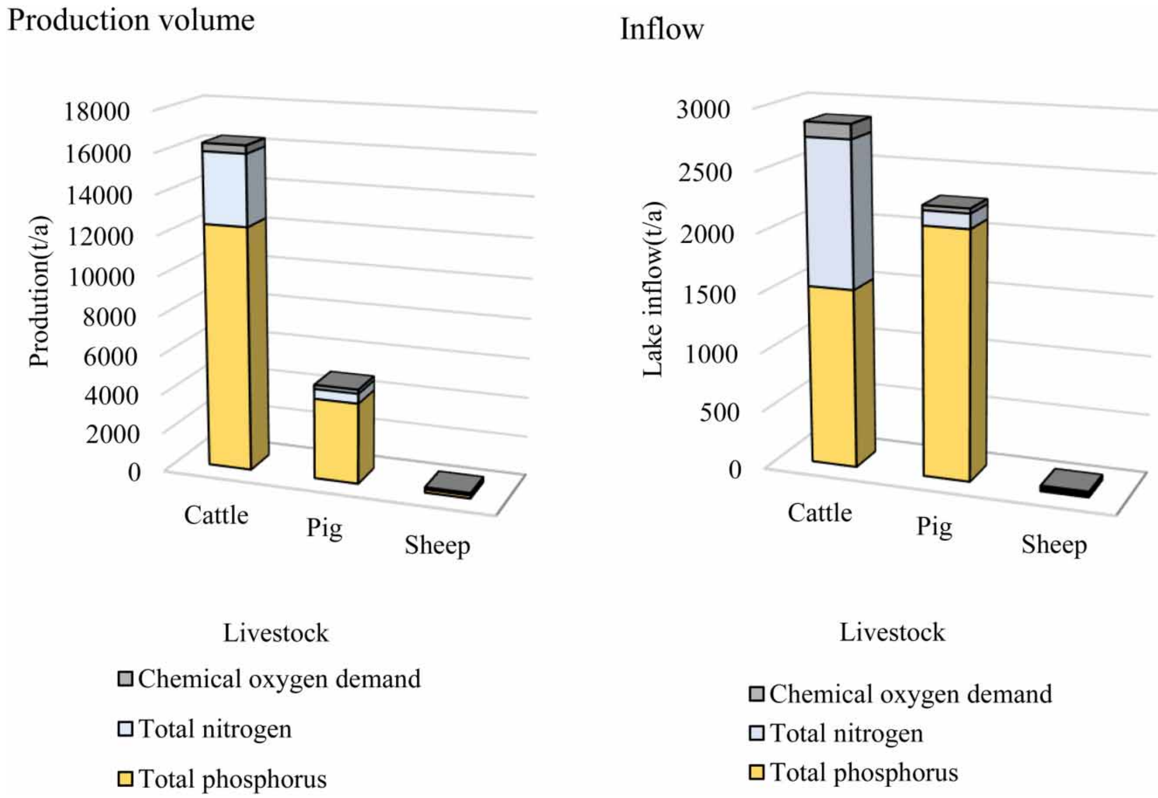

Figure 3 | Production and inflow of pollution from pigs, cattle, and sheep into the lake.

(mainly water and soil resources) in the region determine the choice of agricultural planting structure, and the ecological environment restricts the development of agricultural economy through the environmental carrying capacity. This puts forward new requirements for the harmonious development of the agricultural economy and ecological environment in Nanchang city. On this basis, the use of 'coordination' indicators has laid the foundation for the realization of the two indicators of 'coordination' and 'ecology' in Nanchang city in the future.

For a long time, there has been little investment in various aspects, which has led to a relative lag in the development of agriculture. The development of agriculture is relatively backward, mainly reflected in the low efficiency of agriculture, and there is still a significant gap between farmers' income and urban residents' income. The result of this stage is a contraction in agriculture, ultimately becoming the least developed industry. This has resulted in limitations in the purchasing power of farmers and a low sales share in the rural market. This has led to a further widening of the urban-rural gap, abnormal development of the national economy, and obstacles to economic development.

By analyzing the monitoring data in 2021, it was found that the total phosphorus in the water bodies of Nanchang city ranged from 0.50 to 0.77 mg/L, with an average of 0.66 mg/L. Through the comparative analysis of the average value of total phosphorus at each monitoring point in Nanchang city, the overall water quality situation in this area was obtained. If there are data from other regions or time points, they can be compared with this average to see if there are any significant differences. The data provided show that the total phosphorus content in the water body of Nanchang city ranges from 0.50 to 0.77 mg/L. We can compare this interval with data from other regions or time points to see if there are any significant differences or trends. By analyzing the changes in total phosphorus at each monitoring point and period, the variance or standard deviation values of total phosphorus changes at each period are obtained. The larger the variance or standard deviation, the greater the difference between various water quality indicators. The total nitrogen and total phosphorus contents in the water body are shown in Figure 4.

Agriculture provides people with daily necessities, and after providing them with sufficient agricultural products to meet their needs, it naturally provides production factors for industry. The measures taken on this basis have played an undeniable role in the development of the national economy, but have also brought a series of problems.

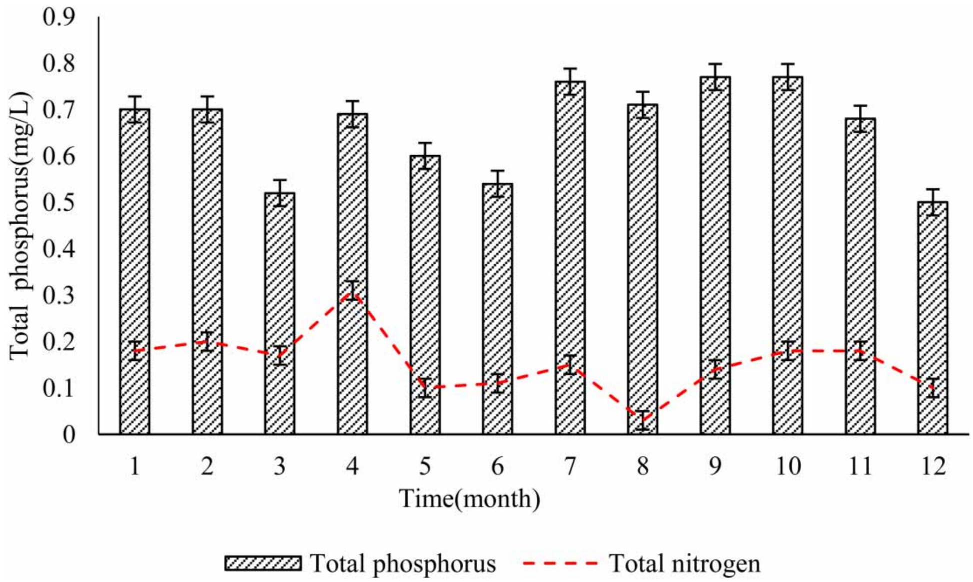

Figure 4 | Total nitrogen and total phosphorus content in water bodies.

Based on the emission index of nitrogen and phosphorus pollutants, three types of restriction schemes are set up, namely: 'low pollution', 'medium pollution', and 'high pollution'. The predicted emissions of total nitrogen and total phosphorus for each major pollutant correspond to different scheme limitations, and the predicted emissions of pollutants for the three schemes are shown in Table 4. The long-term planned annual total nitrogen in Scheme 3 was 7,102 t/a.

In the process of agricultural structural adjustment, strategic agricultural structure can improve the efficiency of ecosystem utilization and maintain sustainability, thereby improving the economic benefits of agriculture, meeting the basic needs of current and future generations for agricultural products, and achieving the goal of a virtuous cycle and sustainable development of agriculture.

Under the constraints of Scheme 1, the total agricultural output value gradually increased, with a short-term increase of 3.66%, a mid-term increase of 1.55%, and a long-term increase of 3.24%. This is closely related to the lower pollution emissions in the plan. Under the constraints of Scheme 2, the growth rate of agricultural output was in a relatively good development process, which was 8.56% in the short term, 6.65% in the medium term, and 10.33% in the long term. At the same time, the emissions of total nitrogen and total phosphorus are also within the range of urban water environmental carrying capacity. Under the constraints of Scheme 3, the total output value of agriculture was relatively high. This approach increases its gross domestic product through the rapid expansion of animal husbandry. Due to the unreasonable industrial structure, it results in higher pollution emissions. At the same time, the speed of industrial and economic development is also very uneven. Therefore, the high development plan not only causes pollution to water bodies but also has adverse effects

Table 4 | Prediction of pollutant emissions for the three schemes

Pollutant (allowable emissions)		Total nitrogen (t/a)	Total Phosphorus (t/a)
Scheme 1	Recent planning year	3,514	533
	Medium-term planning year	3,756	610
	Long-term planning year	6,949	720
Scheme 2	Recent planning year	4,630	784
	Medium-term planning year	5,725	863
	Long-term planning year	5,963	923
Scheme 3	Recent planning year	4,524	732
	Medium-term planning year	6,254	8,120
	Long-term planning year	7,102	8,852

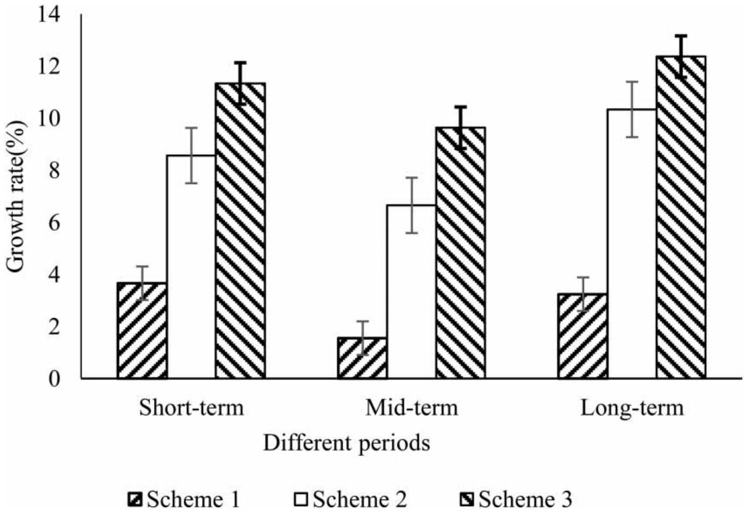

Figure 5 | Growth rate of total agricultural output value under different schemes.

on the balanced development of the economy. The growth rate of total agricultural output value under different schemes is shown in Figure 5.

4. CONCLUSIONS

In this paper, Nanchang city was taken as a case. Using the method of linear programming, three different schemes were selected, the best scheme was selected, and the scheme was extended to other areas. After adjustment, the comprehensive index of ecological economy has improved, the area of grassland and forest land has increased, and the area of cultivated land has decreased. Due to the improvement of water utilization efficiency and water content, grain yield has been improved, which can basically meet self-sufficiency, reduce water deficit, and save irrigation water demand. This also means saving groundwater, reducing water resource utilization efficiency, and having a favorable impact on the sustainable use of water resources. Further exploration is needed on other influencing factors of agricultural structural adjustment in the future.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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