Coupling Relationship Between Production Pattern Change and Ecological Degeneration in Urbanization Process: A Case Study of Mengxi Village of Hangzhou, China

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Abstract. This paper investigates the ecosystem services provided by both natural and human-made ecosystems in the Mingxi Village of Hangzhou, China. By exploring the benefits of these services, the qualitative value of the ecosystem were characterized and the interdependent relationship between ecosystem structure, function, and services were understood. First, the traditional practices of the Mengxi Village were investigated, together with its wildlife inhabitants. The ecosystem services that sustain the inhabitants' livelihoods and wealth were extracted and summarized. The result highlights the composite traditional agriculture that supports livelihoods and the extraction of ecosystem services, including the cultural services that support human well-being and environmental attachment. Secondly, the evolution of the Mengxi Village's ecosystem structure over time and its impact on the extraction of ecosystem services were analyzed. It reveals the human intervention's impact on the natural ecosystem from the perspective of material and species cycles. Third, the impact of policy changes on land use patterns, production methods, and labor and social relationships in the Mengxi Village were explored. Interviews with key individuals in the area revealed significant changes in these aspects due to policy changes, leading to changes in the extraction of ecosystem services. Finally, the underlying reasons for the Mengxi Village's inability to sustain its traditional production and life patterns were discussed. The relationship between changes in ecosystem structure, traditional land use patterns, and surrounding industries highlights how labor-intensive industries are inevitably transformed in the modernization process. This transformation results in changes to the Mengxi Village's traditional lifestyle and land use patterns. In conclusion, this essay provides valuable insight into how ecosystem services are extracted in the Mingxi Village and the changes in extraction caused by changes in ecosystem structure, function, and policy. It highlights the importance of understanding the interdependent relationship between human intervention and natural ecosystems for supporting sustainable development practices.

R. B. B. M. Hussain et al. (Eds.): ICHSSR 2023, ASSEHR 765, pp. 1069–1078, 2023.
https://doi.org/10.2991/978-2-38476-092-3_133

Keywords: Ecosystem Evolution · Urbanization · Sustainable development · landuse

1 Introduction

Urbanization has been one of the most significant demographic shifts in human history, leading to a rapid increase in urban areas and an associated transformation of the natural and agricultural landscapes [1–3]. Previous studies has shown that urbanization can lead to significant changes in the natural environment, including changes in biodiversity, ecosystem services, and the biogeochemical cycles of key elements such as carbon, nitrogen, and phosphorus [4, 5].

The main cause of the ecological degeneration during the urbanization process is the the evolution of production and lifestyle of residents, which result in the change of land-use patterns [4–6]. Ecosystem functioning may be hampered by the effects of anthropogenic and environmental stresses on natural ecosystems [7]. Anthropogenic environmental disruptions are rising in frequency due to the rapid speed of economic growth, industrialization, and urbanization [8, 9]. As a result, ecosystems are becoming more vulnerable and domesticated. With changes in land use and land cover, a changing temperature, and pollution [10]. A significant loss of biodiversity is being caused by the expanding occupancy of ecological areas, including forests, grasslands, wetlands, and water bodies, by agricultural land needed for crop production and urban development land needed to expand living space [11].

This study aimed to identify natural, historical, cultural, and economic values that reflect traditional knowledge and wisdom closely related to the environmental background and community culture.

2 Material and Methods

2.1 Study Area

Mengxi village, located in the Hangzhou, Zhejiang province, China, is situated at the confluence of the hilly Southwest Zhejiang River Valley and the Northeast Zhejiang Water Network Plain. Due to the geological effects of the Quaternary period, this region has gradually evolved into a river-crossed marshy plain with high biological activity. The area is characterized by an abundance of fish ponds and scattered islands, 50% of the total area are covered with water bodies such as river harbors, ponds, and marshes with a network of waterways resembling lanes and rivers.

Located in the monsoon climate zone at the southern edge of the North Asia tropical region, the region experiences a warm and humid climate with long winters and short summers. It is characterized by distinct seasonal changes with ample sunlight and abundant rainfall. The average annual temperature in the region ranges between 15.3 and 16.2 °C, with January being the coldest month of the year. The extreme minimum temperature can drop to −11.8 °C. The average annual precipitation ranges between 1150 and 1550 mm. The summer season is dominated by southeast winds, while winter is dominated by northwest winds.

2.2 Survey Methods

Following the guidance of "Urban Sustainability Framework", the community survey methods for this plan were developed based on the use of the ecosystem by the residents of Mengxi village concerning indigenous peoples and cultural heritage. The study surveyed the ecosystem use by residents of Mengxi village, using a range of methods such as interviews and literature review. The investigation focused on three stages of history, identifying unique production methods and lifestyles that have heritage value or do not negatively affect the ecological process. Identifying these elements is crucial for their protection, given the threats posed by factors such as foreign cultures, national policy influences, and urban expansion.

2.3 Ecological Diagnosis

Ecological diagnosis is a stage in which data and information are centrally analyzed, based on cross-comparisons of species data, social data, and species-social data, systematically analyzing the important structures of the site in a macro framework and its overall internal structure, including a systematic combing of natural and cultural elements of heritage value. This includes macro-ecosystem structure analysis, important ecosystem structure analysis, and the resulting ecological sensitivity assessment. The core content of the assessment stage is to propose rigid requirements for development control and hierarchical management.

Macro-ecosystem structure analysis is based on the overall situation of large-scale ecological space, examining the historical evolution and human interference of ecological space, the current surrounding urban spatial form and human interference, etc., identifying the location of the site in the overall ecosystem of larger time and space scales, to clarify the succession direction, overall restoration direction, and regional ecological functions that should be assumed.

Important ecosystem structure analysis is based on the overall situation of the ecological space inside the site and directly uses the data collected in the survey stage. Based on the analysis of species background data (distribution and adaptation patterns), the structural elements of the overall internal space of the site are identified, including the continuity framework of the ecosystem and small-scale important patterned ecological functional patches.

3 Results

3.1 Ecosystem Service of Mengxi Village

The wetland ecosystem in Mengxi Village provides a diverse range of ecosystem services: (1) It offers habitat support for wildlife by harboring a variety of plant communities in its water channels and ponds. This, in turn, provides breeding, migration, and wintering areas for various species of animals and birds; (2) the wetland vegetation plays a crucial role in pollution control and filtration by serving as a natural filter that can remove toxins and impurities from flowing water; (3) the ecosystem offers hydrological regulation and storage services by regulating river flow, replenishing groundwater, and

maintaining regional water balance; (4) the wetland ecosystem contributes to the agricultural, forestry, and fisheries supply services by providing a range of products such as fish, rice, lotus, and other aquatic plants; (5) the wetlands in Mengxi Village serve as a carrier of cultural heritage and provide recreational opportunities for visitors, making it an essential cultural heritage service.

3.2 Traditional Modes of Production and Subsistence

Traditional modes of production and subsistence of local residences have formed the landscape of human-introduced biosystem in Mengxi village. These biosystems can be broadly classified into three categories, i.e., mulberry-based fish ponds, bamboo-based fish ponds, and residential areas. The mulberry-based fish ponds consist of river channels, aquaculture ponds, mulberry fields, and farmland. Similarly, bamboo-based fish ponds include river channels, aquaculture ponds, bamboo fields, and farmland. The residential areas are comprised of residences, open spaces, aquaculture ponds, paddy fields, and breeding houses. These categories of spaces are not only essential for the survival and existence of traditional Mengxi Village residents but also serve as carriers for the occurrence and inheritance of their culture.

Among the basic pond system in Mengxi village, there are four traditional production systems: (1) Dike-pond system, (2) Farmland system with intensive cultivation, (3) Compound agriculture-herding system and (4) Agroforest system. The details are listed in Table 1 and Fig. 1.

Table 1. Four traditional production systems in Mengxi village.

Production systems	characteristics	Special characteristics	Key process
Dike-pond system	A combined agriculture and aquaculture activities.	Ponds interspersed with forest and agricultural land.	Sediment irrigation; Pond maintance; Use of manure as fertilizer.
Farmland system with intensive cultivation	Small plots of farmland and irrigation ditches.	Small plots of land with relative short periods of flooding.	inter cropping and crop rotation
Compound agriculture-herding system	A combination of crop farming and livestock keeping.	small plots of land, with more detailed terrain and less affected by flooding.	Intercropping, use of manure and plant stems as fertilizer.
Agroforest system	A combination of forest, bamboo, fruit trees and crops.	Forest surrounded by farmland, relatively short periods of flooding.	Growing shade-tolerant plants, bamboo and intercropping.

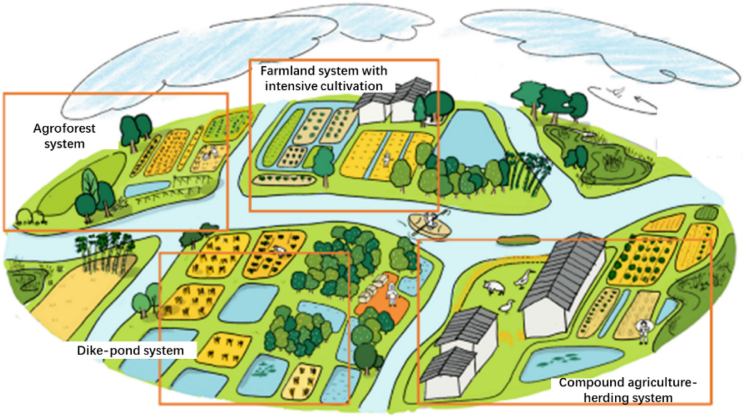


Fig. 1. Schematic diagram of four traditional production systems in Mengxi village3.2 Ecosystem evolution of Mengxi river

3.3 Relations Between Ecosystem Evolution and Production Patterns

As human activities gradually entered natural wetlands, a secondary ecological system, the Jitang wetland ecosystem, has evolved accompanied by subsistence farming systems and circular economy models. Prior to land reform, the Mengxi village was dominated by subsistence agriculture, with families and clans as the basic economic units and small-scale private land ownership as the basis, engaging in individual labor combining fishing and farming. The natural geography, family population conditions, and subsistence farming social system determined the spatial utilization of each Jitang unit, such as whether the pond was used for growing water chestnuts or raising fish and turtles, whether the waterfront and relative highlands were used for growing mulberry and fruit trees, crops and vegetables, or retaining bamboo forests, and whether to raise chickens, ducks, pigs, sheep, and engage in sericulture, or to produce fishing and farming tools and small boats by hand. All of these were jointly determined by the above three factors.

Around 1953, after the comprehensive promotion of land reform in the Mengxi village area, land ownership was transferred to collectives, and the basic economic units were reorganized into village collectives and production brigades. More efficient social organization methods were adjusted around the fishing and farming production process, such as the aquaculture brigade being responsible for the regional ponds, water bodies, and river channels, and each village brigade organizing land allocation, centralized production, and Jitang maintenance. Processing industries and village-run enterprises related to production also emerged.

The fishing and farming production and way of life before and after the land reform did not undergo fundamental changes, and the materials during this period were fully utilized and recycled, with no pollution problems.

Around 1983, the comprehensive implementation of the Household Responsibility System in the Mingshan Water Village area resulted in the separation of land ownership and management rights, which stimulated the farmers' enthusiasm for management in a period of highly centralized management and overly monotonous distribution. This

further increased productivity and led to an increase in village-run enterprises. However, this production model did not change the basic characteristics of the labor-intensive production mode of the pond-based agricultural production system. The release of labor, the development of agricultural modernization (and chemicalization), the increase of village-run industrial enterprises, combined with insufficient ownership of public products, on the one hand, increased residents' income, and on the other hand, increased the overall negative externality on resource and environment.

After 2000, the Mengxi Village area entered a period of comprehensive urbanization development, especially with the entry of the Alibaba Group in 2008, which drove the development of the entire area's industrial agglomeration mode. Various high-end and intelligent industrial headquarters settled in the future science city area, and the rural production and living space faced the triple impact of land requisition for construction, labor outflow, and urbanization construction negative externalities, resulting in a structural change in production and living methods. During this process, early real estate development directly destroyed the water system and occupied the pond wetlands, discharging wastewater and building waste pollutants into the natural space. Rural labor force participation in urban construction and the transition to a rental economy further aggravated the loss of the traditional circular agricultural economic model.

As a result, the production and lifestyle in the era of urban development have undergone fundamental changes, leading to ecological risks. Firstly, the pollutants left in the river channels from early real estate development have not been effectively removed, causing long-term endogenous pollution that cannot be absorbed. Nutrients that were previously fully recycled cannot be fully recycled due to the abandonment of agriculture, which is a traditional production model of the pond system. They are either concentrated in scattered areas or scattered around the original pond system, and plant waste such as rapeseed stalks and bean husks continue to be fully utilized. However, the lack of river channel cleaning has exacerbated the precipitation of nutrients and organic matter, causing the individual mulberry and bamboo shoots to become smaller, the bamboo to become thinner, and the degradation of mulberry and bamboo lands caused by unturned sediment. Sericulture and silk production have completely disappeared in the water village, and livestock and poultry breeding have been banned, which has reduced the industry types with relatively high added value in traditional agriculture and caused a sharp decline in fish and turtle farming, with only a small amount of water chestnut and lotus roots remaining. With the help of plastic processing, the production and daily necessities are no longer dependent on the direct use of bamboo shoots. The direct effect of bamboo shoots has disappeared and they are continuously cut down, replaced by cultivated land and orchards. The scale of pond drying, which used to happen every 2–3 years, has sharply decreased, and the aeration effect brought by pond drying cannot be fully utilized. In addition to the incomplete recycling of materials, the outflow of labor has also brought about the inevitable result of intensive land use, which requires the use of fertilizers, further increasing the overall nutrient level within the system.

4 Discussion

From the perspective of spatial transformation, the gradual shrinking of natural spaces from natural wetlands to secondary wetlands and then to urban development is a process in which the supporting functions of the ecosystem continuously transform into supply, regulation, and cultural services. However, it is also a process in which the area and functions of natural habitats continue to decrease. Facing the remaining traditional agricultural space that is constantly shrinking, it is very important to guide it to integrate into future urban development in terms of spatial form, material circulation, and industrial patterns in a reasonable direction. There are three developing models (shown as Fig. 2).

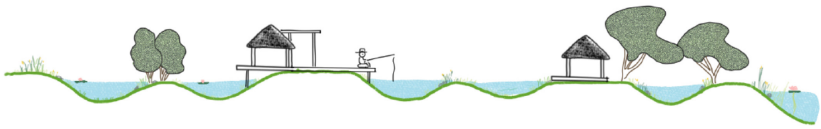
The development model of urban wetland parks often focuses on implementing measures such as landscape planting, pedestrian walkway construction, and tourism facilities. The degree of hardening is relatively high, the degree of artificial vegetation is high, and the overall fragility of the ecosystem is high, with insufficient resilience to environmental disturbances. In addition, compared to a small amount of ticket revenue and service industry income, its maintenance costs are high, and it is a purely input-based construction model from the overall operation perspective.

The development model of agricultural tourism parks is based on the characteristic of the paddy field system, and it is a theme natural park development model created for higher sharing and vitality. The degree of hardening is relatively high, but the application of landscape plants is relatively less. Because agricultural tourism activities are relatively large-scale, their income structure will include land rent income, agricultural product income, research and experience activity income, etc., which will be higher than urban parks and will also have more possibilities for inheriting traditional cultural customs. However, continuous production on the site and maintenance of the paddy field structure still require a large amount of labor, and the feasibility of labor is difficult.

Due to multiple demands, such as the agricultural needs of surrounding towns, the demand for visiting the characteristic paddy field system park space, the improvement of the quality of life of indigenous people, and the inheritance of traditional culture, combined with the overall level of biodiversity improvement required in the ecological civilization era, higher requirements have been put forward for the precision of site space utilization and the diversity of management modes. Based on the goals of better environmental resilience and habitat diversity, higher spatial openness and accessibility goals, and more integrated spatial utilization model goals, Mianxi Shuixiang will be guided towards a finely managed ecological agriculture community in the future.

From the perspective of development economics, the Mianxi Village region is inevitably the natural core area for the urbanization and development of high-tech enterprise clusters. However, the development dilemma in the Mianxi region lies in the fact that compared with the peripheral capital and technology-intensive development areas, traditional labor-intensive agriculture is far behind in production efficiency and product added value, while traditional culture is closely tied to this production lifestyle. The rapid urban renewal brings about great capital temptation and the complete collapse of the social ideology based on agricultural production, and the drastic collision between traditional rural lifestyle and modern urban lifestyle directly leads to the huge psychological gap and behavioral changes of the indigenous people. Therefore, the preservation

(a) Mode 1. municipal wetland mode



(b) Mode 2. Agricultural tourism mode

(c) Mode3. Urban-rural integration community with refined management

Fig. 2. Three developing modes of Mengxi village.

of the natural space form under the enclosure of capital and technology-intensive development, the improvement of ecological environment quality, the self-maintenance of natural system operation, and the inheritance of traditional cultural heritage are bound to be the core issues in the process of seeking a way out for the Mianxi Village region.

In the future, residents in the surrounding urban areas of Mianxi Village will have more demand for ecosystem services provided by natural space, such as the supply of pond system and farmland services, the hydrological and atmospheric regulation services provided by large healthy secondary ecosystems, and the cultural services provided by comfortable wetland parks. At the same time, Mengxi Village community residents also have labor employment and economic development needs, which lead to the inevitable development trend of urban-rural integration and community support-oriented economic models.

In the future, development should first and foremost focus on solving existing environmental risks, i.e., how to promote the complete circulation of material within the system through modern engineering methods in order to change the labor-intensive nature of traditional agricultural models. Secondly, from the perspective of labor feasibility, the preservation of traditional Mengxi Village wisdom through traditional fishing and farming methods should be considered as a living example. At the same time, the demand of modern urban population for self-cultivation activities and beautiful recreational space should also be fully considered, guiding the establishment of new rational human-land relationships, and maximizing the self-regeneration capacity and economic feasibility of natural space through diverse land-use models.

5 Conclusion

From the perspective of development economics, the Mengxi Village area is inevitably the natural core area for the urbanization and development of high-tech enterprise clusters. However, the development dilemma in the Mianxi area lies in the fact that traditional labor-intensive agriculture cannot match the productivity and product added value of peripheral capital and technology-intensive development zones, while traditional culture is closely intertwined with this mode of production and lifestyle. The rapid urban renewal has brought enormous capital temptation and the complete collapse of the social ideology based on agricultural production, while the drastic collision between traditional rural lifestyle and modern urban lifestyle has directly led to a huge psychological gap and behavioral change among the local residents. Therefore, the preservation of natural spatial forms under the enclosure of capital and technology-intensive development, the improvement of ecological environment quality, the self-maintenance of natural systems, and the inheritance of traditional cultural heritage are the core issues in the process of seeking a way out for the Mengxi Village area.

In the future, residents in the surrounding urban areas of Mengxi Village will have greater demand for ecosystem services provided by natural spaces, such as the supply services provided by the base pond system and cultivated land, hydrological and atmospheric regulation services provided by large healthy secondary ecosystems, and cultural services provided by comfortable wetland parks. At the same time, water town community residents also have labor employment and economic development needs, which lead to the inevitable trend of future urban-rural integration and community-supported economic models.

Future development should first focus on solving existing environmental risks, that is, how to promote the complete circulation of materials within the system through modern engineering methods in order to change the labor-intensive nature of traditional agricultural models. Secondly, the feasibility of labor should be considered from the perspective of preserving traditional water town wisdom as a living sample through traditional fishing and farming methods. At the same time, the demands of modern urban populations for self-cultivation activities and beautiful recreational spaces should also be fully considered, guiding the establishment of new rational human-land relationships and maximizing the self-regenerating ability and economic sustainability of natural spaces through diverse land use patterns.

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