From Ecological Agriculture to Ecological Civilization Construction: A Postprint Commemorating the 100th Anniversary of Mr. Ma Shijun's Birth and the 36th Anniversary of the Publication of the Ecological Engineering Concept

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Abstract

"Holistic, coordinated, cyclic, and regenerative" represents the ecological engineering concept proposed by Mr. Ma Shijun in 1979. He asserted: "Ecological engineering is a production process system designed for stratified multi-level utilization of materials, applying principles of species symbiosis and material cyclic regeneration in ecosystems combined with optimization methods from systems engineering." In 1987, Mr. Ma Shijun further elaborated: "Only agriculture established through the application of ecological engineering principles constitutes ecological agriculture." This paper demonstrates the validity and advancement of his concept through several ecological agriculture models, and clarifies that ecological agriculture represents an important component of contemporary ecological civilization. Ecological agriculture is constructed through individual ecological engineering projects, wherein ecological engineering is essentially ecosystem design grounded in ecological principles. Finally, several recommendations for accelerating the development of ecological agriculture are proposed.

Full Text

Preamble

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From Eco-Agriculture to Eco-Civilization Construction: In Memory of Prof. Ma Shijun's 100th Birthday and the 36th Anniversary of

Eco-Engineering Theory Publication

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Abstract: In 1979, Prof. Ma Shijun proposed the eco-engineering principles of "integration, coordination, circulation, and regeneration." He defined eco-engineering as "a production-technology system that applies the principles of species symbiosis and matter cycling in ecosystems, combined with optimization methods of systems engineering, to design multi-level, hierarchical systems for material utilization." In 1987, Prof. Ma further stated that "agriculture built upon eco-engineering principles is eco-agriculture itself." This paper demonstrates the validity and foresight of his theory through several successful eco-agriculture models, and explains why eco-agriculture constitutes an important component of contemporary ecological civilization. Eco-agriculture is built through individual eco-engineering projects, which are essentially ecosystem designs based on ecological principles. The paper concludes with recommendations for accelerating eco-agriculture construction in China.

Keywords: Eco-engineering; Ecosystem; Eco-agriculture; Eco-civilization

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2. Eco-Agriculture Enables Synchronized Development of Agricultural Productivity and Ecological Environment Construction

"Eco-" refers to the relationship between organisms and their environment, while ecology is the science studying these relationships. The ecological environment is the physical environment where organisms, including humans, exist. Eco-agriculture is established according to the ecosystem principles of "integration, coordination, circulation, and regeneration." It can fully express ecosystem productivity while maintaining balanced energy and material exchange with the surrounding environment, achieving coordinated ecological development that perpetuates through generations via continuous cycling and regeneration. The following examples demonstrate the validity and advancement of eco-agricultural engineering concepts.

2.1 Integrated Forest Network and Farmland Population Structure in Northwest Desert Oasis Agriculture

Xiangride Town in the northwest desert region is located 60 km west of Dulan County—an important town on the Silk Road—along the southern edge of

the Qaidam Basin in Qinghai Province, at an altitude of 2,800 m. The climate belongs to the warm temperate arid zone, with July average temperatures of 22–26°C. Effective accumulated temperature, photosynthetically active radiation, and water supplementation conditions basically meet the growth requirements of medium-to-late maturing spring wheat. Large diurnal temperature differences facilitate nutrient accumulation in crops. This region achieved the highest national spring wheat yield per unit area in the early 1980s, reaching 15,195.0 $kg \cdot hm^{-2}$ (equivalent to 1,013.0 kg per 666.67 m^2), and this high productivity has been maintained for decades. Beyond suitable varieties, the optimized integrated structure of shelterbelts and farmland has played a crucial role in sustaining high and stable wheat yields. With a farmland-to-forest area ratio of 3:1, the forest network provides ecological protection and shelter for wheat. Consequently, wheat fields here have never required pesticides, and damage from frost and wind has been significantly reduced.

During a 2002 field investigation, the author observed over 600 shelterbelts (comprising 20 million trees and shrubs) protecting grid-patterned farmland totaling 2,000 hm^2. The golden wheat ears were plump and uniform, free from pests and diseases, creating picturesque scenes. This semi-artificial ecosystem model, which designates specific areas as "ecological land use" [3-4] in combination with farmland, exemplifies how forest and crop communities can form an integrated whole. This design leverages natural ecological conditions to nurture farmland while using forest networks as ecological barriers, promoting stable production, reducing inputs, and increasing benefits. The result is a functional system that mobilizes the self-organizing capacity of ecosystems to achieve high and stable productivity. This represents the application of Prof. Ma Shijun's principles of integration and coordination.

2.2 Mutualistic Symbiosis Model of Rice-Fish Systems

Rice-fish coculture in China has a history of over 2,400 years. In 2013, the national area of rice-fish systems reached 1.52 million hm^2. Recent innovations including rice-crab, rice-shrimp, and rice-duck systems have generated even greater benefits. For example, in 2013, Panjin City in Liaoning Province cultivated rice-crab systems across 155,000 hm^2, producing 65,000 tons of crabs and generating per capita income of 1,650 yuan from crabs alone for the agricultural population. In Qianjiang City, Hubei Province, the transformation of low-lying paddy fields using a one-rice, two-shrimp approach yielded significant benefits [5].

This mutualistic symbiosis and cyclic regeneration between two biological populations not only enhances productivity for both components but also improves soil fertility, reduces carbon emissions, and improves the ecological environment, enabling sustainable ecosystem development. This exemplifies the application of Prof. Ma Shijun's principle of mutualistic circulation and regeneration.

2.3 Large-Scale Ecosystem Cycling Model of Livestock "Breeding in the West and Raising in the East" in Northeastern Inner Mongolia's Agro-Pastoral Transition Zone

Tongliao City in eastern Inner Mongolia lies at the heart of the Horqin Sandy Land, where vegetation was severely degraded due to long-term overgrazing. According to government statistics, by the end of the 20th century, a long-distance agriculture-pastoralism integration approach was implemented to allow the sandy land to recover seasonally. This reduced degraded sandy land area by 60% from 1.33 million hm^2, making it the only sandy land among China's four major sandy regions showing an overall reversal trend. The reversal resulted from applying the "breeding in the west, raising in the east" model, which allowed seasonal recovery of the sandy land.

During an August 2003 field investigation, the author observed local herders excitedly transferring young cattle—bred in western sandy areas during winter and spring—to eastern agricultural areas in summer and autumn. This large-scale ecosystem cycling model successfully mobilized circular economy within the ecosystem at a regional scale. The approach created complementary material and energy flows between agricultural and pastoral industries, enhancing economic benefits while relieving grazing pressure on sandy lands. Simultaneously, the cattle consumed crop residues in farmland while providing manure for soil fertility improvement, promoting coordinated development of agriculture and pastoralism while improving the ecological environment. The boundaries of this system were defined by designers to coordinate seasonal transfers. This represents a successful application of Prof. Ma Shijun's concept of "applying principles of species symbiosis and matter cycling in ecosystems, combined with optimization methods of systems engineering, to design multi-level, hierarchical systems for material utilization" [1].

2.4 Ecosystem Component Balance Model of Introducing High-Quality Forage to Fill Ecological Niches in the Huang-Huai-Hai Grain Production Area

The Huang-Huai-Hai Plain is a major wheat and corn production region with double-cropping systems. However, it lacks high-quality forage, and reliance on crop straw alone (with protein content below 4%) makes it difficult to develop cattle and sheep production, especially for improved livestock breeds. To address this weakened ecological niche, high-protein forage crops were needed. The introduction of high-yield, high-quality grain-forage dual-purpose amaranth (*Amaranthus hypochondriacus*) from the United States produced excellent results.

The experiment was conducted in Gaomi City, Shandong Province, using Italian Piedmontese beef cattle. Originally planned as a purebred embryo engineering reproduction base, the project required high-quality forage. While imported American alfalfa contained about 20% crude protein, it was expensive; domesti-

cally grown alfalfa had reduced crude protein content to about 13%, failing to meet requirements. Approximately 10% of local farmland was low-yield due to secondary soil salinization and sandification near the Yellow River estuary.

American amaranth not only has high crude protein content (leaf: 28%, stem: 14% as measured by Laiyang Longda Food Factory laboratory) but also possesses drought resistance, salt tolerance, sand-fixing ability, and tolerance to poor soils. The experimental design used fresh amaranth stems and leaves mixed with corn and wheat straw at a 7:1:2 ratio to prepare silage, which was fed to 58 heifers and 5 bulls for 300 days without additional grain feed. Results showed daily weight gains of 400 g for heifers and 500 g for bulls, with total weight gain reaching 7,710 kg and production costs of only 3.262 yuan per kg of beef (converted to 2002 prices) [7].

Ecosystems are integrated systems comprising balanced populations of biological components and high-quality species. Weakening of any ecological niche obstructs ecosystem functioning and reduces overall biological productivity. Therefore, introducing excellent and suitable germplasm resources from outside the ecosystem to strengthen ecological niches not only balances ecosystem components and facilitates smooth energy transformation and material cycling to increase overall productivity, but also improves poor soils, achieving synchronized development with environmental construction. This represents another successful example of how eco-agriculture can increase productivity while improving the ecological environment, making it an integral part of ecological civilization construction. It also demonstrates the practical application of Prof. Ma Shijun's concept of "applying principles of species symbiosis and matter cycling in ecosystems, combined with optimization methods of systems engineering, to design multi-level, hierarchical systems for material utilization" [1].

3. Eco-Agriculture Construction as an Important Component of Ecological Civilization

Comrade Xi Jinping's concept that "protecting the environment means protecting productivity, and improving the ecological environment means developing productivity" is profoundly important. China's ecological assets—including mountains, water, and vegetation—have suffered tremendous damage due to agricultural over-cultivation, over-grazing, and improper land use. Simply implementing "returning farmland to forest and grassland," "land greening," or "low-carbon emission reduction" cannot fundamentally resolve these issues, as these measures only allow damaged vegetation to slowly undergo community succession through fallow periods. Effective productivity development requires thorough ecological environment improvement.

Artificial intelligence approaches are needed to create mutually adaptive relationships between organisms and their environment and to leverage ecosystem self-organizing functions, thereby enabling stable and sustainable agricultural development while fundamentally protecting, restoring, and reconstructing the

environment. The examples above confirm that eco-agriculture can harmoniously combine economic and ecological benefits, integrating biomass increase, transformation, and maintenance with ecological environment improvement to unify economic and ecological outcomes. Thus, eco-agriculture construction represents an important pathway to achieving agricultural modernization in China, embodies the basic national policy of resource conservation and environmental protection in agricultural production, stimulates agricultural development potential while synchronizing environmental construction, and constitutes a vital component of contemporary ecological civilization.

The foundation of ecological civilization construction is respecting, accommodating, and protecting nature—principles that align perfectly with eco-engineering. Respecting nature means fully respecting the wisdom of ecosystems' self-maintenance, self-succession, and self-organization. Accommodating nature means understanding and utilizing ecosystem structure and function rather than blindly transforming or destroying ecosystems. Only through such approaches can designed ecosystems truly achieve the goal of protecting nature. We believe that eco-agriculture based on eco-engineering will play an irreplaceable role in national ecological civilization construction while also positively contributing to poverty alleviation in rural areas.

4. Recommendations for Accelerating Eco-Agriculture Construction

1. **Popularize eco-engineering concepts and methods.** We recommend actively conducting training and establishing relevant courses to systematically popularize knowledge and practical cases of ecology, agroecology, eco-economics, and systems engineering among all citizens. Government decision-makers, young agricultural entrepreneurs, agricultural college students, and village officials should particularly study ecological knowledge to avoid simplistic approaches that substitute partial construction for comprehensive development.
2. **Publish and republish relevant books.** Some works, though published decades ago, remain valuable for republication because their fundamental concepts and principles remain valid. Examples include academician Ma Shijun's works on eco-engineering and academician Qian Xuesen's works on systems engineering.
3. **Strengthen research on eco-agricultural engineering technology systems.** This includes developing qualitative and quantitative indicator systems and exploring liability compensation systems for damaged ecological assets.
4. **Conduct academic activities** to discuss development strategies and intelligent construction methods for agricultural eco-engineering under new development, ecological construction, and economic normalcy requirements, and how to integrate agricultural eco-engineering construction into

the ecological civilization system. Particularly in the era of e-commerce and the Internet, we must explore how to leverage these tools to accelerate eco-agriculture construction. Recent discussions should focus on themes like "Moving Toward a New Era of Ecological Civilization" [8] to promote eco-agriculture and ecological civilization construction across all fields.

5. **Expand ecology, systems engineering, and agroecology courses** in universities and research institutions, and increase graduate enrollment quotas.

On the 36th anniversary of Prof. Ma Shijun's eco-engineering concept and the 30th anniversary of Prof. Qian Xuesen's proposal of the sixth industrial revolution and his systems engineering approach to planning agriculture, animal husbandry, grassland, sand industry, and marine industries, we have finally awakened to the value of their ideas in today's journey toward a new era of ecological civilization. Though decades late, it may not be too late. At a commemorative meeting for the 30th anniversary of Qian Xuesen's sixth industrial revolution theory, his son Qian Yonggang shared an anecdote: Qian's grandson once said, "Grandpa, you are truly great!" The elder Qian replied, "If what I did 50 years ago was great, my role in the 21st century will be even greater" [9]. Only now do we comprehend the remarkable scientific foresight of these great scientists, who provided comprehensive guidance on scientific concepts, strategic directions, and systems engineering techniques for synchronized agricultural production and environmental development. The time has come for their ideas to play an even greater role. Continuing their unfinished scientific dreams would be both important and fortunate.

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Note: Figure translations are in progress. See original paper for figures.