China Council for International Cooperation on Environment and Development (CCICED)

Reshaping Land Use toward synergy among biodiversity, climate change, food, and water, etc.

CCICED Special Policy Scoping Study Report

CCICED

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Executive Summary

Currently, the world is facing significant risks due to human activities， and these risks, in turn, threaten the stability and development of human society. Issues such as climate change, biodiversity loss, water, and food security are all directly linked to land use. However, the transformation of land use is not merely a land planning problem; it involves fundamentally changing the development model. Different economic activities require different land use approaches, and these diverse land use practices have varying impacts on the natural environment.

China's ecological civilization construction provides the fundamental direction and assurance for green transformation. To address challenges related to land use, biodiversity loss, climate change, food security, and environmental pollution, it is imperative to move beyond traditional industrialization thinking and cultivate a development paradigm shift. Only by transforming the conflicting relationships inherent in the traditional industrialization model into mutually reinforcing connections under ecological civilization, can we pave the way for a sustainable future.

This study, guided by the principles of ecological civilization, identifies the key issues in achieving synergy between China's land use transformation and the Kunming-Montreal Global Biodiversity Framework, "dual-carbon" goals, water security, and food security. It evaluates the current research status and policy progress both domestically and internationally, sheds light on existing research and policy shortcomings, and proposes new policy approaches to guide the Special Policy Studies (SPS).

Topic 1: Pursuing development from the height of harmonious coexistence between humans and nature

Solving environmental and developmental challenges requires adopting a development approach rooted in "harmonious coexistence between humans and nature" (as stated in the Report of the 20th National Congress of the Communist Party of China). This entails a profound transformation of the development paradigm.

Key land use actualities and issues: China's rapid economic development driven by industrialization, urbanization, and agricultural modernization has had a significant impact on land use changes. There has been an overall decrease in arable land and grassland resources, and a rapid expansion of construction land. Due to recent years' restoration efforts, an increase in forest and wetland areas have been achieved. While desertification has decreased, the threat of desertification and degradation remains.

Future research focus: To achieve harmonious coexistence between humans and nature, it is crucial to study the specific mechanisms behind the transformation of development paradigms since the Industrial Revolution. This includes investigating major theoretical issues related to development paradigm shifts, the impact of the transformation of traditional industrialization and urbanization on land use, the consequences of green agricultural transformation on land use, and the effects of development mode shifts on economic and geographical patterns.

Topic 2: The Green Transition of agriculture

With only 9% of the world's arable land and 6 % of the world's freshwater resources, China has to feed 18% of the world's population, putting enormous pressure on agricultural production. Over the past four decades, China has made great achievements in agriculture. However, it faces significant challenges in the form of agricultural non-point source pollution and ecological environmental issues, necessitating a new Green Revolution. Current research often focuses on mitigating environmental issues caused by agricultural development through green technological innovations while preserving the content of agricultural modernization based on traditional industrialization models. However, true resolution of the conflicts between agricultural development and environmental protection requires a transformation of agricultural production content.

Fundamental Policy Approach: Firstly, adopting a broader perspective of harmonious coexistence between humans and nature to re-evaluate the green agricultural development system. Secondly, reassessing the costs and benefits (including non-monetary aspects) of agricultural development under environmental and health objectives. Thirdly, optimizing and adjusting agricultural support policies to facilitate the transition of agricultural production content toward green and healthy agricultural products and ecological services. Fourthly, establishing a system for agricultural technological innovation and promotion.

Future Research Directions: Firstly, conducting a comprehensive assessment of the costs and benefits of China’s agricultural development under environmental and health objectives, revealing the advantages of China’s agricultural green transformation. Secondly, analyzing the impacts of different agricultural policies on aspects such as agricultural output, health, resources, environment, greenhouse gas emissions, and biodiversity. Thirdly, embarking on research into China’s green agricultural innovation system, aiming to overcome the constraints of green technologies and facilitate the green transformation of chemical-based agricultural production methods.

Topic 3: Pursuing food security in the context of ecological security

Current research on food security predominantly revolves around increasing supply to balance the food market, with limited consideration of the underlying mechanisms driving changes in Chinese food demand and its impact on human welfare, including food security, health, climate change mitigation, and environmental protection. Although there have been numerous studies on food demand from a nutrition perspective, in-depth analysis of the root causes for the deviation between China's actual per capita food demand and health requirements remains lacking.

Fundamental Policy Approach: If the sole focus remains on continually increasing supply to meet market demands for food security under the traditional definition, achieving genuine food security becomes challenging and could potentially exacerbate health and environmental issues. Only by aligning food demand with its inherent health requirements and embodying a people-centred development philosophy can the food system promote the synergistic attainment of food security, ecological security, and health objectives.

Future Research Directions: Firstly, conducting research to look into dual-win dietary models for health and the environment. Secondly, conducting cost and benefit assessments of grain consumption demands. Thirdly, undertaking research on China’s food security policies aligned with health and environmental goals of improving the quality of water, air and soil.

Topic 4: National Spatial Governance and Policies

China has a large population, but the per capita availability of key resources such as land, energy, and minerals is significantly lower than the global average. Additionally, suitable space for production and habitation is limited and unevenly distributed. Prior to the 18th National Congress, various departments in China had numerous types of planning systems that were disjointed, and various types of spatial constraint plans were ineffective. After the 18th National Congress, in the context of comprehensively promoting the concept of ecological civilization, a unified spatial planning system was established. This system focuses on spatial governance and optimizing spatial structure. It forms a national unified, interconnected, and hierarchically managed spatial planning system. China's spatial planning system is unique worldwide and might hold important lessons for other countries. It is extremely relevant for operationalizing the Paris Agreement, and the Kunming-Montreal Gloabal Biodiversity Framework globally, especially for Target 1[1].

Fundamental Policy Approach: To seek systematic and synergistic solutions from a more comprehensive perspective under the guidance of ecological civilization philosophy, national spatial planning could play a significant role at the highest level. By elevating planning expertise and aligning planning standards, optimizing resource allocation, exploring innovative approaches to arable land management and safeguarding the ecological environment, the inter-conflicting relationships between “land use-food-ecological environment” within the traditional industrialization model can potentially be transformed into mutually reinforcing connections.

Future Research Directions: Firstly, harmonizing the relationships between ecological security, food security, and water resource security. Secondly, gaining a thorough understanding of regional resource endowment, environmental context, and socio-economic characteristics, and devise differentiated land use strategies. Thirdly, while strictly adhering to safety bottom lines, fully considering and balancing the

[1] TARGET 1: Ensure that all areas are under participatory integrated biodiversity inclusive spatial planning and/or effective management processes addressing land and sea use change, to bring the loss of areas of high biodiversity importance, including ecosystems of high ecological integrity, close to zero by 2030, while respecting the rights of indigenous peoples and local communities.

interests of stakeholders through policy means. Fourthly, based on the latest dietary guidelines and future population trends, re-evaluating China's food supply and the demand for agricultural land.

Topic 5: Weighing land use through the valuation of natural capital and ecosystem services

The capital provided by nature and the services of ecosystems constitute the foundation for human society and economic development. At present, the evaluation and planning of land use primarily focuses on the economic and social aspects, lacking sufficient integration of the values and benefits provided by natural capital and ecosystem services. Therefore, by utilizing or developing consistent and applicable methods of natural capital accounting and ecosystem service assessment, decision-makers can gain a better understanding of the current and long-term impacts of their choices in land use on the environment, society, and economy.

Fundamental Policy Approach: Firstly, analyzing the essence of collaboration and enhancing model research on multi-objective collaboration. Secondly, employing information technology to predict and showcase the long-term， cross-regional and cross-sectoral effects of land use decisions, thus enhancing decision quality. Thirdly, strengthening the transition toward nature-positive within key industrial sectors' green development.

Future Research Directions: Firstly, studying how to fully consider the preservation and appreciation of natural assets and the stability and sustained supply of ecosystem services in land use planning and management decisions. Secondly, researching the utilization of natural capital accounting and ecosystem service assessment as a basis for land use decisions in the process of sectoral transition to nature positive. Thirdly, developing a nature-positive model and specific measurable indicators applicable at various scales to promote the synergistic effects among multiple environmental goals.

Key words: Green Transformation, Land Use, Biodiversity, Food Security, Health, Synergies, Nature Positive Economy

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I Foreword

Currently, the world is facing significant risks resulting from human activities. These risks, in turn, threaten the stability and development of human society. The “Global Risks Report 2023” released by the World Economic Forum in January 2023 highlights five risks: the failure to mitigate and adapt to climate change, natural disasters and extreme weather events, biodiversity loss and ecosystem collapse, and environmental damage incidents, making it the fourth consecutive year they have been ranked among the top 10 global risks since 2020. Biodiversity loss is particularly considered one of the most rapidly deteriorating global risks for the next decade. Climate change and biodiversity loss directly threaten global food security.

Issues such as climate change, biodiversity loss, and water and food security are directly related to land use. As for terrestrial and freshwater ecosystems, changes in land use have been the most significant direct drivers for biodiversity loss since 1970[1]. “Land is both a source and a sink of greenhouse gases (GHGs) and plays a critical role in the exchange of energy, water, and aerosols between the Earth's surface and the atmosphere.” “If emissions associated with upstream and downstream production activities of the global food system are included, the emissions from the (food system) account for 21-37% of the net anthropogenic GHG emissions,” and “sustainable land management helps reduce various pressures on ecosystems and societies, including climate change.”[2] As the world accelerating energy transition, it’s easily neglected that solar panels and wind tribunes will need a lot of land. Utility-scale solar and wind farms require at least ten times as much space per unit of power as coal fired power plants, including the land used to produce and transport the fossil fuels. [52]

The transformation of land use practices to address issues such as biodiversity loss, climate change, and food security has become a major and urgent topic. However, the transformation of land use is not merely a significant land planning issue; it is fundamentally a question of transforming development patterns. Traditional industrialization models, centred around large-scale production and consumption of material wealth, are based on a foundation of “high carbon emissions, high ecological damage, and high resource consumption,” leading to inherent conflicts between the environment and development.

Land use serves as the primary locus of interaction between human economic activities and the natural world. Different economic activities require different land use practices, which in turn have varying impacts on nature. In China, the past changes in land use and their ecological and environmental consequences are largely products of the traditional industrialization model. The traditional industrialization model views development as a process of industrialization, urbanization, and agricultural “modernization,” leading to land use practices and their consequences under the industrialization model.

Land use function change due to extraction of natural resources, and releasing waste back into the environment were types of consequences closely associated with rapid industrialization and development-centric model. This process inevitably brings about significant pollution, resulting in the loss of land functionality and environmental and biodiversity destruction. Urbanization has been a key driver of China’s rapid economic growth over the past four decades. China’s urbanization rate[1] increased from 17.9% in 1978 to 65.22% in 2022, leading to changes in living and consumption patterns of residents, as well as in significant changes in land use. The "National New-Type Urbanization Plan (2014-2020)" states, “Land urbanization has outpaced population urbanization, and extensive and inefficient land use for construction is a prominent contradiction and problem that must be addressed in the rapid development of urbanization in our country.” Additionally, agriculture has shifted from primarily producing plant-based food to animal-based products such as meat, eggs, and dairy, which directly and indirectly (through feed production) increases the demand for agricultural land. In terms of agricultural production methods, traditional diverse ecological farming practices have been replaced by monoculture and chemical agriculture with long-term risks such as the negative effect on soil productivity due to pollution and increased vulnerability regarding crop disease and climate change.

Under the driving force of the traditional industrialization model, land use practices continue to change. On the one hand, in addition to land for industrialization and urbanization, the demand for agricultural land also continuously increases. For instance, globally, 77% of agricultural land is directly or indirectly used for animal-based product production. On the other hand, this has also brought about numerous environmental and resource issues, including greenhouse gas emissions, ecological destruction, environmental pollution, and resource consumption.

If the transition to green development from traditional industrialization is not made, changing the land use efficiency alone cannot fundamentally solve the issues. Biodiversity loss and climate change are clear examples. On December 19, 2022, under the presidency of China, 196 parties adopted the “Kunming-Montreal Global Biodiversity Framework,” a landmark for global biodiversity conservation. However, making the ambitious goals proposed in this framework self-enforcing presents a significant challenge. The failure to achieve the “Aichi Biodiversity Targets” is

[1] The National Bureau of Statistics (NBS) reflects the urbanisation rate mainly in terms of the urbanisation rate of the resident population, which refers to "the proportion of the resident population in the urban territory of a region to the total resident population of the region, reflecting the urban-rural distribution of the resident population." Refer to NBS website: http://www.stats.gov.cn/zs/tjws/tjzb/202301/t20230101_1903783.html

fundamentally due to seeking biodiversity protection within the framework of traditional industrialization, which ironically contributed to biodiversity destruction.

Therefore, the effective realization of biodiversity conservation goals relies on transforming the traditional development model, shifting the relationship between development and conservation from a trade-off to a synergy, and creating an environment where they are mutually reinforcing. Numerous studies demonstrate that environmental protection presents substantial economic opportunities.[3-5] According to the World Economic Forum's New Nature Economy Report series (2020),[5]15 nature-positive transitions add up to $10.1 trillion in annual business value and could create 395 million green jobs by 2030.

China's ecological civilization construction provides a fundamental direction and assurance for green transformation. The 20th National Congress of the Communist Party of China regards Chinese-style modernization as its central task. The fundamental and strategic position of ecological civilization is reflected in the essential characteristics, nature, and goals of the Chinese path to modernization. China's "14th Five-Year Plan" and China Vision 2035 have also outlined specific plans for the construction of ecological civilization. The 15 nature-positive transitions outlined in the World Economic Forum's New Nature Economy Report series reveal the enormous economic opportunities that environmental protection could bring to China.

Therefore, reshaping land use to address biodiversity loss, climate change, food security, environmental pollution, and other issues must transcend the traditional industrialization mindset. Through paradigm shifts in development, the conflicting relationships among these goals under the traditional industrialization model can transform into mutual reinforcement under the framework of ecological civilization, ultimately forming a nature-positive economy.

In this scoping study, under the requirements of ecological civilization, the main problems in transforming China's land use practices to achieve biodiversity targets, "dual carbon" goals, water security, and food security goals were identified. The domestic and international research status and policy progress regarding these issues were evaluated, exposing existing shortcomings, and innovative policy research directions were proposed, laying the groundwork for subsequent Special Policy Studies (SPS) to identify innovative policy approaches. Specifically, it reveals how to use changes in land use as the main thread to transform the traditional industrialization model into a nature-positive economy, establishing a synergistic relationship between land use, biodiversity conservation, climate change, food security, and water security.

This project primarily investigates five key topics, each of which includes the following four main components:

- Firstly, identifying problems. Identifying significant issues in these five areas.

- Secondly, analyzing problems. Analyzing the identified key issues, evaluating the governance structure, policy, and research status to reveal the key, challenging aspects, and reasons behind these issues.

- Thirdly, solving problems. Building on the previous analysis, providing conceptual policy recommendations for these issues.

- Lastly, based on this foundation, proposing ideas for the focus of future five-year Special Policy Studies (SPS).

II Topic Study

2.1. Pursuing Development From the Height of Harmonious Coexistence Between Humans and Nature

Research Question: Thinking beyond the traditional industrial civilization, under the concept of ecological civilization, research how to promote a paradigm shift in development and establish a mutually reinforcing relationship between ecological environment protection and economic development. To address environmental and developmental challenges, it is necessary to "plan development from the perspective of harmonious coexistence between humanity and nature" (Report of the 20th National Congress of the Communist Party of China) and fundamentally transform the development approach. Therefore, it is essential to comprehensively incorporate international conventions such as the "Kunming-Montreal Global Biodiversity Framework" and the "Paris Agreement", as well as sustainable development goals, into the overall layout of ecological civilization construction, to promote a modernization characterized by harmonious coexistence between humanity and nature.

2.1.1 Rethinking Modernization

The 20th National Congress of the Communist Party of China sets the central task of the party in the new era as "uniting and leading the people of all ethnic groups in the country to comprehensively in building a strong modern socialist country, realize the second centenary goal, and promote the great rejuvenation of the Chinese nation through the Chinese path to modernization." The development of the Chinese path to modernization, guided by a harmonious coexistence between humanity and nature, breaks away from the unsustainable modernization model rooted in anthropocentrism established after the industrial revolution. It represents a redefinition of the unsustainable concept of modernization that emerged post the industrial revolution [6].

Following the Industrial Revolution, social productivity made unprecedented advancements, and a few industrialized nations led the way in achieving what is commonly referred to as modernization. The prevailing global conception of modernization largely equates it with adopting the standards of developed countries as the default norm. If we divide modernization into two dimensions – "What kind of modernization to achieve" (What) and "How to achieve modernization" (How) – the modernization endeavors of developing nations have primarily focused on emulating the developmental path of developed countries. However, there has been relatively limited reflection on the actual substance of modernization.

Undoubtedly, following the Industrial Revolution, developed countries established a modernization model rooted in traditional industrial civilization, significantly propelling the progress of human civilization. China, too, has been among the greatest beneficiaries of this modernization concept. However, this form of modernization based on the traditional industrialization model possesses inherent limitations: firstly, it struggles to avoid the divergence between developmental goals and means; secondly, as it relies on high resource consumption and environmental degradation, it inevitably leads to unsustainable ecological environments; thirdly, due to the high resource and environmental costs associated with this model that in turn affects the long-term productivity of the traditional modernization development model, it allows only a minority of the global population to enjoy a modern lifestyle, and expanding it further could lead to a global sustainability crisis.

Therefore, merely considering “how to achieve modernization” is insufficient; a deeper reflection and redefinition of “what kind of modernization to achieve” is necessary, establishing a forward-looking and globally applicable discourse on the Chinese path to modernization. This modernization fundamentally involves profound reflection and reconstruction of the modernization concept formed after the Industrial Revolution [7].

2.1.2 Changes and Existing Issues in China's Land Use

The industrialization, urbanization, and modernization of agriculture have brought about rapid economic development in China, but concurrently, they have exerted significant impacts on land use patterns. Land use includes arable land, construction land, and unused land, categorized into 12 primary classes and 73 secondary classes (GB/T 21010-2017). According to data from the Third National Land Survey (referred to as the "Third Survey") (Figure 6.2.1), the respective areas of these three types of land in China are as follows: China’s arable land area reaches 101.72 billion mu, accounting for 70.64% of the total land area, making it the dominant land use type. The area of unused land is 3.614 billion mu, constituting 25.10% of the total land area. Among these, areas such as saline-alkali land, sandy land, bare land, and rocky gravel land account for 2.512 billion mu. Construction land covers an area of 613 million mu, representing a mere 4.26% of the total land area. This signifies that Nature-Based Solutions (NBS) hold significant potential as nature-centred approaches, as discussed in detail below:

(1) Farmland resources. The overall quantity of farmland resources has declined. This change is largely influenced by agricultural structural adjustments and land greening initiatives, all the while strictly adhering to a balanced approach when non-agricultural construction occupies farmland. The substantial production of animal-based and processed food products in the agri-food industry directly or indirectly increases the demand for land for such products, leading to the conversion of farmland into grasslands and orchards. According to the data from the “Third Survey,” the area of farmland (1.918 billion mu) decreased by 113 million over a decade relative to the “Second Survey.” Meanwhile, over 87 million mu (58 billion square meters) of

agricultural land can be restored to farmland, and 166 million mu (about 111 billion square meters) of agricultural land can be reclaimed through engineering measures during the same period. Under the strictest ecological and environmental protection regime, around 12 million mu (8 billion square meters) of farmland have been converted into ecological land such as forests and wetlands. The conversion between farmland and other land use not only impacts the security and quality of farmland but also directly or indirectly gives rise to issues of food insecurity, climate change, and biodiversity loss, among other unsustainable crises.

(2) Grassland resources. The overall quantity of grassland resources has declined. This change is also influenced by agricultural production structural adjustments and land greening initiatives. The extensive production of animal-based food products in agriculture has led to a sharp increase in livestock and poultry farming, resulting in overgrazing on limited grassland. The average livestock overload rate on key natural grasslands in China exceeds 10% [8]. Simultaneously, numerous grasslands have been converted into forests to increase cultivated land area and enhance the capacity of natural ecosystems. The conversion of grasslands to other land types has damaged natural grassland vegetation and soil structure, leading to grassland salinization and desertification due to natural activities like surface wind erosion. According to the "Third Survey" data, China's grassland area is 3.968 billion mu, ranking second in the world, but it has still decreased by 342 million mu (228 billion square meters) compared to the Second National Land Survey ("Second Survey").

(3) Forest land and wetland. The overall area of forest land and wetlands shows an increasing trend, mainly driven by government policies. According to data from the "Third Survey," the forest land area in China is 4.262 billion mu, increasing by 453 million mu (302 billion square meters) compared to the "Second Survey," with a growth rate of 11.88%. This contributes a quarter of the world's newly added forest area. China's wetland area is 352 million mu, ranking first in Asia, including 42 types of wetlands classified under the Convention on Wetlands. The expansion of forest and wetland ecological land relies largely on government policy support, essentially forming a national forest (wetland) policy pathway. For example, in forest land, there have been projects such as natural forest protection and restoration, national forest reserve construction, and conversion of marginal farmland to forest and grassland. In wetlands, projects such as conversion of marginal farmland to wetland, cessation of fishing to restore wetlands, and wetland water replenishment have been implemented, establishing a wetland conservation system primarily centred around national parks, natural wetland reserves, and wetland parks.

(4) Construction land. There has been rapid expansion in the total area of construction land, resulting not only in significant reductions in other land types but also in the problems of idle and inefficient use of a large amount of construction land. The results from the "Third Survey" indicate that the total area of construction land in China is 613 million mu (about 409 billion square meters), an increase of 128 million mu (about 85 billion square meters) compared to the "Second Survey," with a growth rate of 26.5%. This implies that a substantial amount of natural land, including farmland,

forest land, and grassland, has been converted into construction land. The latest research conducted by the research group led by Gong Peng from the Department of Earth System Science at Tsinghua University shows that urban built-up areas in China occupy approximately 14.755 million hectares of natural land, with farmland accounting for 80%, forest land conversion accounting for 8.1%, and grassland conversion accounting for 6.6%. Additionally, China’s construction land faces issues of underutilization and inefficiency, with low levels of resource conservation and intensification. By 2017, China’s per capita urban built-up area reached 152 square metres, surpassing Japan’s per capita of 135 square metres[9]. The scale of village land in the country reaches 329 million mu, with idle land in rural residential areas accounting for around 10% to 15%.

(5) Desertification and land degradation. The area of desertification and land degradation has continuously decreased, yet the primary trends of desertification and land degradation remain persistent. According to data from the Sixth National Desertification and Land Degradation Investigation, as of 2019, the area of desertification and land degradation reached 42.615 million hectares, accounting for 44.4% of the total land area. However, compared to 2014, there was a net reduction of 7.1232 million hectares in the area of desertification and land degradation over 5 years, indicating significant achievements in China's desertification control efforts. Nevertheless, the primary trends of desertification and land degradation have not weakened. For instance, extensive livestock farming has led to overgrazing, resulting in the degradation of natural grassland vegetation and causing grassland desertification. Intensive and exploitative utilization of farmland has led to soil quality degradation, fostering farmland desertification and land degradation. Conversion of forest land for other purposes, including cultivation, also poses risks of desertification and land degradation. The areas with evident trends of desertification include grassland, farmland, and forest land, totaling 26.894 million hectares. Hence, if the land use problems contributing to desertification and land degradation are not addressed, the expansion of desertification and sandy land areas will continue in arid and low-rainfall climates.

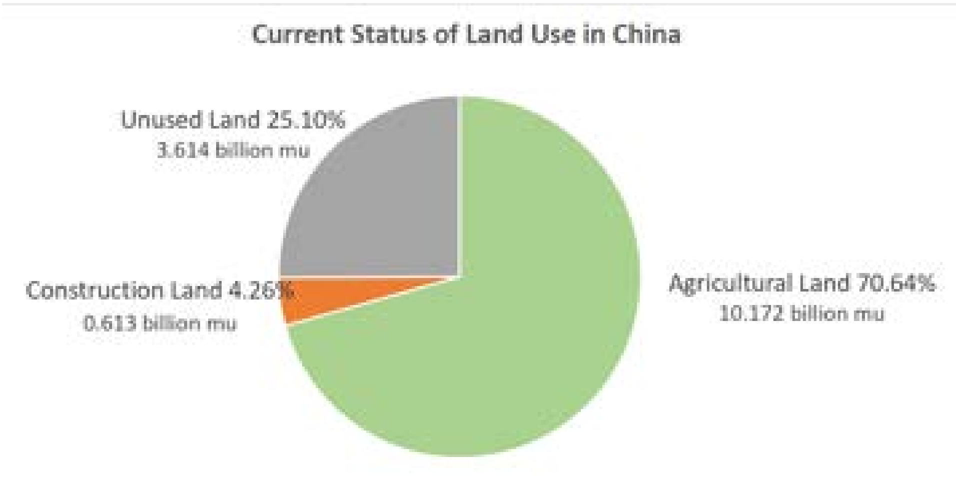


Figure 6.2.1: Current Status of Land Use in China

Data source: Compiled by the author based on the results of the Third National Land Survey.

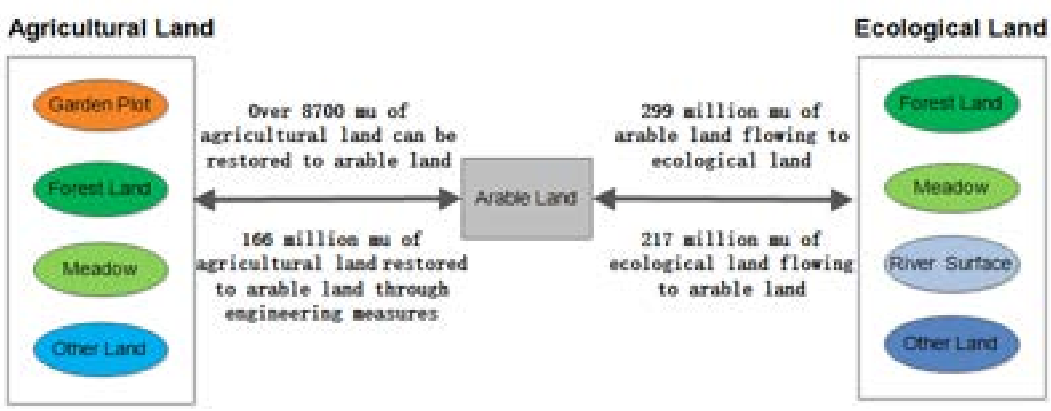


Figure 6.2.2: Conversion between Different Land Categories.
Data source: Compiled by the author based on the results of the Third National Land Survey.

2.1.3 Development in Harmony With Nature

The above-mentioned issues are not merely about land re-planning; they also signify a profound shift in the development paradigm. Only by strategically planning development in harmony with nature and fundamentally altering land utilization methods can we transform the conflicting relationships between biodiversity, food security, and environmental protection into mutually synergistic and even mutually reinforcing relationships.

Based on the ecological civilization, the Chinese path to modernization offers the possibility for this transformation. The fundamental and strategic position of ecological civilization in the Chinese path to modernization is reflected in what this kind of modernization is, how to build it, and its goals.

Firstly, it is reflected in “what the Chinese path to modernization is.” The modernization that China aims to achieve on its path includes "harmonious coexistence between humans and nature" as one of the five fundamental characteristics of Chinese-style modernization, as well as its essential requirement.[1] These five characteristics form an organic whole, and without harmonious coexistence between humans and nature, the foundation for the other aspects of characteristics would be lacking.

Second, it is reflected in “how to achieve the Chinese path to modernization.” The 19th National Congress Report of the Communist Party of China (CPC) pointed out that “achieving high-quality development is the Party's primary task in comprehensively building a socialist modernization country,” which requires the “comprehensive, accurate, and thorough implementation of the new development concept.” Green development is one of the core aspects of the new development

[1] The five fundamental characteristics of Chinese-style modernization are as follows: it is a modernization characterized by a large population scale; it is a modernization where the entire population achieves shared prosperity; it is a modernization that harmonizes material and spiritual civilization; it is a modernization of harmonious coexistence between humans and nature; and it is a modernization pursued through the path of peaceful development.

concept. At the same time, within the Party's "Five Essential Goals" that "must be firmly upheld," implementing the new development concept is "an essential path for the growth of our country in the new era."

Third, it is embodied in the "Goals of the Chinese path to Modernization." The 19th National Congress Report of the Communist Party of China clearly lays out a strategic arrangement for the comprehensive construction of a prosperous socialist modernized country in two stages: from 2020 to 2035, the basic realization of socialist modernization; from 2035 to the middle of the century, building China into a prosperous, strong, democratic, culturally advanced, and harmonious socialist modernized country. Among these, "Beautiful China" is one of the five major goals of a modernized strong nation.

The 20th National Congress of the CPC has laid out a new strategic deployment for ecological civilization construction, fully opening a new chapter in ecological civilization construction. At the strategic level, the Chinese-style modernization is the central task proposed in the Party Congress report for China's future. The essential characteristics, intrinsic requirements, and objectives of Chinese-style modernization will be comprehensively embodied in China's economic and social development strategies and actions. Among these, the ecological civilization construction of "harmonious coexistence between humans and nature" will be fully integrated into all aspects of work.

The 20th National Congress Report of the Communist Party of China dedicates its 10th section specifically to the theme of "Promoting Green Development and Achieving Harmonious Coexistence Between Humans and Nature," emphasizing the importance of ecological civilization construction and making corresponding strategic arrangements. In this section, General Secretary Xi Jinping emphasizes the significance of ecological civilization construction, stating that "nature is the fundamental basis for human survival and development. Respecting, conforming to, and protecting nature are inherent requirements for comprehensively building a socialist modernized country. We must firmly establish and implement the concept that lucid waters and lush mountains are invaluable assets and put planning for development in the perspective of promoting harmony between humans and nature." [10]

In conclusion, the Chinese-style modernization is a rethinking and redefinition of the modernization model established after the Industrial Revolution. Among these, the modernization characterized by harmonious coexistence between humans and nature serves as the foundation for Chinese-style modernization. The transformation of the modernization model implies changes in both development content and methods. Correspondingly, the land use patterns formed under the traditional industrialization model must also undergo profound transformation. This transformation will establish a synergistic relationship between land utilization, biodiversity protection, climate change, food, water, and other objectives.

2.1.4 Future Key Research Directions

Planning development from a perspective of harmonious coexistence between humanity and nature essentially signifies a profound transformation of the development concepts and paradigms formed after the Industrial Revolution. When the traditional industrialization model needs to undergo transformation due to its unsustainability, the underlying development theories, industrialization patterns, urbanization models, agricultural modernization models, infrastructure, and more, all require changes. These changes will be reflected in the transformation of land use patterns and their consequences. Therefore, it is necessary to study the specific mechanisms behind these transformations.

Firstly, there are major theoretical issues. The profound transformation of development paradigms involves a reconsideration of fundamental development questions, including why development is pursued, what content should be developed, how to achieve development, and the global applicability of development models.

Secondly, there's the transformation of the traditional industrialization model and its impact on land use. Disrupt specific mechanisms that are causing ecological environment degradation through transformations in land use patterns.

Thirdly, there's the transformation of the traditional urbanization model and its impact on land use. Changes in urbanization methods and their associated content have implications for the ecological environment.

Fourthly, there's the transformation of green agriculture and its impact on land use. The current "modernization" of agriculture in various countries largely occurs within the framework of traditional industrialization thinking, encompassing both the content and methods of agricultural production. Changes in development methods imply transformations in the content and methods of agricultural modernization, thereby leading to different interpretations of land use.

Fifthly, there's the impact of changes in development methods on the economic geographical pattern. Different development models carry different spatial implications. For instance, the “30x30” goals of the “Kunming-Montreal Global Biodiversity Framework” hold distinct meanings under traditional industrialization and green development models, respectively.

2.2 The Green Transformation in Agriculture

The Green Revolution that emerged in the mid-20th century greatly boosted agricultural productivity and led to significant transformations in the content and methods of agricultural supply and production. However, simultaneously, monoculture farming, chemical-intensive agriculture, and industrialized agriculture have posed substantial challenges to agricultural biodiversity. The widespread use of fertilizers and pesticides has led to severe agricultural non-point source pollution, making agriculture a significant carbon source. Globally, carbon emissions from agriculture, forestry, and land use account for nearly 20% of the total. Therefore, China's agriculture urgently requires an upgraded version of the Green Revolution to effectively address issues such as food security, increased income for farmers, and ecological environmental protection.

2.2.1 The Urgency of China’s Agricultural Green Transformation

Over the past four decades of reform and opening up, China’s agriculture has achieved remarkable accomplishments. The Per capita grain output has reached 486 kilograms (the international safety line is 400 kilograms), and the per capita disposable income of rural residents has exceeded 10,000 yuan. However, due to the development of industrialized and chemical-intensive agriculture, which is based on high resource consumption and severe environmental degradation, there are sustainability issues arising from the excessive use of arable land and water resources, heavy reliance on fertilizers and pesticides, resulting in land degradation, environmental (water, air, and soil) pollution, climate change, and loss of biodiversity. The unsustainability of industrialized agriculture poses a severe challenge to the development of agriculture in China.

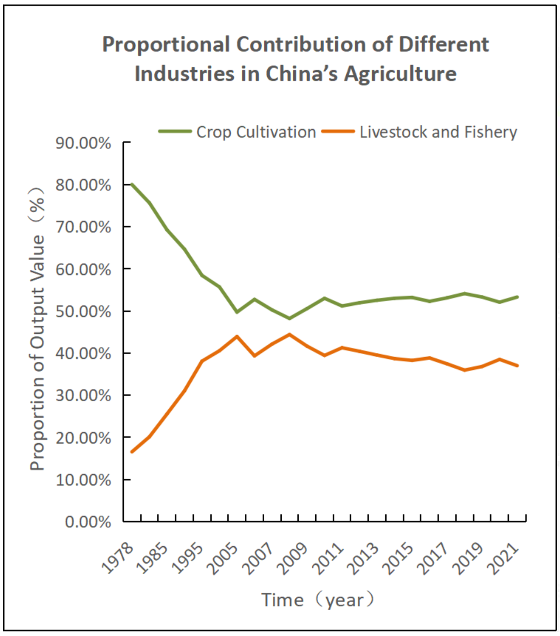
Industrialized agriculture and its consequences largely stem from the traditional industrialization model's transformation of agriculture into "modernization." This transition involves a shift in agricultural production content (what) from plant-based to animal-based products and a change in agricultural production methods (how) from diverse ecological agriculture to single-focused industrial and chemical agriculture. [11] The proportion of agriculture in crop production continues to decline (Figure 6.2.3), accounting for only about half of the total agricultural output in 2021,[1] while livestock and fisheries have grown significantly, with their output in 2021 more than doubling that of 1978, reaching 37%. Consequently, the production of animal products such as meat, eggs, and milk has sharply increased (as shown in Figure 6.2.4), reaching a staggering 90.74 million tons in 2021, significantly surpassing other countries. Extensive production inevitably leads to extensive consumption (as depicted in Figure 6.2.5), with per capita meat consumption in China reaching 61.89 kilograms, surpassing the global average of 42.26 kilograms and approaching the United States’ level of 126.74 kilograms. This shift toward increased animal-based food consumption and reduced plant-based food consumption has caused a divergence from human health dietary requirements, ultimately leading to a rapid rise in the prevalence of “lifestyle diseases”. Currently, the proportion of overweight and obese adults in China has reached 50.7%, [12] leading to a death rate of 41 people per 100,000 (as shown in Figure

[1] The proportion of output value of plantation industry decreased from 80.0% in 1978 to 53.29% in 2021.

6.2.6). Moreover, China's per capita protein consumption rapidly increased from 1999 to 2019, going from far below the global average to surpassing the average of OECD countries and only slightly lower than the protein consumption of the highest-ranking countries such as the United States and France, nearly on par with Australia's, which ranks third. [13]

At the same time, the rapid growth of livestock and fisheries implies more consumption of feed grains and forage, driving land use change, increased consumption of agricultural inputs such as fertilizers and pesticides, and increased emissions of greenhouse gases like methane. For instance, the use of chemical fertilizers per unit of agricultural land in China grew nearly 17 times from 1961 to 2019 (as depicted in Figure 6.2.7), more than 2.7 times the global average level; pesticide use increased by 77.3% (as shown in Figure 6.2.8), surpassing the average growth rate of pesticide use of 50.8% worldwide. The excessive use of chemicals and pesticides results in severe non-point source pollution from agriculture. Due to the land consumption and greenhouse gas emissions of animal-based food production being much higher than that of plant-based products, extensive production of animal-based food leads to greater land resource consumption and greenhouse gas emissions, exacerbating chemical pollution and climate change, which in turn pose a significant threat to agricultural production and food security.

If China’s agricultural development were to converge toward the industrialized agriculture (chemical agriculture) based on the traditional industrialization model, it would undoubtedly result in significant harm to people’s health and the ecological system. This would deviate from the fundamental purpose of agricultural development. The fundamental purpose of agricultural development is to provide healthy agricultural products and ecological services to humanity. Therefore, a pressing need exists for China's agricultural development model to undergo transformation, returning to the fundamental purpose of agricultural development — its original intention — in order to promote food security, water security, human health, curb land degradation, reduce environmental pollution, address climate change, and safeguard biodiversity, thereby establishing a synergistic relationship among multiple objectives.



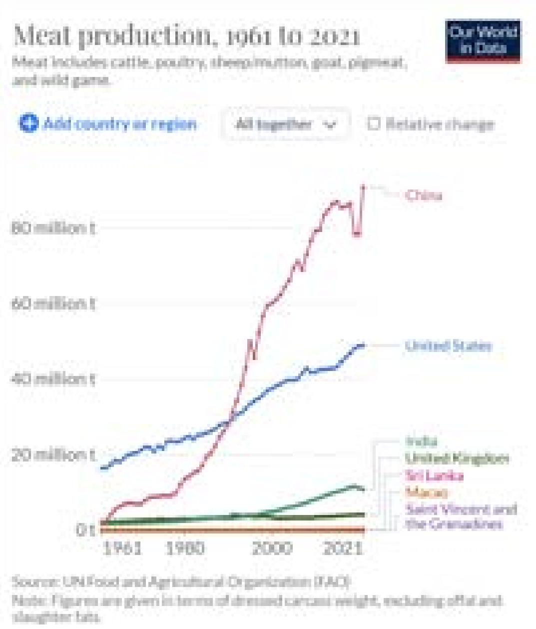


Figure 6.2.3: Proportional Distribution of Agricultural Output by Industry

Figure 6.2.4: Meat and dairy production in China

Data sources: Figure 3 was created by the author based on relevant research data.
Figure 4 is sourced from a relevant database (//https://ourworldindata.org/meat-production//)

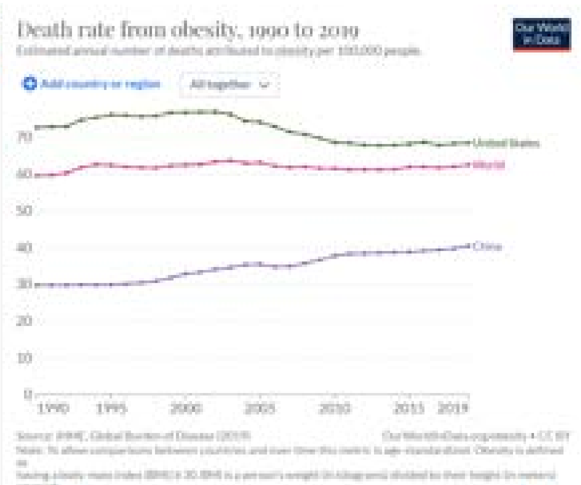


Figure 6.2.5: Per capita meat consumption in China

Figure 6.2.6: Obesity-Related Mortality Rate

Data sources: Figure 5 and Figure 6 are sourced from relevant databases (//https://ourworldindata.org/meat-production//, //https://ourworldindata.org/obesity//)

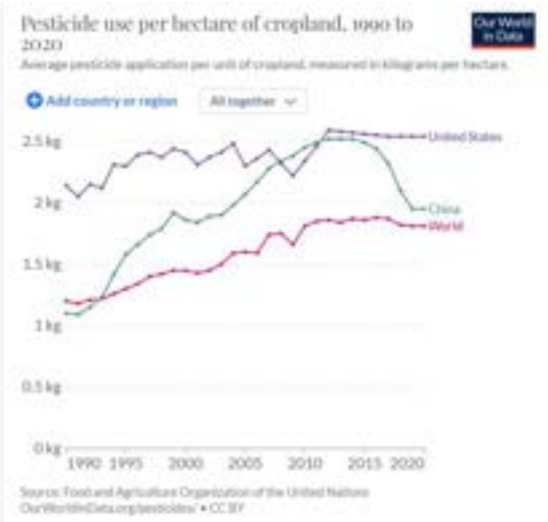


Figure 6.2.7: Agricultural Fertilizer Usage in China **Figure 6.2.8: Agricultural Pesticide Usage in China**

Data sources: //https://ourworldindata.org/pesticides//

2.2.1 Existing Issues and Prominent Issues in Practice

Agricultural Green Transformation: An Upgraded Version of the Agricultural Green Revolution of the 1960s (Agriculture 3.0 Era). FAO recommended agroecological approaches to conserve the basis for production, which includes 10 elements[1]. Existing literature on research related to agricultural green transformation primarily focuses on discussing the greening of agricultural production methods ("how"), with limited attention given to how agricultural development content ("what") can be transformed into environmentally friendly practices. In the literature concerning agricultural green development, whether it pertains to the meaning of agricultural green development, evaluation indicators, policy systems, or implementation mechanisms, the focus is predominantly on discussing how to mitigate environmental damage through improvements in agricultural production methods. For instance, the evaluation indicators system for agricultural green development places emphasis on aspects such as resource conservation, environmental friendliness, ecological conservation, quality, and efficiency. Green technological innovation is regarded as a pivotal means to achieve agricultural green development. For example, improving fertilizer and pesticide utilization through soil testing and disease-control techniques, reducing agricultural waste emissions through anaerobic digestion technology, and minimizing carbon emissions through carbon sequestration techniques. [14-15] This perspective predominantly treats agricultural green transformation as a production technology challenge, aspiring to resolve environmental issues resulting from agricultural development through green technological innovation without altering the essence of agricultural modernization based on the traditional industrialized model.

Regarding the key aspects of China's agricultural green development system and policy framework, there is also a greater emphasis on how to make agricultural

[1] FAO developed the 10 Elements of Agroecology framework to assist countries in fostering transformative change, including: Diversity, Co-creation and sharing of knowledge, Synergies, Efficiency, Recycling, Resilience, Human and social values, Culture and food traditions, Responsible governance, Circular and solidarity economy. Reference: https://www.fao.org/agroecology/overview/overview10elements/en/

production methods environmentally friendly in order to reduce the negative impact of agriculture on the environment. However, there is a lack of attention given to how agricultural development content should be transformed to achieve agricultural green development. For instance, the system of agricultural green development mainly focuses on negative lists for resource management, environmental monitoring, and industry access. The content of the agricultural green development policy framework primarily encompasses agricultural resource and environmental protection (e.g., Soil Pollution Prevention and Control Action Plan and Arable Land Quality Improvement Action Plan), subsidies for green agricultural inputs (such as subsidies for improved crop varieties), and the development of an agricultural green technology system. This includes the layout of agricultural production functional zones, the conservation and utilization of agricultural biological resources, and innovation in agricultural green technologies.

The Chinese government has consistently attached great importance to green agricultural development and has implemented a series of measures that have yielded significant results. For example, the implementation of actions for the utilization of agricultural waste resources has led to a comprehensive utilization rate of over 76% for livestock and poultry manure in 2021. After carrying out actions to reduce chemical fertilizer usage and promote the substitution of organic fertilizers for chemical ones, the total fertilizer application in 2021 decreased by 13.8% compared to 2015, with a fertilizer use efficiency exceeding 40%. Initiatives aimed at straw disposal and agricultural film recycling have resulted in a comprehensive straw utilization rate of 88.1% and an agricultural film recycling rate exceeding 88%. [16] However, China's practice of agricultural green development primarily focuses on reducing the negative impact of agricultural production on the environment. This approach addresses only the localized issues of industrialized agriculture (chemical agriculture) and does not fully address the other unsustainable problems caused by the agricultural system. For instance, issues such as biodiversity loss due to changes in land use and greenhouse gas emissions.

It is evident that if the focus remains solely on changing agricultural production methods without altering the underlying agricultural development content, it will not fundamentally resolve the conflicting relationship between agricultural development and environmental protection. In other words, it will not achieve the synergy between goals like transitioning land use, biodiversity conservation, addressing climate change, ensuring food security, and environmental protection. For example, while reducing greenhouse gas emissions from production stages through agricultural green inputs and the recycling of waste resources can be effective, it has limitations in addressing issues such as greenhouse gas emissions from changes in land use due to agricultural production and biodiversity loss, which are inherently unsustainable.

2.2.3 Approaches to Achieving Green Agricultural Transformation

The direction of agricultural green transformation is rooted in meeting the fundamental objective of providing healthy and nutritious food for people. Therefore, it is not only essential to emphasize the transformation of agricultural production methods but also to underscore the transformation of agricultural production content. In accordance with the principles of ecological civilization, agricultural production activities need to gradually shift from being carbon sources to becoming carbon sinks, reducing excessive production and consumption of animal products under traditional consumption patterns and increasing the production of plant-based meat and dairy substitutes. In terms of agricultural production methods, the shift is toward transitioning from chemical-intensive and monoculture farming to an agriculture that harnesses natural fertilizers and employs climate-smart technologies to cultivate crop diversity. This shift ensures the commercial vitality of the agricultural industry and promotes the development of diverse ecological agriculture. Agricultural green transformation changes the conflicting relationship between agricultural development and environmental protection into a mutually supportive one, thereby achieving a win-win situation for both economic and ecological benefits. [11]

The fundamental approaches to achieving green agricultural transformation are as follows:

Firstly, it is essential to adopt a broader perspective of harmonious coexistence between humans and nature, re-examining the content of the agricultural green development system. This includes exploring the essence of agricultural green development, evaluation frameworks, policies, and implementation mechanisms, all aimed at fostering a mutually reinforcing relationship between agricultural development and environmental protection. This approach involves demonstrating and promoting regenerative agriculture that ensures high and stable yields, thereby achieving synergies across multiple goals such as health, biodiversity conservation, carbon neutrality, and food security.

Secondly, there's a need to re-evaluate the costs and benefits of agricultural development, encompassing both non-monetary and monetary aspects. Drawing inspiration from international carbon-labelling systems, it is important to establish a comprehensive mechanism reflecting the carbon, water, and resource intensities of different food products. This approach aims to internalize the social costs of agricultural production to the greatest extent possible and transform agricultural development by altering relative product prices.

Thirdly, optimizing and adjusting agricultural support policies to facilitate the transition of agricultural production toward green and healthy agricultural products and ecosystem services is crucial. This involves discontinuing subsidies for agriculturally toxic and harmful practices while strengthening fiscal support for the production of environmentally friendly products that promote human physiological health with lower environmental impact. This support includes subsidies for eco-friendly inputs during production and bolstering the information system for pricing at the sales end, all of which contribute to boosting the supply of such products. At the same time, products that are unhealthy or carry high environmental costs should reflect those health and environmental costs in their prices to reduce their supply.

Lastly, the establishment of a robust system for agricultural technological innovation and dissemination is vital. This entails increasing support for revolutionary and integrated green technologies, breaking through technological barriers within the agricultural sector, enhancing the efficiency of agricultural resource utilization, and mitigating negative impacts such as chemical pollution, climate change, and environmental degradation. Additionally, the widespread application of digital and intelligent information technologies should be promoted to advance the efficacy of green and intelligent agriculture.

2.2.4 Future Focus Areas of Research

Building upon existing research, future studies on the issue of agricultural green transformation should focus on several key areas:

Firstly, it's essential to re-evaluate the cost and benefit assessment of China's agricultural development from the perspectives of environmental and health objectives. This entails a systematic analysis to assess the health, resource, and environmental costs associated with China's agricultural development, along with the benefits gained from factors such as boosting farmers' income and rural development. The goal is to uncover the benefits of China's agricultural green transformation.

Secondly, there is a need to evaluate the effectiveness of China's agricultural policies and optimize them to support agricultural green transformation. This involves constructing economic models to analyze the impacts of different agricultural policies on aspects such as agricultural output, health, resources, environment, and biodiversity. The aim is to enhance China's agricultural policies in a way that promotes agricultural green transformation.

Thirdly, research should be conducted on China's agricultural green innovation system, focusing on overcoming barriers to green technology and driving the transition of chemical-intensive agricultural production to environmentally friendly methods. A robust promotion of regenerative agriculture is of utmost importance. This research should take an economic perspective, systematically analyzing the key and challenging aspects of agricultural green innovation and the underlying mechanisms. It should also offer policy recommendations to address the challenges posed by green technology innovation.

2.3 Pursing Food Security in the Context of Ecological Security

Food security is the foundation of the national economy. Existing definitions of food security mostly focus on how food supply meets the demand for food but lack emphasis on whether food demand is reasonable. For example, according to the definition from the 1996 World Food Summit, food security means that all people at all times have access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life. As food supply and demand have become fully market-driven, the assessment and focus of food security efforts primarily revolve around maintaining market supply-demand balance. Currently, a prominent issue is that the market demand for food is primarily driven by commercial forces, failing to adequately reflect the requirement for a healthy life as defined in food security ("healthy life") and deviating significantly from health-related dietary needs (both in terms of quantity and food structure). Rethinking food security calls for consideration not only of market stability but also health and environmental requirements. This reevaluation brings new implications for agricultural development direction, food security, and the impact on resources and the environment.

2.3.1 Achievements and Challenges of China's Food System

Since the opening-up and reform, China's grain system has achieved remarkable success. By 2022, grain production in China had increased by 125.3% compared to 1978, far surpassing the population growth rate of 46.7%. This has contributed greatly to reducing hunger, extending life expectancy, reducing infant mortality, and alleviating poverty. However, along with these achievements, numerous health and environmental issues related to grain have also emerged. Currently, the overweight and obesity rate among Chinese adults has reached 50.7%, [11] and obesity-related mortality stands at 6.4%. [1]Greenhouse gas emissions from the grain system account for 8% of China's total greenhouse gas emissions[2]. These health and climate-related issues, in turn, affect the security of the grain system, creating a vicious cycle between food, health, and the environment.

Food security, health, climate change, and related problems are all closely connected to shifts in food demand. In terms of food security, China's continuously increasing demand for grains has led to a persistent tight balance between supply and demand, despite the growth in grain production and escalating net grain imports. The rapid growth in China's grain demand is closely related to excessive consumption and waste of food. The dietary structure in China is shifting from plant-based foods toward highly processed and animal-based foods, causing a constant rise in feed grain demand. Loss rates throughout the entire chain of China's three main grain crops account for approximately 20.7% of total production. Reducing these losses by 40% could save 110 billion kilograms of grain.[3] Concurrently, the transition in residents' dietary patterns has led to a deviation from nutritional and health requirements, resulting in numerous

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[1] https://ourworldindata.org/obesity//
[2] Ministry of Ecology and Environment Bulletin, 2018
[3] China Agricultural Industry Development Report 2023

health issues. Furthermore, the persistent increase in demand for processed foods and animal-based products has directly or indirectly contributed to changes in land use, leading to issues of climate change and biodiversity loss that are unsustainable.

Consequently, achieving the synergistic realization of goals related to food security, health, climate change, and biodiversity protection urgently requires a transformation in food demand patterns. This transformation should align with the essence of nutritional health needs and reflect a people-centred development philosophy.

2.3.2 Prominent Issues in Existing Research

Currently, the literature on food security mainly discusses how to increase supply to ensure a balance between food market demand and supply. However, there is limited attention to whether the food demand is reasonable and its impacts. For instance, discussions of food demand primarily focus on market demand for food and lack an analysis of the demand for food based on health considerations[17,18]. Regarding the nutritional perspective on food demand, these works mainly use national dietary guideline to perform simple calculations of food demand[19] yet lack an analysis of the reasons and mechanisms behind the deviation between actual demand and healthy dietary demand. Regarding the research on the impact of the food system on health and the environment, the literature focuses more on discussing the benefits of healthy eating and reducing food waste losses [20], lacking analysis of the underlying mechanisms behind the evolution of current dietary structure.

The Chinese government attaches great importance to food security and has formulated a series of policies and regulations to ensure it. In general, China's food security policies have consistently centered around expanding production and increasing supply. Current research on China's food policies is predominantly focused on the supply side and seldom addresses the demand side of food. If the food system is solely considered from the perspective of supply, overlooking the demand side that is central to the development of the food system, achieving food security goals becomes challenging. Moreover, this approach can negatively impact human health and environmental protection. For instance, when food demand deviates from health requirements, simply increasing food supply to meet demand will inevitably lead to the consumption of a large number of agricultural production factors, such as fertilizers, pesticides, land, and water resources, which in turn results in environmental pollution, climate change, and biodiversity loss—creating unsustainable problems. This, in turn, affects food security. Of particular importance is the maintenance of soil fertility and the prevention and control of soil pollution. Reducing and combating industrial pollution, reducing and scientifically using chemical fertilizers, pesticides, insecticides and agricultural plastics, and maintaining and restoring soil health and fertility are important for both food security and food safety. Furthermore, supportive food policies lead to grain being used as lower-priced animal feed, prompting the mass production of highly processed foods and animal-based products, encouraging excessive consumption, deviating from healthy dietary patterns, and causing a significant increase in the prevalence of diseases such as cardiovascular diseases. Ultimately, a vicious cycle emerges among food security, health, and environmental goals. Hence, food security policies need to consider not only food supply but also food demand, guiding the formation of a mutually reinforcing relationship between the food system and the ecosystem.

2.3.3 Food Security Approach Under Environmental and Health Goals

If we aim only to meet the market's demand for food by increasing supply under the traditional definition of food security, it's difficult to truly achieve food security and may exacerbate health and environmental issues. Only by recognizing its essential health requirements and embodying a people-centred development philosophy can the food system effectively promote the simultaneous realization of food security and ecological safety goals. The basic approaches are as follows:

The first approach involves optimizing the definition of food security to provide scientific guidance for the sustainable development of the food system. Under the conditions of synergistically achieving multiple objectives, such as food security, health, and ecological safety, it is necessary to reconsider the framework of the current definition of food security and assess the limitations of these aspects in achieving multiple goals.

The second approach entails adjusting food security policies to optimize the supply of the food system. Shift the direction of food fiscal support policies. Enhance financial support for nutritious and sustainable food to increase the supply of high-quality staple foods and reduce the production of inferior-quality grains. Restructure food prices to comprehensively reflect the external costs of food consumption on health and the environment. Lessons can be drawn from international carbon labeling systems to establish a comprehensive mechanism that reflects the carbon, water, and resource intensity of different foods. Gradually incorporate these costs into market prices, guiding dietary pattern choices.

The third approach involves optimizing China's dietary guidelines to facilitate the simultaneous realization of multiple objectives such as food security, health, and environmental protection. Evaluate China's current dietary structure and the health and environmental effects of dietary guidelines. Based on human health requirements and nutritional principles, consider conditions that synergistically achieve multiple objectives, including health, economic affordability, environmental (water, air, earth) and agricultural biodiversity protection. Optimize China's existing dietary guidelines to promote the simultaneous realization of goals such as food security, human health, and ecological safety.

2.3.4 Future Key Research Directions

Building upon the existing research, addressing the issue of food security should encompass the following directions:

- Conducting research on dual-benefit health and environment dietary guidelines to guide the transformation of residents' dietary structures toward healthier patterns, and the shift of agricultural and food system production toward healthier and sustainable food production. This will facilitate the simultaneous realization of multiple objectives, including food security, dual-carbon goals, and biodiversity conservation.
- Undertaking research on the cost and benefit assessment of food consumption

demands to promote the transformation of the food system. Developing economic models to analyze the evolution of system variables related to food security, health, and environmental resources under different scenarios of food consumption demands. The aim is to propose a multi-objective synergistic development model for the food system.

- Conducting research on China's food security policies under the objectives of health and environmental (water, air, soil) protection to promote the simultaneous realization of multiple objectives, such as food security, dual-carbon goals, and biodiversity conservation. Developing economic models to analyze the impacts of different food security policies on aspects including food security, health, environment, and climate change. The goal is to establish a multi-objective synergistic food security policy framework.

2.4: National Spatial Governance and Policies

Land resources, including soil, water, and biodiversity, provide fundamental products and services for humanity, such as food, water, fibre, energy, raw materials, and places for living and working. Land is a finite resource, and its functions are crucial for our economic, environmental, and socio-cultural well-being. However, under the current land use system, the functions of these lands are not always compatible or can even conflict, resulting in dysfunctional trade-offs for sustainability under conventional land use systems. To seek systematic solutions from a more holistic and synergistic perspective, national spatial planning could play a significant role at the highest level.

Traditional land use, particularly unsustainable expansion of arable land, hinders the progress of sustainable development. The IPCC report further highlights [1] that land degradation exacerbates climate change, while climate change, in turn, intensifies land degradation and desertification, leading to food security issues. While food security is a global goal that requires consideration of multiple factors, soil health, especially its fertility status is the fundamental building block on which all agricultural production systems are built[1]. Therefore, in formulating the integrated national spatial governance system, decision-makers must address the challenges of rapid urbanization while also coordinating grand objectives such as biodiversity conservation "30x30"[2], "dual-carbon" goals, water, and food security, which can be highly demanding.

China's spatial planning system is unique worldwide and might hold important lessons for other countries. It is extremely relevant for operationalizing the GBF globally, especially for Target 1.

2.4.1 Challenges and Current Situation of Multi-Objective Integrated Governance in China's National Spatial Planning

China's vast population of over 1.4 billion people has surpassed the total population of all developed countries combined. [21] At the same time, suitable space for production and living is limited and unevenly distributed. Although overall natural resources are abundant, the per capita share of land, energy, minerals, and other major resources is far below the global average. [22] Rapid urbanization has resulted in significant reductions in farmland, [23] and by 2030, China's urbanization rate is projected to reach 70%, potentially leading to a loss of around 20 million acres of high-quality arable land, [24] posing a potential threat to food security.

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[1] Referred to the insights from Ronald Vargas, the Secretary, Global Soil Partnership, Food and Agriculture Organization of the United Nations, https://www.un.org/en/un-chronicle/soils-where-food-begins.

[2] Hereby referring to the targets of the Kunming-Montreal Global Biodiversity Framework on conservation and restoration, including TARGET 2: Ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and marine and coastal ecosystems are under effective restoration; TARGET 3: Ensure and enable that by 2030 at least 30 per cent of terrestrial and inland water areas, and of marine and coastal areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed, so global communities call it "30x30".

The "Outline of National Overall Land and Spatial Planning (2016—2030)" issued by the State Council highlighted four key points: [25] (1) Since the reform and opening-up, China's industries and employment have continuously concentrated in the eastern coastal areas, leading to a spatial mismatch between market consumption and resource-rich regions. The mismatch between economic layout, population, and resource distribution has resulted in long-distance transportation of energy resources and large-scale cross-regional flows of products and labour, increasing economic operational costs, social instability, and ecological environmental risks. (2) Structural contradictions between urban, agricultural, and ecological spaces are becoming more pronounced. With the expansion of urban and rural construction land, agricultural and ecological spaces are squeezed, intensifying conflicts between urban, agricultural, and ecological spaces. (3) The intensity of land development in some regions does not match their resource and environmental carrying capacity. For example, the Beijing-Tianjin-Hebei (Jing-Jin-Ji), Yangtze River Delta, and Pearl River Delta regions have land development intensities close to or exceeding their resource and environmental carrying capacity, while some regions in the central and western parts of China with better natural endowments still have significant development potential. (4) The land development in coastal areas does not align with the marine resources and environmental conditions. Rapid and extensive land reclamation has led to the depletion of available coastal and nearshore resources. Meanwhile, conflicts in the marine industry have caused severe damage to fisheries resources and the ecological environment.

Before the 18th National Congress, various departments in China had a variety of planning systems, each with its own framework, and various spatial constraint plans lacked sufficient strength. A relatively common phenomenon was that the same piece of land was categorized as basic farmland in national land planning and as forest land in forestry planning. The specific reasons hindering the capacity for national spatial governance include: (1) different planning timelines, and (2) different technical standards and information platforms, especially the use of different technology platforms, different basic maps, inconsistent statistical criteria, and non-uniform land classification. After the 18th National Congress, against the backdrop of comprehensively promoting the concept of ecological civilization, it became imperative to establish a unified spatial planning system. In September 2015, the Central Committee of the Communist Party of China and the State Council issued the "Integrated Reform Plan for Promoting Ecological Progress", proposing to construct a national unified, interconnected, and hierarchically managed spatial planning system centred on spatial governance and structural optimization. The goal is to address problems such as spatial planning overlap and conflicts, overlapping responsibilities between departments, and frequent changes in local planning.

In 2019, the country issued the "Several Opinions on Establishing the National Spatial Planning System and Supervising Its Implementation", requiring the integration of main functional zone planning, land use planning, urban and rural planning, and other spatial planning into a unified national spatial planning, implementing a "multiple plans integration" approach, [26] and calling for the establishment of a "Five-level, Three-category" national spatial planning system. The "Five-level" planning includes national, provincial, city, county, and township levels, corresponding to China's administrative management system, formulated from top to bottom, implementing national strategies and reflecting the will of the state. The "three-category" refers to the three categories of planning that horizontally connect the "overall planning", "detailed planning", and "special planning". In the same year, the Chinese government issued the "Notice on Comprehensive National Territory Spatial Planning (Ministry of Natural Resources [2019] No. 87)", officially launching the compilation of national spatial planning at all levels. Currently, "The Outline of National Overall Land and Spatial Planning (2021 – 2035)" (hereinafter referred to as the "Outline") has been approved by the State Council but has not yet been publicly released. The "Outline" encompasses the overall arrangement of the national spatial planning, including policies for the protection, development, utilization, and restoration of land and serves as the fundamental basis for local spatial planning. The spatial planning at all levels of administrative divisions (provinces, cities, counties, and townships) is compiled and organized by the local government and is currently in the approval stage. Provincial-level planning is compiled based on the goals, indicators, strategies, layout, major projects, and policy requirements specified in the "Outline", guiding the formulation of lower-level plans. City-level spatial master plans requiring State Council approval are compiled by municipal governments and submitted for approval after review by the local People's Congress Standing Committee. Other urban, county, and township plans are determined and compiled by provincial-level governments based on local conditions and must comply with specific content and procedural approval requirements.

However, as pointed out in the "Master Plan of National Important Ecosystem Protection and Restoration (2021-2035)" published by the National Development and Reform Commission in 2020, [27] there is still a considerable gap in understanding the intrinsic mechanisms and laws of mountains, rivers, forests, farmland, lakes, and grasslands as a community of life, which hampers the implementation of the concept and requirements of integrated protection, systematic restoration, and comprehensive governance. Additionally, a management system based on reciprocity of authority and responsibility and coordinated mechanisms are still lacking, posing significant pressure and resistance to coordinating ecological protection and restoration. Thus, while optimizing land use, China must also strive to coordinate multiple objectives. Currently, provinces such as Zhejiang, Jiangxi, Shanghai, Shandong, Anhui, and Sichuan have already issued detailed management regulations on ecological protection redlines, while most other provinces are soliciting opinions or preparing to issue relevant regulations. The Ministry of Natural Resources will regularly evaluate the effectiveness of ecological protection redlines and promote collaborative efforts among various departments to strengthen supervision over ecological protection redlines. The delimitation of the "Three Zones and Three Lines" further indicates that the total area of ecological protection redlines nationwide is no less than 3.15 million square kilometres, of which the land ecological protection redline area is no less than 3 million square kilometres, accounting for over 30% of the country's land area. The area of marine ecological protection redlines is no less than 150,000 square kilometres. Ecological protection redlines cover most key ecosystems, including grasslands, important wetlands, coral reefs, mangroves, and sea grass beds. By integrating research results from aspects such as biodiversity, "dual-carbon"[1] goals, water and food security, and spatial planning, policymakers can formulate more comprehensive strategies to optimize land use. These integrated approaches can lead to more resilient and balanced

[1] This refers to China's goals of reaching peak carbon emissions before 2030 and achieving carbon neutrality before 2060.

land use management, ensuring the sustainable future of China's land and other resources.

2.4.2 Challenges Faced in Promoting Integrated National Spatial Governance in China

Existing literature on national spatial governance has focused more on urban construction and paid less attention to rural spatial governance, resulting in a lack of theoretical support to cope with the ever-changing urban-rural relationships. This, in turn, hinders the country's ability to meet the requirements of the current era for "multiple plans integration" national spatial planning. [35] The lack of effective implementation measures has presented significant challenges in scientifically controlling the decentralized, bottom-layer, and complex rural spatial aspects. [29-30]

An important goal of national spatial planning is to establish a unified spatial layout and comprehensive development and protection strategy nationwide. [31] However, the current irrational state of rural space development and utilization poses a significant obstacle to achieving the goal of integrated spatial planning. In particular, the results of the Third National Land Survey indicated that even though about 229 million acres of farmland flow into regions with stronger ecological functions, such as forests, grasslands, wetlands, rivers, and lakes, about 217 million acres of land flow back to farmland. Although the need to integrate urban and rural spaces in comprehensive governance has been recognized, specific implementation measures are lacking. In the context of "multiple plans integration" spatial planning, efficient and equitable utilization and governance of urban and rural spaces remain crucial challenges that require attention and innovative solutions. [32-33] Solving these issues is crucial to achieving balanced spatial development, coordinating urban and rural areas, and advancing the overall progress of national spatial governance in China.

Furthermore, while the institutional and policy framework for national spatial governance in China has been preliminarily planned, significant challenges remain in coordinating regulatory bodies. To enhance interdepartmental coordination, the control of national spatial regulation has been delegated to the Ministry of Natural Resources for unified exercise. However, there is still ambiguity surrounding the boundaries of national spatial control by the Ministry of Natural Resources, including (1) the distinction and cooperation between law enforcement by the Ministry of Natural Resources and comprehensive ecological environmental law enforcement, (2) the division of responsibilities between the Ministry of Natural Resources and forestry departments in ecological protection and nature reserve management, and (3) the coordination of regulation between the Ministry of Natural Resources and the Ministry of Agriculture and Rural Affairs. [34]

Despite some progress, optimizing the regulatory system is still an ongoing task. There is a lack of clear and unified technical standards and management systems for key policies such as spatial access and land use conversion.[35] Comprehensive regulations for various types of land conversion, particularly the conversion rules for different land types within agricultural and ecological spaces, are still lacking. [36] There are inconsistencies in the delineation and regulation of different natural reserves and ecological protection redlines. [37] In addition, there is a lack of a comprehensive monitoring and evaluation mechanism, and improvement is needed in feedback and in-process supervision to establish a more complete national spatial correction mechanism. [38]

Column 6-2-1[1]: National Strategy on Spatial Planning and the Environment (NOVI) of the Netherlands [1]

Spatial Planning in The Netherlands

The Netherlands is renowned for its spatial planning tradition, that blossomed in the second half of the 20th century. The first decades of the 2000s, however, saw a stepped-down ambition of national spatial visions and planning. This modest national spatial planning activity was reinforced by the financial crisis from 2008 onwards. The National Strategy on Spatial Planning and the Environment (Nationale Omgevingsvisie – NOVI), from 2020, fully regrets this statement and stresses the urge to revive national spatial planning.

The Netherlands faces complex challenges that significantly impact its physical living environment. The NOVI focuses on achieving competitiveness, accessibility, liveability, and safety while taking an integrated approach to address urbanization, sustainability, and climate adaptation.

The Netherlands has about three-quarters of its population residing in urban areas. [2] Similarly, China has experienced an urbanization rate of 64.7% since the implementation of its opening-up policies in 1978.[3] These urban areas are now facing significant challenges due to the rapidly changing climate, which poses threats to human life, health, infrastructure, assets, ecosystems, and nature.

Notwithstanding its small size (33.000 square km land area) and a relatively large number inhabitants (almost 18 million), the Netherlands exports agricultural products at a large scale – second only to the United States in terms of value. However, the intensity of agricultural production, especially animal husbandry in this setting has become an environmental and political problem with a strong spatial dimension. Modernization of agricultural business models in a sustainable and viable way poses a conundrum. Persistent exceedance of nitrogen deposition, from agriculture and other sources, has led to a legal freeze of many important construction projects.

Given the similarities in China's southeast coastal areas with competitive ports, this Dutch case study offers valuable insights for China as it develops its spatial planning framework, especially in urban land in coastal zones, for developing robust strategies for sustainable and resilient development in the face of climate challenges and ongoing change.

Three principles guide the decision-making process: prioritizing combinations of functions over single functions, focusing on the characteristics and identity of each area, and preventing the shifting of responsibilities to future generations or other locations. The aim is to strike a balance between protection and development, ensuring an integrated and sustainable approach to spatial planning that respects the

[1] Enriched and edited by Jan Bakkes (The Integrated Assessment Society), Karel Van Bommel (Embassy of the Kingdom of The Netherlands, Beijing) and Arjan Harbers (PBL Netherlands Environmental Assessment Agency)

diverse interests and qualities of different areas.

Key priorities in the NOVI

a. **Space for climate adaptation and energy transition:** The Netherlands faces significant challenges in adapting to climate change and managing water effectively. Rising sea levels, increased river discharge, extreme weather events causing excess water as well as drought, and soil subsidence pose threats to water safety and necessitate climate-resilient and water-robust spatial planning.
b. **Sustainable economic growth potential:** The Netherlands is aiming at a 100 percent circular economy and a 95 percent greenhouse gas emissions reduction by 2050. These ambitions require space and international connectivity. The space already in use for industrial and port functions must continue to be available for the planned transition, unless alternatives become available.
c. **Strong and healthy cities and regions:** With a large urban population and stronger-than-expected population growth, the Netherlands seeks to strike a balance between urbanization and sustainability. Urban areas are vital for the country's economy and competitiveness. Urban regions face pressure on infrastructure, environmental quality, etc. Sustainable urban development and revitalisation of urban brown fields are essential to create liveable and safe cities. For economic and sustainability reasons inner city densification is prioritised over urban expansion.
d. **Futureproof development of rural areas:** The agricultural and horticultural sectors, being the largest users of rural space, face the challenge of transitioning to circular agriculture. This entails balancing future-proof earning models with sustainable food production and biodiversity conservation. To achieve this, the government aims to support agriculture and horticulture in contributing to the quality of the living environment and delivering ecosystem services. Conservating and recovering biodiversity is a national and EU-level interest to ensure a high-quality living environment and biodiversity resources. At a general level, the government aims to encourage natural processes to meet nature objectives; promotes nature-inclusive development in major developments and considering biodiversity in agriculture, the energy transition, and infrastructure expansion. The Netherlands Nature Network will be expanded by 80,000 ha (800 square km).

Identifying the pain points and opportunities

The Dutch Government focuses on future-proof development of rural areas and sustainable urban development. Among many aspects, below are some of the selected challenges that can be helpful for the future formulation of national spatial planning in China, which aims to coordinate with grand objectives such as biodiversity conservation, "dual carbon" initiatives, water, and food security.

Climate Adaptation and Water Safety: Recognizing the complex interweaving of challenges like urbanization, sustainability, and climate adaptation, the government of the Netherlands intends to adopt an integrated approach to accelerate decision making for its living environment. A key pain point is the need to become climate-resilient and water-robust by adapting to climate change effects, including sea level rise, droughts and halting soil subsidence. Prioritizing water safety, the government focuses on flood prevention, spatial planning for flood protection, and disaster management plans. How to allocate space for climate adaptation and how to combine it with other demands in such a small country?

Sustainable Agricultural Transition: After the famine of World War II, the nation aimed at no more famine and becoming a net exporter of food. Thanks to agricultural innovation and on the basis of imported soya, the goal was well met. As a consequence in parts of the Netherlands the cattle-density became among the highest of Europe. The current situation features vested interests and path dependencies for many individual farmers which results in uncertainty and especially a difficult situation for many individual producers. The later typically find themselves between a rock and a hard place, having invested in producing against world market prices while operating in a location with high cattle densities close to nitrogen sensitive nature reserves and thus requires very careful environmental management.

Biodiversity Conservation: The conservation status of almost all natural areas in the Netherlands is registered as bad or very bad. Nutrient overloading and water management are among the important factors. Both have an agricultural aspect to them, although other sectors, too, exert pressure. For all official European nature areas, specific restoration plans are being drafted and assessed, as a matter of urgency. Nature-inclusive aspects are promoted in major developments, considering biodiversity in agriculture, energy transition and infrastructure expansion.

Considering the problems with the implementation of the NOVI and other national policy documents, the national government started in 2022 in close collaboration with regional authorities the elaboration of the Spatial Report (Nota Ruimte). This policy document is positioned as a tightened version of the NOVI, aimed at offering a more solid and implementation-oriented spatial planning.

<u>Monitoring, scenario's and outlooks</u>

As system of assessment and progress monitoring for NOVI has been set up. It consists of a strategic environment impact assessment (*ex ante*) and periodic monitoring of progress (*ex durante*), including a system of quantitative indicators. The periodic monitoring highlighted that the quality of the living environment in the Netherlands is still structurally inadequate on several indicators. The actual failure to achieve European targets in environmental policy currently limits the development of residential areas, business parks and infrastructure. Only with a certain excess of quality, it is possible that living, working, agriculture and nature develop faster and with more flexibility. [4,5]

As a spatial plan that balances current needs may be present-proof but not necessarily future-proof. PBL recently developed a fresh spatial development outlook for the Netherlands. Its core is a set of four contrasting scenarios. Each scenario depicts a plausible development towards sustainability goals, but each in a different way.
Kuiper and Hamers explain the *key questions are to be considered: What are the most important spatial challenges for the Netherlands up to 2050? How could a future-proof Netherlands with quality environment around 2050 look like? Via which pathways could policy makers work toward this? What does this produce in*

terms of strategic policy messages for the coming years? What can be the 'framework-setting' spatial choices for a future-proof ambient and environmental policy? How can we go about uncertainties? [6]

Conclusion

The Netherlands' government has recently realized that it faces an inextricable mix of issues, all with a strong spatial dimension: re-thinking urbanization and demographics, organizing climate resilience, pervasive sectoral changes in energy and agriculture, shifting balance between regions, and an urgent need to pull almost all nature areas from a bad status of conservation. The country prioritized climate resilience, water safety, circular agriculture, and biodiversity preservation, for a sustainable and resilient future. Collaborative efforts with regional authorities and stakeholders should ensure a comprehensive strategy to safeguard its competitiveness, accessibility, liveability, and safety for generations to come.

Potential insights for China and worldwide members of CCICED would include the following.

- Spatial Planning is a matter of integrating spatial interests rather than adding up specific territorial claims. Regional design might be helpful in solving or mitigating conflicting interests.
- Temporarily slackening ambitions in spatial planning may leave difficult and costly problems thereafter.
- A forward-look perspective needs to marry short and long-term perspectives.
- Developing a long term vision and policy pathway requires multiple contrasting scenarios. This includes scenarios deviating from official beliefs and accepted trends, even if the official objectives are unambiguous.

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2.4.3 Studying the Progress of the National Spatial Planning and Identifying Opportunities for Synergies

To address complex issues such as land use, biodiversity loss, climate change, food security, water security, and environmental pollution, a more holistic perspective must be embraced, moving away from traditional industrial development thinking, and seeking systemic solutions tailored to China's specific situation. Only through ecological civilization construction, optimized resource allocation, elevated planning capacity, and enhanced ecological environment protection can the conflicting relationship between "land use-food-ecological environment" under the traditional industrialization model be transformed into a mutually reinforcing one. The following are some suggestions in China's context, aiming to achieve a resilient and balanced national spatial governance system with a vision of creating synergies between biodiversity protection, climate actions, ensuring food security and water security, etc. :

a) Harmoniously Integrating Multiple Objectives to Establish a Coupled Pattern and Process for National Spatial Planning

Given China's vast and diverse regions, a comprehensive and systematic approach to national spatial governance is necessary. Decision-makers should recognize the interconnections between different objectives, such as biodiversity conservation, dual carbon goals, water and food security, and socio-economic development. Scholars like Ou Minghao have emphasized the need to consider the interactive mechanisms and response mechanisms between "patterns (indicators and layouts)" and "processes (ecological processes)" in future national spatial planning, particularly in defining the "Three Zones" (agriculture, urban, and ecological) and the rational allocation of spatial elements. By coupling "patterns (indicators and layouts)" with "processes (ecological processes)", a comprehensive optimization of the national spatial layout can be sought, leading to the formulation of reasonable spatial pattern allocation scenarios. [39]

Another aspect of harmoniously integrating multiple objectives lies in reviewing the measures taken to address climate change. Policymakers need to analyze the effectiveness of measures taken in terms of farmland quantity, quality, and ecological aspects, including continuously improving farmland protection policies, implementing farmland renovation, and increasing land use efficiency.

b) Coordinated Governance and Unified Planning for Synergizing National Spatial

Planning Goals, Indicators, and Regulations

China's national spatial planning faces complex challenges, making it crucial to enhance coordination among regulatory departments. This can be achieved through clarifying responsibilities, simplifying decision-making processes, and strengthening policy implementation. [39] An important measure is to integrate various planning systems, such as the main functional zone planning, land use planning, and urban-rural planning, into a unified national spatial governance framework, thereby coordinating planning goals, indicators, and regulations. [40] Regarding the comprehensive regulation needs of the entire region and all elements of national spatial planning, policy-makers also need to further develop regulatory rules for ecological spaces and their different ecological functional zones. [41] Such measures will help achieve more effective multi-objective national spatial governance and promote the scientific development of national spatial planning.

Up to this point, the Ministry of Natural Resources has released several technical standards aimed at laying the foundation for territorial spatial planning. These standards include the establishment of land-use and sea-use guidelines, which serve to streamline the classification of land usage and facilitate the integration of both land and sea aspects. Furthermore, the Ministry has issued directives on the preparation of territorial spatial planning at the provincial and municipal levels. These guidelines play a crucial role in guiding and regulating the development of local plans. Additionally, efforts have been made to construct a fundamental information platform for territorial spatial planning, with the ultimate goal of enhancing the level of data intelligence involved in the planning process.

c) Strengthening Rural Spatial Governance for Balanced Urban-Rural Development

Amid rapid urbanization in China, rural spatial governance must be prioritized and given equal importance to urban development. A sound national spatial governance system must protect agricultural land and natural ecosystems while fully considering improvements to rural livelihoods. Through the development of regenerative agriculture, support for rural communities, and maintenance of ecological balance, better balanced urban-rural spatial development can be achieved.

Moreover, addressing climate change in the context of rural spatial governance requires adjusting agricultural planting layouts and developing adaptive varieties to maintain and increase crop yields. To achieve this, connections between climate change adaptation and government decision-making need to be established, providing a theoretical basis for government decision-making agencies to formulate corresponding agricultural adaptation measures. Simultaneously, scientific guidance for stakeholders such as farmers, herders, and scenic area managers must be provided, enabling the implementation of agricultural ecosystem service adaptation measures.

2.4.4 Recommendations for Research

a) Coordinating the Relationships Between Ecological Security, Food Security, and Water Security

   i. The intense conversion between ecological land and arable land requires comprehensive consideration. The Third National Land Survey indicates that over the past decade, ecological land has increased overall, but frequent conversions between ecological land and arable land have been observed, with about 229 million acres of farmland flowing into regions with stronger ecological functions, while about 217 million acres of land in those regions have flowed back to farmland. This reflects the fact that the ecological construction pattern in some areas is not stable, with issues such as blind ecological construction and unreasonable ecological layout. The drastic land use conversion, to some extent, reflects policy conflicts between different periods, objectives, and value orientations. It is essential to balance ecological construction and farmland protection according to the principle of "cultivate suitable land, plant trees on suitable land, cultivate grass on suitable land, conserve wetlands on suitable land, leave uncultivated land uncultivated, and leave sandy land as sandy land."

   ii. Water resource security is related to food security, ecological security, natural disaster mitigation and prevention, and the spatial matching needs improvement. China's water resources are unevenly distributed in time and space and do not match the distribution of population, economy, farmland, and energy. In recent years, the increase in farmland in water-resource-deficient areas in the northwest has contributed to relatively high agricultural water consumption in some regions, exacerbating regional water supply-demand conflicts. Additionally, climate change has led to frequent droughts and floods in some areas, affecting agricultural production and causing ecological degradation. Therefore, seeking a balance point in quantity, quality, structure, and layout between ecological protection, farmland protection, and water resource security is of utmost importance.

b) Fully Understanding Regional Resource Endowments, Environmental Backgrounds, and Socio-Economic Characteristics to Develop Differentiated Land Use Strategies

i. In Northwest China, focus on water resource security and ecological security. Further optimizing water use structure, improving water resource utilization efficiency, preventing the encroachment of ecological water, and enhancing wind and sand fixation ecological functions are essential. Addressing grassland degradation and land desertification should also be prioritized, along with promoting the development of clean energy.

ii. In Northeast China, focus on ecological security and food security. Vigorously advancing sustainable use of black soil, consolidating the region's position as a nationally important commodity grain production base, protecting forests with significant water conservation functions in the Northeastern Forest Zone, and promoting the transformation of old industrial bases.

iii. In North China, focus on the matching of water resources and land resources. Emphasize the development of water-saving agriculture and address groundwater overexploitation.

iv. In East China, focus on water body pollution in specific areas. Promote regional integration development, facilitate industrial green transformation, and control eutrophication in lakes.

v. In Central China, focus on farmland protection. Given the concentration of high-quality farmland in the region, steps should be taken to prevent its loss and soil pollution.

vi. In South China, focus on ecological protection and environmental quality improvement. Utilize the ecological service functions of the southern hilly and mountainous areas, protect biodiversity, and address environmental pollution.

vii. In Southwest China, coordinate mineral resource development and ecological protection. Protect plateau lakes and plateau biodiversity, promote desertification control, commit to geological disaster prevention.

c) Studying Policy Instruments that Strictly Adhere to Safety Bottom Lines while Balancing the Interests of Stakeholders

i. In national key ecological functional areas involving the relocation of farmers, herders, and enterprises, long-term livelihood considerations must be taken into account, encouraging them to become protectors, participants, promoters, and practitioners of ecological space, ecological construction, ecological protection, and the theory " Lucid waters and lush mountains are invaluable assets".

ii. In national main grain production areas, complementary policies should be improved to reflect national policies for strengthening agriculture and benefiting farmers, safeguarding the rights and interests of stakeholders such as large-scale grain growers.

iii. Land designated as permanent basic farmland should be solely used for planting food crops. Meanwhile, developing regenerative agriculture through reasonable planning of non-agricultural crops (such as trees and shrubs) around farmland and pastures friendly to pollinators can be a typical practice. In policy implementation, providing a certain degree of flexibility to environmentally friendly regenerative agricultural practices will improve the quality and yield of permanent basic farmland.

d) Redefining Food Security and Aligning it with Appropriate Land Planning

Based on the latest dietary guidelines and future population trends, re-evaluate China's demand for crops and other kinds of foods and estimate the corresponding demand for agricultural land. With this information, re-examine current food production targets with the aim of guiding healthy, low-carbon, environmentally friendly, and zero-waste dietary habits and culture. Seek synergy among food security, ecological security, "dual-carbon" goals, water security, and other essential objectives.

2.5 Weighing Land Use through the Valuation of Natural Capital and Ecosystem Services

The natural capital and ecosystem services provided by nature are the foundation of human society and economic development. Achieving multiple environmental and social goals, such as the "dual-carbon" goals, water and food security, also relies on natural capital and ecosystem services. Changes in land use can lead to variations in natural capital and ecosystem services, and assessing these can help measure the contributions of different land uses to economic and social objectives,[1] reducing or avoiding adverse impacts resulting from inappropriate land use decisions.

2.5.1 Inadequate consideration of preserving and enhancing natural capital in current land planning and decisions

Currently, the evaluation of land use primarily focuses on economic and social aspects, lacking comprehensive assessments of natural capital and ecosystem services. Current land use is often driven by singular demands, overlooking the impact on ecosystems and the maintenance of other services. In present national statistical and accounting practices natural capital and ecosystem services are still not valued at their true price; and are even treated as being available for free for companies.[42] Simultaneously, economic globalization has increased the influence of international capital flows on local land use decisions, [43] weakening national policies aimed at preserving and increasing public goods. Therefore, by employing mature and applicable methods for natural capital and ecosystem services accounting, decision-makers can better understand the current and long-term impacts of their land use choices on the environment, society, and economy, and redefine the "value" in modern economic systems to include the value of nature.

2.5.2 The current status and opportunities of natural capital accounting and ecosystem services evaluation

Because of the significance of natural capital and ecosystem services, biodiversity conservation is not only a global conservation goal but also a crucial foundation for synergizing the multiple crucial global objectives, including biodiversity targets, "dual-carbon" goals, food security, and water security. Quantifying and evaluating natural capital and ecosystem services will provide stakeholders with concrete and unified reference values, facilitating more reasonable land use to align with these global goals.

a) Progress in Natural Capital Accounting and Ecosystem Service Assessment

Research progress on natural capital accounting and ecosystem service assessment has been rapid both domestically and internationally. Natural capital accounting primarily focuses on the relationship between natural resource consumption and national debt, while ecological debts are not only national but affect all economic agents. As research on evaluating natural capital and ecosystems is also steadily increasing, it worth particular attention that debts to nature have to be measured firstly in biophysical terms and secondly in terms of the costs (restoration, compensation) to mitigate them. Natural capital accounting (NCA[1]) is an umbrella term covering efforts to use an accounting framework to provide a systematic way to measure and report on stocks and flows of natural capital. Ecosystem services refer to the various benefits that humans obtain from ecosystems. The essential objective of achieving biodiversity conservation and rational utilization is essentially preserving and appreciating natural capital while maintaining the balanced and stable supply of ecosystem services. However, due to excessive demand on ecosystem services and increased human activities, natural capital in many regions is depleting, and the capacity to supply ecosystem services is declining.

i. Progress in international research on natural capital accounting and ecosystem services evaluation

Since 1993, the United Nations has successively released comprehensive environmental economic accounting frameworks, incorporating environmental assets into the national economic accounting system. In 2012, the “System of Environmental-Economic Accounting 2012—Central Framework ” (SEEA-CF) was released, including environmental management costs and natural resource losses or gains in the national economic accounting, known as Green GDP accounting. Subsequently, the United Nations Statistical Commission published the System of Environmental-Economic Accounting – Ecosystem Accounting” (SEEA-EA) standard in 2021, describing the relationship between ecosystems and economic assets, integrating economic, environmental, and social data into a unified and coherent conceptual framework, providing a theoretical and methodological basis for conducting ecosystem asset accounting. This standard’s release indicates the United Nations Statistical Commission’s adoption of international standards for ecosystem services and ecosystem asset physical quantity accounting, recommending macroeconomic indicators such as Gross Ecosystem Product (GEP), and now further research on the valuation of ecosystem services, ecosystem asset, and marine ecosystem accounting is in progress.

[1] Referred to Natural Capital and Ecosystem Services FAQ, https://seea.un.org/zh/content/natural-capital-and-ecosystem-services-faq

ii. Progress in relevant research and practice in China

Chinese scholars have localized the ecosystem services valuation principles and research methods proposed by Costanza, greatly promoting the development of such methods in China. [44-45]

The assessment of ecological and environmental resources began with "Overall Plan for the Reform of Eco-civilization System" issued by the Central Committee of the Communist Party of China and the State Council in 2015. In the same year, the "Pilot Scheme for Compiling Natural Resource Balance Sheets" proposed the content and methods for compiling natural resources balance sheets. In 2018, based on the practical experience of pilot work, China compiled the 2015 national natural resource balance sheet, mainly accounting for land, forest, and water resource physical quantity accounts, and conducted a trial compilation for mineral resources, grasping the quantity and quality of land, forest, and water resources. In 2020, the Ministry of Ecology and Environment issued three technical guidelines (for trial use) on GGDP/EDP, GEP, and GEEP, proposing corresponding indicator systems, accounting methods, data sources, and other requirements during the accounting process. In 2021, the State Council released the "Special Report on the State-owned Natural Resource Asset Management in 2020", which introduced the state-owned natural resource assets, including state-owned land, forests, grasslands, wetlands, mineral resources, marine resources, and wildlife. This was the first time the state of natural resources was publicly disclosed. In 2022, the National Development and Reform Commission and the National Bureau of Statistics issued the "Guidelines for Gross Ecosystem Product Accounting". According to incomplete statistics, up to the present, various pilot projects for Gross Ecosystem Product (GEP) accounting have covered 18 provinces and 57 prefecture-level cities in China, with approximately 15 provinces implementing related policies to carry out the valuation of ecosystem products as a key initiative.

b) Key Issues

The concepts of natural capital, ecosystem assets, and ecosystem services still need to be unified between international and domestic contexts and among different stakeholders to guide relevant practices and support the construction of a complete and unified evaluation system and indicators. Currently, ecosystem services assessment lacks comprehensive data, unified evaluation methods, and validation of results, facing conflicts arising from the varying emphasis on services in different spatial and temporal scales. On the spatial scale, larger ecosystems tend to prioritize regulating services, while smaller ecosystems prioritize provisioning services. On the temporal scale, the pursuit of short-term benefits has damaged the long-term sustainability of ecosystem services.

Natural capital accounting **should ideally be an institutionalized information system,** with documented data assurance and methods and regular production cycles. This means decision-makers can rely on information being available over the long term. While in practice, it is important that the iterative nature of how the natural capital accounts can be improved over time is appreciated. It is desirable to build momentum quickly by **producing good accounts over the short term rather than perfect accounts over the long-term**.

2.5.3Research to achieve synergy, exploring systematic land use through models and technologies

a) Analyzing the essence of synergy and strengthening research on multi-objective synergy models

Although land use and cover change (LUCC) often occur at the local level, their cumulative impact worldwide can severely impact the Earth system. The land use goals of different departments and stakeholders are not always compatible and often conflict. Choosing a specific land use function in a geographical region often requires balancing and negotiating between different temporal and spatial dimensions and stakeholders (see Figure 6.2.9). The basis for such balancing and negotiation should be **the optimal solution for natural capital and ecosystem services**. For example, expanding soybean production in Brazil has driven economic growth, improving farmers' livelihoods, and national food security. However, converting vast areas of tropical rainforests into arable land for soybean production has also led to biodiversity loss, increased carbon emissions, and reduced carbon sequestration, causing overall damage to the forest's regulatory and supporting ecosystem services, with these negative impacts spilling over to the local, regional, and global levels.

Figure 6.2.9: Balancing local, regional, and global ecosystem services

However, defining the **"optimal solution for natural capital and ecosystem services"** is a significant challenge we face.

Trade is a critical dimension of sustainable land management. On the one hand, trade provides incentives for local stakeholders and investors to decide land use based on the natural resource endowment and comparative advantages of the land. This trade-facilitated division of labour and specialization may amplify ecological destruction through economies of scale. On the other hand, land forms the basis of many public goods, such as water quality, biodiversity, and stable climate, all of which can be traced back to land use. **Therefore, ensuring the supply of public goods is a priority at the global level, but at the local level, local stakeholders will inevitably seek to increase production and improve livelihoods—these objectives may often conflict in many cases.** Therefore, land use planning needs to not only balance different land functions but also consider and coordinate the interests of stakeholders at various scales.

Currently, s**hort-term demands and economic gains are the primary motivations behind land use decisions, neglecting the long-term risks caused by unsustainable land use patterns.** A scientific and unified framework with indicators is an essential tool for all stakeholders to promote dialogue and collaborate on transformational pathways.

Column 6-1-2: Research on Sustainable Utilization of Natural Capital through More Effective Land Use Management

The World Bank, in collaboration with the Natural Capital Project, has developed a novel approach based on ecosystem services and biodiversity assessments. This approach builds on the concept of designing resource efficiency frontiers (Polasky, S. et al., 2008) and integrates biological and economic models. Its primary objective is to evaluate how countries worldwide can achieve sustainable land use and effectively manage their natural capital. The research report titled "Nature's Frontiers: Achieving Sustainability, Efficiency, and Prosperity with Natural Capital" was published in 2023 by Damania.

The newly developed model can assess ecosystem services and economic output to estimate a country's efficiency gap, which refers to the difference between the current provision of products and services and those that could be sustainably provided without sacrificing other benefits. The report provides recommendations on how countries can better leverage their natural capital to achieve economic and environmental objectives.

Key findings include:

1. Land use efficiency is low for countries at all income levels and across all regions, presenting opportunities for most countries to increase economic output and ecological performance. For many low-income countries, substantial net economic returns are achievable without compromising environmental quality. On average, countries can nearly double their performance in at least one objective without sacrificing others.
2. By utilizing land more efficiently, the world can sequester an additional 85.6 billion tons of carbon dioxide equivalent without adverse economic impacts. This amount is approximately equivalent to 2 years' worth of global emissions, providing much-needed decarbonization time before atmospheric greenhouse gas concentrations reach critical levels. Tropical low-income countries, in particular, benefit significantly from initiatives that incentivize carbon sequestration through forests, far surpassing other nations in terms of gains.
3. Efforts to better allocate and manage land, water, and other inputs can increase agricultural, pastoral, and forestry income by approximately $3.29 trillion (along with enough additional food to feed the global population until 2050) without sacrificing biodiversity provided by forests and natural habitats or greenhouse gas storage and sequestration. Improved cultivation strategies and spatial planning can reduce the land footprint of agriculture while increasing global food production by over 150%. Many middle- and low-income countries currently achieve less than half of their agricultural potential, while high-income countries reach an average of 70% of their potential. By increasing agricultural productivity potential and reducing demand for agricultural land, middle- and low-income countries can avoid the development of biologically diverse and carbon-rich lands, meaning economic development need not come at the expense of a country's

biodiversity or increased carbon emissions. For most countries, improving agricultural production efficiency through strategic planning that does not impose fatal pressure on biodiversity is possible through land use, technological advancements, and better management.

As the global implementation of the new post-2020 biodiversity framework progresses, the resource efficiency frontier described in the report can become a valuable tool for optimizing land use, achieving increased income, and multiple environmental objectives.

In China, the World Bank collaborates with the Chinese Academy of Sciences' Research Center for Eco-Environmental Sciences to apply the sustainable resource efficiency frontier approach proposed by the Natural Capital Project. The study selects carbon sequestration, biodiversity, water conservation, soil retention, and food production as optimization targets for land use and management in China and conducts assessments of land use efficiency and multi-objective optimization. The Research Center for Eco-Environmental Sciences develops a land use multi-objective optimization model suitable for China by combining multiple objective functions and spatial optimization models, generating China's sustainable resource efficiency frontier.

The research analyzes the potential for improving ecosystem services, biodiversity, and food production through land use and management optimization in China. The study explores how nature-based solutions can play a crucial role in achieving climate and economic goals.

The results indicate that from 2000 to 2015, China's land use efficiency has improved, leading to simultaneous improvements in ecosystem services and food production. However, opportunities still exist for carbon sequestration and other ecosystem service improvements. Further analysis reveals that China can further enhance ecosystem services and increase food production through nature-based solutions. In principle, China can increase land carbon sequestration without reducing net food production. There is also a high degree of synergy between carbon sequestration and other ecosystem services, leading to increased biodiversity (represented by wild animal habitats), water conservation, and soil retention. The analysis is also used to evaluate relevant policy measures contributing to these objectives, including China's "ecological red line" policy, afforestation and reforestation, transforming unsustainable and inefficient irrigation agriculture in arid regions into rain-fed agriculture, and improving food production efficiency through more effective fertilizer use and irrigation practices.

b) Enhancing Decision Quality through Information Technology for Long-term and Cross-regional Impacts of Land Use

Natural capital accounting and ecosystem service assessments can serve as crucial support for comprehensive land use planning. By using integrated models and leveraging technologies such as artificial intelligence and the "metaverse", real-world multidimensional data can be simulated and presented in a visual manner to assist multi-stakeholders and decision-makers in visualizing the future scenarios and improving the quality of land use decisions.

Taking agriculture as an example, global climate warming has significantly affected the structure and distribution of agricultural crops in China. Rising temperatures have enriched heat resources in northern regions, extending the crop-growing season and shifting the accumulated temperature zone northward. The impact of climate warming on China's arable land utilization has become increasingly apparent. Since 1990, there has been a notable northward migration of rice cultivation in China, particularly in the northeastern region, where the core latitude of rice cultivation has shifted from 39°-46°N to 41°-47°N. Additionally, Qinghai Province has experienced an increase in mild spring drought and a decrease in severe summer drought, significantly affecting agricultural production.[1] These changes were factors that past land use decisions could not adequately consider. By employing technology to display these trends and corresponding scenarios, decision-makers can formulate more scientifically and comprehensively planned policies. For instance, they can focus on climate and water resource constraints, dynamically adjust lands that are no longer suitable for cultivation due to climate change, and optimize the addition of new arable land within suitable climate zones.

c) Natural Capital Preservation and Appreciation as a Crucial Basis for Achieving Synergistic Objectives

The research team believes that the essence of the **"nature-positive" vision model lies in preserving and appreciating natural capital and ensuring the stable and balanced supply of ecosystem services.** "Nature-positive" plays a vital role in multiple environmental sustainability agendas and economic development. It should be better recognized and integrated into fundamental considerations.

i. About "Nature-positive"

Despite increased investments in nature conservation over the past decades, we have not successfully "reversed the curve of biodiversity decline". [46] In response to biodiversity loss, several international institutions have jointly proposed the global "Nature-positive" conservation goal, which serves as a core

[1] Referred to content of the supporting reports on managing cropland and agro-ecosystem services in response to climate change.

concept for formulating biodiversity targets or industrial transformation processes. [47] "Nature-positive" seeks to slow down the rate of biodiversity decline compared to the state in 2020 through the efforts of various levels of governments, businesses, and the public. By 2030, it aims to surpass the state of 2020 and achieve full nature recovery by 2050, fostering harmonious coexistence between humans and nature [48].

ii. The Role of Nature-Positive Transitions in creating synergies

The World Economic Forum's insight report "Seizing Business Opportunities in China's Transition Towards a Nature-positive Economy" released in early 2022 identified three economic systems most closely associated with nature loss: the food, land- and ocean-use system; infrastructure and built-environment system; and energy and extractives system [5]. By comparing the potential economic opportunities in these three major socio-economic systems under the "Nature-positive" scenario and the "business as usual" scenario, it was estimated that realizing all the "Nature-positive" transitions across the three systems could create approximately $1.9 trillion in business opportunities and 88 million sustainable jobs in China by 2030. This vision aligns closely with China's ambition for high-quality green development, emphasizing nature protection and restoration, as well as rational and sustainable use and management of natural resources, leading to substantial synergistic effects.

Moreover, because nature provides services such as food, water, energy, and climate regulation, **nature-positive transformation is also a crucial pathway for achieving the crucial global objectives, such as food and water security and climate change mitigation** (see Figure 6.2.10). To realize this vision, it requires **funding, technological and governance innovations, multi-stakeholder collaboration, and implementation in both macro- and micro-level land management and utilization.**

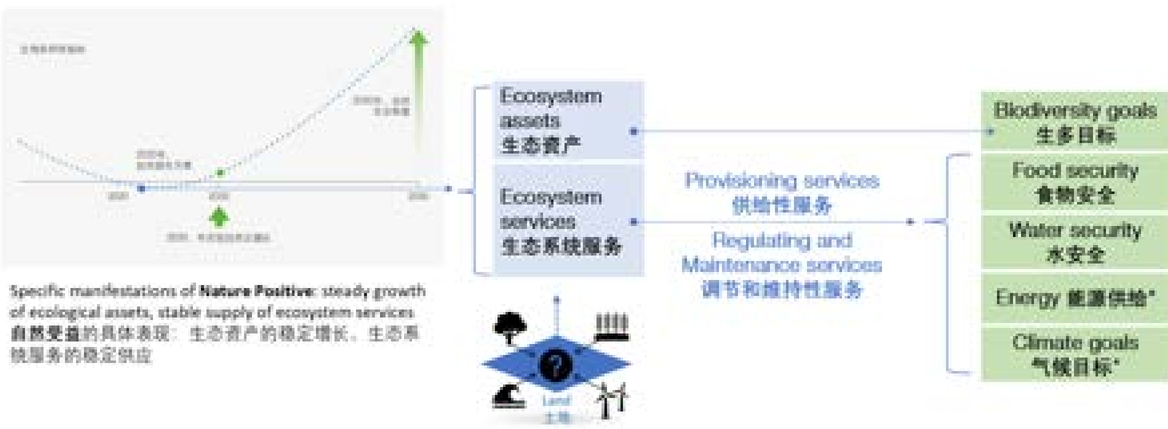

Figure 6-2- 10: Nature-Positive and Multiple Global Objectives

d) Strengthening Nature-Positive Transformation in Key Industrial Sectors' Green Development

According to the report "Seizing Business Opportunities in China's Transition Towards a Nature-positive Economy", 65% of China's GDP is at risk due to nature loss. [49] The three major socio-economic systems identified in the report are closely related to about two-thirds of industrial sectors classified in China's national economic activities. This implies that about two-thirds of China's industries have the opportunity to support global nature conservation goals through implementing nature-positive transformation (see Figure 6.2.11) and seize the economic opportunities brought by this transformation by 2030. In December 2022, the "Kunming-Montreal Global Biodiversity Framework" was adopted by all parties, and its multiple objectives are closely related to businesses and financial institutions. For example, Target 15 requires businesses and financial institutions to assess, disclose, and manage the risks, dependencies, and impacts of their operations, supply chains, and portfolios on biodiversity. The framework will accelerate changes in policies, regulations, stakeholder expectations, [50] and market conditions globally and signifies the transformation of various industries will become a common global trend.

The nature-positive transition of industrial sectors requires collaboration among policy-makers, industry associations, companies, and consumers, among other stakeholders. At the macro level, China has proposed the concept of "ecological civilization", including biodiversity protection to a national strategy and taking the lead in proposing ecological conservation redlines. Ambitious "dual-carbon" goals have also been set. China can break down barriers between climate and environmental actions and enhance synergy between "dual-carbon" goals and biodiversity goals, leading the way for a new type of high-quality development. In terms of practical transformation, more incentivizing policies, investments, and actionable tools and roadmaps are needed. Frameworks and tools being promoted internationally, such as Science-Based Targets for Nature, especially those related to land use, and the International Sustainability Standards Board (ISSB), can serve as crucial references for the transformation of relevant industries in China. In the future, industry-specific transformation paths that better align with China's socio-economic context will significantly contribute to advancing and implementing biodiversity goals and related objectives, such as climate goals, food security, and water security.

Figure 6.2.11: The Three Socio-economic Systems and 15 Nature-Positive Transitions

2.5.4 Recommendations for Research

a) Investigate how to fully consider the preservation and appreciation of natural assets and the stable and sustainable supply of ecosystem services in land use planning and management decisions.

i. Clarify the concepts of ecological assets and ecosystem services, refine the classification system for ecological assets and ecosystem services, and explore standardized indicators for valuing ecological assets and ecosystem services.

ii. Study the current practices of using natural capital accounting and ecosystem service assessments for national spatial planning and land use decision making and improve the principles and methods for land use decisions that involve ecosystem service assessments and engage multiple stakeholders (at both macro and micro levels). Natural capital can contribute to optimizing national spatial planning in several ways: (1) Provide a consistent, systematic, and transparent information system for development planners and policy-makers to effectively integrate nature into their decision-making processes for optimizing spatial planning; (2) Highlight the value of nature to decision-makers; (3) Provide direct information support to land use planning and zoning; (4) Evaluate the equity of access to ecosystem services and the benefits they provide; (5) Evaluate development, ecosystem restoration, and nature-based solutions investments on the basis of the value of expected ecosystem services return

iii. Conduct integrated research on ecosystem services, construct comprehensive models, quantitatively analyze the relationships between ecosystem services under different scenarios of natural and land use changes, and optimize combinations through exploration, optimization, and visualization using technologies such as artificial intelligence and the metaverse, aiming to find the best land use patterns.

b) Research the use of natural capital accounting and ecosystem service assessments as the basis for land use decisions in industry's nature-positive transformation processes. For example:

i. Agriculture (or agriculture, forestry, animal husbandry, and fishery): Agricultural biodiversity is a critical component of biodiversity and provides various ecosystem services needed for human sustainable development. However, public awareness of its importance is far from sufficient for nature conservation. More specific topics could include: support regenerative agriculture, reduce harmful subsidies, promote the sustainable utilization of agricultural land resources through ecosystem service functions, innovate ecological compensation mechanisms for arable land, and improve mechanisms for dynamic balancing of arable land quantity, etc.

ii. Renewable energy: Evaluate land use decisions for renewable energy, etc. Research shows that at 25–80% penetration in the electricity mix by 2050, solar energy may occupy 0.5–5% of total land. The resulting land cover changes, including indirect effects, will likely cause a net release of carbon ranging from 0 to 50 gCO2/kWh. Hence, a coordinated planning and regulation of new solar energy infrastructure should be enforced to avoid a significant increase in their life cycle emissions through terrestrial carbon losses. [51]

c) Develop specific measurable indicators for the nature-positive model that can be applied at multiple scales and advance the implementation of synergistic effects among multiple environmental objectives.

Given the importance of realizing nature-positive and related objectives, a key research and practical foundation is to assess and measure nature-positive objectives. However, comprehensive studies in this area are currently lacking. In the preliminary research, the research team plans to explore the construction of an assessment model for nature-positive objectives (see Table 6-2-1), followed by the development of a scientifically grounded comprehensive indicator evaluation method, baseline and tracking assessments, and methods that incorporate stakeholder knowledge. The goal is to implement actions to achieve multiple sustainable objectives through nature-positive transformation in industry sectors and business operations in the future.

Table 6-2: Proposed Nature-Positive Evaluation Indicators

Indicator Types	Evaluation Indicators
Ecosystem Pattern	Proportion of Natural Ecosystem Area
	Average Patch Area of Ecosystems
Ecosystem Quality	Vegetation Biomass Density
	Vegetation Coverage
	Water Body or Wetland Water Quality
Ecosystem Function	Net Ecosystem Productivity
	Total Ecosystem Productivity
	Soil Organic Matter Content
Species Diversity	Species Richness
	Habitat Fragmentation Index
Ecological Issues	Proportion of Desertified Land Area
	Proportion of Land Area with Moderate to Severe Soil Erosion
	Proportion of Land Area with Moderate to Severe Rocky Desertification
Environmental Quality	Water Environment
	Air Environment
	Soil Environment
Climate Change	Carbon Dioxide Concentration
	Other Greenhouse Gas Concentrations (Nitrous Oxide, Methane)

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