land

MDPI

Article

Assessment of the Implementation Effects of Main Functional Area Planning in the Yangtze River Economic Belt

Ming Wei [1,2], Wen Chen [1,3,*] and Yi Wang [4]

1 Key Laboratory of Lake and Watershed Science for Water Security, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing 210008, China; weiming17@mails.ucas.ac.cn
2 University of Chinese Academy of Sciences, Beijing 100049, China
3 College of Resources and Environment, University of Chinese Academy of Sciences, Beijing 100049, China
4 School of Water Resources and Hydropower Engineering, North China Electric Power University, Beijing 102206, China; hywy02@foxmail.com
* Correspondence: wchen@niglas.ac.cn

Abstract: The Yangtze River Economic Belt, relying on the golden waterway of the Yangtze River, serves not only as a vital industrial and urban stronghold in China but also bears the significant responsibility of the Yangtze River's major conservation efforts. The implementation of the main functional zones within the economic belt can provide regional synergies for development and protection through the optimization and organization of spatial structures, which is conducive to promoting the green and high-quality development of the Yangtze River Economic Belt in accordance with local conditions. In pursuit of these objectives, this paper utilizes multi-source data and selects corresponding indicators based on the main form of functional zoning to analyze the land protection and development patterns of the Yangtze River Economic Belt and to assess the effectiveness of the main functional zone planning implementation. The findings reveal that the enactment of main functional area planning has incrementally enhanced the level of land development and conservation in terms of certain aspects across the Yangtze River Economic Belt. This is evidenced by the burgeoning expansion of construction land in areas earmarked for optimization and pivotal development, bolstered by robust population and economic concentration capabilities, alongside a surge in per capita output. Moreover, ecological lands within critical ecological function zones exhibited signs of rejuvenation. Nonetheless, the outcomes are not universally aligned with the anticipated goals: the expanse of arable land in primary agricultural production zones has contracted, accompanied by a downturn in the proportion of grain output; the proliferation of construction land within key ecological function zones continues unabated, and ecological lands have experienced reductions over various intervals. The main functional zones have yet to fully embrace and enact protective strategies, highlighting an urgent need for more formidable institutional frameworks to guarantee their rigorous enforcement.

Keywords: Yangtze River Economic Belt; main functional area; land use/cover change; development and protection; ecosystem services

Citation: Wei, M.; Chen, W.; Wang, Y. Assessment of the Implementation Effects of Main Functional Area Planning in the Yangtze River Economic Belt. *Land* **2024**, *13*, 940. https://doi.org/10.3390/land13070940

Academic Editor: Dagmar Haase

Received: 7 May 2024
Revised: 21 June 2024
Accepted: 24 June 2024
Published: 28 June 2024

1. Introduction

The Yangtze River Economic Belt, a vital geographical axis that stretches from east to west and extends its influence from north to south, stands as one of the pivotal corridors for territorial spatial development in China [1,2]. In 2022, the total population of the Yangtze River Economic Belt reached 608 million, with a GDP of CNY 55.98 trillion, accounting for 43.1% and 46.5% of the nation's total, respectively, bearing nearly half the weight of China's economic and social development. At present, the region is characterized by robust population density and economic concentration, reflecting a consistent elevation in the standards of economic and social advancement [3,4]. Nevertheless, it grapples with substantial constraints due to resource and environmental limitations, and the expansion of construction land has, to a certain degree, encroached upon the sanctity of arable and ecological territories [5,6]. There are considerable disparities between the upper, middle, and lower reaches of the river, which increase the difficulty and pressure of achieving coordinated regional development [7–9]. The quest to refine spatial structuring and enhance regional governance, thereby catalyzing the green and high-caliber growth of the Yangtze River Economic Belt, remains a focal point of societal attention across various sectors [10–12]. In alignment with the guiding ethos of "emphasizing conservation over development", the Yangtze River Economic Belt is suggested to more intimately align with the national land development strategies, carving out innovative and tailored pathways for its protection and advancement [13].

The quest for regional green and high-quality development hinges on the optimization of comprehensive benefits. The main form of functional area planning has sketched a novel territorial spatial development and protection scheme for the Yangtze River Economic Belt, facilitating the construction of differentiated development and assessment pathways [14,15]. This holds significant strategic importance for the region's coordinated and sustainable development, making the implementation of main functional area planning an intrinsic requirement for high-quality development [16].

"National Main Functional Area Planning", promulgated in 2010, takes into account the varying resource and environmental capacities of distinct regions. It integrates current developmental intensities and prospective growth, assigning explicit territorial functions at the county echelon [17,18]. This demarcation engenders a zoning control paradigm imbued with distinctive Chinese features, offering a steadfast trajectory for the spatial organization of regions over the long haul [19–21]. Main functional areas are categorized into four types according to development approaches: optimized development regions, key development regions, restricted development regions, and prohibited development regions. The first two categories encompass urban territories, whereas the restricted development regions are subdivided into major agricultural production areas and key ecological function areas [22].

According to the policy, targeted spatial development and protection optimization strategies for the Yangtze River Economic Belt have been proposed. For instance, Fan Jie and others (2015) have analyzed the strategic position of the Yangtze River Economic Belt under the context of globalization and regional integration, outlining the spatial pattern and innovation-driven development blueprint of the belt [23]. Similarly, Chen Wen and associates (2015) have painted a picture of the developmental and protective landscape of the belt, informed by an analysis of regional disparities and spatial development suitability assessments, and have provided strategic guidance and policy recommendations based on the ecological–economic traits of various regions [24].

Moreover, the main form of functional area planning offers a fresh perspective for the regional classification assessment of high-quality development in the Yangtze River Economic Belt: urbanized areas should promote economic growth and enhance quality and efficiency, while in restricted development areas, the major agricultural production areas should be charged with safeguarding food security, and the key ecological function areas should be entrusted with the preservation of the integrity of natural and cultural resources [25]. Land, as a fundamental element, is intricately linked to high-caliber development and necessitates alignment with the varied functional zone typologies [26–28]. Under the anticipated state of functional zoning implementation, the increase in construction land in optimized development regions needs to be controlled. The arable land in major agricultural production areas and various types of ecological land in key ecological function areas should see stable growth. By constructing diversified local schemes for development and protection according to the zoning guidance of main functional area planning, and thereby enhancing the overall economic–ecological benefits from the perspective of the regional spatial division of labor, we can effectively propel the construction of ecological civilization in the new era to a higher level [29–31].

Existing research has delved into the domain of functional zoning, evaluating regional development from a multitude of perspectives. Academics have devised indicators across economic, social, and ecological dimensions to gauge governmental efficacy within distinct zonal classifications [32–34]. Some have integrated functional zones into the municipal level, combining multiple subsystems to assess the development of the Yangtze River Economic Belt through coupled coordination and scheduling [35]. Others have conducted performance evaluations based on specific provinces or districts [36,37]. In current studies, most scholars have pointed out the shortcomings in the implementation of functional zoning plans [38–40]. For instance, Wu Dan et al. (2018) have noted an uptick in the average vegetation coverage across the Yangtze River Economic Belt, signaling a positive trend [41]. However, they observed that the land use conversion rate in key ecological function areas surpasses that in both optimized and key development regions, a trend at odds with their designated developmental constraints.

Therefore, to address whether the development and protection of the Yangtze River Economic Belt are being effectively implemented, one could consider whether or not the changes in resource allocation factors in various regions are consistent with the requirements of functional zoning. This includes a specific analysis of the following issues: Are the regions adjusting the structure of arable land, ecological land, and construction land in accordance with functional zoning plans? Have they achieved the effect of increasing the proportion of grain production in major agricultural production areas and enhancing the ecosystem service functions in key ecological function areas? Have they achieved the effect of promoting the continuous concentration of population and economic total volume towards urbanized areas within a certain limit, particularly those earmarked for significant development?

To achieve this objective, the present study conducts a county-level assessment of the efficacy of main functional zone implementation, leveraging statistical data to analyze the conservation and development status of the Yangtze River Economic Belt. It also takes into account the expected requirements of the functional zones. Specifically, the main functional zones are analyzed in four categories: zones earmarked for optimized development, areas designated for key development, regions identified as major agricultural producers, and sectors critical for ecological functions. Considering that the "National Main Functional Area Planning" and the "Outline of the Yangtze River Economic Belt Development Plan" were released at the end of 2010 and in September 2016, respectively, this study uses the years 2011, 2016, and 2021 as time points for analysis, with five-year intervals. Based on the core concept of the Yangtze River's major protection, the study analyzes the on-the-ground implementation status and effects of the main form of functional area planning. This includes assessing the impact on food security and ecological safety by examining changes in arable land and ecological land area, as well as the implementation of protection requirements in the main functional zones. It also evaluates the effects of grain production and ecological function changes. The implementation status of development requirements in the main functional zones is observed through the area of construction land, while urbanization and industrialization effects in the Yangtze River Economic Belt are assessed from aspects such as permanent population and economic output (Figure 1). We conduct a relatively comprehensive indicator analysis of the Yangtze River Economic Belt in the Section 3, while in the Section 4, we focus on the main functions of different main functional areas and analyze corresponding indicators to see if the functions were implemented effectively. The overarching goal is to deliver an encompassing appraisal of the symbiotic relationship between development and conservation efforts in the Yangtze River Economic Belt, thus furnishing a scientifically grounded reference to inform and bolster high-caliber, sustainable growth. This study emphasizes the importance of understanding the land use land cover change model through the policies of the main functional areas, which is a possible direction for future sustainable development research.

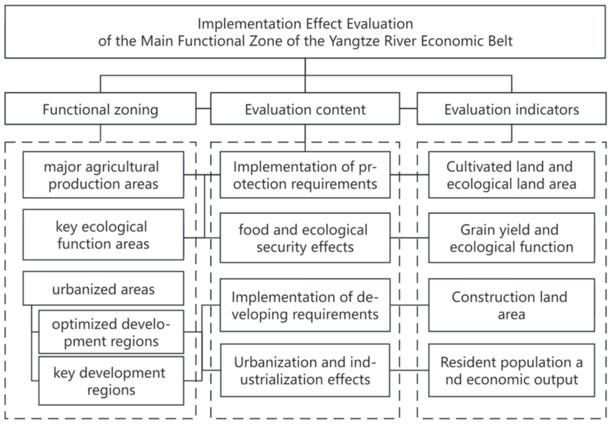


Figure 1. Analytical framework.

2. Research Methods and Data Sources

2.1. Main Functional Zones in the Yangtze River Economic Belt

The existing provincial main functional area plans were independently compiled, resulting in inconsistencies in naming and unit division. To address this, this paper refers to "National Main Functional Area Planning" and uniformly organizes the main functional zoning of the Yangtze River Economic Belt into three categories: urbanized areas, major agricultural production areas, and key ecological function areas. Urbanized areas further include optimized development regions and key development regions. Considering the significant changes in zoning and the differences in statistical units among provinces, for statistical convenience, this study will merge prefecture-level city districts belonging to the same main functional zones. In total, 843 regions were obtained, including 30 optimized development zones, 242 key development zones, 306 main agricultural product production zones, and 265 key ecological function zones (Figure 2). Among these, the urban districts of most prefecture-level cities are designated as key development regions, while the optimized development regions only involve the core development zones of Shanghai, Jiangsu, and Zhejiang, thereby exhibiting a pronounced spatial gradient from east to west.

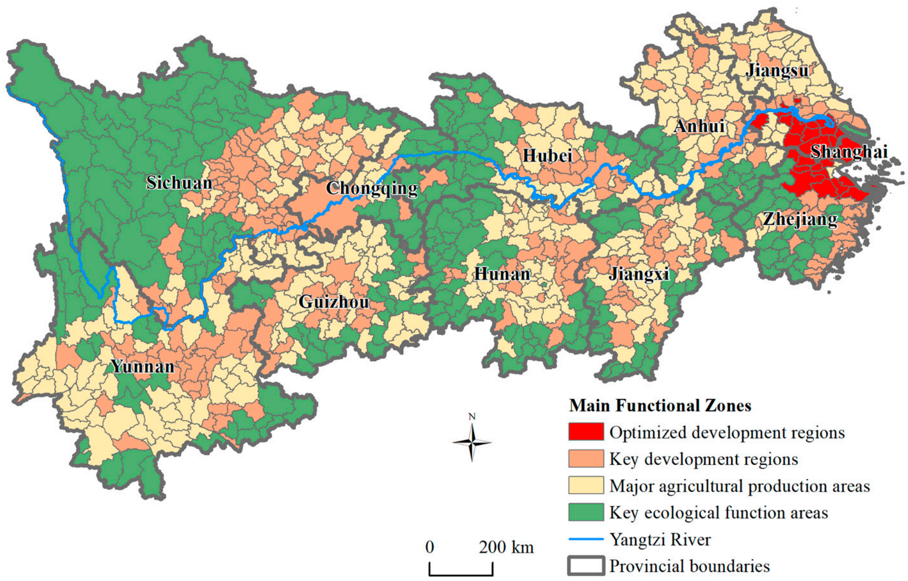


Figure 2. Main functional zones in the Yangtze River Economic Belt.

2.2. Calculation of Relevant Indicators

2.2.1. Single Land Use Dynamics Index and Relative Land Use Change Rate

In this research, the single land use dynamics index (SLDI) is utilized to characterize the evolution within a particular category of land use, while the relative land use change rate (RLCR) is applied to gauge the disparities between localized alterations and the aggregate transformation [42]. The respective equations are as follows:

$$K = \frac{U_b - U_a}{U_a} \cdot \frac{1}{T} \times 100\% \quad (1)$$

$$R = \frac{L_b}{L_a} / \frac{C_b}{C_a} \quad (2)$$

In the formulas, K and R represent the single land use dynamics index and the relative land use change rate, respectively. U_a and U_b denote the initial and final area of a specific land use category, while T stands for time. L_a and L_b refer to the initial and final area of a specific land use type in a local region, and C_a and C_b correspond to the initial and final area of the same land use type in the entire region. If R is greater than 1, it indicates that the change in the local area is greater than that in the entire region.

2.2.2. Ecosystem Service Value

The valuation of ecosystem service value (ESV) can be effectively determined through land use analysis [43]. In this study, drawing upon the methodologies of Xie Gaodi and others (2003), and further refining the parameters set forth by Costanza (1997) in his evaluation of ecosystem service values, we established a valuation table for the per unit area service value of China's terrestrial ecosystems [44,45]. To calculate the ecosystem service value equivalence factor of the Yangtze River Economic Belt, we use one-seventh of the annual per hectare market price of grain. The average grain yield in China from 2011 to 2021 was around 5565 kg/hm^2, and with the 2021 minimum procurement price for wheat being CNY 2.26 /kg, the ecosystem service value equivalence factor for the Yangtze River Economic Belt is determined to be CNY 1796.7. Due to the limited and fragmented wetland patches, they are incorporated into the water area for treatment. Utilizing this factor, we computed the unit area ecosystem service values for various land use categories (as shown in Table 1), which in turn allows for an analysis of the ecosystem service value fluctuations within the Yangtze River Economic Belt. The formula for computation is as follows:

$$ESV = \sum A_k \times VC_k \quad (3)$$

In the formula, ESV denotes the ecosystem service value, A_k represents the area of the k-th land use category, and VC_k is the value coefficient indicating the unit area service value of the k-th category.

Table 1. Ecological service value per unit area of different land use types (CNY/hm^2).

Ecosystem Service Functions	Forest	Grassland	Cropland	Water	Barren	Construction Land
Gas regulation	6288.45	1437.36	898.35	0	0	0
Climate regulation	4851.09	1617.03	1599.06	826.48	0	0
Water conservation	5749.44	1437.36	1078.02	36,616.75	53.90	0
Soil formation and protection	7007.13	3503.57	2623.18	17.97	35.93	0
Waste disposal	2353.68	2353.68	2946.59	32,664.01	17.97	0
Biodiversity conservation	5857.24	1958.40	1275.66	4473.78	610.88	0
Food production	179.67	539.01	1796.70	179.67	17.97	0
Raw material	4671.42	89.84	179.67	17.98	0	0
Entertainment	2299.78	71.87	17.97	7797.68	17.97	0
Total	39,257.90	13,008.11	12,415.20	82,594.30	754.61	0

2.3. Data Sources

The data of the main functional area come from relevant plans released by the Chinese government. The land use data utilized in this study were sourced from the publication "30 m annual land cover and its dynamics in China from 1990 to 2019" in the *Earth System Science Data* journal (DOI: 10.5281/zenodo.8176941). Due to the absence of snowland and the fragmentation and scarcity of shrubs and wetland patches in the research area, this dataset, which encompasses nine land use categories, is integrated into six categories: forest, grassland, cropland, water, barren, and construction land. The socio-economic data referenced in this study were obtained from the "China City Statistical Yearbook", the "China County Statistical Yearbook", and respective annual reports from various provinces and cities. Data gaps were filled using information retrieved from official government websites.

3. Analysis of Protection and Development Indicators for the Yangtze River Economic Belt

3.1. Implementation and Effectiveness of Protection

3.1.1. Status of Indicator Implementation for Land Protection

Our analysis has assessed the land use dynamics and the relative rates of land use change across various functional zones within the Yangtze River Economic Belt for two periods, 2011–2016 and 2016–2021, as detailed in Table 2. It should be noted that the year 2016 will not be counted twice because when we use 2011–2016, we calculate the growth rate rather than the total amount, which is the difference between the 2016 and 2011 data, and the same goes for 2016–2021. Due to the limited and fragmented wetland patches, they will be incorporated into the water area for treatment. Looking at the aggregate data, the past decade has seen a generally stable pattern in the fluctuations of both cultivated and ecological lands. Despite this overall stability, there has been a discernible downward trend in the extent of cultivated and ecological lands within all main functional zones, signaling that the objectives set for land conservation and management have not been entirely met. More specifically, the interval between 2011 and 2016 witnessed a contraction in the areas designated as grasslands, forests, and cultivated lands. In the subsequent period from 2016 to 2021, there was a continued shrinkage in the expanses of water bodies, grasslands, and cultivated lands, although forested areas experienced a marginal recovery. The annual average decrease in cultivated land for the two respective time frames stood at 0.03% and 0.21%.

Table 2. Dynamic degree and relative change rate of land use in various functional areas of the Yangtze River Economic Belt.

Functional Zoning	Periods	Index	Forest	Grassland	Cropland	Water	Barren	Construction Land
Optimized development regions	2011–2016	SLDI	−0.94	−15.60	−0.81	−0.84	−0.20	3.19
		RLCR	0.96	0.22	0.96	0.96	0.85	0.97
	2016–2021	SLDI	−0.20	−13.82	−0.04	−0.89	1.23	1.55
		RLCR	0.98	0.32	1.01	1.01	1.01	0.99
Key development regions	2011–2016	SLDI	−0.07	−1.86	−0.25	0.11	−0.14	4.51
		RLCR	1.00	0.92	0.99	1.01	0.85	1.03
	2016–2021	SLDI	0.33	−2.97	−0.28	−1.22	1.27	2.23
		RLCR	1.01	0.88	1.00	1.00	1.01	1.02
Major agricultural production areas	2011–2016	SLDI	−0.13	−1.78	−0.03	0.26	−6.64	3.34
		RLCR	1.00	0.93	1.00	1.01	0.57	0.98
	2016–2021	SLDI	0.23	−3.30	−0.15	−1.62	−2.91	1.47
		RLCR	1.00	0.86	1.00	0.98	0.81	0.98
Key ecological function areas	2011–2016	SLDI	−0.12	−0.18	0.66	−0.23	3.37	4.38
		RLCR	1.00	1.01	1.03	0.99	1.00	1.02
	2016–2021	SLDI	0.09	−0.24	−0.23	0.36	0.99	2.63
		RLCR	1.00	1.02	1.00	1.08	1.00	1.03
Yangtze River Economic Belt	2011–2016	SLDI	−0.12	−0.37	−0.03	0.01	3.28	3.84
	2016–2021	RLCR	0.17	−0.54	−0.21	−1.17	0.98	1.87

In terms of land type, the major agricultural production areas saw a greater reduction in the area of cultivated land, with the decrease expanding from 0.134% in the period from 2011 to 2016 to 0.744% in the period from 2016 to 2021 (Table 3), accompanied by a reduction in grassland and water body areas. In key ecological function areas, ecological lands such as grasslands, forest lands, and water bodies experienced declines during different periods. All categories of ecological land in optimized development regions showed a tendency to decrease, while in key development areas, the area of land used for construction purposes significantly increased, with corresponding reductions in grasslands, water bodies, and cultivated lands (Table 4).

Table 3. Changes in cropland in the Yangtze River Economic Belt from 2011 to 2021 (10,000 km^2).

Functional Zoning	2011	2016	2021	Yearly Change from 2011 to 2016 (%)	Yearly Change from 2016 to 2021 (%)
Optimized development regions	2.308	2.214	2.210	−0.81	−0.04
Key development regions	24.857	24.553	24.207	−0.25	−0.28
Major agricultural production areas	31.349	31.307	31.074	−0.03	−0.15
Key ecological function areas	10.470	10.816	10.689	0.66	−0.23
Yangtze River Economic Belt	68.985	68.889	68.180	−0.03	−0.21

Table 4. Changes in ecological land in the Yangtze River Economic Belt from 2011 to 2021 (10,000 km^2).

Functional Zoning	2011	2016	2021	Yearly Change from 2011 to 2016 (%)	Yearly Change from 2016 to 2021 (%)
Optimized development regions	1.386	1.323	1.288	−1.13	−0.66
Key development regions	22.323	22.161	22.245	−0.18	0.10
Major agricultural production areas	34.937	34.652	34.647	−0.20	−0.003
Key ecological function areas	76.313	75.791	75.832	−0.17	0.01
Yangtze River Economic Belt	134.959	133.926	134.012	−0.19	0.02

3.1.2. Impact of Food Security and Ecological Security in the Yangtze River Economic Belt

In agricultural production, the Yangtze River Economic Belt has witnessed a contraction in arable land. However, this has been offset by a surge in grain yield per unit, propelling a consistent increase in total grain production. Over the decade spanning 2011 to 2021, the Belt's grain output swelled by 25.76 million tons, with an annual growth rate exceeding 1% (Table 5). Although optimized development regions recorded a marginal dip in grain production, key development areas experienced robust gains, bolstering the overall grain output in urbanized areas and elevating their contribution to the Belt's aggregate production. The decrease in arable land within the principal agricultural zones was modest, at 0.03% and 0.15% for the intervals 2011–2016 and 2016–2021, respectively. Yet, the share of the Belt's total arable land area climbed from 45.44% in 2010 to 45.45% in 2016, and to 45.58% by 2021. The increment in the grain production of major agricultural production areas also saw a significant leap, from 679,700 tons in the initial five-year period to 4,761,500 tons in the subsequent five years. Contributions to grain production growth were observed across all regional types, with the exception of optimized development areas.

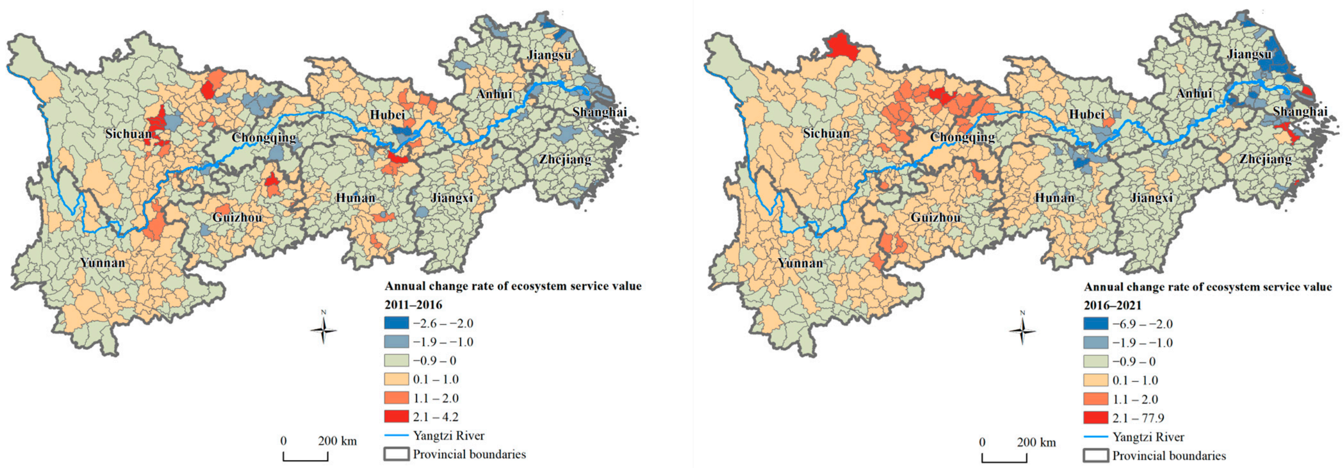
Table 5. Changes in grain yield in the Yangtze River Economic Belt from 2011 to 2021 (10,000 tons).

Functional Zoning	2011	2016	2021	Yearly Change from 2011 to 2016 (%)	Yearly Change from 2016 to 2021 (%)
Optimized development regions	676.31	634.74	601.49	−1.23	−1.05
Key development regions	5997.99	6842.23	7174.17	2.82	0.97
Major agricultural production areas	12,070.25	12,138.22	12,614.37	0.11	0.78
Key ecological function areas	2952.38	3513.01	3883.31	3.80	2.11
Yangtze River Economic Belt	21,696.93	23,128.21	24,273.34	1.32	1.24

In terms of ecological security, the ecosystem service value in key ecological function areas saw a modest recovery between 2016 and 2021. Nevertheless, the value of ecosystem services in optimized development regions, key development areas, and primary agricultural production zones all exhibited declining trends (refer to Table 6), with the optimized development regions facing the steepest reduction. This highlights the critical necessity and significance of establishing functional zones for ecological conservation. Moreover, an analysis of the ecosystem service value change map (see Figure 3) reveals that areas with an uptick in ecosystem service values are predominantly located in the main agricultural production zones and key ecological function areas, with a particular concentration in the central and western regions. In the period from 2011 to 2016, the increase in ecosystem service values was more evenly distributed across regions. However, between 2016 and 2021, a distinct pattern emerged, characterized by expansive growth in the central and western areas and a consistent decline in the eastern parts.

Table 6. Ecosystem service value in various functional areas of the Yangtze River Economic Belt (100 million CNY).

Functional Zoning	2011	2016	2021	Yearly Change from 2011 to 2016 (%)	Yearly Change from 2016 to 2021 (%)
Optimized development regions	1112.76	1064.72	1038.59	−1.08	−0.61
Key development regions	12,207.98	12,136.80	12,126.17	−0.15	−0.02
Major agricultural production areas	18,264.80	18,187.78	18,124.24	−0.11	−0.09
Key ecological function areas	26,753.53	26,630.06	26,699.96	−0.12	0.07
Yangtze River Economic Belt	58,339.07	58,019.36	57,988.96	−0.14	−0.01



(**a**) Yearly change from 2011 to 2016 (**b**) Yearly change from 2016 to 2021

Figure 3. Ecosystem service value change rate of the Yangtze River Economic Belt (%).

We extracted the top five and bottom five cities in terms of ecosystem service value growth rates from 2011 to 2016 and from 2016 to 2021 (Table 7). Between 2011 and 2016, the regions with the fastest growth rates were all key development areas located in Central and Western China, with Sichuan Province being the most important. This was mainly due to the impact of policies such as the pilot program of returning farmland to forests and grasslands in Sichuan, which resulted in a large amount of farmland being converted into ecological land. From 2016 to 2021, although the overall ecosystem service value of the Yangtze River Delta region showed a downward trend, the fastest growing areas still shifted to the coastal areas of Jiangsu and Zhejiang. Some of them are key ecological function areas. For example, the ecosystem service value of Shengsi County increased by 77.93% annually from 2016 to 2021, because of its small original size and significant expansion of forest land over the past five years. Others are the counties and cities in key and optimized development areas where the mudflat resources are continuously increasing.

Table 7. Top 5 and bottom 5 cities with growth rate of ecosystem service value in 2011–2021.

City	Functional Zoning	2011–2016 (%)	Province	City	Functional Zoning	2016–2021 (%)	Province
Dujiangyan	Key development regions	4.20	Sichuan	Shengsi	Key ecological function areas	77.93	Zhejiang
Danling	Key development regions	4.19	Sichuan	Haiyan	Major agricultural production areas	19.11	Zhejiang
Yueyang	Key development regions	2.88	Hunan	Qidong	Key development regions	7.73	Jiangsu
Qingshen	Key development regions	2.74	Sichuan	Yuyao	Optimized development regions	5.01	Zhejiang
Qionglai	Key development regions	2.67	Sichuan	Haining	Optimized development regions	4.99	Zhejiang
Lengshuijiang	Key development regions	−2.06	Hunan	Xinghua	Major agricultural production areas	−3.34	Jiangsu
Xiantao	Key development regions	−2.32	Hubei	Sheyang	Major agricultural production areas	−3.58	Jiangsu
Lianyungang urban districts	Key development regions	−2.37	Jiangsu	Gaochun	Major agricultural production areas	−3.86	Jiangsu
Xiangshui	Major agricultural production areas	−2.39	Jiangsu	Dongtai	Major agricultural production areas	−5.99	Jiangsu
Kunshan	Optimized development regions	−2.59	Jiangsu	Dafeng	Major agricultural production areas	−6.89	Jiangsu

For the last five, they were mainly in key development areas from 2011 to 2016, while from 2016 to 2021, they were main agricultural production zones, all located in Jiangsu. The reason is that in the early stage, due to rapid economic development and urban expansion, ecological land and arable land were squeezed out, and a large amount of barren and ecological land such as mudflat wetlands were converted into agricultural land in the later period.

3.2. Implementation and Effectiveness of Development

3.2.1. Implementation Status of Land Development Indicators

Over the decade from 2011 to 2021, there was a consistent trend of growth in the development of construction land across the various principal functional zones within the Yangtze River Economic Belt (refer to Table 8). The increase in construction land as a percentage of the total land area occurred in the following order: optimized development regions, key development areas, main agricultural production zones, and key ecological function zones. Nevertheless, the expansion rate in each functional zone experienced a deceleration in the period from 2016 to 2021. Optimized development regions sustained their growth in construction land, with the proportion of new development reaching a significant 3.35% of the regional area from 2011 to 2016. Key development areas intensified their consolidation of construction land, accounting for the largest addition in area. The main agricultural production zones exhibited a relatively modest growth rate over the decade, whereas the key ecological function zones experienced an increase in construction land that surpassed the average level. These trends suggest that, despite the implementation of the main functional area strategy, the control over construction land use has been somewhat effective, but the containment of land expansion in optimized development regions and critical ecological function zones has not been adequately enforced.

Table 8. Changes in land use for construction in the Yangtze River Economic Belt from 2011 to 2021 (10,000 km^2).

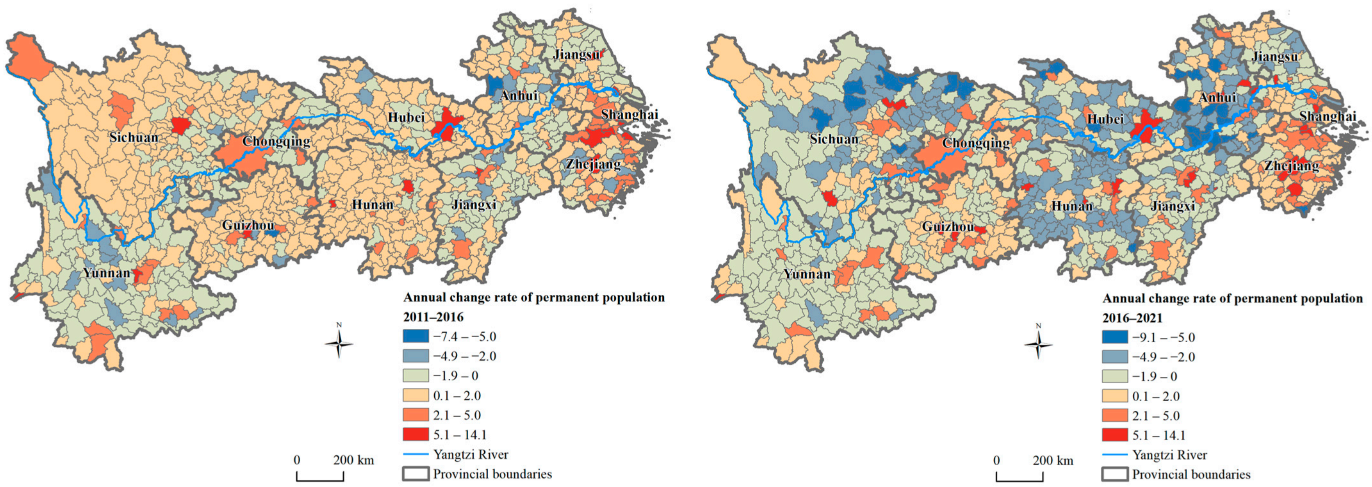
Functional Zoning	2011	2016	2021	Yearly Change from 2011 to 2016 (%)	Yearly Change from 2016 to 2021 (%)
Optimized development regions	0.984	1.141	1.229	3.19	1.55
Key development regions	2.069	2.536	2.819	4.51	2.22
Major agricultural production areas	1.965	2.293	2.461	3.34	1.47
Key ecological function areas	0.392	0.478	0.541	4.38	2.63
Yangtze River Economic Belt	5.410	6.449	7.050	3.84	1.87

3.2.2. Impact of Urbanization and Industrialization on Population and Industry

From 2011 to 2021, the population density in the Yangtze River Economic Belt increased further, and the population growth rate of each functional area became relatively balanced, with the rise in permanent residents predominantly occurring in urbanized areas (refer to Table 9). Optimized development regions have consistently been focal points for surges in population density. In the period from 2011 to 2016, population growth rates were generally higher in urbanized areas, especially in key development zones of Central and Western China. This trend decelerated between 2016 and 2021, with the most rapid population increases localized in Southern Jiangsu, Zhejiang, and the central sections of the Yangtze River Economic Belt (Figure 4). The trajectory of population density changes mirrored this pattern, with a more equitable increase in population density from 2011 to 2016, whereas from 2016 to 2021, the growth in population density became more pronounced in optimized and key development regions. This shift indicates a deceleration in the large-scale urbanization of the population, with a new trend emerging of population concentration in areas with more advanced development.

Table 9. Population Changes in the Yangtze River Economic Belt from 2011 to 2021 (ten thousand people).

Functional Zoning	2011	2016	2021	Yearly Change from 2011 to 2016 (%)	Yearly Change from 2016 to 2021 (%)
Optimized development regions	7770	8665	9149	2.302	1.118
Key development regions	24,140	25,982	28,278	1.526	1.767
Major agricultural production areas	18,288	18,139	16,551	−0.163	−1.751
Key ecological function areas	8054	8087	7689	0.083	−0.986
Yangtze River Economic Belt	58,252	60,873	61,666	0.900	0.261



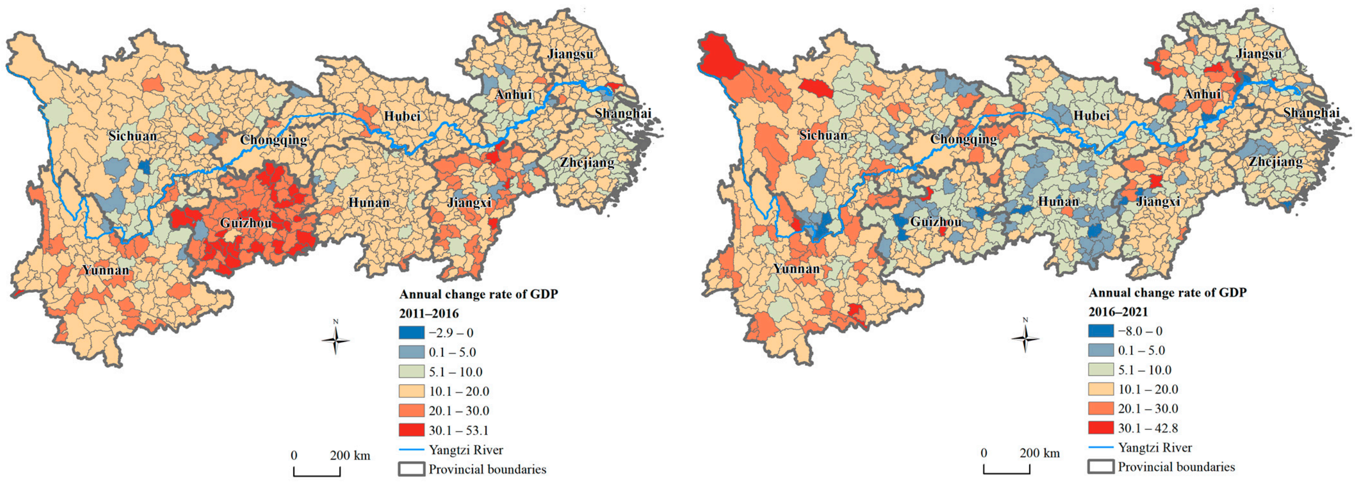
(**a**) Yearly change from 2011 to 2016 (**b**) Yearly change from 2016 to 2021

Figure 4. Permanent population change rate of the Yangtze River Economic Belt (%).

In terms of economic output, from 2011 to 2021, all functional areas within the Yangtze River Economic Belt advanced in economic development, with an annual average GDP growth rate exceeding 10% (refer to Table 10). The GDP growth rate slowed down from 2016 to 2021, but there was an increase in the absolute growth amount to varying degrees. Urbanized areas accounted for approximately 75% of the GDP increment in the Yangtze River Economic Belt, making a significant contribution to the economic growth of the region. Major agricultural production areas have the fastest annual growth rate, and the proportion of GDP in key development areas to the Yangtze River Economic Belt has increased the most. From 2016 to 2021, the areas with high growth rates shifted from the central part of the Yangtze River Economic Belt to the western part, with some areas in Anhui and Jiangxi also exhibiting high economic growth trends (Figure 5).

Table 10. Changes in GDP of the Yangtze River Economic Belt from 2011 to 2021 (trillion CNY).

Functional Zoning	2011	2016	2021	Yearly Change from 2011 to 2016 (%)	Yearly Change from 2016 to 2021 (%)
Optimized development regions	6.74	9.95	15.33	9.525	10.818
Key development regions	10.19	16.63	25.19	12.632	10.302
Major agricultural production areas	3.54	6.14	9.60	14.710	11.265
Key ecological function areas	1.43	2.44	3.69	14.162	10.295
Yangtze River Economic Belt	21.90	35.16	53.82	12.111	10.616



(**a**) Yearly change from 2011 to 2016 (**b**) Yearly change from 2016 to 2021

Figure 5. GDP growth rate of the Yangtze River Economic Belt (%).

4. Analysis of the Implementation Effects of the Main Functional Zones in the Yangtze River Economic Belt

4.1. Main Agricultural Production Zones

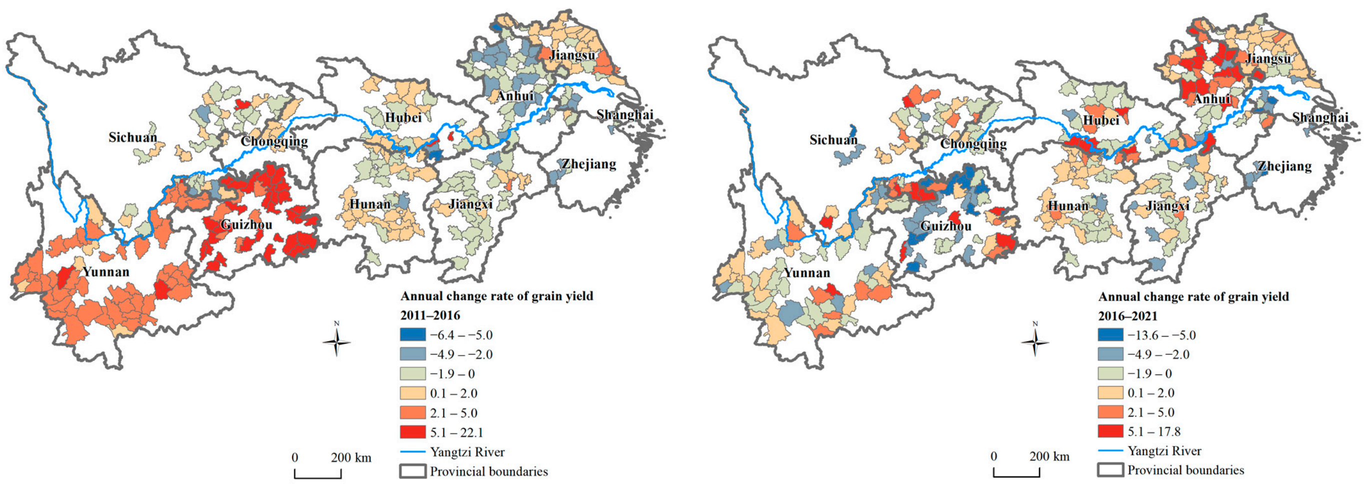
In the years 2011, 2016, and 2021, the total grain output of the main agricultural production zones in the Yangtze River Economic Belt was 120.7 million tons, 121.4 million tons, and 126.1 million tons, respectively, showing a stable growth trend. However, the proportion of grain output from these main agricultural production zones in both the Yangtze River Economic Belt and the entire country declined from 55.63% and 21.13% to 51.95% and 18.47%, respectively (refer to Table 11). This indicates that the main agricultural production zones have not fully played their role in accordance with their primary function. The function of grain production has, to some extent, shifted to other types of regions, and there is a trend of spreading beyond the Yangtze River Economic Belt. The role of the main agricultural production zones in ensuring grain security still requires further attention.

Table 11. Changes in the proportion of grain yield in the main agricultural production areas.

Year	Grain Yield (100 million tons)	Proportion in the Economic Belt (%)	Proportion in China (%)
2011	1.207	55.63	21.13
2016	1.214	52.49	19.70
2021	1.261	51.95	18.47

Specifically, the distribution of grain output share and growth in the main agricultural production zones is uneven, with the central and western regions outperforming the eastern region. In the 306 statistical units of major agricultural production areas, the majority have seen a decline in their share of the national grain output. Compared to 2011, only 105 units experienced an increase in their proportion of the national grain production in 2016. Between 2016 and 2021, merely 66 units saw an uptick in their share. Concurrently, only 16 units (5.23%) managed to increase their share during both the 2011−2016 and 2016–2021 periods, while 89 regions were unable to maintain their grain supply levels from 2016.

Figure 6 depicts the shifts in the proportion of grain production from the primary agricultural zones relative to the national output (measured in %). From 2011 to 2016, regions including Yunnan, Guizhou, and some areas in Northern Jiangsu and Eastern Sichuan witnessed an uptick in their grain production shares, whereas the remaining provinces saw a decline, with Northern Anhui experiencing the most pronounced drop. This phase demonstrated a pattern of grain production shares increasing from the east to the west. In the subsequent period from 2016 to 2021, Northern Anhui and certain areas in Hubei, Guizhou, and Western Yunnan observed growth in their grain output shares, while Jiangsu, Jiangxi, Hunan, and Western Yunnan experienced reductions in their respective shares.



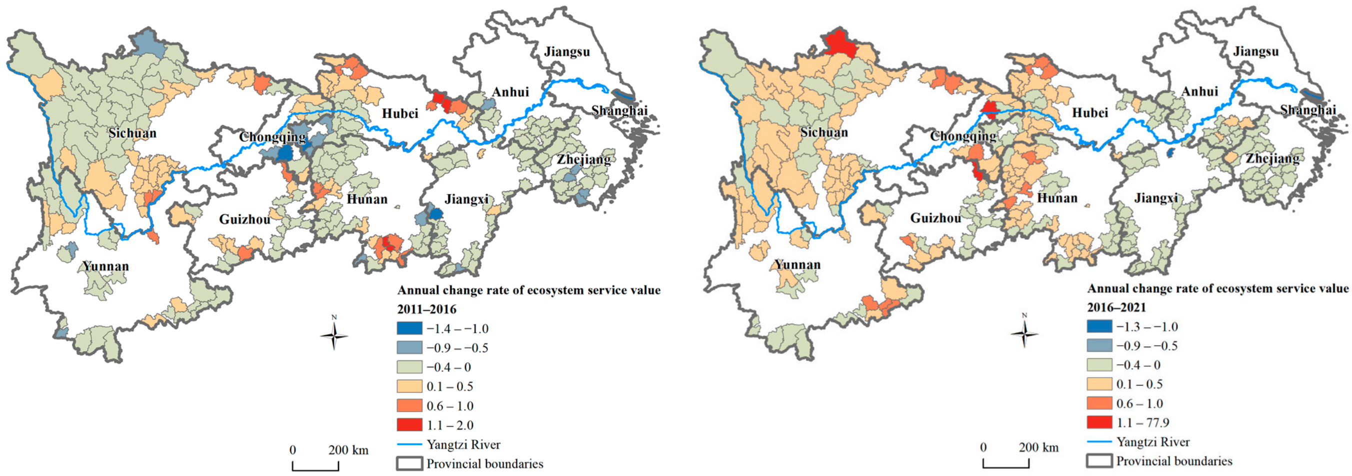
(**a**) Yearly change from 2011 to 2016 (**b**) Yearly change from 2016 to 2021

Figure 6. Grain yield change rate in the main agricultural production areas (%).

4.2. Key Ecological Functional Areas

The ecological land area in key ecological functional areas has shown a trend of decreasing to rebounding. In recent years, after the introduction of the Yangtze River Economic Belt planning scheme, the effect of ecological function protection has gradually become prominent. According to Tables 3 and 5, the ecological land area of the key ecological functional areas in the Yangtze River Economic Belt decreased by 5222 square kilometers from 2011 to 2016, with an average annual decrease of 0.17%. However, there was a slight recovery from 2016 to 2021, with an additional area of 408 square kilometers. At the same time, the growth rate of cultivated land and the relative change rate of water body growth in key ecological functional areas between 2011 and 2016 are leading the entire region.

In terms of the value of ecosystem services, among the 264 key ecological function zones, the number of areas showing an upward trend increased from 80 (30.3%) during 2011–2016 to 130 (49.2%) in the period of 2016–2021. Moreover, the decline in ecosystem service values across various regions has moderated, which to some extent highlights the effective implementation of ecological function conservation (Figure 7). From 2011 to 2016, the areas with growth in ecosystem service value were concentrated in a few regions, such as northern Hubei, southern Hunan, and southern Sichuan. Between 2016 and 2021, these areas expanded to include western Hubei, western Hunan, northern Sichuan, and northern Yunnan, showing a trend of contiguous development. The eastern districts, however, still generally exhibited a downward trend, indicating that there is still a need to strengthen ecological protection in key ecological function zones to safeguard ecological resources effectively.



(**a**) Yearly change from 2011 to 2016 (**b**) Yearly change from 2016 to 2021

Figure 7. Ecosystem service value change rate in key ecological functional areas (%).

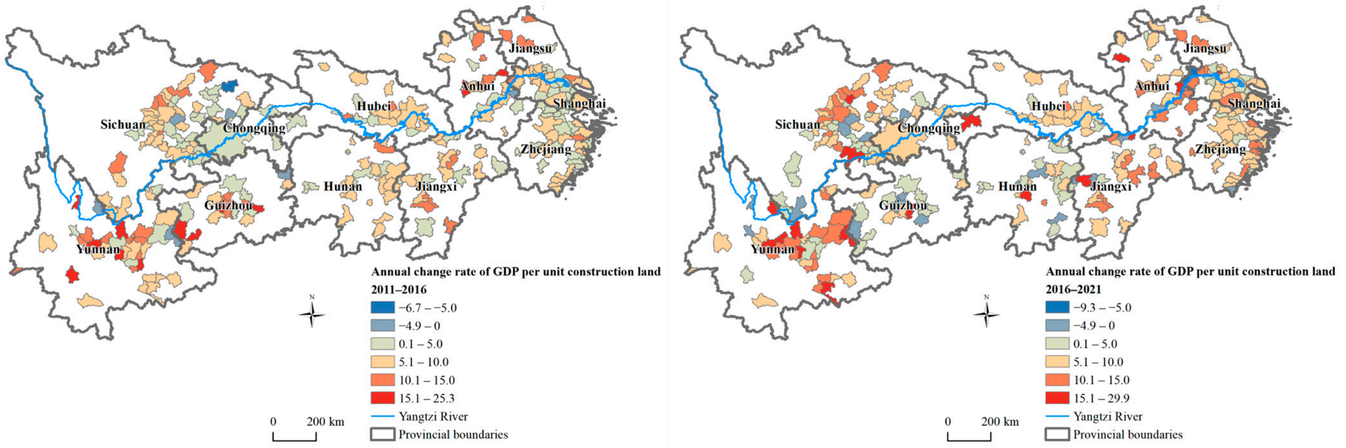
4.3. Urbanized Areas

Urbanized areas take the critical responsibility of economic development and serve as the key engine driving high-quality growth along the Yangtze Economic Belt, with a relatively stable share of GDP. Among the 272 optimized and key development zones, 192 and 136 zones saw an increase in their GDP share of the national total during the periods of 2011–2016 and 2016–2021, respectively, demonstrating the strong economic agglomeration capabilities of these optimized and key development areas. In terms of GDP share, the optimized development zones have experienced steady growth, maintaining a stable yet important share of the national total; the economic contributions of key development zones have seen a significant increase in 2011–2016, with a slight decline observed in the period from 2016 to 2021 (Table 12).

Table 12. Changes in the proportion of GDP in urbanized areas.

Year	Optimized Development Regions		Key Development Regions	
	Proportion in the Economic Belt (%)	Proportion in China (%)	Proportion in the Economic Belt (%)	Proportion in China (%)
2011	30.78	13.81	46.54	20.89
2016	28.30	13.33	47.30	22.28
2021	28.49	13.34	46.81	21.92

Over the decade, land use efficiency in the urbanized regions of the Yangtze Economic Belt has seen an enhancement. The period from 2016 to 2021 marked a more prevalent and concentrated increase in GDP per unit construction land across the provinces within the Belt (Figure 8). The fastest growth in GDP per unit area from 2011 to 2016 was in Lincang urban district, with an average annual increase of 25.3%; the slowest was in Bazhong urban district, with a growth rate of −6.7%. In the subsequent period from 2016 to 2021, Hekou Yao Autonomous County recorded the highest average annual growth rate at 29.9%, in stark contrast to Pukou District, which experienced a decline of 9.35%. Part of the reason for this may be due to a mismatch between urban expansion and the level of economic development, leading to a period of low land use efficiency. For example, in the 2016–2021 period, the expansion of construction land in Bazhong urban district was considerably less pronounced, and with the uptick in urban economic development, the land use efficiency saw a recovery. Furthermore, areas with less favorable locational conditions and a weaker developmental base have also managed to make significant strides in GDP per unit area, propelled by tourism and urban development initiatives.



(**a**) Yearly change from 2011 to 2016 (**b**) Yearly change from 2016 to 2021

Figure 8. GDP per unit construction land change rate in urbanized areas (%).

5. Conclusions and Discussion

5.1. Conclusions

This paper focuses on the green and high-quality development of the Yangtze River Economic Belt, adopting a multi-index analysis at the county level to examine the patterns of land space protection and development over the past decade. It evaluates the effectiveness of the implementation of various principal functional areas. This study will contribute to breaking through the monolithic standards of regional development assessment, better coordinating population, resources, and the environment, and maximizing the comprehensive benefits of the economy, agriculture, and ecology. This will lead to more regionally accurate assessment results. The conclusions of this study are as follows:

(1) The trajectory of territorial space conservation and development within the Yangtze River Economic Belt, guided by functional zoning strategies, has maintained a consistent and stable course, with marked effectiveness, particularly post-2016, following the introduction of strategic planning. This period has been characterized by a significant uptick in results. Urban regions have exhibited robust capabilities for population and economic concentration, coupled with a progressive enhancement in land utilization efficiency. The economic belt as a whole has seen a steady climb in grain output, alongside an appreciable increase in the ecological worth of pivotal ecological function zones.

(2) The current state of protection and development does not fully align with the anticipated outcomes of the implementation of main functional area planning. The

main functional indicators of some areas tend to weaken. In optimized development regions, urban space continues to expand, while ecological land and arable land in key development areas have decreased. The scale of arable land and the proportion of grain production in major agricultural production areas have declined nationally. Construction land in key ecological function areas has rapidly increased, with ecological land experiencing declines in different periods. Furthermore, the annual valuation of ecosystem services across the various functional areas has been on a downward trajectory.

(3) The prospects for the implementation of main functional area planning in the Yangtze River Economic Belt are promising. Moving forward, it is essential to advance protection and development in tandem, strategically coordinate efforts, and leverage the strengths of different areas. By refining the functional division of labor, the region can further capitalize on its comparative advantages and establish a cooperative mechanism based on shared costs and mutual benefits. This approach will help to alleviate the tensions between population dynamics and resource–environmental constraints.

5.2. Discussion

This paper analyzes the status of protection and development indicators in the Yangtze River Economic Belt from the perspective of principal functional areas, assessing the effectiveness of its green development. This approach helps to overcome the limitations imposed by traditional administrative boundaries, taking into account China's population and economic patterns, as well as land use configurations. It explores differentiated high-quality development paths from a multi-functional regional perspective, aiming to further optimize policy layouts based on the current principal functional area schemes and development plans. Depending on the resource endowments and development trajectories of different regions, urbanized areas should pursue high-level development while balancing food security and ecological protection; restricted development areas should prioritize protection and engage in reasonable development within the limits of resources and the environment.

However, the Yangtze River Economic Belt is a large-scale system with strong stability, and fluctuations in its development process can be easily overlooked, making it challenging to delve into the complex mechanisms behind observed phenomena. The division of principal functional areas at the county level may face difficulties due to the extensive size of counties, leading to development constraints on planning in some regions and making it hard to fully implement the requirements of main functional area planning. Furthermore, land use changes stand as one of the primary indicators that directly reflect governmental policy decisions. The government's steering of protection and development activities, as guided by main functional area planning, is predominantly manifested through land policy. However, the actual impact of these policies is not exclusively contingent upon governmental conduct; market dynamics and societal actors may also play a role, and these interactions merit further scholarly exploration. Furthermore, the indicators and analysis methods we use are not complicated, as it is difficult to collect county-level data at a large scale. We look forward to breakthroughs in data and methods in future research. In addition, with the advent of the "dual circulation" paradigm, the strategic significance and spatial organizational framework of the Yangtze River Economic Belt are poised for potential shifts, which calls for more in-depth research.

Author Contributions: Conceptualization, M.W. and W.C.; methodology, W.C.; data curation, M.W.; writing—original draft preparation, M.W. and Y.W.; writing—review and editing, W.C. and Y.W.; supervision, W.C.; funding acquisition, W.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Natural Resources Development Special Fund (Marine Science and Technology Innovation) Project of Jiangsu Province, grant number JSZRHYKJ202205; Independently Deployed Scientific Research Project of Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, grant number NIGLAS2022GS06.

Data Availability Statement: Data are contained within the article.

Acknowledgments: We would like to thank the Regional Economic Transformation and Management Reform Collaborative Innovation Center of Nanjing University for supporting this paper.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Liu, L.; Yang, Y.; Liu, S.; Gong, X.; Zhao, Y.; Jin, R.; Duan, H.; Jiang, P. A comparative study of green growth efficiency in yangtze river economic belt and yellow river basin between 2010 and 2020. *Ecol. Indic.* **2023**, *150*, 110214. [CrossRef]
2. Yang, X.; Feng, Z.; Chen, Y.; Xu, X. A comparative analysis of the levels and drivers of regional coordinated development in the yangtze river economic belt and yellow river basin, China. *Heliyon* **2024**, *10*, e26513. [CrossRef]
3. Chen, C. Changes in the spatial distribution of the employed population in the yangtze river delta region since the 21st century: An analysis and discussion based on census data. *Land* **2023**, *12*, 1249. [CrossRef]
4. Feng, Y.; Sun, M.; Pan, Y.; Zhang, C. Fostering inclusive green growth in china: Identifying the impact of the regional integration strategy of yangtze river economic belt. *J. Environ. Manag.* **2024**, *358*, 120952. [CrossRef] [PubMed]
5. Ma, X.; Wu, H.; Qin, B.; Wang, L.C. Spatiotemporal change of landscape pattern and its eco-environmental response in the yangtze river economic belt. *Sci. Geogr. Sin* **2022**, *42*, 1706–1716.
6. Wang, J.; Zhang, X. Land-based urbanization in China: Mismatched land development in the post-financial crisis era. *Habitat Int.* **2022**, *125*, 102598. [CrossRef]
7. Guan, X.; Wei, H.; Lu, S.; Dai, Q.; Su, H. Assessment on the urbanization strategy in China: Achievements, challenges and reflections. *Habitat Int.* **2018**, *71*, 97–109. [CrossRef]
8. Xu, Y.; Tang, Q.; Fan, J.; Bennett, S.J.; Li, Y. Assessing construction land potential and its spatial pattern in China. *Landsc. Urban Plan.* **2011**, *103*, 207–216. [CrossRef]
9. Wang, N.; Li, S.; Kang, Q.; Wang, Y. Exploring the land ecological security and its spatio-temporal changes in the yangtze river economic belt of China, 2000–2020. *Ecol. Indic.* **2023**, *154*, 110645. [CrossRef]
10. Liu, Y.; Zhou, Y. Territory spatial planning and national governance system in China. *Land Use Policy* **2021**, *102*, 105288. [CrossRef]
11. Chen, M.; Liang, L.; Wang, Z.; Zhang, W.; Yu, J.; Liang, Y. Geographical thoughts on the relationship between 'beautiful China' and land spatial planning. *J. Geogr. Sci.* **2020**, *30*, 705–723. [CrossRef]
12. Wang, L.; Shen, J. Spatial planning and its implementation in provincial China: A case study of the Jiangsu region along the yangtze river plan. *J. Contemp. China* **2016**, *25*, 669–685. [CrossRef]
13. Fu, H.; Liu, J.; Dong, X.; Chen, Z.; He, M. Evaluating the sustainable development goals within spatial planning for decision-making: A major function-oriented zone planning strategy in China. *Land* **2024**, *13*, 390. [CrossRef]
14. Chen, W.; Duan, X.J.; Chen, J.L.; Xu, G. The methods of spatial development function regionalization. *Acta Geogr. Sin.* **2004**, *59*, 53–58.
15. Fan, J. Spatial organization pathway for territorial function-structure: Discussion on implementation of major function zoning strategy in territorial spatial planning. *Geogr. Res.* **2019**, *38*, 2373–2387.
16. Fan, J.; Li, P. The scientific foundation of major function oriented zoning in China. *J. Geogr. Sci.* **2009**, *19*, 515–531. [CrossRef]
17. Fan, J.; Wang, Y.; Wang, C.; Chen, T.; Jin, F.; Zhang, W.; Li, L.; Xu, Y.; Dai, E.; Tao, A. Reshaping the sustainable geographical pattern: A major function zoning model and its applications in China. *Earth's Future* **2019**, *7*, 25–42. [CrossRef]
18. Wang, Y.; Fan, J. Multi-scale analysis of the spatial structure of China's major function zoning. *J. Geogr. Sci.* **2020**, *30*, 197–211. [CrossRef]
19. Bao, S.; Lu, L.; Zhi, J.; Li, J. An optimization strategy for provincial "production–living–ecological" spaces under the guidance of major function-oriented zoning in China. *Sustainability* **2024**, *16*, 2248. [CrossRef]
20. Fan, J.; Sun, W.; Zhou, K.; Chen, D. Major function oriented zone: New method of spatial regulation for reshaping regional development pattern in China. *Chin. Geogr. Sci.* **2012**, *22*, 196–209. [CrossRef]
21. Qi, F.; Qiu, S.; Zhao, C.; Chen, J.; Shao, S.; Liu, B. Improve policy system of main functional zones in national spatial planning. *Bull. Chin. Acad. Sci. Chin. Version* **2024**, *39*, 714–725.
22. Fan, J. Draft of major function oriented zoning of China. *Acta Geogr. Sin.* **2015**, *70*, 186–201.
23. Fan, J.; Wang, Y.F.; Chen, D.; Zhou, C.H. Analysis on the spatial development structure of the yangtze river economic belt. *Prog. Geogr.* **2015**, *34*, 1336–1344.
24. Chen, W.; Sun, W.; Wu, J.W.; Chen, C.; Yan, D.S. Constructing a spatial pattern of development and protection in the yangtze river economic belt and its analysis. *Prog. Geogr.* **2015**, *34*, 1388–1397.
25. Wang, C.S.; Zhu, S.S.; Fan, J.; Liu, H. Key indicators and their data requirements for supervision and evaluation of mfoz planning. *Prog. Geogr.* **2012**, *31*, 1678–1684.

26. Chen, S.; Yao, S. Evaluation of the protection effectiveness of national key ecological functional area based on land use and ecosystem service value. *Environ. Dev. Sustain.* **2024**, *26*, 12467–12487. [CrossRef]
27. Wang, J.; Lin, Y.; Glendinning, A.; Xu, Y. Land-use changes and land policies evolution in China's urbanization processes. *Land Use Policy* **2018**, *75*, 375–387. [CrossRef]
28. Zhu, C.; Dong, B.; Li, S.; Lin, Y.; Shahtahmassebi, A.; You, S.; Zhang, J.; Gan, M.; Yang, L.; Wang, K. Identifying the trade-offs and synergies among land use functions and their influencing factors from a geospatial perspective: A case study in Hangzhou, China. *J. Clean. Prod.* **2021**, *314*, 128026. [CrossRef]
29. Wen, C. *Economic Analysis of Spatial Equilibrium*; The Commercial Press: Beijing, China, 2008.
30. Xu, X.; Na, R.; Shen, Z.; Deng, X. Impact of major function-oriented zone planning on spatial and temporal evolution of "three zone space" in China. *Sustainability* **2023**, *15*, 8312. [CrossRef]
31. Liu, J.Y.; Liu, W.C.; Kuang, W.H.; Ning, J. Remote sensing-based analysis of the spatiotemporal characteristics of built-up area across China based on the plan for major function-oriented zones. *Acta Geogr. Sin* **2016**, *71*, 355–369.
32. Xia, H.; Zhang, W.; He, L.; Ma, M.; Peng, H.; Li, L.; Ke, Q.; Hang, P.; Wang, X. Assessment on China's urbanization after the implementation of main functional areas planning. *J. Environ. Manag.* **2020**, *264*, 110381. [CrossRef] [PubMed]
33. Guo, Y.; Tong, Z.; Chen, H.; Wang, Z.; Yao, Y. Heterogeneity study on mechanisms influencing carbon emission intensity at the county level in the yangtze river delta urban agglomeration: A perspective on main functional areas. *Ecol. Indic.* **2024**, *159*, 111597. [CrossRef]
34. Tang, C.C.; Liu, H.D. Construction of government performance appraisal system of the major function oriented zones in the yangtze river basin. *Econ. Geogr.* **2015**, *35*, 36–44.
35. Ma, Z.Y.; Duan, X.J.; Wang, L.; Wang, Y.Z. Study on spatial coupling characteristics of regional development andresource-environment carrying capacity and path of high-quality development in yangtze river economic belt. *Resour. Environ. Yangtze Basin* **2022**, *31*, 1873–1883.
36. Li, Z.; Hu, B.; Ren, Y. The supply–demand budgets of ecosystem service response to urbanization: Insights from urban–rural gradient and major function-oriented areas. *Remote Sens.* **2022**, *14*, 5670. [CrossRef]
37. Lu, Y.; Wu, P.; Xu, K. Multi-time scale analysis of urbanization in urban thermal environment in major function-oriented zones at landsat-scale: A case study of Hefei city, China. *Land* **2022**, *11*, 711. [CrossRef]
38. Geng, L.; Zhang, Y.; Hui, H.; Wang, Y.; Xue, Y. Response of urban ecosystem carbon storage to land use/cover change and its vulnerability based on major function-oriented zone planning. *Land* **2023**, *12*, 1563. [CrossRef]
39. Huang, X.; Pan, B. Progress, problems and suggestions on the implementation of major function area planning. *Nat. Res. Econ. Chin* **2020**, *33*, 4–9.
40. Wang, J.F.; Li, L.F.; Li, Q.; Hu, S.X.; Wang, S. Monitoring spatio-temporal dynamics and causes of habitat quality in yellow river basin from the perspective of major function-oriented zone planning. *Contemp. Probl. Ecol.* **2022**, *15*, 418–431. [CrossRef]
41. Wu, D.; Zou, C.X.; Lin, N.F.; Xu, M.J. Characteristic analysis of ecological status in the yangtze river economic belt based on the plan for major function-oriented zones. *Resour. Env. Yangtze Basin* **2018**, *27*, 1676–1682.
42. Liu, J.Y.; Liu, M.L.; Zhuang, D.F.; Deng, X.Z.; Zhang, Z.X. Spatial pattern analysis of recent land use changes in China. *Sci. China Ser. D* **2002**, *32*, 1031–1040.
43. Chen, W.X.; Zhao, H.B.; Li, J.F.; Zhu, L.J.; Wang, Z.Y.; Zeng, J. Land use transitions and the associated impacts on ecosystem services in the middle reaches of the yangtze river economic belt in China based on the geo-informatic tupu method. *Sci. Total Environ.* **2020**, *701*, 134690. [CrossRef] [PubMed]
44. Xie, G.D.; Lu, C.X.; Leng, Y.F.; Zheng, D.; Li, S.C. Ecological assets valuation of the tibetan plateau. *J. Nat. Resour.* **2003**, *18*, 189–196.
45. Costanza, R.; D'Arge, R.; de Groot, R.; Farber, S.; Grasso, M.; Hannon, B.; Limburg, K.; Naeem, S.; O'Neill, R.V.; Paruelo, J.; et al. The value of the world's ecosystem services and natural capital. *Nature* **1997**, *387*, 253–260. [CrossRef]