Sustainable land resource management for food security in the Red River Delta, Vietnam

Mai Van Thong^{1*}, Mai Thi Phuong Lan¹, Bui Thi Thanh Nga¹, and Le Duy Hieu¹

¹Branch of Hanoi University of Natural Resources and Environment in Thanh Hoa province, Hanoi, Vietnam

Abstract. This paper analyzes the key challenges impacting rice cultivation in the Red River Delta, including land fragmentation, declining farmer engagement, and limited adoption of modern agricultural technologies. We examine the trends in rice land area, productivity, and consumption, highlighting the need for strategies that balance economic development with the preservation of agricultural land. The paper explores potential solutions, focusing on land consolidation efforts, improved infrastructure development, and the promotion of advanced technologies to enhance rice production efficiency and ensure long-term food security in the region.

1 Introduction

The Red River Delta, a vital agricultural region in Vietnam and a cornerstone of the nation's rice production, faces a convergence of escalating pressures that threaten its long-term food security. This fertile delta, historically a breadbasket for the country, is increasingly stressed by rapid urbanization, expanding industrialization, and the intensifying impacts of a changing climate. These interconnected forces present a complex challenge to the region's capacity to sustainably produce rice and maintain its crucial role in national food security.

The demand for land for urban expansion and industrial development is in direct competition with agricultural land use, leading to a concerning decline in rice cultivation areas. This land use transformation is further exacerbated by demographic shifts, as younger generations migrate to urban centers, resulting in a shrinking agricultural workforce and a potential erosion of traditional farming practices. Simultaneously, the adoption of modern, climate-resilient agricultural technologies, essential for increasing productivity and adapting to environmental changes, remains limited in the delta, hindering its capacity to meet future food demands.

Furthermore, the Red River Delta's vulnerability to climate change impacts, including rising sea levels, increased salinity intrusion, and more frequent extreme weather events, adds another layer of complexity to the challenge of ensuring food security. These environmental changes pose significant risks to rice production and necessitate the development of adaptive strategies to build resilience within the agricultural system.

^{*} Corresponding author: <u>mvthong.ph@hunre.edu.vn</u>

[©] The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

2 Challenges in Land Resource Management and Strategies for Enhancing Food Security

The Red River Delta's agricultural landscape faces a complex interplay of challenges that threaten its ability to sustainably produce rice and ensure food security. Key issues include:

- Land Fragmentation: Decades of agricultural practices have resulted in increasingly fragmented land holdings, making it difficult to implement modern farming techniques and achieve economies of scale. Small, scattered plots hinder mechanization, increase labor costs, and limit the adoption of improved irrigation and water management practices.
- Declining Farmer Engagement: Younger generations are increasingly migrating to urban areas in search of higher incomes and different lifestyles, leading to a decline in the agricultural workforce. This trend results in a loss of traditional farming knowledge and a decrease in the overall productivity of the agricultural sector.
- Limited Technology Adoption: The adoption of modern agricultural technologies, such as improved rice varieties, precision farming techniques, and efficient irrigation systems, remains limited in the delta. This is often due to financial constraints, lack of access to training and technical support, and the complexity of implementing these technologies on fragmented land holdings.
- Climate Change Impacts: The Red River Delta is highly vulnerable to the impacts of climate change, including sea-level rise, increased salinity intrusion, and more frequent extreme weather events. These changes pose significant risks to rice production and require adaptive strategies to ensure the resilience of the agricultural system.

2.1 Strategies for Enhancing Food Security

Addressing the challenges in land resource management and ensuring food security in the Red River Delta requires a multi-faceted approach that incorporates the following strategies:

- Promoting Land Consolidation: Implementing effective land consolidation programs is crucial for overcoming the limitations of fragmented land holdings. These programs should incentivize farmers to voluntarily pool their land resources, enabling the adoption of mechanized farming practices, improved water management, and more efficient use of inputs.
- Investing in Infrastructure Development: Improving rural infrastructure, particularly irrigation and drainage systems, transportation networks, and storage facilities, is essential for enhancing agricultural productivity and reducing post-harvest losses. These investments will facilitate access to markets, reduce transportation costs, and enhance the overall efficiency of the agricultural value chain.
- Fostering Technology Adoption: Facilitating the adoption of modern agricultural technologies, such as improved rice varieties, climate-resilient farming practices, and precision agriculture techniques, is crucial for increasing yields and improving the sustainability of rice production. Providing farmers with access to training, financial support, and technical assistance will be key to successful technology transfer.

2.2 Towards a Sustainable Future

Ensuring long-term food security in the Red River Delta requires a commitment to sustainable land resource management. This necessitates a shift towards more integrated and holistic approaches that consider the interconnectedness of environmental, social, and

economic factors. Collaboration among government agencies, research institutions, farmers, and other stakeholders is essential for developing and implementing effective strategies that balance economic development with the preservation of the delta's valuable agricultural resources. By prioritizing sustainable land management practices, investing in infrastructure development, and fostering technology adoption, the Red River Delta can enhance its resilience to climate change, improve the livelihoods of its farmers, and ensure a secure and sustainable food supply for its growing population.

3 Results and Implementation

This research achieved the following key results:

- Systematized the theoretical and practical basis of rice land management and utilization.
- Assessed the current state of rice land management and utilization in Hanoi, Thai Binh, and Hai Duong, revealing a declining trend in rice land area in the Red River Delta due to conversion to non-agricultural purposes. However, increased rice productivity and quality contribute to food security stability.
- Provided directions for rice land utilization in the Red River Delta to 2030, balancing land protection with enhanced efficiency through flexible crop restructuring and high-tech application.
- Proposed solution groups to enhance rice land management and utilization effectiveness, encompassing policy, management, science and technology, employment solutions and vocational training, and legal framework improvements.

The Red River Delta, formed by alluvial deposits from the Red and Thai Binh rivers, is the cradle of wet rice civilization in Vietnam. The delta comprises Hanoi, Hai Phong, Vinh Phuc, Bac Ninh, Quang Ninh, Hai Duong, Hung Yen, Thai Binh, Ha Nam, Nam Dinh, and Ninh Binh. Statistical data indicate that the winter-spring rice cultivation area in 2024 reached 2,954,000 hectares nationwide, a 1,200-hectare increase compared to the 2023 winter-spring season. Within this, the Red River Delta accounted for 471,400 hectares, a decrease of 5,700 hectares.

3.1 Current Status and Changes in Rice Land in the Red River Delta (2015-2025)

According to data published by Ministry of Natural Resources and Environment (MONRE) [5-12], the rice land area in the Red River Delta in 2015 was 598,870 hectares, accounting for 39.51% of the total natural area. In 2020, this decreased to 560,812 hectares (28.17%), and by 2025, it is projected to be 510,669 hectares (26.36%). Due to rapid industrialization and urbanization, rice land area has been declining. Details are provided in Table 1.

Table 1. Current Status and Changes in Rice-Cultivated Land in the Red River Delta from 2015 to2025.

Administrative Unit	Area 2015 (ha)	Area 2020 (ha)	Area 2025 (ha)	Change (ha) 2020-2015	Change (ha) 2025-2015	Change (ha) 2025-2020
Total	598,870	560,812	510,669	-38,058	-88,201	-50,143
Hanoi	111,396	100,725	97,593	-10,671	-13,803	-3,132
Vinh Phuc	34,226	31,954	31,713	-2,272	-2,513	-241
Bac Ninh	40,015	37,719	28,550	-2,296	-11,465	-9,169
Quang Ninh	32,372	30,324	29,762	-2,048	-2,610	-562
Hai Duong	62,973	58,981	53,905	-3,992	-9,068	-5,076
Hai Phong	44,023	41,125	28,612	-2,898	-15,411	-12,513
Hung Yen	37,541	31,524	24,966	-6,017	-12,575	-6,558
Thai Binh	79,736	77,728	73,936	-2,008	-5,800	-3,792
Ha Nam	34,282	32,444	31,653	-1,838	-2,629	-791
Nam Dinh	76,336	74,389	70,761	-1,947	-5,575	-3,628
Ninh Binh	45,970	44,439	39,200	-1,531	-6,770	-5,239

(Source: Ministry of Natural Resources and Environment, 2015, 2020, 2025)

3.2 Assessment of Shortcomings and Limitations in Rice Land Management and Utilization in the Red River Delta within Socio-Economic Development

In the course of economic development and rural economic restructuring, the Red River Delta faces the following shortcomings:

• The regional economic structure relies heavily on agricultural production, primarily rice cultivation. Therefore, investment focuses mainly on rice development. Due to low per capita land area, rural economic restructuring is crucial but faces challenges such as employment pressure, conflicting crop and labor productivity, and lower commodity production rates compared to other regions.



Trends in Rice-Cultivated Land Area by Region

Fig. 1. Trends in Rice-Cultivated Land Area from 2010-2020 (in thousands of hectares).

Nationwide, the decline in rice-growing land is concentrated in the Red River Delta, Southeast, and Mekong Delta regions. Despite the reduction in rice land compared to 2010, increased irrigation efforts, application of scientific and technological advancements, intensified cropping, and introduction of new varieties have increased rice productivity from 5.34 tons/ha to 5.87 tons/ha, and total rice production from 40 million tons to 42.76 million tons (a 6.9% increase). The land use coefficient for rice cultivation reached 1.95, a 0.13 increase from 2010 (1.82) [1-2]. Rice production has ensured national food security, establishing Vietnam as a leading rice exporter globally.

 Table 2. Balance of rice consumption demand in the Red River Delta region in the period 2008-2018 (Units: million tons).

	2008			2018			
	Rice produced	Amount of rice consumed	Difference	Rice produced	Amount of rice consumed	Difference	
Nationwide	27.11	12.36	14.75	30.79	9.14	21.64	
Red River Delta	4.75	2.92	1.84	4.40	1.91	0.95	

(Source: Ministry of Agriculture and Rural Development, 2019)

- The lack of comprehensive solutions in agricultural production, such as inadequate coordination between land exploitation and improvement, production and product consumption and processing, and economic objectives and environmental protection, has significantly impacted land use efficiency in the region.
- Limited land area, high population density, and low per capita arable land pose obstacles to land conversion for other purposes to meet the needs of industrialization and modernization.

Table 3. Average rice output per capita in the Red River Delta in the period 2008-2018.

	Unit	2008	2013	2018	
Grain production	Kg/person/year	508.7	548.5	516.4	
Rice	Kg/person/year	455.0	490.6	464.6	

(Source: Ministry of Agriculture and Rural Development, 2019)

The Red River Delta (or Red River Basin) is a vast region surrounding the lower Red River in northern Vietnam. It covers approximately 21,260.8 km², representing 4.6% of the country's total area. With a population of approximately 22,920,200, it accounts for 23.49% of Vietnam's population. The population density is very high at 1,078 people/km², the highest in the country and 3.65 times the national average (295 people/km²). By 2025, the Red River Delta's projected population is 22,920,200, with 8,512,200 urban residents and 14,408,100 rural residents. This represents a 1,551,800 increase from 2015. Between 2015 and 2025, the average annual population growth in the region is estimated at 310,360 (according to the 2025 Statistical Yearbook). This highlights the region's high population pressure, necessitating appropriate policies, management models, and efficient rice land utilization to ensure regional food security.

Proportion of Transferred Land Parcels in Vietnam



Fig. 2. Proportion of Transferred Land Parcels within Total Agricultural Land by Period (%).

3.3 Slow economic restructuring limits the speed of land use restructuring

The agricultural land use rights market is weak and even declining. Of the transferred agricultural land, 29% was transferred before 1994, 41% between 1994 and 2003, and 30% from 2004 to the present.

- Land Abandonment: Thousands of hectares of agricultural land are abandoned across provinces and cities in the Red River Delta. Landowners have either migrated for work or transitioned to other occupations within their hometowns, sharing a common disinterest in rice cultivation.
- Rice land area exhibits a continuous downward trend.
- Implementation of Party and State Directives: Land policies have significantly impacted land accumulation and concentration. While facilitating land accumulation, these policies also create certain barriers, particularly by restricting land use right transfers and setting agricultural land allocation limits.

3.4 Proposed Solutions for Enhancing Rice Land Management and Utilization to Ensure National Food Security

Based on the agricultural development perspective for 2010-2020, Vietnam's population is projected to stabilize around 104 million by 2030. Per capita rice consumption is expected to decrease, reaching 110 kg and 100 kg by 2030. National rice reserves for 2030 are estimated at 17% of domestic consumption, approximately 5.3 to 6.3 million tons of paddy per year. According to Decision 555/QĐ-BNN-TT (January 26, 2021) by the Minister of Agriculture and Rural Development, approving the Restructuring Scheme for the Vietnamese Rice Industry to 2025 and 2030, rice exports are projected at 4-5 million tons (equivalent to approximately 7,692,000 tons of paddy) between 2021 and 2030. Provinces and centrally-affiliated cities in the Red River Delta are expected to contribute approximately 1,094,290 tons.

			Including					
No.	Province	Total rice production demand	Demand for rice for consumption	Demand for national reserves	Demand for breeding, livestock, loss, waste, processing, etc.	Demand for export contribution		
	Whole							
	region (Red	8.080.59	4.616.14	1.015.10	1.355.05	1.094.29		
	River Delta)							
1	Ha Noi	2.453.43	1.664.32	326.45	255.96	206.70		
2	Vinh Phuc	406.87	238.47	51.53	64.66	52.21		
3	Bac Ninh	526.95	290.03	65.43	94.87	76.62		
4	Quang Ninh	419.57	271.23	54.90	51.70	41.75		
5	Hai Duong	718.49	383.42	88.38	136.48	110.21		
6	Hai Phong	672.13	415.22	86.60	94.22	76.09		
7	Hung Yen	419.02	257.48	53.89	59.55	48.09		
8	Ha Nam	344.74	171.39	41.53	72.93	58.89		
9	Nam Dinh	808.03	362.60	94.63	194.07	156.72		
10	Thai Binh	867.85	364.56	99.91	223.16	180.21		
11	Ninh Binh	443.52	197.43	51.83	107.47	86.79		

 Table 4. Forecast of rice production demand in provinces and centrally-run cities in the Red River

 Delta (Unit: 1,000 tons).

Land policies must be reformed to align with market mechanisms, contribute to sociopolitical stability, meet socio-economic development, defense, security, and international integration requirements, effectively mobilize land resources for national development, ensure harmony among state, land user, and investor interests, and promote a healthy real estate market (including land use rights) while preventing speculation. Strengthen the effective use of price and tax instruments in land management to address land abandonment, wasteful use, corruption, complaints, and speculation. The Land Law must serve as the foundation for regulating land relations.

Incentivize and prioritize land accumulation for intensive agricultural development while gradually limiting extensive land accumulation. Implement regulations to eliminate speculative land accumulation, concentration, and utilization (for land use conversion applications) and sharecropping practices. Establishing a suitable and transparent legal framework for land accumulation and concentration is crucial. This involves creating reasonable linkages with shared responsibilities, obligations, benefits, and risks among farmers, cooperatives, businesses, and related stakeholders. The Party and Government should establish clear viewpoints, objectives, principles, directions, and a general policy framework for land accumulation and concentration to develop a modern and efficient commodity-based agriculture.

Review and raise agricultural land allocation and transfer limits to promote land concentration for large-scale agricultural production models like large-scale fields and agricultural production cooperatives. Expand permissible grounds for state land acquisition to include acquisition based on publicized annual land use plans for land allocation and lease through auctions. Localities should develop detailed rice land planning to 2030, zoning areas according to strict management, flexible management, and permissible conversion as per the Land Law, with the possibility of reverting to rice cultivation if needed.

To enhance rice land utilization efficiency, restructure cropping towards concentrated, large-scale production, promote land consolidation and exchange, encourage proactive agricultural production by farmers based on regional advantages, and integrate preservation, processing, and consumption along the value chain. Utilize modern technologies like GIS, satellite imagery, and land databases to identify rice land locations, current scale of use, and areas requiring strict protection for food security. Develop a national rice land database for protection and management. Reform administrative procedures for accessing preferential investment capital in agriculture towards simplification and diversify support forms, including direct support and indirect support through training, research, technological application, and infrastructure development.

Financial support policies should shift from dispersed to targeted support, prioritizing sectors with comparative advantages. Provinces should establish specialized units to monitor and analyze market information, providing timely updates to agricultural businesses. Guide and support farmers and businesses in adopting international production standards (ISO, HACCP, GAP, etc.) [3-15].

To apply high technology in agricultural production, particularly rice production, develop rural infrastructure, including rural roads and irrigation systems.

According to Table 5, the land demand for infrastructure development to 2030 is as follows: The area by 2030 is 298,679 ha, with a planned area of 268,188 ha by 2025. Transportation infrastructure accounts for the largest proportion.

Administrative Unit	Area by 2030 (ha)	Land use plan to 2025 (ha)	
Ha Noi	60.829	55.243	
Vinh Phuc	19.700	16.938	
Bac Ninh	16.994	15.309	
Quang Ninh	31.098	26.653	
Hai Duong	32.054	26.523	
Hai Phong	21.691	20.569	
Hung Yen	19.319	16.833	
Ha Nam	15.234	14.081	
Nam Dinh	30.810	29.069	
Thai Binh	32.803	29.871	
Ninh Binh	18.147	17.099	
Whole region	298.679	268.188	

Fable 5.	Orientation	of land use	for infrastructu	re in the Red	River Delta	region to 2030.

(Source: National Land Use Planning, 2021-2030)

4 Conclusion

This study has systematically analyzed the intricate challenges facing land resource management and food security in the Red River Delta, Vietnam. Our findings confirm that the convergence of land fragmentation, a declining agricultural workforce, limited adoption of modern technologies, and the escalating impacts of climate change pose significant threats to the region's capacity to sustainably produce rice and maintain its critical contribution to national food security. The research has demonstrated a clear downward trend in rice land area due to competing land uses driven by urbanization and industrialization, while simultaneously revealing the vital role of increased rice productivity in mitigating the impact of this land loss on overall food security.

Quantified the declining trend in rice land area in the Red River Delta from 2015 to 2025, highlighting the urgency of implementing effective land preservation strategies. This quantitative analysis provides concrete evidence of the escalating pressure on agricultural land.

Projected the direction of rice land utilization to 2030, offering a roadmap for balancing land protection with enhanced production efficiency through strategic crop restructuring and targeted application of advanced technologies. This forward-looking perspective provides crucial guidance for future policy development.

Acknowledgement

The authors express sincere gratitude for the valuable data and figures provided by the Ministry-level scientific research project of M.S. Nguyen Thi Hang, project code TNMT. 2020.01.04, and to the agencies and organizations that supported the completion of this paper.

References

- 1. Land Law of 2013, Vietnam (2013)
- 2. Land Law of 2024, Vietnam (2024)
- 3. Statistical Yearbook of Vietnam and Red River Delta Provinces, 2015, 2020, 2025, Vietnam (2015)

- 4. Institute of Agricultural Planning and Design, Report on the Master Plan for National Rice Land Use to 2020 and Vision to 2030, Vietnam (2011)
- 5. Institute of Agricultural Planning and Design, Report on the Implementation of the Project: "Review and Adjustment of the Agricultural Sector Development Plan to 2020 and Vision to 2030", Vietnam (2017)
- 6. Summary Report on the Implementation of the Land Law and Proposed Orientations for Amending the Land Law in Red River Delta Provinces, Vietnam
- 7. Report on the National Land Use Plan 2021-2030 and Vision to 2050, Vietnam (2021)
- Report on the Implementation of Socio-Economic Development Tasks in 2024 and the Socio-Economic Development Plan for 2025 in Red River Delta Provinces, Vietnam (2024)
- 9. Nguyen Thi Hang, Research on the current situation and develop solutions to improve the efficiency of management and use of rice land in the Red River Delta. Synthesis report of ministerial-level science and technology topics, Code: TNMT. 2020.01.04, 217, Vietnam (2022)
- Ministry of Science and Technology, General Review No. 7/2019: Sustainable Agricultural Development Policies of Selected Countries and Recommendations for Vietnam in the New Context, Vietnam (2019)
- Ministry of Agriculture and Rural Development, Decision No. 555/QĐ-BNN-TT on Approving the Restructuring Scheme for the Vietnamese Rice Industry to 2025 and 2030, Vietnam (2021)
- 12. FAOSTAT Database (2017), http://www.fao.org/faostat
- IRRI (2007), Annual Report of the Director General, 2006-2007, http://irri.org/resources/publications/annual-reports/annual-report-of-the-directorgeneral-2006-07
- S. Peng, K.G. Cassman, S.S. Virmani, J. Sheehy, G.S. Khush, "Yield potential trends of tropical rice since the release pff IR8 and the challenge of increasing rice yield potential", Crop Sci, 39, 1552-1559 (2007)
- D.V. Khanh, T.T. Son, P.A. Tuan, N.V. Thang, Empirical Analysis Using a Hedonic Model of High-End Apartment Pricing. International Journal of Engineering, Transactions A: Basics, 38(10), 2426-34 (2025)