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The impact of land conversion on rice production vulnerability in south Bangka regency: A GIS-based analysis

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Abstract

Bangka Selatan Regency is a district designated as one of the locations for the Food Estate and food security in Indonesia. Bangka Selatan Regency is situated on Bangka Island. The Food Estate and food security policy for this district are strategically important because they ensure food security on a small island like Bangka. The strategic nature of this policy is linked to the potential difficulty in sourcing food from other islands. However, this policy is not aligned with the current development activities in Bangka Selatan Regency. The phenomenon shows a trend of land-use conversion of rice fields. This situation will undoubtedly affect rice production in this district. The objective of this study is to describe the land-use conversion of agricultural land and the vulnerability of rice production in Bangka Selatan Regency. The approach used is spatial recording through Geographic Information System (GIS). Input data are sourced from the Geospatial Information Agency (BIG) and satellite image map analysis. Data are input from the period of 2013-2023, followed by overlay analysis and estimation, which resulted in the spatial conditions of land-use conversion and estimation of land-use changes. The overlay results show a reduction in rice fields converted to other uses. The study findings indicate that rice field conversion decreased by 17.8%, leading to a reduction in rice production. These findings can provide feedback for improving food waste and food security policies in Bangka Selatan Regency, especially due to its location on an island. The island's position makes it vulnerable to food supply shortages from external sources.

Keywords: Land conversion, Rice fields, rice, South bangka regency, Vulnerability.

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1. Introduction

South Bangka Regency (Kabupaten Bangka Selatan) is one of the regions in Indonesia focusing on food estate development and food security initiatives. According to the Central Bureau of Statistics (BPS) in the publication *Bangka Belitung in Figures* 2021, South Bangka Regency has the largest area of rice fields in the Bangka Belitung Islands Province, with harvested rice fields covering an area of 13,120 hectares and a rice production of 49,620 tons. As a designated food estate and food security hub in Indonesia, South Bangka must preserve its rice fields as a vital component of the rice processing chain to achieve food security for Bangka Island.

Food security has become a key focus of national policy, as food production is heavily influenced by climate. Climate change significantly impacts agricultural productivity, while the demand for food continues to rise. Food security must be persistently pursued to be achieved, and this is particularly relevant for South Bangka Regency, which has been designated by the national government as a food estate and food security area. This designation means that South Bangka must not only fulfill its own food consumption needs but also provide food for other regions. The strategic location of South Bangka on Bangka Island emphasizes the necessity of maintaining consistent food security efforts, as the island's isolation makes it particularly vulnerable to external food supply disruptions.

The conversion of rice fields in South Bangka Regency has led to increased vulnerability in rice production. The national food estate policy faces challenges in its implementation, significantly affecting rice consumption on Bangka Island. Previous studies related to land conversion, such as the "contemporary processes of land grabbing and the global land rush," highlight how governments and multinational corporations have seized land for food and fuel production, threatening food security and the ecological sustainability of local communities [1, 2]. Spatial planning that integrates the interests of farmers has also been addressed [3, 4].

Previous research on land conversion has primarily focused on rural land conditions rather than island-specific regions. Furthermore, land conversion in these studies was not driven by government initiatives to create food estates. The novelty of this study lies in the exploration of government policy on land use within an island context, an area that has been overlooked in previous research. This research examines how national food estate policies are applied to island regions and how these policies have been neglected despite their significant potential to improve food security. Consequently, this study aims to describe the process of land conversion in South Bangka and its implications for food estate policy and food security.

GIS (Geographic Information System) technology has become an essential tool in the global study of rice field conversion. GIS provides valuable spatially explicit data that allows researchers to track land use changes over time and understand the underlying causes of land conversion, particularly in the context of rice fields. Previous studies using GIS have extensively analyzed land conversion worldwide, demonstrating its capacity to assess the impact of urbanization, industrialization, and climate change on agricultural landscapes [5, 6].

Several studies have examined rice field conversion in Southeast Asia, where the rapid expansion of urban areas and infrastructure projects has led to the loss of agricultural land, including rice paddies [7]. Similarly, research in countries such as China and Vietnam has used GIS to monitor changes in rice field areas, highlighting the economic pressures and development policies that drive land conversion [8-10]. The GIS approach has proven particularly effective in capturing the scale and speed of land use changes in these regions, providing crucial data for policymakers seeking to balance development with food security.

A GIS-based study by Bakr and Afifi [7] demonstrated the effectiveness of using remote sensing data to monitor rice field conversion in Southeast Asia, focusing on urban expansion. GIS has also been used in China to explore the conversion of rice fields due to infrastructure development [11, 12]. These studies provide crucial insights into the environmental consequences of land conversion, particularly in the context of food security and sustainable land management.

The South Bangka Regency study contributes to this growing body of research by providing a novel application of GIS to monitor rice field conversion in an island setting. This research builds upon previous studies by focusing on how national policy influences land use changes in an island region, which is particularly vulnerable to the impacts of land conversion due to its geographical isolation. The unique feature of this study lies in its integration of GIS with food estate policy analysis, offering a new perspective on how land conversion affects food security in a local context.

This research in South Bangka Regency is the most recent among several studies on rice field conversion that have been published previously using the GIS approach. The strong point of this research lies in its island-specific context, which has not been extensively studied in prior research. While previous studies have focused on land conversion in rural and mainland areas, South Bangka provides a unique case of how national food estate policies can influence rice field conversion on an island, where geographic isolation adds another layer of complexity. The integration of GIS in this study offers a novel approach to understanding how national policies intersect with land conversion processes, making this research a critical contribution to the ongoing discourse on food security and land use management.

Climate Vulnerability and Food Security [13, 14] provide essential insights on how climate change impacts rice production and the vulnerability of agricultural systems. GIS and Land Use Change, as Bakr and Afifi [7], Lu and Talamini [15] and Taniushkina, et al. [16] emphasize GIS’s role in monitoring land conversion. Policy Impact on Food Security: Research by Wang Chun, et al. [8], Cuong, et al. [9] and Kan and Sun [1] discusses how policy decisions drive land use changes that affect local food security, highlighting the complexity of balancing food production with urbanization and infrastructure development. These citations will help to build a strong theoretical framework and empirical analysis for the study of the vulnerability of rice production in South Bangka, especially in relation to land conversion and food security policy.

2. Methods

2.1. Context of Study

The study is located in South Bangka Regency, a part of the Bangka Belitung Islands Province (see Figure 1). South Bangka Regency, which was formed by the splitting of Bangka Regency, is situated in the southern part of Bangka Island with an area of 359,728.60 hectares. Geographically, South Bangka Regency is located at 2° 26' 27" to 3° 5' 56" South Latitude and 107° 14' 31" to 105° 53' 09" East Longitude. The total area of South Bangka Regency is approximately 3,607.08 km² or 360,708 hectares. Administratively, South Bangka Regency borders other regencies and cities in the Bangka Belitung Islands Province, including:

a. North: Central Bangka Regency
b. East: Gaspar Strait
c. West: Bangka Strait and Java Sea
d. South: Java Sea

The Regency consists of 8 sub-districts, 3 urban villages, and 50 rural villages, supported by 163 hamlets. These sub-districts include Simpang Rimba, Payung, Air Gegas, Toboali, Lepar, Pulau Besar, and Tukak Sadai.

Figure 1.
Map of research locations in South Bangka Regency.

2.2. Data Collection Procedure

The data collected for this study includes secondary data. The sources are:

1. Population and rice production data in Bekasi Regency were collected from the Central Statistics Agency of Bangka Regency. Data were collected online by accessing the Central Statistics Agency. The data collected included: a. Population of South Bangka Regency from 2013 to 2022, b. Rice production in Bangka Regency from 2013 to 2022.
2. Spot-7 Satellite Imagery for 2013, 2018, and 2023 from BRIN (Indonesian National Research and Innovation Agency).
3. Indonesian Topographic Map (Rupa Bumi Indonesia, RBI) for South Bangka Regency at a 1:50,000 scale from BIG (Geospatial Information Agency) dated 2022.
4. Land area data for rice fields by village sourced from the Department of Agriculture and Food Security of South Bangka Regency.

2.3. Data Analysis

The analytical approach used in this study basically consists of 2 steps, namely:

1. Analysis of rice consumption by calculating the surplus deficit and
2. Analysis of land conversion using GIS.

Next, the following analytical approach framework can be seen in Figure 2.

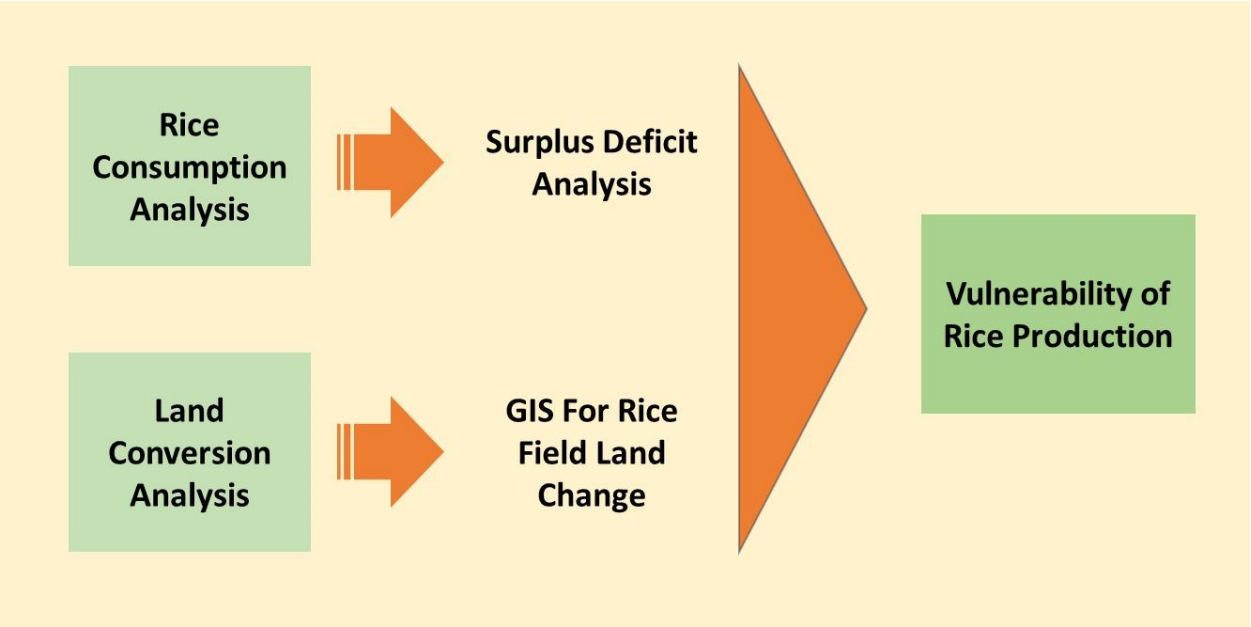

Figure 2.
Analytical approach framework.

2.3.1. Rice Consumption Trend Analysis

Rice consumption analysis is necessary to assess the vulnerability of rice production. This analysis employs the surplus and deficit calculation approach. The purpose of analyzing rice surplus and deficit is to determine whether rice availability in South Bangka Regency is in surplus or deficit. This analysis compares rice production in South Bangka Regency with the rice consumption of its population. The consumption requirement formula is as follows:

$$K_k = S_k \times y_t$$

Where:

- K_k = consumption requirement of the population (kg/capita/year);
- S_k = standard consumption, valued at 99 kg/capita/year;
- y_t = population in year t (persons).

Next, the rice consumption requirement is converted into the requirement for unhusked rice (paddy) using the following formula:

$$K_g = K_k \times \frac{100}{62.74}$$

Where:

- K_g = paddy requirement (kg/capita/year);
- K_k = rice consumption (ton/capita/year);
- The value 62.74 is the conversion factor from rice to paddy, based on surveys on harvest losses and post-harvest handling conducted by the Central Statistics Agency in cooperation with the Ministry of Agriculture.

This methodology helps determine whether the supply of rice in South Bangka Regency meets the population's demand or if there is a shortage (deficit) or excess (surplus).

2.3.2. Land conversion analysis using Geographic Information Systems (GIS)

The analysis aimed to determine the trends in land conversion from rice fields to non-rice uses (LSD). The land conversion analysis was carried out using Geographic Information Systems (GIS), specifically ArcGIS 10.8 software. GIS

is a system that integrates hardware, software, and data to perform simultaneous data analysis and spatial data processing, making it easier and faster to display spatial information. By integrating remote sensing data and GIS, we can represent and analyze land surface conditions to address various issues related to land use changes.

Maps are categorized based on the decrease in rice field area. The materials used in the study include:

1. Spot-7 Satellite Imagery for 2013, 2018, and 2023 from BRIN.
2. Indonesian Topographic Map (RBI) for South Bangka Regency at a 1:50,000 scale from BIG dated 2022.
3. Land area data by village sourced from the Department of Agriculture and Food Security of South Bangka Regency.

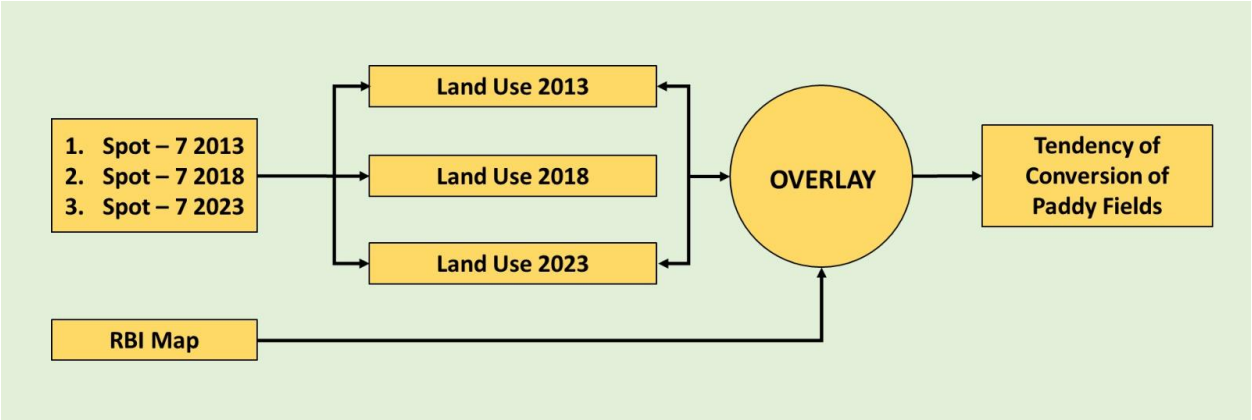

Figure 3.
Diagram of map use in GIS analysis.

The steps in the analysis include:

- Digitization Process: This involves implementing the system into ArcGIS by creating digital maps from the 2013, 2018, and 2023 satellite images, which are then classified into land use categories, resulting in polygons/areas representing specific land uses.
- Data Analysis: Spatial data analysis is conducted by comparing land use maps from 2013, 2018, and 2023. This overlay analysis helps identify land use changes by superimposing one map on top of another to highlight changes. The result of this overlay analysis is a map showing the spatial distribution of land use changes. Additionally, statistics on land use changes during the periods 2013-2018 and 2018-2023 are obtained.
- Land Use Change Statistics: This provides data on the type, size, distribution, and trends in rice field conversion in South Bangka Regency.
- Estimation of land conversion: estimations for rice field conversion were made by assigning numerical codes 2 for rice fields and 1 for non-rice land use. The average decline in rice field area was estimated based on a 10x10 cell size, assuming each cell represents 10m in actual size. The formula used for cell growth estimation is as follows:
-

$$y(2043) = \frac{\text{Area of decrease over 5 years} \times 20}{5}$$

Where:

- $y(2043)$ is the estimated rice field area in 2043.
- 5 represents the period between 2018-2023.
- 20 represents the predicted time range from 2018 to 2043.

Recent studies on rice food security have highlighted the critical role that sustainable land management plays in island regions like Bangka Island. Research has shown that food security in such islands is highly vulnerable to land use changes, particularly the conversion of rice fields to non-agricultural uses. The impact of land conversion on food security is exacerbated by the island's geographical isolation, making external food supply chains unreliable [17-19]. GIS-based studies, such as those conducted by Cheng, et al. [20], Mathenge, et al. [21] and Xue, et al. [22] have demonstrated the effectiveness of spatial analysis in tracking changes in rice production areas and their direct correlation with food security outcomes. GIS tools offer critical insights into trends of rice land conversion, providing valuable data to help policymakers mitigate risks related to food security in island settings like Bangka Island.

Through GIS, this study aims to quantify and visualize the changes in land use, particularly rice fields, to forecast the future vulnerabilities of rice production and to inform strategies for ensuring long-term food security for Bangka Island's residents.

3. Result and Discussion

3.1. Rice consumption Trends and Trends in Rice Field Conversion

The surplus/deficit table of rice consumption in South Bangka Regency from 2013 to 2022 shows a significant shift in the region's rice balance (See Table 1). From 2013 to 2017, the region faced a continuous deficit, where the annual rice production was insufficient to meet grain consumption needs. The deficit reached its peak in 2014, with a shortfall of 25,248.29 tons. However, in 2018, the region achieved a surplus of 288.02 tons, primarily due to a substantial increase in rice production. Despite this positive turn, the years following 2018, including 2020 and 2022, saw deficits once again, with figures ranging between -2,646.36 tons and -12,386.40 tons, indicating ongoing challenges in maintaining a balanced rice supply.

- 2025: Based on population growth and rice production projections, South Bangka Regency is expected to experience a surplus of 10,915.64 tons, as production will outpace the rising demand from the growing population. This projection suggests that the region will achieve a better balance between supply and consumption.
- 2028: The surplus will narrow to 9,507.50 tons, with continued population growth leading to an increase in rice consumption. However, production levels will still maintain a surplus, reflecting effective agricultural strategies.
- 2038: By 2038, the surplus will decline further to 4,401.31 tons, as population and consumption increase while production remains stable. This suggests that future planning must address potential vulnerabilities in production to meet the growing needs.
- 2043: In 2043, the surplus will be only 1,591.17 tons, signaling a critical point where the region will have minimal buffer between rice production and consumption. This projected near-equal balance implies that any disruptions in rice production could lead to deficits in the near future.

The growing population and increasing rice consumption in South Bangka Regency present significant challenges for the region's rice production capabilities. Over the years, the region has experienced periodic deficits, indicating vulnerabilities in local rice production.

Table 1.
Rice Consumption Trends 2025 -2043.

Year	Population (People)	Rice Production (Tons)	Grain Consumption (Tons)	Surplus (+)/Deficit (-) (Tons)
2013	185,514	17,757.20	33,023.66	(15,266.46)
2014	189,492	8,483.50	33,731.79	(25,248.29)
2015	193,583	8,000.18	34,460.03	(26,459.85)
2016	197,670	18,009.68	35,187.57	(17,177.89)
2017	201,783	16,384.00	33,765.41	(17,381.41)
2018	205,901	34,333.00	34,044.98	288.02
2019	209,973	38,484.37	33,765.94	4,718.43
2020	198,189	29,248.15	31,894.51	(2,646.36)
2021	200,051	26,381.49	33,437.43	(7,055.94)
2022	202,263	21,224.18	33,610.58	(12,386.40)
Population Projection				
2025	215,824	46,718.14	35,802.50	10,915.64
2028	224,312	46,718.14	37,210.64	9,507.50
2033	239,208	46,718.14	39,681.69	7,036.45
2038	255,093	46,718.14	42,316.83	4,401.31
2043	272,033	46,718.14	45,126.97	1,591.17

Source: South Bangka Regency in Figures, BPS South Bangka Regency 2022 and analysis.

The trend in rice field conversion in South Bangka Regency has become increasingly evident over recent years. Analysis from the GIS-based overlay mapping indicates that rice fields are being converted, primarily due to land use changes driven by industrial and commercial interests. This conversion trend has raised concerns about the ability of South Bangka Regency to meet its rice production goals, as stipulated in the Spatial Planning Regulation (RTRW). This non-compliance with spatial planning policies further exacerbates the challenges to food security. In particular, the growing pressure to convert agricultural land for non-agricultural purposes, such as real estate development or mining activities, directly conflicts with the region's food security goals.

Table 2.
Rice Sufficiency Percentage for South Bangka Regency (2013-2022).

No.	Year	Rice Sufficiency Percentage (%)
1	2013	12.25
2	2014	13.17
3	2015	30.00
4	2016	30.14
5	2017	73.85
6	2018	79.00
7	2019	58.23
8	2020	85.17
9	2021	84.00
10	2022	77.90

Source: Department of Agriculture, South Bangka Regency, 2024.

The data on rice sufficiency from the Department of Agriculture between 2013 and 2022 (see Table 2) reveals a significant shortfall in rice production, underscoring the growing vulnerability of South Bangka's food security. The fluctuation in rice sufficiency percentages highlights that the region is struggling to maintain self-sufficiency, with rates ranging from as low as 12.25% in 2013 to a peak of 85.17% in 2020. The variation in these percentages reflects the challenges in stabilizing rice production, which can be attributed to a combination of land conversion, climate change, and other socio-economic factors.

The conversion of rice fields in South Bangka Regency directly impacts the capacity to meet local rice consumption needs. As rice fields are converted to other land uses, the available land for rice cultivation decreases, diminishing local production capacity. The result is a growing dependency on external rice supply, which is highly susceptible to disruptions in the global food market or external environmental factors. This has particularly negative implications for island regions like Bangka Island, which face additional vulnerabilities due to their geographical isolation [23-28].

Moreover, rice consumption patterns are directly tied to production levels. When local production falls short, rice must be sourced from other regions, creating potential challenges in ensuring a steady supply and affordable prices for the local population. This is especially concerning in the context of a Food Estate policy aimed at ensuring self-sufficiency in food production, which could be undermined by the trend in rice field conversion.

Research on land conversion has shown that land use changes, particularly in rural areas, are closely linked to shifts in food security and agricultural productivity [29, 30]. In the case of South Bangka Regency, the reduction in rice fields directly influences the area's ability to meet rice demand, further exacerbated by global environmental changes that impact agricultural cycles. The increased frequency of climate-related events such as floods, droughts, and temperature extremes could disrupt the stability of rice production [31, 32] as evidenced by the declining rice sufficiency percentages in recent years.

A study by Bakr and Afifi [7] and Kan and Sun [1] discusses how land conversion for agricultural intensification has often led to decreased food security in island communities, particularly when coupled with the pressures of climate change and inadequate infrastructure to support external food supply chains. Similarly, Taniushkina, et al. [16] and Wang, et al. [18] suggest that climate change adaptation strategies, such as improving agricultural resilience and investing in sustainable land management, are crucial to addressing food security vulnerabilities in such regions.

In South Bangka Regency, addressing these issues through strategic policy and better management of rice field conversion is imperative. Integrating GIS-based monitoring tools, as suggested by Mathenge, et al. [21] and Xue, et al. [22] can provide decision-makers with real-time data to inform land use planning and mitigate the impacts of conversion on food security. The government must prioritize not only the implementation of food estate policies but also consider socio-economic and environmental factors that influence land use patterns, ensuring that long-term food security is maintained despite the pressures of urbanization and industrialization.

The land conversion trend in South Bangka Regency presents significant challenges to the region's rice production capacity, with direct implications for food security. While the Food Estate policy aims to enhance self-sufficiency, the conversion of rice fields undermines these efforts, making the region vulnerable to food insecurity. To address these concerns, sustainable land management practices must be implemented, and effective climate change adaptation strategies should be integrated into agricultural policy. GIS tools offer valuable insights into land use trends, providing a data-driven approach to ensure that land use policies align with the broader goal of maintaining rice production and food security in South Bangka Regency.

3.2. Estimation of Land Conversion

The projections for land use change, specifically the conversion of rice fields to non-rice land, are based on data from the spatial analysis of land use patterns in South Bangka Regency. From 2023 to 2043, the analysis predicts a 17.26% reduction in the area dedicated to rice cultivation (see Table 3), with significant variations observed between different villages. For example, villages such as Bedengung, Delas, and Irat are projected to experience substantial reductions in rice field areas, with conversions reaching as high as 51.35%, 51.25%, and 51.02%, respectively. These trends reflect the pressures of urbanization, infrastructure development, and the growing value of agricultural land for non-agricultural purposes such as residential, industrial, and commercial uses. Figure 2 spatially illustrates these changes, emphasizing the

extent to which rice fields are being replaced with other land uses. The projections for land use change or the conversion of rice fields to non-rice land from 2023 to 2043 can be seen in the following Table 3 and spatially illustrated in Figure 2.

Table 3.
Estimation of Land Use Conversion.

No.	Village	Year (Ha)	Change (Ha)	% Change
1	Batu Betumpang	1,375.09	1,122.69	18.36
2	Bedengung	352.04	171.27	51.35
3	Bencah	208.40	33.41	16.03
4	Bikang	331.96	9.76	2.94
5	Delas	148.25	75.97	51.25
6	Fajar Indah	538.45	155.54	28.89
7	Gadung	715.35	70.06	9.79
8	Gudang	96.17	42.37	44.05
9	Irat	66.18	33.77	51.02
10	Jelutung II	320.43	127.76	39.87
11	Jeriji	319.26	19.26	6.03
12	Kepoh	258.88	5.15	1.99
13	Malik	60.69	17.45	28.75
14	Nadung	59.40	0.00	0.00
15	Panca Tunggal	1,188.01	184.05	15.49
16	Pangkal Buluh	358.94	55.48	15.46
17	Penutuk	266.91	0.00	0.00
18	Pergam	1,485.98	348.14	23.43
19	Pongok	164.18	0.00	0.00
20	Ranggung	160.87	61.35	38.14
21	Rias	2,410.36	268.29	11.13
22	Sebagin	480.89	200.82	41.76
23	Serdang	1,374.28	40.41	2.94
24	Sidoharjo	194.68	194.68	100.00
25	Sukajaya	421.12	21.62	5.13
26	Sumber Jaya Permai	69.90	0.00	0.00
27	Tanjunglabu	125.87	0.00	0.00
28	Tanjungsangkar	340.59	0.00	0.00
	Total	13,893.15	2,398.51	17.26%

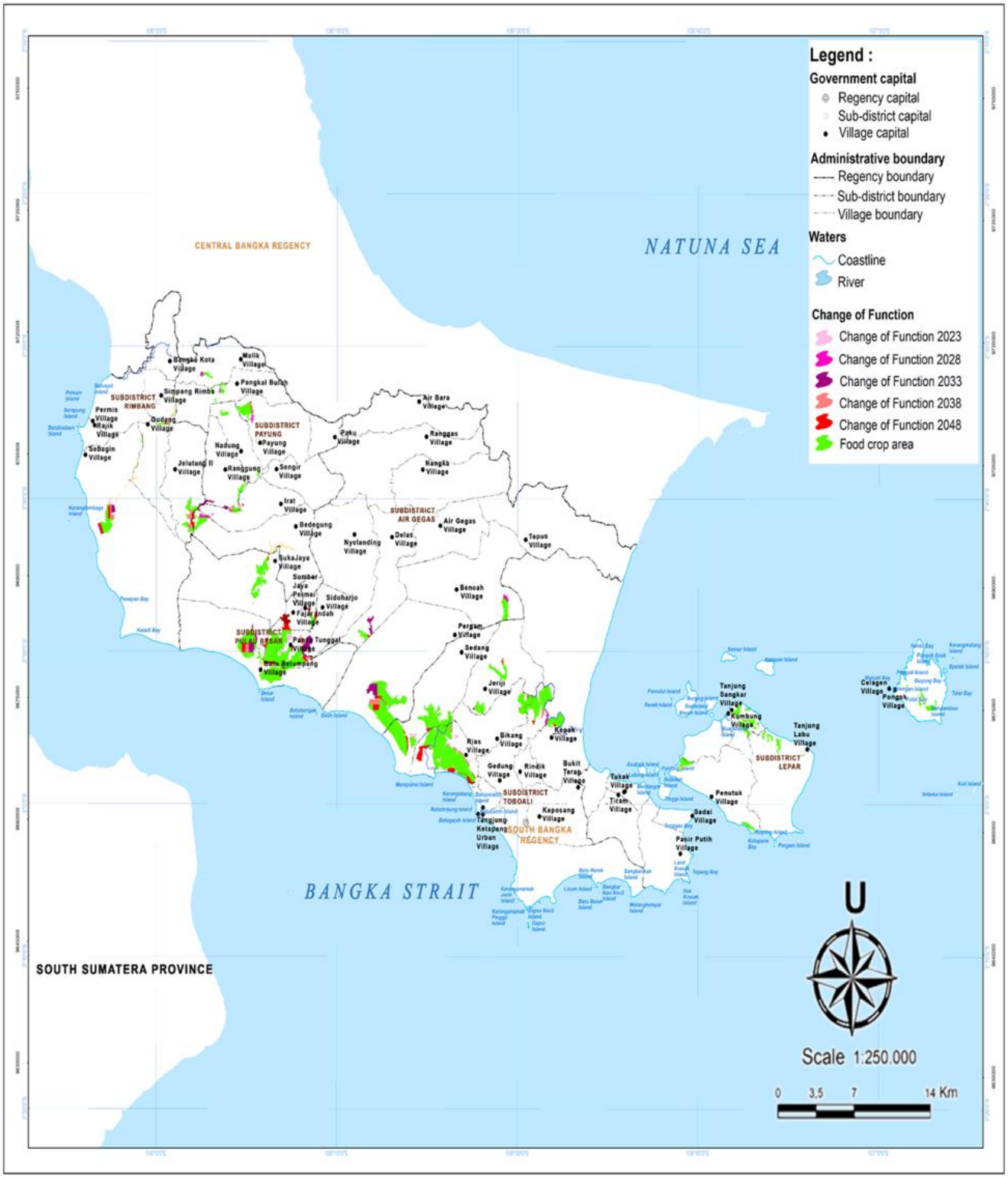

Figure 4.
The projections for land use change or the conversion of rice fields to non-rice land from 2023 to 2043.

The tendency for agricultural land to be converted for other purposes can be understood as a complex intersection of economic, political, and social forces Molotch [33] has the concept of the "Growth Machine" that highlights how local elites, including landowners, developers, and public officials, often form coalitions to promote the conversion of agricultural land for higher economic value uses, such as real estate and infrastructure development. This economic logic prioritizes the monetary benefits of land development over its agricultural productivity. In the case of South Bangka Regency, the market value of agricultural land for non-rice uses is increasingly outweighing its value for rice production. This is leading to a gradual but significant reduction in the area available for rice cultivation, posing challenges to the region's long-term food security.

Similarly, Hajer [34] theory of planning as a state activity that regulates the use of space is crucial in understanding the dynamics of land conversion in South Bangka. The competition between agricultural land and non-agricultural interests

such as residential development, commercial expansion, and infrastructure projects has led to a decline in rice production areas, despite the existence of policies designed to protect agricultural land. Land conversion decisions are heavily influenced by the framing of arguments from various actors, with those advocating for economic growth often securing more favorable outcomes.

The ongoing conversion of rice fields in South Bangka Regency presents a direct challenge to government policies aimed at ensuring food security and supporting the Food Estate program. As the area of rice cultivation decreases, the region's ability to meet its rice production goals becomes increasingly uncertain. The Food Estate initiative, part of the broader food security policy, was introduced to secure stable rice supplies and improve food resilience in regions like South Bangka. However, the ongoing trend of land conversion undermines these efforts by reducing the available land for food production.

The Food Estate policy, which aims to concentrate efforts on increasing agricultural output and stabilizing food supplies, is becoming less effective as agricultural land is gradually converted to other uses. This land-use change exacerbates food insecurity, particularly in island regions like Bangka Island, where the isolation of the island makes it more difficult to rely on external food supplies. As observed in other island regions, food security is often highly vulnerable to fluctuations in local agricultural production, which are impacted by land use changes and environmental factors [28].

Furthermore, the geographical isolation of Bangka Island means that the region faces unique challenges in implementing food security measures. The reliance on external food supply chains can lead to increased vulnerability to global food market fluctuations, climate change, and other external shocks. A study by Kan and Sun [1] highlights how island communities are disproportionately affected by land use changes and climate events due to their dependence on local production and limited import capabilities. The continued conversion of rice fields to non-rice uses will only exacerbate this vulnerability.

To address these concerns, it is imperative for local government policies to prioritize sustainable land management practices, which include stricter enforcement of spatial planning regulations and incentives for maintaining rice fields. GIS-based monitoring systems, such as those used in other regions, could provide crucial data on land use changes and help policymakers develop more effective strategies for land preservation and food security [21]. Moreover, the alignment of the Food Estate policy with land preservation efforts could help mitigate the risks of food insecurity caused by the reduction in rice production areas.

Research has consistently shown that land conversion poses a significant threat to food security, especially in regions where agricultural land is already limited. In the case of South Bangka Regency, the conversion of rice fields to non-rice agricultural uses has been identified as a key factor contributing to the area's food insecurity. Studies by Erekalo and Yadda [35] and Yu, et al. [36] emphasize the need for policies that address both land conversion and climate change impacts on food production systems. In island settings, the reduction of arable land for rice cultivation is even more concerning, as geographical isolation limits the availability of alternative sources for food supply [37, 38].

Additionally, the competition for land resources, as discussed by Molotch [33] It is increasingly evident in South Bangka that economic interests related to land development are overshadowing the agricultural value of rice production. The rising market value of land for residential and industrial purposes means that landowners and developers have little economic incentive to preserve rice fields. This creates a policy gap where the objectives of food security and the Food Estate program are undermined by broader economic forces driving land use changes.

To mitigate the effects of rice field conversion, it is essential for local governments to implement stronger regulations that protect agricultural land from being converted to non-agricultural uses. Additionally, integrating climate change adaptation strategies into food security policies, as suggested by Moussa et al. [39], can help strengthen the resilience of rice production systems in South Bangka. Moreover, the use of GIS-based spatial analysis, as highlighted by Mathenge, et al. [21] can be instrumental in monitoring land use changes and providing the data needed to guide policy decisions effectively. A global system of openness must align rice production with the principles of sustainable development, as outlined in SDG 12, which focuses on responsible consumption and production [39]. Similarly, rice production on Bangka Island should also be harmonized with the SDG framework.

4. Conclusion

Based on the study objectives, it can be described that the conversion of rice fields in South Bangka Regency has occurred from 2013 to 2023, and it is estimated that a 17.26% conversion will take place by 2043. The findings of the study indicate that there is a tendency for rice consumption to increase in 2043, so that rice production in South Bangka Regency is affected. The continuing trend of land conversion in South Bangka Regency presents significant challenges to rice production and food security in the region. This condition is inevitable and will impact the vulnerability of rice production in South Bangka Regency. The estimation results can serve as a risk mitigation effort for the policies established as food estates and food security locations. If these policies are to be enforced, preventive efforts and strategies to prevent land conversion are needed, especially policies that can curb the rapid increase in the value of agricultural land compared to rice production. Although the government has made efforts through the Food Estate policy, land conversion driven by industrialization, urbanization, and other economic factors threatens to undermine these efforts. This study highlights the importance of strategic land management, effective enforcement of spatial planning regulations, and integration of climate change adaptation strategies to ensure sustainable rice production and food security. By combining GIS-based tools for land monitoring, this study provides valuable data to inform policy decisions and improve agricultural sustainability in South Bangka and other island regions in Indonesia.

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