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PADDY FIELD LAND CHANGE ANALYSIS BASED ON GEOGRAPHY INFORMATION SYSTEM AND REMOTE SENSING IN THE KUBU RAYA DISTRICT

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ABSTRACT

Rice plays an important role in ensuring food security worldwide, especially in Southeast Asia and Indonesia. This study aims to determine the changes in paddy field area and spatial distribution of changes in 2019-2024 using Geographic Information Systems and Remote Sensing in Kuburaya Regency. The data used in this study include the area of paddy fields in Kubu Raya Regency in 2019-2024, an Indonesia Biomass Image, and a Topographic map. The data obtained were then processed using ArcGIS Pro software. Data analysis used a geoprocessing tool with the clip, Intersect, and Dissolve tools and Spatial Analysis using the Map Algebra Tool. The study results showed that overall changes in paddy field area from 2019-2023 were 9036,88 ha. Of the fourteen villages in the Teluk Pakedai sub-district, eight villages experienced an increase in area. The villages are Sungai Nibung, Kuala Karang, Seruat Satu, Tanjung Bunga, Teluk Pakedai Hulu, Madura, Sungai Nipah, and Teluk Pakedai Satu. Overall, the eight villages experienced an increase in the paddy field area of 578.94 ha or 21% of the total area in 2024. Two villages, namely Sungai Nibung and Kuala Karang experienced a 100% increase from 2019. The Geographic Information System and Remote Sensing provide convenience in monitoring and analyzing changes in land use, in this case, changes in the area of paddy fields. Therefore, in the future, this technology will be more effective in its use, because with this technology the data will be easy to update.

Keywords: *Paddy Field; Geographic Information System; Change; Remote Sensing*

INTRODUCTION

Rice plays an important role in ensuring food security worldwide, especially in Southeast Asia (Barchia et al., 2022; Sulistyo & Alfa, 2016; Yen & Le Ngoc, 2024). Around 95% of Indonesians consume rice as a staple food (BPS, 2021), so rice is one of the considerations that is considered in all assessments of the impact of consumption on population growth (Arifin et al., 2021). Its production must be maintained in line with population growth (Kumar et al., 2021) especially in Indonesia. Based on USDA data

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during 2020 – 2024, Indonesia has taken a share of rice supply of around 5.29% of the world's total rice supply of 752 million tons and is the country with the third largest rice supply in the world, after China (34.76%) and India (22.42%) (Sabarella, 2024). In 2020, from irrigated paddy fields covering an area of 10.65 million ha, farmers were able to produce 54.65 million grains of rice to meet the food needs of 270 million people (BPS, 2021). he rice harvest from this very large area is still insufficient to meet the needs of the population. Therefore, for almost all years, the Indonesian government has been convinced to import rice to maintain stock availability, ensure supply flow, and stabilize rice prices (Kassim, 2021). Rice production must be increased to avoid rice imports.

Paddy fields cover about 12% of the world's agricultural land area (Yen & Le Ngoc, 2024). Recently, in Asian countries, paddy fields have been significantly converted from paddy fields to other types of land to achieve higher economic efficiency (Redfern et al., 2012). On the one hand, food security and sustainable resource management must remain a very important global concern (Bazkiaee et al., 2024). Conversion of Paddy fields to Non-Paddy fields is a complex problem when viewed from the level of excessive land use growth, topographic factors, its relationship to socio-cultural life, population growth, farmer welfare, irrigation, urban expansion, and the political will of the government and other stakeholders (Fitri et al., 2022). Some of the reasons for the high rate of conversion of paddy fields to non-paddy fields are low profits in farming, non-compliance with spatial planning regulations (low enforceability), the desire to get cash by selling land, and low coordination between institutions and departments related to land use planning (Rosada, 2016; Saragih et al., 2024), long-term climate change and environmental degradation (Sonyinderawan, 2020). Periodic assessment of the status of changes in paddy fields will help agricultural planners provide direction for sustainable rice production (Jiao et al., 2017; Jin et al., 2021; Yen & Le Ngoc, 2024).

Based on data from the National Land Agency of Kubu Raya Regency in 2024, the area of paddy fields in Kubu Raya Regency has changed. Overall, the change in the area of paddy fields from year to year over 4 years. In 2019, the area of paddy field land use was 42951.77 ha, while in 2024 the area was 33914.90 ha (BPN 2024). This means that from these data it can be seen that the reduction in paddy fields is 9036.879161 ha. This condition contradicts the government's efforts to create food security and efforts in self-sufficiency, especially rice. This condition requires monitoring of changes in land, especially paddy fields. The method used is to continue updating information on land use changes. The aim is to participate in efforts to support rice security and self-sufficiency in Kubu Raya District.

Suwanlee et al (2023) In his research, he stated that significant changes in agricultural land and land cover (LC) have occurred, mostly due to the introduction of new agricultural practices, techniques, and crops. In particular, the use of Remote Sensing data provides spatial consistency and reliable information to support local sustainable agricultural land management, policy-making decisions, and many stakeholders.

Land use change studies need to be carried out by utilizing Remote Sensing and GIS technology to carry out zoning and characterization of land use changes (Barchia et al., 2022). Remote Sensing and Geographic Information Systems (GIS) are current technologies that can be used as alternatives or complements to traditional methods in managing land use changes (Atay Kaya & Kut Görgün, 2020; MohanRajan et al., 2020; Yasir et al., 2020). In many Asian countries, low to high-resolution optical remote sensing imagery is also widely used in creating land change maps (Suwanlee et al., 2023). Many studies in monitoring land changes utilize Remote Sensing imagery, one of which is the Sentinel-2A satellite imagery with a spatial resolution of 10m provided free of charge by the European Space Agency (ESA) (Liu et al., 2020; Son et al., 2020; Zhang et al., 2020).

This study aims to use geographic information systems and remote sensing in Kuburaya Regency to determine changes in land use and the spatial distribution of changes in paddy field areas in 2019-2020.

MATERIALS AND METHODS

Area

This research was conducted in Kubu Raya Regency, West Kalimantan from August to November 2024.

Astronomically, Kubu Raya Regency is located between 109º 03’ 11,48” E-109º 58’ 23,50” E and 0º 13’ 47,16” N-1º 00’ 51,38” S. Kubu Raya District area is shaped in land by 698.520 ha. In terms of geographic position, Kubu Raya Regency has boundaries as follows: West – Natuna Sea; East – Ketapang Regency and Sanggau Regency; North – Mempawah Regency, Pontianak City, and Landak Regency; South – Kayong Utara District (see **Figure 1**).

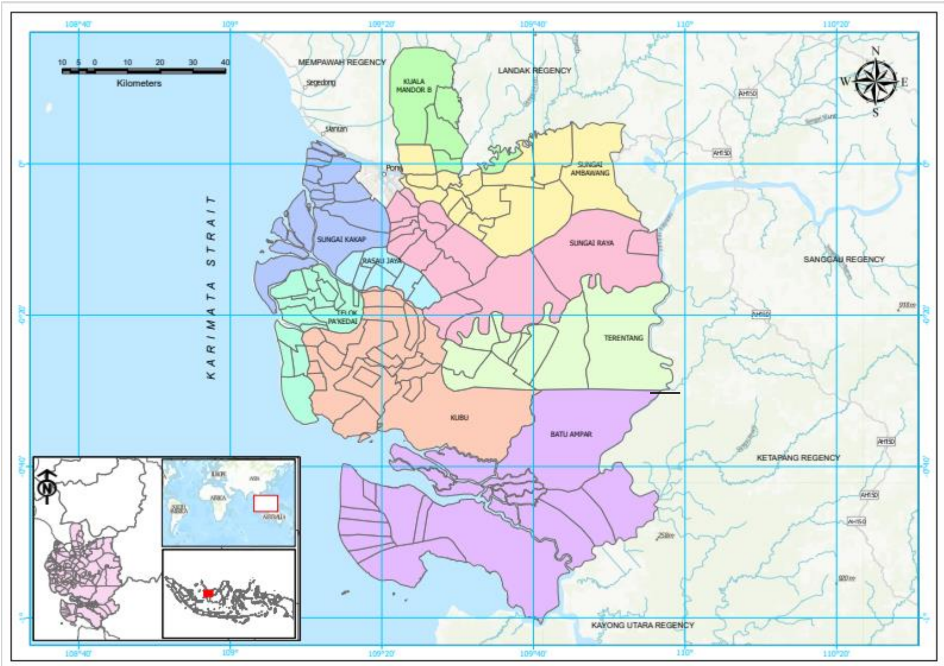

Figure 1. Area Study

Research on changes in paddy fields and zoning and characterization of land use changes requires imagery, namely Sentinel 2A (Barchia et al., 2022; Setiawan & Yoshino, 2020) to facilitate interpretation. Sentinel-2A has a positive impact on monitoring land use/cover, especially in monitoring food crops, forests, urban areas, and water resources, including changes in land use. The data used in this study include the area of paddy fields in Kubu Raya Regency in 2019-2024, MapBomas Indonesia V.2.0 topographic map as supporting data in detecting land cover types. The data obtained were then processed using ArcGIS Pro software to produce a map of changes in the area of paddy fields and their distribution in Kubu Raya Regency in 2019-2024.

Data Analysis

Simpler tools are used in GIS to calculate changes in the area of paddy fields in 2019-2024, namely geoprocessing with the clip function to cut the image in vector, the Intersect and Dissolve tools function to overlay maps and grouping, and the Spatial Analyst Tool uses the Map Algebra Tool to calculate the area of changes in paddy fields. Validation is carried out by comparing the calculation results with data from BPN. Paddy field change analysis process shown in **Figure 2**.

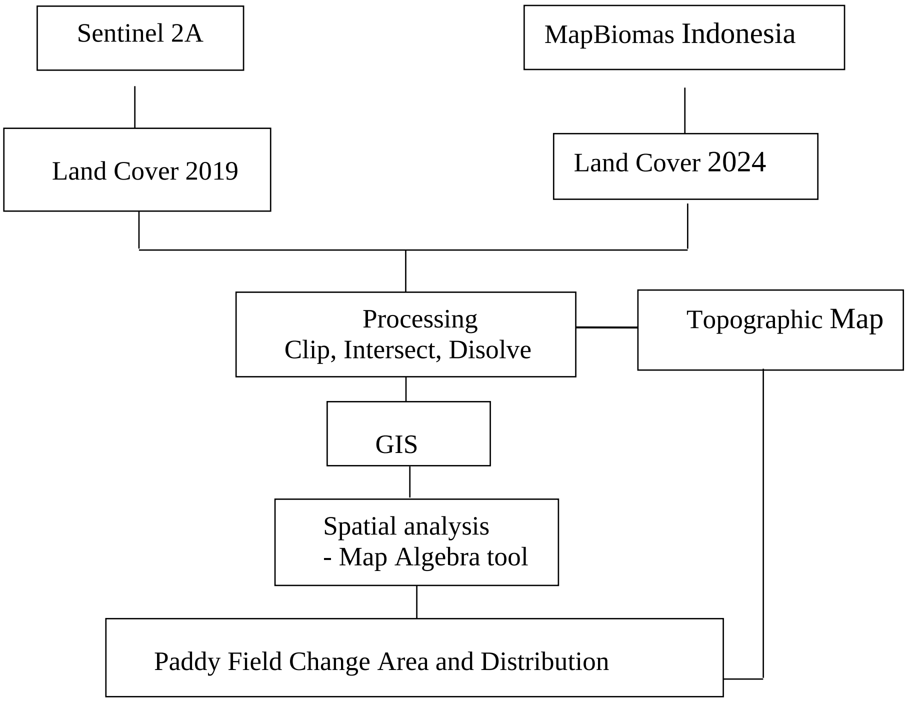

Figure 2. Paddy Field Change Analysis Process

RESULTS AND DISCUSSION

Kubu Raya Regency based on the latest data and analysis of MapBiomas Indonesia data in 2023 has eleven land uses. The land uses are Forest Formation, Mangrove, Wood, Non-forest Plantation, Other Agriculture, Other Non-vegetation, Mining Pits, Ponds, Rivers, Lakes, Seas, Palm Oil, and Paddy fields.

The use of paddy fields is spread across nine sub-districts in Kubu Raya Regency, namely Batu Ampar, Kubu, Terentang, Teluk Pakedai, Rasau Jaya, Sungai Raya, Sungai Kakap, Ambawang and Kuala Mandor sub-districts. Sungai Kakap has the largest paddy field area

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compared to other sub-districts, while the smallest is in Kuala Mandor. In this study, the author tried to map the distribution of paddy field areas from 2019-2024. The results of image interpretation and data analysis of paddy field areas in 2019 were 42951.78 ha (6%) of the total area of Kubu Raya Regency. The paddy fields are spread across various sub-districts as can be seen in **Table 1** and **Figure 3**.

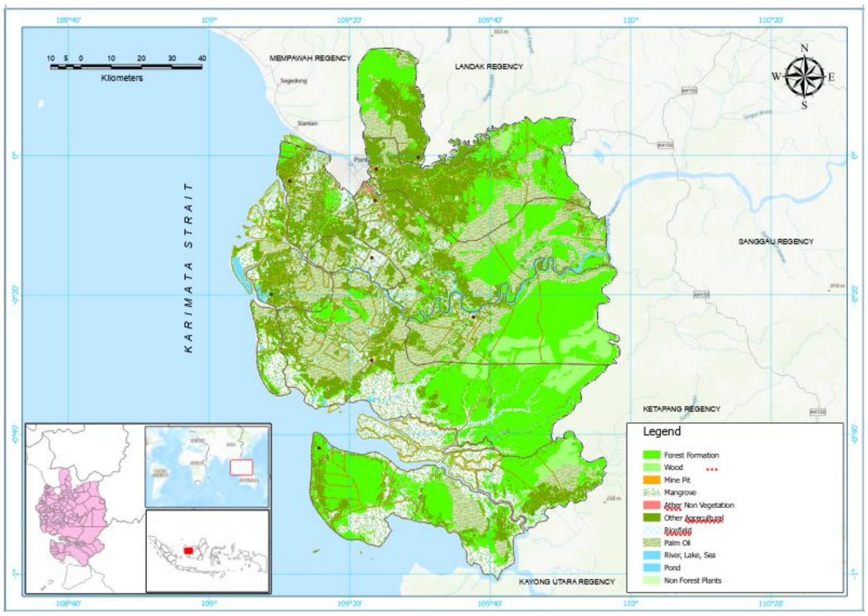

Figure 3. Land Cover Study Area

Table 1. Paddy Fields Area in 2019 Kubu Raya Regency

Regency	2019	Percent
Batu Ampar	7547.50	18
Kubu	6752.18	16
Terentang	1720.38	4
Teluk Pakedai	2366.41	6
Rasau Jaya	2116.90	5
Sungai Raya	6321.83	15
Sungai Kakap	13858.76	32
Ambawang	1200.55	3
Kuala Mandor	1067.28	2
Sum	**42951.78**	**100%**

Based on the data above, the sub-district with the largest area of paddy fields is the Sungai Kakap sub-district. Sungai Kakap sub-district has an area of 13858.76 ha (32%) of the total area of paddy fields in Kuburaya Regency, while the sub-district with the smallest area of paddy fields is Kuala Mandor sub-district 1067.28 ha (2%). Briefly, the distribution of paddy fields in Kuburaya Regency can be seen in **Figure 4**.

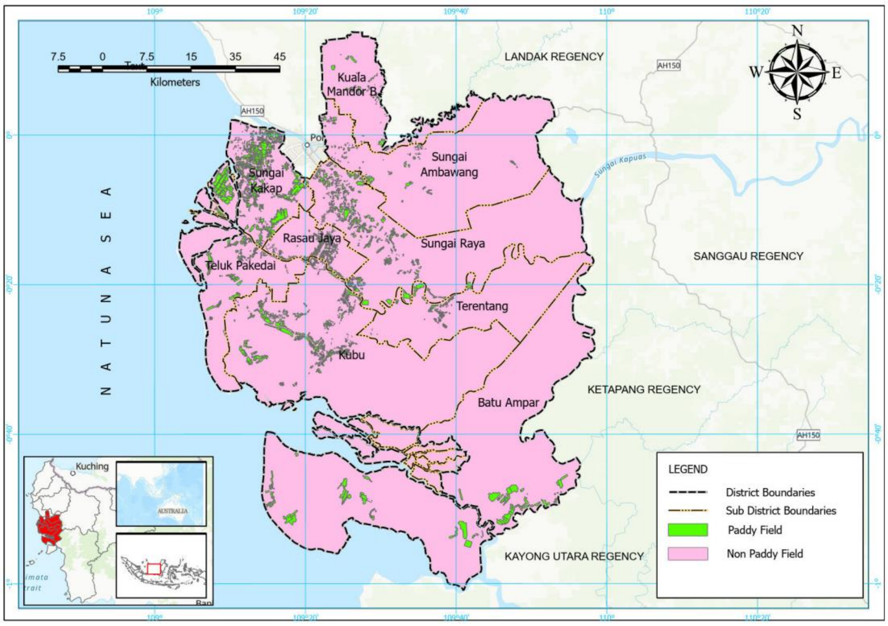

Figure 4. Paddy Field Area 2019

The area of paddy fields in 2024 is 33914.89531 ha (5%) of the total area of Kubu Raya Regency. The paddy fields are spread across various sub-districts as can be seen in **Table 2**.

Table 2. Paddy Fields Area in 2024 Kubu Raya Regency

Regency	2024	Percent
Batu Ampar	5448.34	16
Kubu	6011.78	18
Terentang	1549.91	5
Teluk Pakedai	2810.41	8
Rasau Jaya	1444.26	4
Sungai Raya	4145.55	12
Sungai Kakap	10900.01	32
Ambawang	618.35	2
Kuala Mandor	986.29	3
Sum	**33914.90**	

Based on the data above, the sub-district with the largest area of paddy fields is the Sungai Kakap sub-district. Sungai Kakap sub-district has an area of 10900.01 ha (32%) of the total area of paddy fields in Kuburaya Regency, while the sub-district with the least area of paddy fields is Ambawang Sub-district 618.35 ha (2%). Briefly, the distribution of paddy fields in Kubu Raya Regency can be seen in **Figure 5**.

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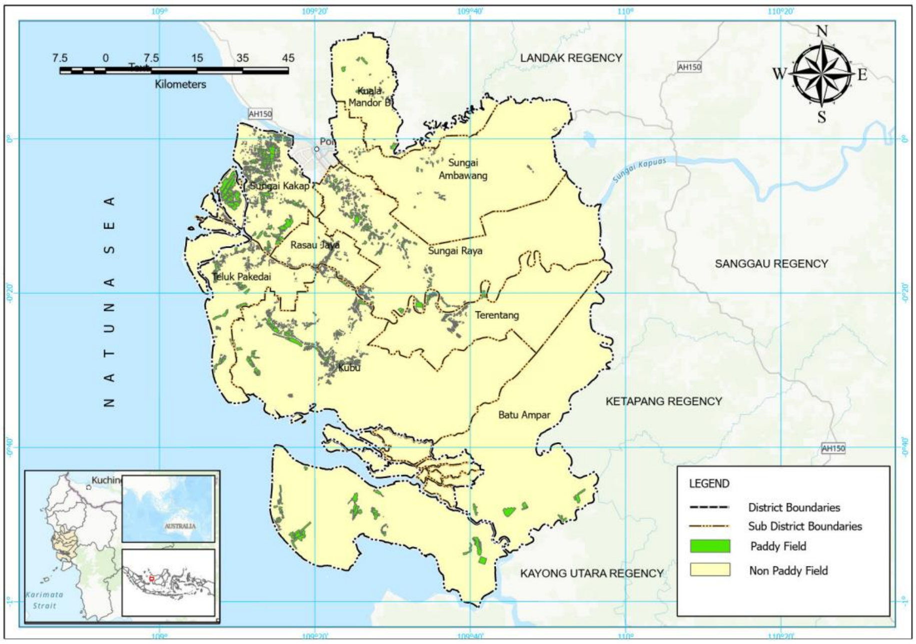

Figure 5. Paddy Field Area 2024

Based on data analysis and the intersecting process of land cover maps in 2019 and 2024, changes in land cover in Kubu Raya Regency as a whole can be seen in **Table 3.**

Table 3. Changes in Land Cover 2019-2024 Kubu Raya Regency

Changes from 2019 to 2024	**Area (Ha)**
Fields/Fields to Non-Irrigated paddy fields	619.95
Bush to Non-Irrigated Paddy fields	323.48
Mixed Gardens to Non-Irrigated Paddy Fields	156.7
Smallholder Plantations to Non-Irrigated Paddy Fields	16.92
Non-Irrigated Paddy Fields to Emplacements	25.18
Non-Irrigated Paddy Fields to Non-Agricultural Industry	0.01
Non-Irrigated Paddy Fields to Villages 272.69	272.69
Non-Irrigated Paddy Fields to Mixed Gardens	355.39
Non-Irrigated Paddy Fields to Ponds	2.31
Non-irrigated Paddy Fields to graves	5.65
Non-irrigated Paddy Fields to large plantations	70.34
Non-irrigated Paddy Fields to smallholder plantations	1725.53
Non-irrigated Paddy Fields to housing	276.33
Non-irrigated Paddy Fields to bushes	226.17
Non-irrigated Paddy Fields to ponds	7.9
Non-irrigated Paddy Fields to temporary open land	1
Non-irrigated Paddy Fields to dry fields/fields	3284.26
Bush to irrigated Paddy Fields	41.75
Mixed gardens to irrigated Paddy Fields	71.92
Smallholder plantations to irrigated Paddy fields	34.68
Dry fields/fields to irrigated Paddy fields	437.13

This pattern of change is similar to other areas such as in the research of (Fitri et al., 2022) in Ciampea sub-district, Barchia, (Barchia et al., 2022) in Bengkulu and (Jiao et al., 2017) in the Tai Lake Basin, changes in paddy land cover tend to experience changes to other land cover, especially for non-agricultural land.

In this study, the main focus is the area of paddy field use. The results of data analysis from the National Land Agency in 20219-2023 and the results of interpretation from MapBiomas Indonesia and Sentinal 2A imagery showed changes in the area of paddy fields. Changes in the area of rice fields are shown in **Table 4** and **Figure 6.**

Table 4. Changes in the Area of Use of Paddy Fields in 2019-2024

Regency	2019 (ha)	2024 (ha)	Area of Change (ha)	Description
Batu Ampar	7547.500139	5448.337932	-2099.162207	Decrease
Kubu	6752.176445	6011.777039	-740.399406	Decrease
Terentang	1720.378512	1549.914557	-170.463955	Decrease
Teluk Pakedai	2366.413206	2810.407467	+443.994261	Increase
Rasau Jaya	2116.894424	1444.25841	-672.636014	Decrease
Sungai Raya	6321.826881	4145.545805	-2176.281076	Decrease
Sungai Kakap	13858.75654	10900.01257	-2958.743979	Decrease
Ambawang	1200.548978	618.350256	-582.198722	Decrease
Kuala Mandor	1067.279346	986.291283	-80.988063	Decrease
Area	**42951.77448**	**33914.89531**	**9036.879161**	

Overall, the change in the paddy field area during the 5 years from 2019-2023 was 9036.879 ha. This means that from the data it can be seen that the change from paddy fields to other land uses in one year is an average of 1,807.3758 ha. This change is very spectacular because if calculated, the paddy fields in Kuburaya Regency experience an average reduction of 5.0204 ha per day. Factors causing land conversion include rapid population growth which has an impact on increasing demand for housing (Hailu et al., 2020; Heilig, 2023; Maja & Ayano, 2021; Zhou et al., 2020). In addition, the high income obtained from non-agricultural sector activities compared to the agricultural sector. This condition is the same as that also stated by previous researchers in various countries (Daymard, 2022; Lipton, 2023; Wang et al., 2020).

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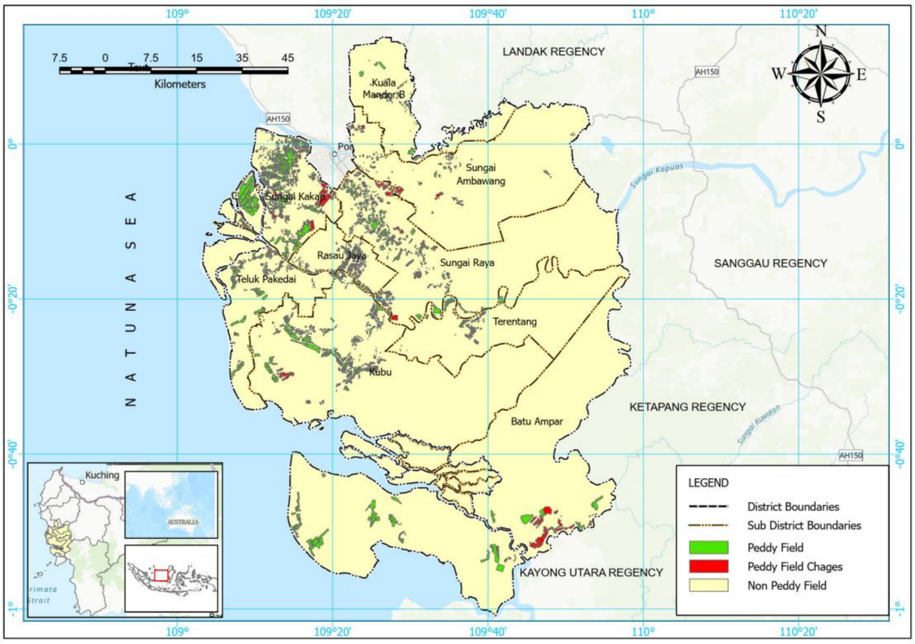

Figure 6. Map of Changes in Paddy Fields 2019-2024

However, if we look at each sub-district of the nine sub-districts in Kubu Raya district, there is one sub-district that actually experienced an increase in its area, namely Teluk Pakedai sub-district. The results of the data analysis show that the increase in land area is shown in **Table 5.**

Table 5. Changes Paddy field Area in Teluk Pakedai District 2021-2024

Village	2019 (ha)	2024 (ha)	Changes (ha)
Sungai Nibung	0	88.229478	+88.229478
Kuala Karang	0	270.325116	+270.325116
Seruat Satu	55.486936	72.981145	+17.494209
Teluk Gelam	168.265822	127.551815	-40.714007
Tanjung Bunga	231.218849	240.027654	+8.808805
Selat Remis	156.526408	136.53389	-19.992518
Arus Deras	20.263834	15.484962	-4.778872
Teluk Pakedai Hulu	360.761506	371.37136	+10.609854
Teluk Pakedai Dua	160.450193	159.884688	-0.565505
Madura	88.9356	102.965797	+14.030197
Sungai Deras	222.068262	210.692845	-11.375417
Sungai Nipah	157.770631	159.462861	+1.69223
Pasir Putih	421.095522	363.576059	-57.519463
Teluk Pakedai Satu	323.569643	491.319797	+167.750154
Area	**2366.413206**	**2810.407467**	**443.994261**

Based on the data in **Table 1**, it is known that Teluk Pakedai District is the only one of the nine districts in Kubu Raya Regency that experienced an increase in paddy field area in 2019-2024. From the fourteen villages in Teluk Pakedai District, eight villages experienced an increase in area. These villages are Sungai Nibung, Kuala Karang, Seruat Satu, Tanjung Bunga, Teluk Pakedai Hulu, Madura, Sungai Nipah, and Teluk Pakedai Satu. Overall, the eight villages experienced an increase in the paddy field area of 578.94 ha or 21% of the total area in 2024. Two villages, namely Sungai Nibung and Kuala Karang experienced a 100% increase from 2019.

Based on the analysis of the increase in paddy field area in the two villages of Sungai Nibung and Kuala Karang, there may be local government efforts to support the national food program, namely by accelerating paddy field printing (Alaerts, 2020; Rustiadi et al., 2021; Sutardi et al., 2022). To strengthen national food security to achieve food sovereignty, the government is preparing a new paddy field printing program that targets the development of 3 million hectares of paddy fields (Yuniarto, 2024). The paddy field printing program is expected to ensure the sustainability of the national food supply and support the agricultural sector as a strong pillar of the economy amidst the threat of a global food crisis (Basset, 2024; Fan et al., 2021; Kumareswaran & Jayasinghe, 2022; Shi et al., 2022).

The change in agricultural land use for paddy crops has decreased relatively significantly; economically, the impact is the loss of potential food crop production. In addition, several phenomena have proven that, compared to environmental issues, economic considerations are considered to have greater benefits. These findings have important implications for policy-making by local governments in their efforts to improve environmental management and food provision in several areas, especially Kuburaya Regency. Changes in agricultural land use to non-agricultural land are partly due to population growth and the demand for housing as a place to live for the population.

CONCLUSION

Teluk Pakedai District is the only one of the nine districts in Kubu Raya Regency that experienced an increase in paddy field area in 2019-2024. From the fourteen villages in Teluk Pakedai District, eight villages experienced an increase in area. The villages are Sungai Nibung, Kuala Karang, Seruat Satu, Tanjung Bunga, Teluk Pakedai Hulu, Madura, Sungai Nipah, and Teluk Pakedai Satu. Overall, the eight villages experienced an increase in the paddy field area of 578.94 ha or 21% of the total area in 2024. Two villages, namely Sungai Nibung and Kuala Karang experienced a 100% increase from 2019. Below are detailed recommendations to address current and future food security challenges: enhancing agricultural productivity, diversifying food systems, building resilient food supply chains, addressing inequities in access, mitigating climate change impacts, strengthening research and policy frameworks, promoting global and local collaboration, educating and empowering communities. The Geographic Information System and Remote Sensing provide convenience in monitoring and analyzing changes in land use in this case changes in paddy field area. Therefore, in the future, this technology will be more effective in its use, because with this technology the data will be easy to update. Remote Sensing and GIS can automate data processing, find patterns, and make predictions about land cover conditions and classifications accurately.

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