SUITABILITY AND BIOPHYSICAL CHARACTERISTICS OF SUSTAINABLE FOOD AGRICULTURAL LAND IN ACEH SINGKIL

Muhammad Yasar*, Syahrul[*], Zulfa Fijannah[*], Nor Diana Mohd Idris[**]
**Agricultural Engineering Department, Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, Aceh, Indonesia, yasar@usk.ac.id, syahrul@usk.ac.id, zulfafijannah03@gmail.com*
***Institute For Environment and Development (LESTARI), Universiti Kebangsaan Malaysia, Bangi, Malaysia, nordiana@ukm.edu.my*

Email Correspondence : yasar@usk.ac.id

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Abstract: Identification of the suitable and biophysical characteristics of land is crucial to meeting sustainable food production both locally and globally. This study aims to examine the suitability of paddy land and classify land quality based on the biophysical characteristics of paddy fields designated as sustainable food fields in Aceh Singkil District, Indonesia. The qualitative technique is through observation and soil sampling in the field from five sub-districts with the highest level of land availability, namely: Danau Paris, Simpang Kanan, Suro Makmur, Kuta Baharu, and Gunung Meriah. Soil sample testing was carried out in the laboratory, and the records received were analyzed for the use of the Matching Method as a means of evaluating the traits of the land inside the Land Use Unit (SPL). The results of the analysis are visualized using a Geographic Information System (GIS) approach. We found that, based on suitable characteristics, land can be improved by improving the limiting factors, while biophysical characteristics can be improved by increasing land suitability. The subdistricts of Danau Paris, Simpang Kanan and Kuta Baharu are included in the category of the first primary paddy land. The land category must be protected, preserved, and designated as LP2B, while Suro Makmur and Gunung Meriah Subdistricts are included in the category of the first secondary paddy land that requires improvement efforts to improve its biophysical condition. The first primary paddy land is the land that has technical or semi-technical irrigation status with a cropping index (IP) ≥ 2 and productivity ≥ 4.50. Whereas the first secondary paddy land is the land that has technical or semi-technical irrigation status with a cropping index (IP) ≥ 2, but productivity ≤ 4.50. Both of them should be zoned as protected areas.
Keywords: biophysical characteristics; sustainable agriculture; agricultural land

Abstract*:* Identifikasi karakteristik dan biofisik lahan yang sesuai sangat penting untuk memenuhi produksi pangan berkelanjutan baik secara lokal maupun global. Penelitian ini bertujuan untuk mengkaji kesesuaian lahan sawah dan mengklasifikasikan kualitas lahan berdasarkan karakteristik biofisik lahan sawah yang ditetapkan sebagai lahan pangan berkelanjutan di Kabupaten Aceh Singkil, Indonesia. Metode yang digunakan adalah kualitatif melalui observasi dan pengambilan sampel tanah di lapangan dari 5 (lima) kecamatan dengan tingkat ketersediaan lahan tertinggi yaitu: Danau Paris, Simpang Kanan, Suro Makmur, Kuta Baharu, dan Gunung Meriah. Pengujian sampel tanah dilakukan di laboratorium dan data yang diperoleh dianalisis dengan menggunakan Metode Matching dengan cara mengevaluasi sifat-sifat tanah dalam

Satuan Penggunaan Tanah (SPL). Hasil analisis divisualisasikan dengan menggunakan aplikasi Sistem Informasi Geografis (SIG). Hasil penelitian menunjukkan bahwa berdasarkan karakteristik yang sesuai, lahan dapat diperbaiki melalui perbaikan faktor pembatas, sedangkan karakteristik biofisik dapat ditingkatkan melalui peningkatan kesesuaian lahan. Kecamatan Danau Paris, Simpang Kanan dan Kuta Baharu masuk dalam kategori lahan persawahan primer ke-1, kategori lahan harus dilindungi dan dilestarikan serta ditetapkan sebagai LP2B, sedangkan Kecamatan Suro Makmur dan Gunung Meriah masuk dalam kategori ke-1. lahan sawah sekunder yang memerlukan upaya perbaikan untuk memperbaiki kondisi biofisiknya. Lahan sawah primer ke-1 adalah lahan yang berstatus irigasi Teknis atau Semi Teknis dengan indeks tanam (IP) ≥ 2 dan produktivitas ≥ 4,50. Sedangkan lahan sawah sekunder ke-1 adalah lahan yang berstatus irigasi Teknis atau Semi Teknis dengan indeks tanam (IP) ≥ 2, namun produktivitas ≤ 4,50. Keduanya harus dijadikan kawasan lindung.

Keywords: karakteristik biofisik; pertanian berkelanjutan; lahan pertanian

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Introduction

The competition between land uses has increased because of the recent significant growth in the global population (Smith et al, 2012; Wu et al, 2018; Margaret et al, 2023). Indonesia has 272.7 million inhabitants and a population growth rate of 1.22% annually (Badan Pusat Statistik, 2018), making it the fourth most populated country in the world after China, India, and the United States (Roser et al, 2022). The population of Indonesia will be 320 million, or 318.9 million, in 2045 (Badan Pusat Statistik, 2022). Therefore, land is needed to accommodate the world's population growth of approximately 3.4 million people per year in Indonesia or at a comparable rate elsewhere to fulfil infrastructure and food needs. Indonesia is an agrarian nation where most people live in rural areas and depend on farming for their living (Abduh, 2023). For their daily necessities and to support their economy, Indonesians often consume agricultural products (Rozaki, 2022). The greatest difficulty facing Indonesia today is the country's shrinking agricultural area, however, there are things that may be done to prepare for that, including agricultural sector development (The Jakarta Post, 2020).

The high rate of conversion of paddy fields both for other agricultural uses outside the crops sub-sector and for the use of other development activities outside the agricultural sector has become a serious threat to national food security (Claudia et al, 2022; Nurliani & Ida, 2016). Paddy fields are often preferred for development because they are flat and easily accessible, as well as because of their advantageous locations near urban cores and major transit corridors (Santos et al, 2017). According to FAO (2017), besides being able to reduce rice production directly, land conversion is also a threat from a social perspective that can reduce farmers' income or welfare and can disrupt natural

stability in terms of the environment. Therefore, the Government of Indonesia through Law Number 41 of 2009 concerning the Protection of Sustainable Food and Agriculture Farm intends to limit the space for conversion by prohibiting the conversion of certain lands for other purposes other than the national interest in maintaining food security (UU, 2009).

Through this Law, the Central Government instructs all Governments at the Provincial and District/Municipality Levels to apply for and determine agricultural land that meets certain criteria according to the expected standards in accordance with regulatory provisions to be used as Sustainable Food Agricultural Land (LP2B). One of the regions that has applied for the LP2B Area is Aceh Singkil District through Aceh Singkil Regent Regulation Number 188.354/42/2020 dated December 14, 2020, concerning the Protection of Sustainable Food Agricultural Land in Aceh Singkil District. In the Head of District Regulation (Perbup), it was said that the land in query is an area of agricultural land this is decided to be blanketed and advanced continually so one can produce staple meals for self-reliance, resilience and local meals sovereignty (UU, 2009; Peraturan Bupati, 2020).

Literature review

Sustainable agriculture depends on a variety of elements, including the land. Long-term objectives in agricultural development, however, have not entirely trumped consideration for the protection of agricultural land in economic development and making this problem to the agriculture sustainability (Triyono et al, 2022). Regional meals independence, resilience and sovereignty are the primary milestones for the conclusion of country-wide meals self-reliance, resilience, and sovereignty (Ario et al, 2019; Yasar & Chamhuri, 2016). Achieving food security is one of the pillars supporting the sustainability of the Indonesian government, state and nation (Suryana, 2008) and is the foundation of national development which should be made a priority by the government. Targets and aspirations to realize Indonesia as a world food bar will be realized if sufficient land resources are available. According to Mulyani et al. (2017), there are three main keys to realizing the world's food storage, namely: (1) maintaining existing agricultural land so that it is not converted, (2) providing new expansion land, and (3) advanced technological innovation for intensification.

Therefore, as the pilot project of the implementation of the national program, the regions must be able to provide quality land, following the expected technical criteria so as not to trigger new issues and problems in the context of land use policies (Committee on World Food Security, 2014). The increase in development activities in various sectors has implications for increasingly high competition for land use (Helmut, 2015; Eric & Patrick, 2011). For preserving the food supply, concerns with the growing population, land conversion, and other agricultural land challenges are interconnected (Potapov et al, 2022). The need for

food and land will increase as the population grows, but at the same time, the amount of productive agricultural land will decrease because of conversion. The change drastically reduces the amount of productive agricultural land that is now available for growing staple foods (Panuju et al, 2013), which compromises food security. Furthermore, the conversion of paddy fields becomes a logical consequence of development that puts the land rent ratio as the basis (Mohammad et al.,2018; OECD, 2009). Hence, the unsurpassed strategy to strategically fulfil demand is to increase the regions where food is produced by using suitable abandoned land as land reserves (Mulyani et al, 2023).

If the land use is determined based on the land rent ratio, it can be ascertained that land use in the agricultural sector, especially the crops sub-sector, will not be able to compete properly. Compared to the paddy field business, land rent for oil palm farming is 25% higher (Anis, 2016). Based on the financial analysis of the Net Present Value (NPV) between agricultural and non-agricultural land, there is a very large land rent ratio, namely: 1:1,261.99 (Akib, 2002). Comparison of land rent between rice fields and industry 1: 500, rice fields with housing 1: 622, rice fields with tourism 1: 14, and even rice fields with production forests 1: 2.6 (Imelda, 2010). This shows that if the economic motive is the main priority, the conversion of paddy fields is difficult to avoid. However, we also cannot deny the need for land use in other sectors. In the midst of continuous efforts to control land conversion, wise steps are needed to improve living standards and improve people's welfare. The willpower of sustainable food and agricultural land ought to be primarily based on robust technical considerations, especially from the aspect of suitability and adequate land quality. So that lands that do not meet the standards can be upgraded or can be an alternative for other land use needs. This study aims to see the level of suitability of paddy fields and classify land quality based on the biophysical characteristics of paddy land that is designated as sustainable food and agricultural land in Aceh Singkil District, Indonesia. So, standards through the results of the study can be used as a parameter in determining a better land use pattern.

Material and Instrument

Method and study area

This research was conducted qualitatively with data collection techniques carried out observably through observation and soil sampling (Husein et al, 2006) in the field of 5 (five) sub-districts that have the highest level of availability of rice fields in Aceh Singkil District, namely: Danau Paris Sub-District (20.52 %), Simpang Kanan Sub-District (18.68 %), Suro Makmur Sub-District (17.94 %), Kuta Baharu Sub-District (17.48%), and Gunung Meriah Sub- District (13.16 %). Soil samples taken, tested, and analyzed represent 87.78% of the observed land area. Soil sampling locations are shown in Table 1 and Figure 1.

Table 1. Coordinate Point of Soil Sampling

X	Y	Sub District	Village
098 10'28.56" E	02 14'22.03" N	Danau Paris	Lae Balno
098 01'30.65" E	02 27'30.33" N	Simpang Kanan	Lae Riman
098 00'03.24" E	02 28'30.30" N	Suro Makmur	Alur Linci
097 50'47.97" E	02 28'10.82" N	Kuta Baharu	Butar
097 57'24.69" E	02 22'11.53" N	Gunung Meriah	Suka Makmur

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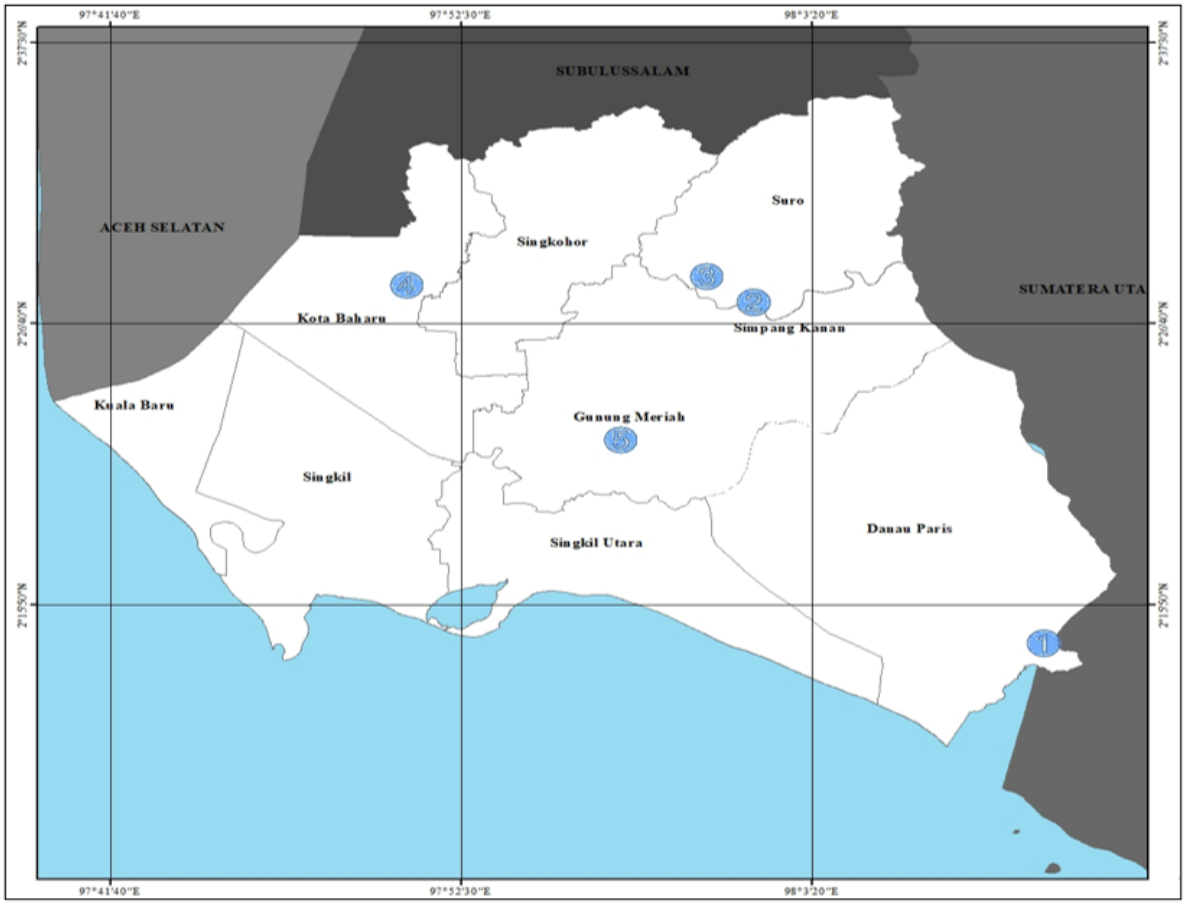

Figure 1. Research Areas

Soil sample testing was carried out at the Plant and Land Research Laboratory, Faculty of Agriculture, Syiah Kuala University and the facts received have been analyzed the usage of the Matching Method (Guido, 2015), via way of means of evaluating the traits of the land withinside the Area Use Unit (SPL) (Hari, 2013) in accordance with the Criteria for Area Suitability Class for Irrigation Paddy Field (Djaenudin et al, 2011).

Table 2. Land Quality Criteria

Irrigation Status	Planting Index (IP)	Productivity (Ton/Ha)	Category	Zone
Technical/Semi-Technical	≥ 2	≥ 4.50	The 1st Primary Paddy Land	Protected Area (PA)
Technical/Semitechnical	≥ 2	≤ 4.50	The 2nd Primary Paddy Land	Protected Area (PA)
Technical/Semitechnical	≤ 2	≥ 4.50	The 2nd Primary Paddy Land	Protected Area (PA)
Technical/Semitechnical	≤ 2	≤ 4.50	The 2nd Primary Paddy Land	Protected Area (PA)
Modest/Rainfed	≥ 2	≥ 4.50	The 1st Primary Paddy Land	Limited Conversion Area (LCA)
Modest/Rainfed	≥ 2	≤ 4.50	The 1st Secondary Paddy Land	Limited Conversion Area (LCA)
Modest/Rainfed	≤ 2	≥ 4.50	The 1st Secondary Paddy Land	Limited Conversion Area (LCA)
Modest/Rainfed	≤ 2	≤ 4.50	The 2nd Secondary Paddy Land	Limited Conversion Area (LCA)

Source: Modification Abdurrachman, A. et al. (2005) and BPN (2004) *in* Yasar (2013)

A literature review is needed to determine biophysical characteristics to be classified according to the level of land quality, namely the 1st primary paddy land, the 1st primary paddy land, the 1st secondary paddy land and the 2nd secondary paddy land as shown in Table 2 (Yasar et al, 2013). The 1st primary paddy land is the land that has Technical or Semi-Technical irrigation status with a cropping index (IP) ≥ 2, and productivity ≥ 4.50. Meanwhile, the 1st primary paddy land is land that has technical or semi-technical irrigation status but its IP and productivity are the same as or complement each other. If the IP is less then the productivity is more. Likewise with the 1st secondary paddy land, what makes it different is that its irrigation status is still modest or rainfed. Meanwhile, the 2nd secondary paddy land is land with the lowest quality compared to the others. Irrigation status is still modest or rainfed, and IP and productivity are very low.

Furthermore, the results of the study were visualized using the Geographic Information System (GIS) method (Ndidi & Monday, 2014) using the AcrGIS10.8 application. The flow chart of this research can be seen in Figure 2.

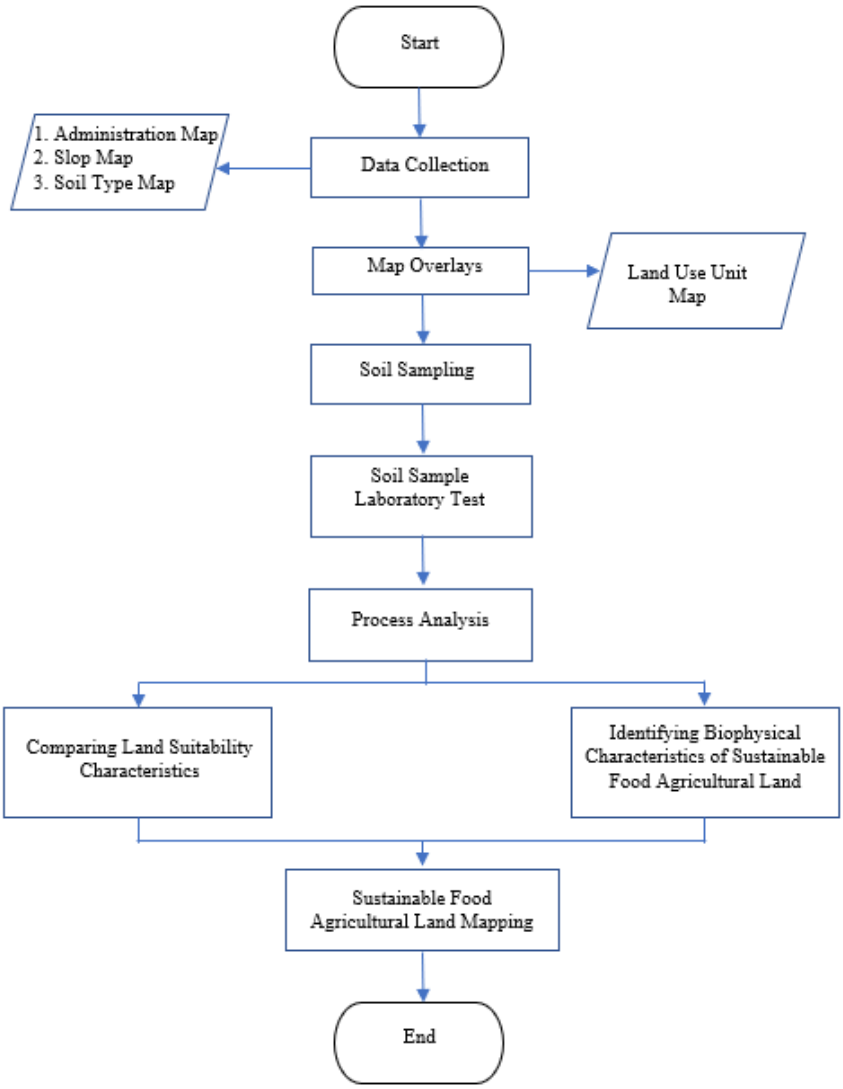

Figure 2. Research Flowchart

Results and discussion

General Description of the District

Aceh Singkil District is located in the southern part of Aceh Province, Indonesia. Astronomically, Aceh Singkil District is located between 2°0'20"-2°36'40' North Latitude and 97°04'54"-98°11'47" East Longitude. Topographically, Aceh Singkil District is located on the West–South coast of the Aceh Province, which stretches from the north in the form of hills to the south in the form of a coastal area. Around 146.274.65 Ha (66.88%) of the area is located at an altitude of 0-100 meters above sea level. While the area at an altitude of 100-500 m above sea level is around 68,821.89 Ha (31.47%). The remaining 1.65% of the total area is an area with an altitude above 500 m above sea level. Based on the topographic map, most of the area of Aceh Singkil District is plain. Aceh

Singkil District has an area of 1,857.88 km^2 /185,803 Ha consisting of 11 sub-districts and 116 villages.

Area Designation of LP2B

Based on the Head of Aceh Singkil District Regulation Number 188.354/42/2020 in Article 8 Paragraph 3, there are 10 Sub- Districts out of 11 Sub-Districts in Aceh Singkil District which are designated as LP2B Aceh Singkil District. The lands are located in the Sub-District of Danau Paris (223 Ha/20.52 %), Mount Meriah Sub-District (143 Ha/13.16%), Kota Baharu Sub-District (190 Ha/17.48 %), Singkohor Sub-District (21 Ha/1.93 %), Pulau Banyak Sub-District (39 Ha/3.59 %), Pulau Banyak Barat Sub-District (9 Ha/0.83 %), Simpang Kanan Sub-District (203 Ha/18.68 %). Singkil District (58 Ha/5.34 %), North Singkil Sub-District (6 Ha/0.55% %), and Suro Makmur Sub-District (195 Ha/17.94 %). Meanwhile, the sub-district that is not included in the area is Kuala Baru Sub-District.

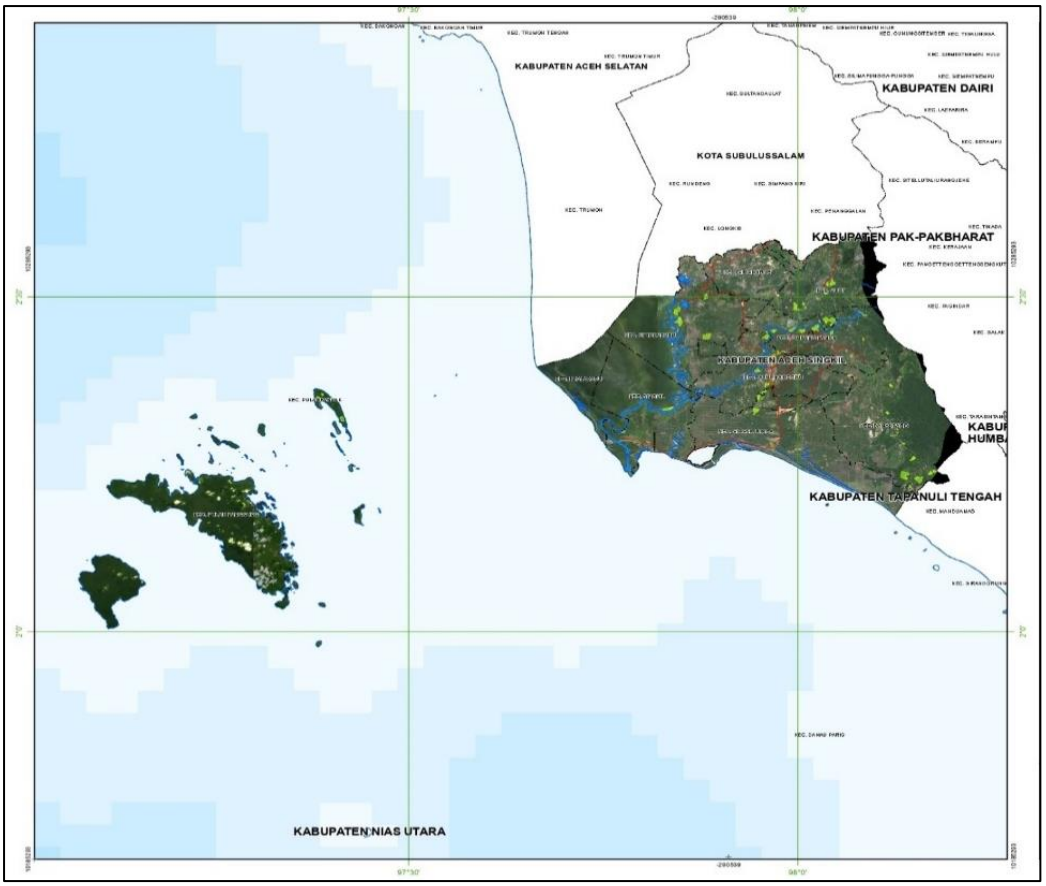

Figure 3. Raw Paddy Fields in Aceh Singkil District

The total area of paddy fields used as LP2B areas in Aceh Singkil District is 1.087 hectares, equivalent to 0.58% of the district's area. The land area data is in accordance with the total area of Aceh Singkil raw paddy fields in 2019 published

by the Indonesian Ministry of Agriculture. The raw land in question is dynamic existing paddy fields that are periodically planted with paddy or interspersed with other crops (secondary crop/palawija). Ideally, all these lands have irrigation networks, have been planted twice a year and have a high level of productivity. However, this is not the case as shown in Table 2 (and will be discussed further).

Land Suitability for Rice Plants Land

Suitability classes in all study areas are the same, both actual and potential, namely S3 (marginally appropriate) and S2 (fairly appropriate), but the limiting factors are different from each other. These limiting factors are nr (nutrient retention), na (available nutrients), rc (root media), fh (inundation/flood during planting), and eh (erosion hazard). The actual land suitability class is the land suitability class at the time of the research, while the potential land suitability class is the land suitability class after obtaining or taking corrective actions to reduce the existing limiting factors (Hardjowigeno & Widiatmaka, 2001).

The Danau Paris Sub-District has a real land suitability elegance of S3 (nr, na), and a capability land suitability elegance of S2 (rc, nr), and na. Simpang Kanan sub-district has a real suitability elegance of S3 (nr, na, fh) and a capability land suitability elegance of S2 (rc, nr, na, fh). Suro Makmur Sub-district has a real land suitability elegance of S3 (nr, na), and a capability land suitability elegance of S2 (nr, na). Kuta Baharu sub-district has a real land suitability elegance of S3 (na, fh), and a capability land suitability elegance of S2 (na, fh). And Gunung Meriah Sub-District has a real land suitability elegance of S3 (nr, na, eh), and a capability land suitability elegance of S3 (eh). The distribution of land suitability may be visible visually in Figure 3.

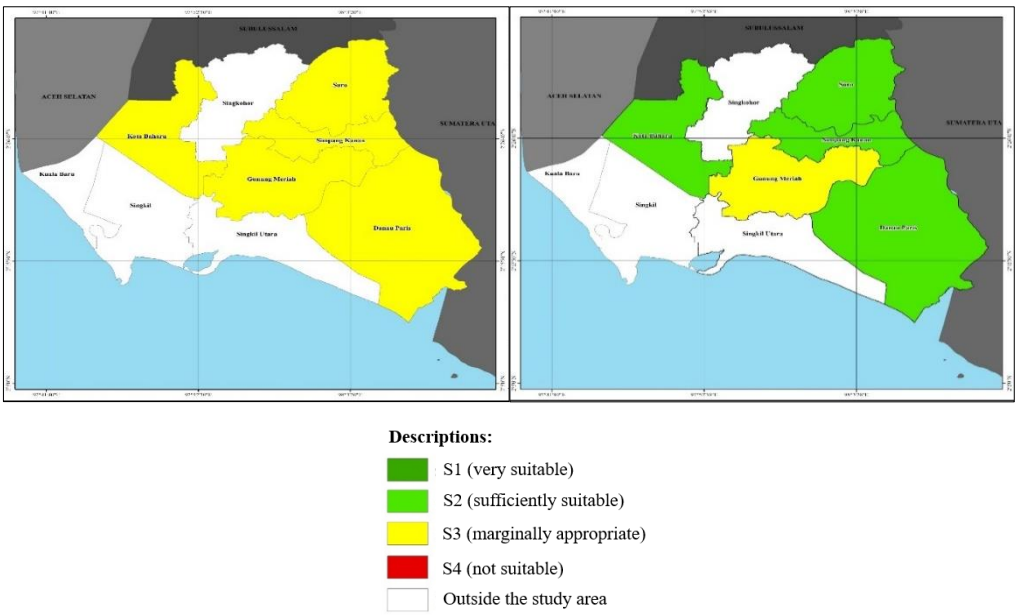

Figure 3. Land Suitability (Left: Actual, Right: Potential)

S3 class (marginally suitable) is land that has an extreme proscribing aspect, and this proscribing aspect will substantially have an effect on its productivity, requiring extra inputs which can be greater than land categorized as S2. Convening the proscribing aspect in S3 calls for excessive capital, so there may be a want for help or intervention through the authorities or the personal sector. While S2 (fairly suitable) is land that has a restricting issue, and this restricting issue will have an effect on its productivity, requiring extra input. These limitations can normally be conquered via the means of the farmers themselves. Meanwhile, the most desirable is Class S1 (very suitable), which is land that does not have a significant limiting factor or real for sustainable use, or minor limiting factor and will not significantly affect land productivity (Kementerian PUPR RI. Jakarta, 2016).

Riceland Quality Criteria

The biophysical characteristics of sustainable food agricultural land in Aceh Singkil District based on irrigation status parameters, planting index, and productivity level consist of 2 categories of paddy fields, namely primary paddy fields I and secondary paddy fields I. Sub-districts included in the 1st Primary Paddy Land s I are Danau Paris Sub-District Simpang Kanan Sub-District, and Kuta Baharu Sub-District. Meanwhile, the sub-districts included in the secondary paddy fields I am Suro Makmur Sub-District and Gunung Meriah Sub-District. Visually, the paddy field area according to the land quality criteria can be seen in Figure 4.

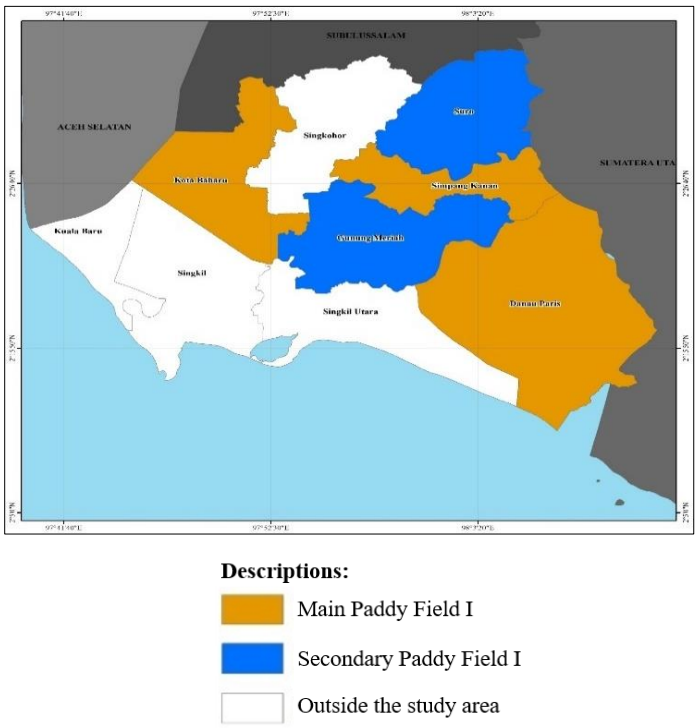

Figure 4. Paddy Fields Quality Criteria

The 1st Primary Paddy Land is land with reliable biophysical criteria, with sufficient water sources and equipped with technical/semi-technical irrigation systems. Paddy can be planted more than or equal to two plantings in a year so that the results obtained reach a productivity level above or equal to 4.5 tons/ha. The areas included in the 1st Primary Paddy Land category I are the Danau Paris Sub-District, Simpang Right Sub-District, and Kuta Baharu Sub-District. These three sub-districts have semi-technical irrigation with planting index 2 times a year and with productivity levels ranging from 4.5 tons/ha – to 5.6 tons/ha.

The 1st Secondary Paddy Land is a paddy field that has simple irrigation/rainfed and has a planting index of more than or equal to 2 planting times a year and has a productivity level of less or equal to 4.5 tons/ha. This kind of land has only one constraint. However, it does not mean that paddy land is included in the convertible category. Secondary rice field I is also a type of land that has the potential to develop paddy plants, but greater efforts are still needed to improve its biophysical conditions. This type of paddy field is considered fertile land with sufficient water sources, but its utilization and development are not optimal. The areas included in the secondary paddy field category I are Suro Makmur Sub-District and Gunung Meriah Sub-District. These two sub-districts have a planting index of 2 times a year with a productivity level of 3.5 tons/ha.

Table 3. Quality of Paddy Land in Main Areas of Aceh Singkil District

Sub-District	Irrigation Status	Planting Index (IP)	Productivity (Ton/Ha)	Category
Danau Paris	Semitechnicall	2	5,6	The 1st Primary Paddy Land
Simpang Kanan	Semitechnicall	2	5	The 1st Primary Paddy Land
Kuta Baharu	Semitechnicall	2	4,5	The 1st Primary Paddy Land
Suro Makmur	Rainfed	2	3,5	The 1st Secondary Paddy Land
Gunung Meriah	Rainfed	2	3,5	The 1st Secondary Paddy Land

Table 3 shows the quality of paddy land in the main areas of Aceh Singkil Districts by irrigation status, planting index, productivity and category either the 1st primary or 1st secondary of paddy land. The 1st paddy land is a paddy field that must be protected and preserved from conversion activities. The 1st secondary paddy land is a paddy field that needs improvement efforts to improve the biophysical condition of the land (Yasar, 2014). Land that still uses semi-technical irrigation is expected to be upgraded to technical irrigation. Moreover, if there is still rainfed, the government should immediately provide adequate irrigation facilities so that IP and land productivity can be further increased.

Conclusion

Based on the description above and the effects of this, a look at the subsequent conclusions may be drawn. The LP2B location of Aceh Singkil District has a real land suitability magnificence of S3 (marginally appropriate) and a capacity land suitability magnificence of S2 (fairly suitable). For this reason, intervention from outside farmers, especially the government or the private sector, is needed so that the suitability class can be increased. Based on its biophysical characteristics, the LP2B area of Aceh Singkil District consists of two categories, namely: the 1st primary paddy land and the 2nd secondary paddy land. For the 1st primary paddy land, it is feasible to set up or serve as LP2B, while the 1st secondary paddy land could still be converted for urgent needs or can also be designated as an LP2B reserve.

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