Jurnal Agroekoteknologi Tropika Lembab
Volume 8, Nomor 1, Agustus 2025
Halaman: 17-24

ISSN: 2622-3570
E-ISSN:2621-394X
DOI.10.30872/jatl.8.1.2025.19153.17-24

Land Suitability of Tunjung Plateau of Barongtongkok Regency for Rain-Fed Upland and Bunded Rice Cultivation, East Kalimantan

MULYADI[1)] *, MAKHRAWIE[1)], dan DONNY DHONANTO[1)]

[1)]Department of Agroecotecnology, Agriculture Faculty, Mulawarman University. Jl. Pasir Balengkong Gedung C1 Kampus Gunung Kelua, Samarinda, East Kalimantan, Indonesia. Telp +62-541-2083337, *email: mulyadi_srm@yahoo.com

Manuscript received: 13 April 2025 Revision accepted: 1 June 2025

ABSTRACT

Land conversion is a serious threat to efforts to increase rice production in Indonesia. Effort is needed to improve the welfare of farmers so that the land does not change function so that the land continous to produce rice suitanability. This study aimed to obtain information about the land characteristics for rain-fed upland and bunded rice on old vulcanic parent materials in Barongtongkok of East Kalimantan. In general, the climate characteristics of Barongtongkok are suitable (S2) for upland and bunded rice cultivation due to relative humidity and sunshine hours on growing season. Base on the pedon analyzed, the soil of Bangun Sari village classified as actually moderately suitable (S3ctf) but potentially suitable (S2ct) and unsuitable (N1ctf) for upland rice, unsuitable (N1ctf) but potentially suitable (S3ct) for bunded rice. Moderately suitable (S3cf) and unsuitable (N1cf) for upland and bunded rice but potentially suitable (S2c) in Ma. Asa, Johan Asa and Galeo Asa villages. Land evaluation of Asa, Galeo Baru and Engkuni villages, unsuitable (N1cf) but potentially suitable (S2c) of both of land utilization type. Soil of the study area has highly developed and show low activity clay less than 16 C mol (+) and isohyperthermic temperature and perudic soil moisture regime, clasified as Andic Kandiperox (Asa and Galeo Baru villages), Typic Kandiperox (Engkuni village). The soil less developed in Bangun Sari village (Eutric Humudepts), and more developed in Ma. Asa, Galeo Asa dan Jihan Asa (Andic Palehumults).
Keywords: soil morphology, taxonomy USDA, land suitability, old volcanic, barongtongkok, bunded rice.

INTRODUCTION

East Kalimantan has significant agricultural potential, with 2,468,328 hectares of cultivable land, comprising 1,846,328 hectares of dryland (upland) and 622,000 hectares of wetland (lowland). West Kutai Regency is a key contributor to the province's food supply, producing approximately 27% of its rice (4,867.22 Mg) from 1,121 hectares of cultivated land. The agricultural sector also contributes 12.27% to the regency's Gross Regional Domestic Product (GRDP), ranking second after mining. However, cultivated land has sharply declined from 4,550.6 hectares (2020) to 2,416.7 hectares (2023), leading to a drastic drop in rice production from 12,515.9 Mg (2020) to 6,496.1 Mg (2023). This decline poses a serious threat to local and national food security if not urgently addressed.

Indonesia's rice production has fluctuated over the past decade, peaking at 79 million Mg (2016) before plummeting to 5.5 million Mg in 2022 (Annur, 2022). Meanwhile, household rice demand has risen steadily from 21 million Mg (2019) to 22.64 million Mg (2023), forcing the government to rely on imports to bridge the deficit (Ahdiat, 2024; Ahmad Dahlan, 2024). The crisis worsened when India, the world's largest rice exporter, banned exports in July 2023, creating a global shortfall of 10.4 million Mg and driving international prices to record highs (VOA Indonesia, 2023). Although Indonesia imports only 0.39% of its rice from India, the policy disrupted supply chains and intensified inflationary pressures in exporting countries (Nugroho 2023; Rizky 2024).

Land conversion poses a critical threat to rice production. In East Java, 1,100 hectares of farmland are lost annually, with a national total of 659,200 hectares converted since 2020 (Hendri & Susilo 2023). A study in Linggang Melapeh Village, West Kutai, revealed that upland rice farmers earn only IDR 522 million per planting season, with production costs reaching IDR 328 million, reflecting low profitability and incentives for farmers. Purwanti & Sidik (2023) emphasize the need to improve farmer welfare and enforce stricter land-use regulations to ensure sustainable rice production.

The soils of West Kutai, particularly in the Tunjung Plateau, originate from the weathering of ancient volcanic parent materials, shaped by climate, topography, and time (Mulyadi 2022). Geologically, the area is dominated by Neogene volcanic rock, divided into three geomorphological units: lava fields (80–230 meters above sea level), volcanic shields (180–350 masl), and extinct volcanoes (320–550 masl) (Tanaka 1994). These conditions make the Tunjung Plateau suitable for rain-fed lowland and upland rice cultivation, supported by available land and the agricultural traditions of local communities.

In response to the rice crisis, Trade Minister Zulkifli Hasan (2023) urged Indonesia to achieve rice self-sufficiency by revitalizing idle land and empowering farmers through incentives and NGO partnerships. This aligns with recommendations by Purwanti & Sidik (2023) to strengthen land productivity and regulatory frameworks. This study aims

to evaluate soil characteristics for rain-fed upland and bunded rice cultivation in Barongtongkok, East Kalimantan, focusing on old volcanic parent materials. The findings are expected to inform sustainable agricultural planning in volcanic regions, supporting Indonesia's goal of food sovereignty. This study aimed to obtain information about the land characteristics for rain-fed upland and bunded rice on old vulcanic parent materials in Barongtongkok of East Kalimantan.

MATERIAL AND METHODS

Study Area

The study was conducted in Barongtongkok, East Kalimantan, Indonesia, focusing on seven villages: Bangun Sari, Ma. Asa, Johan Asa, Galeo Asa, Galeo Baru, Engkuni, and others. The area is characterized by volcanic parent materials, including extinct volcanoes, volcanic shields, and lava fields. Soil samples were collected from two depths (0–20 cm and 20–40 cm) across villages with varying slopes (1 to 11%). The region has a tropical climate with an isohyperthermic temperature regime (mean annual temperature: 26°C) and perudic moisture regime (annual rainfall: 3,134 mm). Geomorphological features included volcanic plateaus, lava fields, and undulating terrains.

Procedures

Soil Sampling and Laboratory Analysis:

Four representative pedons were selected based on landform and village locations. Soil samples were analyzed for:

a. Physical properties: Particle size distribution, bulk density, water permeability.
b. Chemical properties: pH (H_2O and KCl), CEC, Base Saturation (BS), organic carbon (%), total nitrogen (%), available NH_4^+ and NO_3^-, total and available P_2O_5.
c. Soil morphology (color, texture, structure) and genetic horizons were described in the field. Part of data pedons were selected to study of soil morphology, genesis and classification (USDA, 2022) on Volcanic Parent Materials in Barongtongkok Area, East Kalimantan Indonesia from JICA expert report.

Climatic Data Assessment:

Climatic parameters (rainfall, temperature, evapotranspiration) were evaluated using the Newhall Simulation Model to determine soil moisture and temperature regimes. Annual water balance was calculated from precipitation (3,134 mm) and potential evapotranspiration (1,545 mm).

The methodology suggested in the evaluation of the climate with us aim, the determination of climatic rating to be introduced in the overall evaluation. For this reason, the climatic characteristic is grouped into 3 groups, they are: Characteristics related to rainfall, temperature and radiation. For calculation of the climatic index (Sys and Van Ranst, 1993) said that the lowest characteristics rating of each group is used. This is because there is always a strong interaction between characteristics of the same group of climatic groups and because they do not act together.

Land Suitability Evaluation:

The land suitability is processed to determine the degree of suitability of one area for a cartain use. The land suitability of one area maybe different depends on the specific land utilization type required. Area can be considered suitable actually or potentially, when the area is considered potentially, the suitability can develop to actually after improving limiting factors. The land suitability classification is the evaluation of an area systematically and grouping inti some categories based on land characteristics (physical environment) as a limiting factor (BPPT, 2012).

Sys and Van Ranst (1991), said that in evaluating the fertility of an area, there are some components that must be taken into account such as the quality and characteristics of the land. Based on the quality and characteristic of the land, the land suitability of an area is determined in the Orders, Classes, or oven subclass levels.

The Storie Index Method was applied to assess suitability for rain-fed upland and bunded rice cultivation. Nineteen thematic layers (climate, topography, soil, hydrology) were integrated. Limitations (e.g., climate, fertility, topography) were classified using the FAO framework (orders S1–S3 and N1–N2).

Data Analysis

Soil Classification:

Based on land characteristics (climate, soil and landscape) of the surveyed area, the degree of land suitability classification for rain-fed upland and bunded rice plantation of each soil mapping units as a specific land utilization type have been determined.

Soils were classified according to USDA (2022):

1. Bangun Sari: Inceptisols (Umbric epipedon, Cambic subsurface horizon, high base saturation).
2. Ma. Asa, Johan, Galeo Asa: Ultisols (Argillic/Kandic horizons, low base saturation, high clay content).
3. Ma. Asa, Galeo Baru, Engkuni: Oxisols (Kandic horizon, low-activity clay, CEC <16 cmol kg^{-1}).

Climatic Suitability:

East Kalimantan has a rainfall and Potential Evapotranspiration (PET) throughout the year without dry season, resulting in effective rainfall (R-PET) of more than 1000 mm per year causing in increased leaching rain. Leaching of weathering results has occurred if the annual effective rainfall is more than 150 mm and increases significantly if the annual effective rainfall is more than 400 mm.

a. This climatic index will be used in the total land evaluation by formula:

Climatic rating = 16.67 + 0.9 (43.23) = 65

b. The climatic index (rating = 65) was derived from humidity (98%), sunshine hours (5.1 hrs per day), and temperature (24–36°C optimal for rice).

Land Suitability:

a. Rain-fed upland rice: Classified as S3 (marginally suitable) to N1 (potentially suitable) due to limitations in climate (excessive rainfall), topography (slope), and low soil fertility (CEC, pH).
b. Bunded rice: Mostly N1 (unsuitable) due to poor drainage and high clay content. Key limiting factors included:

- c (climate): High rainfall leading to leaching.
- f (fertility): Low base cations and organic carbon.
- t (topography): Slopes >2% in some villages.

The suitability classification for rain-fed upland and bunded rice cultivation using storie method by formula:

A = B/100 x C/100 x D/100 ……. where: B, C, D: rating

Statistical Integration:

a. Soil parameters (pH, CEC, BS) were cross-referenced with climatic data to determine suitability subclasses.
b. The formula A = (B/100 × C/100 × D/100) was used to aggregate ratings for final suitability scores.

RESULT AND DISCUSSION

Climatic characteristics

Based on climate data in Barongtongkok, it has an isohyperthermic soil temperature regime and perudic soil moisture regime, with an annual average rainfall of 3134 mm, mean monthly air temperature of 26 ºC and an annual PET of 1545 mm so that it has a surplus of around 1589 mm. This means that a large amount of rainfall reaches the ground surface and some of it evaporates through transpiration. The amount of rainfall that reaches the soil surface will enter the soil through the infiltration, some of that moves on the surface (runoff) or move laterally (seepage) in the soil when the soil have been saturated with water (impermeable layers). The amount of water that enters the soil (infiltration) depends on how much water is lost in the soil (seepage) and this process continues until the rain stops.

Mulyadi (2022), said that the East Kalimantan has a rainfall and Potential Evapotranspiration (PET) throughout the year without dry season, resulting in effective rainfall (R-PET) of more than 1000 mm per year causing in increased leaching rain. Leaching of weathering results has occurred if the annual effective rainfall is more than 150 mm and increases significantly if the annual effective rainfall is more than 400 mm.

Table 1. Climatic records of Barong Tongkok

Station : Barong Tongkok	**Latitude : -0.2332°**
Station ID : BRT	Longitude : 115.6861°
Period of Record : 1980 – 2012	Elevation : 90 m
Period Type : normal	Waterholding Capacity : 200 mm
Mean Annual Precipitation : 3134 mm	Soil Moisture Regime : Perudic
Soil Temperatur Regime : Isohyperthemic	Subgroup Modifier :

Table 2. Soil Climate Regime-Newhall Simulation Model (MAST – MAAT + 2.5ºC; amplitudo 0.66)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Mean Monthly Air Temperature (°C):												
25.70	25.80	26.10	26.10	26.30	26.10	25.80	26.10	26.10	26.30	26.10	26.00	26.00
Mean Monthly Precipitation (mm):												
263.00	274.00	320.00	324.00	277.00	201.00	172.00	177.00	230.00	259.00	306.00	332.00	3134.00
Modeled Estimate of Monthly Total Potential Evapotranpiration (mm):												
125.11	114.61	132.07	128.21	135.60	128.15	126.63	132.02	128.21	135.78	128.38	130.40	1545.17
Modeled Estimate of Monthly Total Water Balance (mm):												
137.09	159.39	107.93	195.79	141.40	72.85	45.37	44.98	101.79	122.22	177.52	201.60	1588.83

Source: Makhrawie (2020).

The high average temperature per year (27.2ºC) without any temperature difference between summer and winter of 5ºC with a water balance that never experiences deficit throughout the year, then the soil has an isohyperthermic soil temperature regime (USDA 2022).

Isohyperthermic soil temperature regime mean that the annual soil temperature is 22º C or higher (USDA 2014); in climate (USDA 2022) Perudic Soil Moisture Regime obtained where precipitation exceeds evapotranspiration in all month of normal years, the moisture tension rarely reaches 100 kPa in the soil moisture control section, although there are occasional brief periods when some stored moisture is used.

Genesis and classification

Soil profile (Power 2023), is a layer of soil that visible in vertical section, including top topsoil, subsoil, and bedrock below. The pedogenesis of horizon in the soil profile must be identified in the field and then identified genetic horizon. Reyes (2017) suggested to observe the soil profile according to horizon boundary, horizon thickness, texture, structure, consistency, effective depth, type and number of pores, and other characteristics. On the other hand, physiographic criteria observed were relief, slope, drainage, permeability, erosion rate and flooding, rock surface, irrigation system, natural vegetation, and environmental conditions. In this research, four observation points were determained based on geomorphology of Tunjung Plateau such as lava field Engkuni village) by slope 2%, Volcanic shield (Ma. Asa, Johan Asa, and Galeo villages) and Extinct volcano in Ma. Asa, Galeo Baru villages by slope 1% and in Bangunsari village by slope 11%.

Table 3. Pedon depth soil colors, Texture, chemical properties

Landform Village	Hor. Symbol	Depth (cm)	Soil Color	Texture (%)	Chemical properties					
					pH H_2O	KCl	CEC	BS	C	N
Bangun Sari Slope 11%	A	0-8	7.5 YR 3/3	Clay (52)	5.24	4.03	35.01	88.9	6.35	410
	B1	8-26	7.5 YR 3/3	Clay (55)	5.09	3.99	23.47	40.9	3.24	134
	B2	26-52	7.5 YR3/4	Clay (60)	5.49	4.19	20.95	75.5	1.71	64
	B3	52-80	7.5 YR3/4	Clay (58)	5.65	4.50	23.08	90.4	0.81	74
	B4	80-115	5 YR 3/4	Clay (46)	5.88	4.73	27.52	98.7	0.78	15
	C	115-160	5 YR 3/6	Loam (11)	6.09	5.33	34.77	97.4	0.52	37
Ma. Asa, Johan, Galeo Asa Slope 1%	Ah	0-20	2.5 YR 2/4	Clay (56)	4.91	3.80	30.99	63.9	5.07	198
	B1	20-43	2.5 YR 3/4	Clay (75)	4.80	3.78	16.85	15.6	2.09	83
	Bt2	43-78	2.5 YR 3/4	Clay (81)	5.10	3.81	13.17	21.0	1.43	57
	Bt3	78-110	2.5 YR 3/4	Clay (83)	4.99	3.83	15.79	11.1	0.83	41
	Bt4	110-154	2.5 YR 3/5	Clay (82)	4.84	3.80	13.55	17.8	0.62	29
	Bt5	154-200	2.5 YR 3/6	Clay (83)	4.80	3.80	13.71	10.7	0.44	31
Ma. Asa, and Galeo baru Slope 1%	Ah	0-18	10 YR 2/2	Clay (66)	4.08	3.68	35.69	14.7	8.49	391
	AB	18-46	10 YR 3/3	Clay (70)	4.65	3.99	21.47	16.0	2.48	112
	Bt1	46-70	10 YR 4/3	Clay (78)	4.76	4.01	12.63	7.4	1.67	74
	Bt2	70-96	10 YR 4/4	Clay (78)	5.05	4.08	10.74	11.0	1.15	71
	Bt3	96-160	10 YR 4/4	Clay (80)	4.92	4.10	9.54	9.5	0.82	68
	Bt4	160-200	10 YR 4/6	Clay (84)	5.08	4.12	9.26	11,9	0.55	64
Engkuni Slope 2%	Ah	0 - 10	10 YR 3/3	CL (40)	4.88	3.96	44.73	21.0	10.38	233
	B1	10 - 32	10 YR 2/3	Clay (71)	4.88	4.20	16.29	26.6	3.57	127
	B2	32 - 67	10 YR 3/3	Clay (74)	5.00	4.46	16.61	54.2	1.73	75
	Bt3	67 - 100	10 YR 3/3	Clay (81)	5.08	4.48	9.56	49.0	0.85	54
	Bt4	100 - 148	10 YR 3/3	Clay (81)	5.16	4.52	8.25	55.4	0.68	42
	Bt5	148 - 200	10 YR 3/3	Clay (81)	5.29	4.65	8.32	65.6	0.56	42

KCl: Potassium Chloride; CEC: Chemical Exchange Capacity; BS: Base Saturation; C: Carbon; N: Nitrogen; CL: Clay Loam

1. Bangun Sari Village

Soil in Bangun Sari village developed from extinct volcano parent materials indicated by dark brown soil color at the A (0-8 cm) and AB (8-26 cm) horizon by hue and chroma 3 and base saturation content 40% only, especially on AB horizon. During soil profile description such as morphological evidence of illuvial clay (clay cutans) was not found in any horizon observed up to a depth of 200 cm, as well as the addition of clay as required for clay increase from eluvial to illuvial horizon of any subsurface horizon does not fulfill as a criteria of Argillic or Kandic horizon (CEC clay ≥ 16 cmo^{+}).

The soil has an Umbric epipedon surface layer underlying a Cambic subsurface horizon with a base saturation of more than 60% at a depth of 26 - 160 cm. Soil with these criteria is classified as the Inceptisols (order) which has a perudic soil moisture regime (Udepts) with an Ochric epipedon (Eutrodepts) and high base saturation content, without free carbonate (Dystric Eutrodepts).

Soil layer near the surface was developed from relatively new volcanic ash sedimentation/extinct Volcano that later change into porous soil. The process of eluviation's and illuviation's on soil profile has cause the formation of genetic Cambic subsurface horizon. The parent material is one of the main factors that influence pedogenesis. Soil formed in the different geological content have different physical, chemical, and mineralogical properties. That processes of soil formation of the Bangun Sari villages which geomorphological extinct volcano developed genetically an Umbric epipedon and Cambic subsurface soil horizon.

2. Ma. Asa, Galeo Asa and Johan Asa Villages

Soil on this villages developed from volcanic shield of geomorphological of research area by slope 2% has an Ochric epipedon due to high of chroma (4) of surface soil color underlying of Argillic and Kandic horizons. Morphologically, the soil has clay cutans on ped faces during 43 cm to 200 cm depth by hue 2.5 YR value 3 and chroma 4-6. Clay content increase by increasing of soil depth from 55.7% to more than 80% at Bt2 – Bt5 horizons.

Soil characterictics on area classified as order Ultisols, which has a high organic content in the 0-100 cm depth, the clay content does not decrease regularly to a depth 150 cm by more than 20%. By those criteria, the soil classified as Andic Palehumults.

The pedogenetic of this area more or less as in Bangun Sari village, but different in geomorphology (volcanic shield). The soil has an Argillic subsurface horizon caused of process Eluviation and illuviation but more developed. (USDA 2022) stated that an argillic horizon is normally a subsurface horizon with a significantly higher percentage of phyllosilicate clay than the overlying soil materials. On the diagnostic subsurface horizon, Argillic horizon more developed than Cambic horizon where the horizon is the result of physical alteration, chemical transformation, or removals or of a combination of two or these process (USDA 2014; Buoul *et al.* 2011).

3. Ma. Asa and Galeo Baru Villages

Like in Bangun Sari village, the soil also has an Umbric epipedon (0-18 cm) but underlying by Argillic and Kandic subsurface horizons where the texture transition to the Kandic from upper layer no abrupt, the clay increase more than 8 %, the total thickness of Kandic horizon 130 cm, the texture clay, CEC clay ≤ 16 c mol (+) at 70-200 cm depth and regularly decrease of organic carbon with increase of depth.

The soil could not be classified as Ultisols even though the argillic horizon has been detected at Bt3 (67-100 cm) or even to a depth 200 cm (Bt5) but at the same time, Kandic horizon has been detected also at the same horizons. By the key to soil order (USDA 2022) that the upper layer at 18 cm depth, the soil has 66.2% clay content that fulfills to be classified as order Oxisols. The order Oxisols soil that have perudic soil moisture regime (Peroxs), with kandic horizon (Kandiperoxs) and bulk density less than 1 (0.57 – 0.93 g cm^{-3}).

4. Engkuni Village (MC3)

The soil in Engkuni village also has an Umbric epipedon (0-32 cm) due to low base saturation content, and has Argillic and Kandic horizons in the 67 – 200 cm depth. Like Asa and Galeo Baru villages, the soil is also classified as the Oxisols order because it has a clay content on the surface (0-18 cm) after mixing has 53.87%. Although the organic carbon content is high in the Ah layer (10.38%) but based on the calculation results including organic carbon content, bulk density and horizon thickness at a depth of 0-100 cm was obtained so that it is not classified as Humox but a suborder Perox (perudic soil moisture regime), Kandiperox (great group) and Typic Kandiperox (subgroup).

Soil below the surface (Asa, Galeo Baru, and Engkuni villages) with high content of clay is come from old volcanic rock that have gone through hydrothermal alteration process in the old time. Calabrese *et al*. (2018) stated that the transport of clay particles mainly occurs vertically during percolation events but can be more complex, depending on water flow dynamic. The phenomenon of finding clay illuviation in the forest is expected due to the high rainfall in Malaysia (Shamsuddin & Fauziah 2010).

The different between Argillic and Kandic horizons, the Argillic should have a morphological evidence of illuvial clay (oriented clay bridging or clay film/clay skin), the thickness and clay increase; the Kandic horizon can be need all requirements of Argillic but has low activity clay or CEC clay less than 16 cmol (+) per hundred gram clay on one or more of subsurface horizon (USDA 2022).

In general, the soil of researched area has thick soil, and many layers has high content of clay. The formation of thick soil is due to series of sedimentation of Volcanic ash which is later developed to become soils Volcanic ash has high content of mineral and is easily decomposed to produce clay (Pulungan & Sartohadi 2018).

Evaluation of Land Suitability Classification of Survey Area

Rice is typically grown in bunded fields that are continuously flooded up to 7–10 days before harvest. The term of sawah refer to a leveled rice field surrounded by bunds with inlets and outlets for irrigation and drainage respectively (Nwite *et al.* 2016).

Raes *et.al*. (2007), rain-fed lowland is by far the most common production system in South Eastern Tanzania. Rice is typically cultivated in river valley and plains on diverse soil type although heavy soil types are preferred as they can retain moisture for a longer period.

Gairola *et.al.* (2024), upland rice is cultivated trough varies methods including permanent cultivation, block rotations, slush and burns and is established trough broadcasting seedling behind plough, or drilling fields in small holes.

A land suitability evaluation technic is designed, combining nineteen thematic layers form five categories: climatic parameters, topographic features, soil characteristics, lucidean distance, and land elements.

Based on land characteristics (climate, soil, and landscape) of the surveyed area, the degree of land suitability classification for rain-fed upland and bunded rice plantation of each soil mapping units as a specific land utilization type has been determined.

1. Climate

The climatic evaluations of the surveyed are show that the climatic characteristics such as precipitation on 1st, 2nd, 3rd and 4th month (mm) after planting, mean, and mean maximum temperature at growing cycle, mean temperature crop development stage (2nd), mean minimum temperature at ripening stage (4th month, relative humidity (1st and 2nd month) - harvest stage, and n/N growing cycle. The humidity and mean annual sunshine hours (n/N) during growing cycle has moderate value, but the whole the climatic characteristics has optimum value by rating value 65 due to relative humidity (98%), and sunshine hours (5.1 hours).

2. Soil

Good management is more important than an ideal soil or climate. Soils on Alluvial deposits with a heavy clay texture are usually better suited than those with a light texture. It should be possible to puddle the soil to maintain a high water-table during growth and to drain the soil for ripening and haervest. pH range of soil between 4.5 – 8.2 and optimum at pH 5.5 to 7.5 (Sys *et al.*1993).

3. Suitability Classification for Rain-fed Upland and Bunded Rice Cultivation

The result of land evaluation on rain-fed upland and bunded rice as show in Table 3 below.

Table 4. Land suitability subclasses (actual-potential) for rain-fed upland and bunded rice

Vilage/ Landform area	Soil Taxonomy (USDA, 2022)	Land suitability			Limiting Factors	Conclussion
		Upland Act. Pot.	Bunded Act.	Pot.		
Bangun Sari	Eutric Humudepts Kandiperox	S3ctf S2ct	N1ctf	S3ct	Climate, topography and soil fertility.	Low CEC and sum of Cation and topography
Ma. Asa, Johan Asa and Galeo Asa	Andic Palehumults	S3cf S2c	N1cf	S2c	Climate and soil fertility	Sum of cation and pH
Asa and Galeo Baru	Andic Kandiperox	N1cf S2c	N1cf	S2c	Climate and soil fertility	Sum of cation and pH
Engkuni	Typic Kandiperox	N1cf S2c	N1cf	S2c	Climate and soil fertility.	Sum of cation

S2: moderately suitable; **S3**: marginally suitable; **N1**: unsuitable but potentially suitable; **c**: climate; **t**: topography; **f**: soil fertility

Rainfall, air temperature, air humidity. and duration of exposure are land characteristics that are very necessary in evaluating land suitability for rain-fed upland and bunded rice (Sys *et al.*1993). Purwanti & Sidik (2023) states that environmental temperature and humidity are very important for plant growth and development. Plants have an optimum temperature to grow, where temperatures that are too high or too low, plants can lose their physiological abilities such as photosynthesis, respiration, transpiration, water and nutrient absorption.

Gusira *et.al*. (2021) stated that although the duration of sunlight on the rice production index is still relatively low in influence and not significant, the duration of sunlight factor is very important to consider because rice plants with sensitive genotypes can cause a small number of grains or panicles, the percentage of empty grains is very high, so that the

production of seeds or rice is very low and can reduce carbohydrates formed during rice flowering. The relationship between air humidity and sunlight intensity on the production of lowland and upland rice plants has an effect of 34% (Purba 2018).

Stated that optimum soil moisture is a combination of wet, slightly wet, and dry soil moisture levels for the early growth phase, vegetative, mid-season, and late season. Soil moisture at wet levels for the early and vegetative growth phases is very important for plants because of the availability of sufficient water for root, stem, and leaf growth; then irrigation water is reduced to a slightly wet level in the mid-season growth phase which aims to avoid and reduce the number of unproductive grains. In the final growth phase, soil moisture is reduced to a dry level because the plants no longer need water.

Apart from climate factors, soil properties are also needed for land evaluation. According to the result of soil chemical analysis of representative profile, the soil study sites could be characterized to be an acidity with a lower content of an exchangeable base cation (Ca, Mg, K, Na). The higher pH value in subsoil is due to the reduced value of organic matter. The lower pH value at the layer across the study sites were related to the larger amounts of organic matter in the topsoil, reflecting the organic matter is responsible for acidity through litter composition. Therefore, soil organic matter could be the determinant factor for CEC of the soils (Yusoff *et.al.* 2017). The amount of exchangeable base was much lower than the CEC value, indicating that development of negative charge of soil organic matter would be limited under acidic soil condition (Khairul *et.al*. 2017).

According to BPPP (2012) that CEC, BS, pH, and Organic Carbon are needed in land evaluation as nutrient retention criteria and if they become limiting factors then they can be improved by liming and adding organic materials. Sys *et al.*(1993) stated that fertility characteristics such as apparent CEC, Base Saturation, Sum of Cation, pH, and organic carbon are need to be evaluated.

CONCLUSION AND RECOMMENDATION

*S*oil profile observation on selected area of Tunjung plateau, Barongtongkok on extinct Volcano, Lava Field and Volcanic shield, where from soil morphology, chemically, and other data are classified using soil taxonomy (USDA 2022) up to subgroup level and it was found that soil of Village:

The genesis of soil showed that the soil less developed on extinct volcano (Inceptisols and Ultisols) but more developed on volcanic shield and lava field (Oxisols). Soils were classified according to USDA Soil Taxonomy (2022):

a. Bangun Sari: Inceptisols (Umbric epipedon, Cambic subsurface horizon, high base saturation) belongs to Eutric Humudepts
b. Ma. Asa, Johan Asa, Galeo Asa: Ultisols (Argillic/Kandic horizons, low base saturation, high clay content), belong to Andic Palehumults.
c. Ma. Asa, Galeo Baru: Oxisols (Kandic horizon, low-activity clay, CEC <16 cmol.kg^{-1}), belongs to Andic Kandiperoxs
d. Engkuni: Oxisols (Kandic horizon, low-activity clay, CEC <16 cmol.kg^{-1}), belongs to Typic Kandiperox.

Base on the climate rating using table for suitability classification to rain-fed upland and bunded rice growing requirements such as precipitation on 1st, 2nd, 3rd, and 4th month (mm) after planting, mean and mean maximum temperature at growing cycle, mean temperature crop development stage (2nd), mean minimum temperature at ripening stage (4th month, relative humidity (1st and 2nd month) - harvest stage, and n/N growing cycle, obtained a rating of sixty five (65) because relative humidity (98%) and sunshine hours (5.1 hours).

Based on the climate index obtained, then combined with soil and landscape requirements such as topography, wetness (flooding, drainage), physical soil characteristics, soil fertility characteristics, salinity and alkalinity, its obtained that land actually marginally suitable (S3) to Unsuitable (N1) to become moderately suitable potentially (S2c) by climate limiting factors, except on Bangun Sari village has topography limiting factor. The soil has low fertility because of pedogenesis process that leached out amount of silica and base cations due to high temperature and rainfall, the data of pedons showed that low in CEC, Base Saturation, pH (H_2O) and sum of base.

REFERENCES

Ahdiat A. 2024. Kebutuhan beras nasional naik pada 2023, rekor tertinggi baru. Databoks. https://databoks.katadata.co.id

Annur CM. 2022. Produksi padi cenderung menurun dalam 10 tahun terakhir. Databoks. https://katadata.co.id/publish/2023

BPPP. 2012. Petunjuk teknis evaluasi lahan untuk komoditas pertanian. Badan Penelitian dan Pengembangan Pertanian. http://www.bbsdlp.litbang.deptan.go.id

Boul SW, Hole FD, McCracken RJ. 2011. Soil genesis and classification. Lowa State University Press, Lowa.

Calabrese S, Richter DD, Porporato A. 2018. The formation of clay-enriched horizons by lessivage. Geophysical Research Letters 45(15): 7588–7595. https://doi.org/10.1029/2018gl078778

Career Power. 2023. Soil profile-definition, layers and composition of soil. https://www.careerpower.in

Dahlan A. 2024. Indonesia menghadapi darurat beras: Tantangan dan upaya mengatasinya. Ahmad Dahlan University News. https://news.ahmaddahlan.ac.id

Gairola A, Kumar U, Kumar S, Patil A, Singh S. 2024. Upland rice: A water-efficient rice production system in India. BioResearch Today 6(1): 46–55. https://doi.org/10.54083/BioResToday/6.1.2024/46-5

Gusira G, Sudarto, Putra AN. 2021. Pengaruh lama penyinaran matahari terhadap potensi produksi padi berdasarkan analisa spasial di Kabupaten Malang. Jurnal Teknik Sipil dan Lingkungan. https://jtsl.ub.ac.id

Hendri E, Susilo E. 2023. Lahan produktif Jatim berpotensi makin menyusut, per tahun 1000 hektar beralih fungsi. Jawa Pos. https://jawapos.com

Khairul HMY, Arifin A, Sakurai K, Tanaka S, Kang Y. 2017. Influence of agriculture activity on soil morphology and physicochemical properties on sandy beach ridges along the east coast of Peninsular Malaysia. Soil Science and Plant Nutrition 63(1): 55–56. https://doi.org/10.1080/00380768.2004.14408524

Makhrawie. 2020. Genesis dan klasifikasi horison argilik pada klimosekuen Ultisol [Disertasi doktor]. Universitas Brawijaya, Malang.

Mulyadi. 2022. Regional pedologi: Karakteristik, potensi, kendala, dan pengelolaan untuk pembangunan pertanian di Kalimantan Timur. The Publish.

Nugroho RA. 2023. Heboh India larang ekspor beras, gula, begini efeknya ke RI. CNBC Indonesia. https://www.cnbcindonesia.com

Nwite JC, Suday E, Obalum SE, Igwe CA, Toshiyuki W. 2016. Soil physical properties and grain yields of lowland rice in response to sawah preparation intensities and soil amendment types. Soil Use and Management 32(2): 241–249. https://doi.org/10.1016/j.agwat.2016.1152507

Pulungan NA, Sartohadi J. 2018. New approach to soil formation in the transitional landscape zone: Weathering and alteration of parent rock. Journal of Environmental Science 5(1): 1–7. https://doi.org/10.20448/journal.505.2018.51.1.7

Purba. 2018. Regresi linear berganda kelembaban udara dan intensitas cahaya matahari terhadap produksi tanaman padi di perkotaan. ResearchGate. https://www.researchgate.net

Purwanti A, Sidik B. 2023. Alih fungsi lahan mengancam produksi padi nasional. Kompas. https://www.kompas.id

Raes D, Kafiriti EM, Wellens J, Decker J, Martens A, Mugogo S, Descheemaeker K. 2007. Can soil bunds increase the production of rain-fed lowland rice in South Eastern Tanzania? Agricultural Water Management 89(3): 217–228. https://doi.org/10.1016/j.agwat.2007.01.005

Reyes ML. 2017. Morfologi dan klasifikasi tanah. Universitas Brawijaya Press, Malang.

Rizky M. 2024. Larangan ekspor ternyata tak bergigi, harga beras di India belum turun. CNBC Indonesia. https://www.cnbcindonesia.com

Shamsuddin J, Fauziah CI. 2010. Weathered tropical soils: The Ultisols and Oxisols. Universiti Putra Malaysia Press, Malaysia.

Sys C, Van Ranst E, Debaveye J. 1991. Land evaluation part I and II. International Training Centre for Post-Graduate Soil Scientists, State University of Ghent, Belgium.

Sys C, Van Ranst E, Debaveye J, Beernaert F. 1993. Land evaluation part III. International Training Centre for Post-Graduate Soil Scientists, State University of Ghent, Belgium.

Tanaka N. 1994. Characteristics of soil developed on volcanic parent materials in Barong Tongkok area, East Kalimantan, Indonesia (JICA Expert Report No. 7). Japan International Cooperation Agency.

USDA. 2014. Keys to soil taxonomy (12th ed.). Natural Resources Conservation Service. Kansas

USDA. 2022. Keys to soil taxonomy (13th ed.). Natural Resources Conservation Service. Kansas

VOA Indonesia. 2023. Larangan ekspor beras oleh India berdampak luas. https://www.voaindonesia.com

Yusoff KHM, Abdu A, Sakurai K, Tanaka S, Kang Y. 2017. Soil morphological and chemical properties in homegardens on sandy beach ridges along the east coast Peninsular Malaysia. Soil Science and Plant Nutrition 63(5): 501–512. https://doi.org/10.1080/00380768.2017.1340077