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AGROFORESTRY SYSTEMS BASED ON LAND SUITABILITY IN SOCIAL FORESTRY AREAS IN BARRU REGENCY, SOUTH SULAWESI

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ABSTRACT

Selecting appropriate plant species based on land suitability evaluation is essential for developing sustainable agroforestry systems in Social Forestry regions. This study assessed land suitability in the Social Forestry area of Barru Regency, South Sulawesi, Indonesia (04°06'–04°47' S; 119°32'–119°49' E). Data were obtained from six sampling points through field observations, soil analysis, and farmer interviews. Parameters analyzed included soil pH, organic carbon, texture, erosion hazard, and water availability. Land suitability classification was based on the FAO framework and supported by GIS mapping. Limiting factors such as nutrient retention (nr), rooting media (rc), and erosion hazard (fh) were evaluated to determine current and potential suitability classes. Results indicated considerable variability across sites. Soil pH was acidic (4.18–6.26), organic carbon ranged from 1.71% to 2.30%, and soils were mainly loam to sandy clay loam. The landscape was characterized by steep slopes (25–45%) and elevations of 150–450 m above sea level. Most areas were classified as marginally suitable (S3), though improvements such as liming, organic matter addition, and erosion control could enhance suitability to moderately suitable (S2). Proposed agroforestry designs combine primary crops coffee, candlenut, aren palm, mahogany, and durian with complementary species including cacao, rambutan, and sengon. These combinations are expected to balance production, conservation, and shade functions according to site conditions. This study emphasizes the role of land evaluation in optimizing agroforestry planning within social forestry landscapes. Findings provide practical recommendations for integrating ecological sustainability with community-based resource management.

Key Words: Agroforestry; Biophysical; Forest; Land_Suitability; Social_Forestry.

INTRODUCTION

The transformation of forested areas into agricultural land has caused considerable ecological and environmental damage. Driven by the demand for food and agricultural expansion, this conversion has triggered biodiversity loss (Ababu et al., 2024; Lamb et al., 2005), soil erosion (Verchot, 2010), and disrupted ecosystem services (Sorker et al., 2023), while also exacerbating global climate change (Ariandi & Mukti, 2023). Although such conversion may increase short-term agricultural output, it often undermines ecological functions and long-term sustainability (Cochard et al., 2020). Hence, integrated and sustainable land management strategies are urgently required.

Agroforestry, which integrates trees with crops or livestock, has emerged as a promising approach to address these challenges. Beyond improving ecological stability and food security (Febryano et al., 2024), agroforestry is now recognized as a nature-based solution for climate change mitigation and adaptation.

By enhancing carbon sequestration, reducing greenhouse gas emissions, and improving microclimate regulation, agroforestry directly contributes to global efforts against climate change. At the same time, diversified crop systems provide multiple income streams, thereby supporting local livelihoods and community welfare (Kumar, M and Singh, H, 2020; Thevathasan et al., 2023).

However, the effectiveness of agroforestry depends on selecting species that match local biophysical conditions. Land suitability evaluation—covering soil pH, organic carbon, texture, slope, erosion risk, and water availability (Ahmad et al., 2017)—is therefore critical. Such analysis ensures agroforestry systems are both productive and ecologically sustainable, especially in Social Forestry areas that are ecologically sensitive. In Barru Regency, South Sulawesi, agroforestry is actively promoted within Social Forestry programs. The region experiences a tropical wet climate with mean annual rainfall of 2,600–2,800 mm, average temperatures of 26–27°C, relative humidity between 80–85%, and is classified under the Schmidt–Fergusson type B (wet). Rainfall peaks in December–January and declines sharply during August–September, reflecting a distinct monsoonal pattern. These climatic conditions strongly influence crop growth potential, soil fertility, and erosion risks, highlighting the need for adaptive agroforestry strategies.

Despite this potential, spatially explicit land suitability assessments remain underutilized in guiding agroforestry design in Barru. The absence of GIS-based land suitability maps limits effective decision-making. Integrating GIS with land evaluation allows for spatial matching between land characteristics and plant growth requirements, thereby identifying context-specific species combinations and technical interventions (Hermita et al., 2023). This study aims to design an optimal agroforestry system in the Social Forestry area of Barru Regency by combining biophysical assessments with GIS-based spatial analysis. It seeks to bridge the gap in existing research while providing practical recommendations for sustainable agroforestry development that simultaneously supports climate change mitigation, adaptation, and community welfare.

RESEARCH METHODOLOGY

In Paccekke Village, Barru Regency, the Mega Buana Community Forest (HKM) Social Forestry area was the site of research on agroforestry methods based on land suitability analysis. The research location can be seen in Figure 1.

Data Collection

The research was conducted in five phases: information and data collection, field surveys and soil sampling site selection, soil sample collection and field observations, laboratory sample analysis and GIS processing, and land suitability class assessment. Six soil sample observation points were determined using the purposive sampling method. The criteria for selecting these observation points were based on the results of overlay analysis of slope, soil type, land cover, and elevation maps, ensuring representation of the main land units within the study area. This approach allowed each observation point to capture variations in topography, soil characteristics, and land use patterns relevant to agroforestry development. Soil sampling was conducted by extracting cores using a soil ring at a depth of 20–40 cm. Field observations included elevation (m a.s.l.), vegetation type, and land cover. Secondary data included topographic (slope), soil type, rainfall (climate), land cover, and administrative maps, which were further analyzed using a Geographic Information System (GIS) approach.

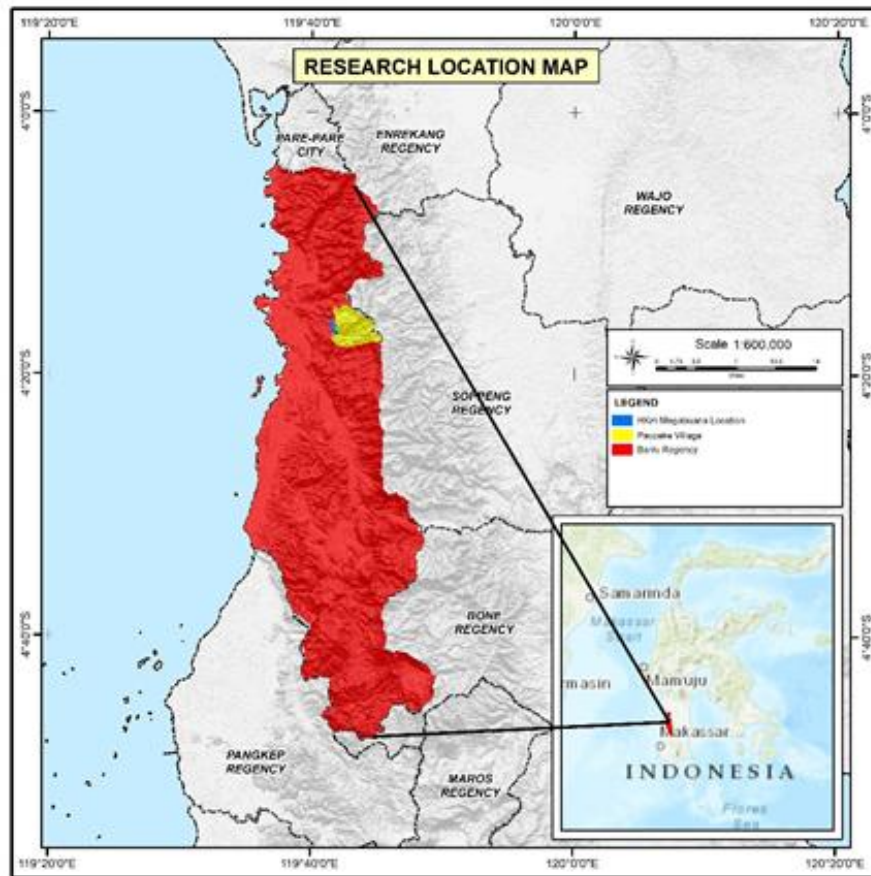


Figure 1. Research Location Map

Data Analysis

To determine the characteristics of land in the Social Forestry area of Barru District, soil laboratory analysis have been done through analysis of soil samples collected. Laboratory analysis data were also utilized to complement the evaluation of land suitability and fertility. Field observations of land characteristics and the corresponding laboratory results from soil sample analysis were organized into tables to aid in interpretation (Hermita et al, 2023). Laboratory analysis is used to determine land quality based on land characteristics including soil C-organic, soil pH, texture and soil depth. Meanwhile, to determine the characteristics of a land based on temperature, slope, and rainfall parameters, Geographic Information System (GIS) analysis can be used. The variables used in the land evaluation criteria can be seen in Table 1.

The actual and potential suitability categories are the two groups into which the land suitability evaluation results are separated. ArcGIS 10.8 software is then utilized to produce land suitability maps based on these findings. S1 (very suitable), S2 (moderately suitable), S3 (marginally suitable), and N (unsuitable) are the four classifications for the land (Wardani et al, 2024). In this analysis, the limiting factor is identified as the parameter with the lowest suitability score (Wakiah et al, 2016).

Table 1. Variables used in land evaluation criteria

No	Symbol	Land quality	Land characteristics
1	Tc	Temperature	Temperature
2	Wa	Water availability	Rainfall (mm)
3	Rc	Rooting Media	Texture Soil permeability
4	Nr	Nutrient retention	pH C-Organic (%)
5	Eh	Danger of Erosion	Slopes (%)

The ultimate classification is established by the most limiting factor among all identified constraints. An improvement to a higher suitability class is possible if these constraints are fully addressed. Each sub-category within the land suitability classification indicates specific types of limiting factors. A total of seven types of constraints were identified: erosion, drainage, soil texture, soil acidity, slope, soil depth, and climate (Azis et al., 2006). Land suitability categorization is done by sorting land characteristic data based on the specific suitability requirements for each plant species. The connection between land characteristics and the level of limiting factors is shown in Table 2.

Table 2. Relationship between land suitability characteristics and level of constraints

Restriction Level	Land Suitability Characteristics
0 : no	S1 : Very suitable
1 : Slight	S2 : Quite suitable
2 : Moderate	S3 : Marginal Fit
3 : Severe	N : Not suitable
4 : Very severe	

The subsequent step involves evaluating land suitability through the matching method, which compares land characteristic data from field and laboratory analyses with the suitability criteria and growth requirements of plantation crops. This approach is applied to determine the most appropriate agroforestry system for the study area. Land suitability classification is performed by matching plant growth needs with the land's physical and chemical properties. The plant species considered include both perennial and seasonal types, making this classification process commonly referred to as species matching (Ikhsani et al., 2021).

RESULT AND DISCUSSION

Land Characteristics in Social Forestry Areas of Barru District

The land characteristics within the Social Forestry area of Barru District exhibit diverse biophysical conditions, including variations in soil pH, texture, organic matter levels, and slope classifications. This information is important as a basis for assessing land suitability and designing appropriate and sustainable agroforestry systems.

Soil Characteristics

Field observations and laboratory analyses conducted at six soil sampling locations in HKM Mega Buana provided land characteristic data, which are presented in Table 3.

Table 3. Results of soil sample analysis

Sample Point (Land Cover)	pH	Texture	C-Organic (%)	Soil Type
T1	4.18	Clay	2.30	<i>Inceptisols</i>
T2	4.33	Clay	2.16	
T3	4.33	Clay	2.23	
T4	6.26	Silty clay	2.27	
T5	4.31	Clay	2.18	
T6	5.82	Sandy clay loam	1.71	

Source: Silviculture and Tree Physiology Lab, Faculty of Forestry Hasanuddin University, 2025

From the analysis of soil samples taken from six observation points representing land units obtained from the overlay of slope and soil type maps in the Social Forestry area of Barru Subdistrict, soil pH values range from 4.18 to 6.26. The results of GIS analysis on soil type parameters can be seen in Figure 2.

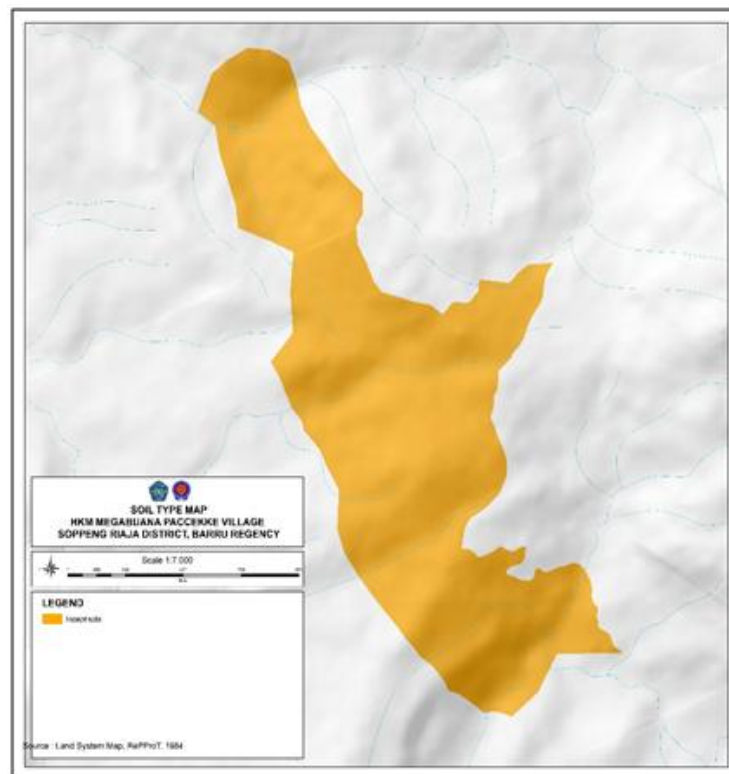


Figure 2. Soil type map

Most sites show acidic soil conditions ($\text{pH} < 5.5$) except for T4 and T6 which have pH of 6.26 and 5.82 respectively, which are close to neutral. The dominant soil texture is clay with variations of sandy clay in T4 and sandy clay in T6. This texture indicates that the soil has relatively good water and nutrient retention capabilities, although in T6 the presence of sand increased permeability and decreased water retention. The C-organic content in the soil across all observation points ranged from 1.71% to 2.30%, which is considered medium according to land fertility classification. The highest C-organic content was found in T1 (2.30%), while the lowest was in T6 (1.71%). This indicates that a sizable proportion of the land has organic matter reserves to support soil biological activity and plant growth but requires further management to improve fertility.

Overall, these results are critical for assessing land suitability and developing recommendations for optimal agroforestry systems (Barus et al., 2022).

Slope Class

One of the key considerations when assessing the potential of a piece of land for the establishment of an agroforestry system is its slope class, which has a direct impact on the level of soil erosion risk and the efficiency of land conservation measures. The data on slope classification are presented in Table 4.

Table 4. Slope Class

No	Slope Class	Extensive (Ha)	Percentage (%)
1	Flat (0 - 8%)	9,29	6,18
2	Ramps (8 - 15)	17,35	11,54
3	Somewhat Steep (15 - 25%)	37,41	24,88
4	Steep (25 - 45%)	61,91	41,18
5	Very steep (>45%)	24,39	16,22
Total		150,35	100

Source: GIS analysis, 2025

Based on data obtained from Social Forestry areas in Barru District, it can be seen that most areas are in the steep slope class (25-45%) at 41.18%, followed by the moderately steep class (15-25%) at 24.88%, and very steep (>45%) at 16.22%. Thus, about 82% of the total area has the potential for moderate to high erosion risk. This is a serious concern because erosion that occurs on land with steep slopes can cause the loss of fertile top soil, reduce land productivity, and damage soil structure. The results of GIS analysis on slope class parameters can be seen in Figure 3.

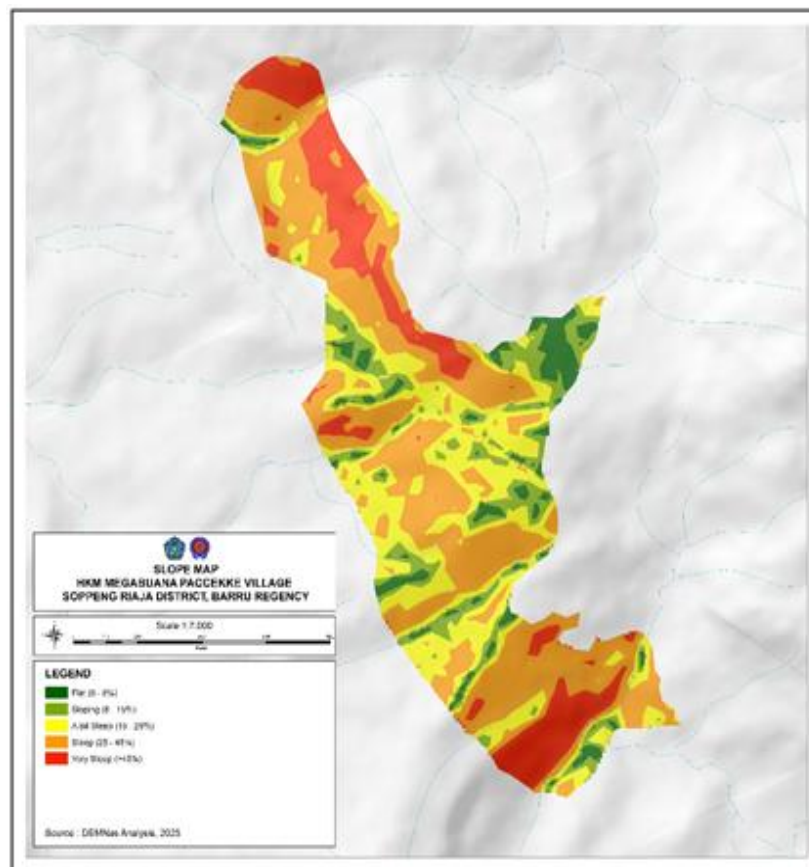


Figure 3. Slope class map

The important role of slope class in agroforestry systems is to determine appropriate plant species and soil and water conservation strategies. On steep to very steep land, it is necessary to apply conservation techniques such as terracing, planting erosion-blocking vegetative strips, and selecting perennial plant species with strong roots to strengthen soil structure. In contrast, flat to gently sloping land with a total area of only about 17.72% of the total area, is more ideal for seasonal crops or an intensive combination of annual and seasonal crops. Therefore, mapping and understanding the slope class is essential to design a sustainable and adaptive agroforestry system to the land characteristics, as well as to minimize the risk of soil degradation in social forestry areas. Based on previous research, slope classification helps to identify appropriate agroforestry systems for different terrains, ensuring that practices match the physical characteristics of the soil (Warkotsch et al., 1990).

Topography

Topographic data from the research site in Barru District Social Forestry indicates that the largest area is situated at elevations ranging from 300 to 400 meters above sea level (masl), which is 64.19% of the total area. This distribution indicates that most of the area is located in the highland zone with a cool climate and high rainfall potential. These conditions generally support the growth of perennial agroforestry crops such as coffee, cloves, and cacao, which are suitable for development at altitudes above 300 masl. In addition, these altitudes are usually correlated with steep slopes, requiring special attention to erosion risks and the application of soil conservation techniques (Cassamo et al., 2022). The results of GIS analysis on topographic parameters can be seen in Figure 4.

Meanwhile, areas with altitudes below 300 meters above sea level cover about 32.57% of the total area. Land in this zone generally has warmer temperatures and allows for the development of a combination of annual and seasonal crops such as maize, beans, or midland vegetables. This zone also has greater potential in terms of accessibility and intensive land management. Different heights can determine which species thrive in certain zones. For example, taller trees can provide shade for understory plants, while shorter plants can be selected for areas with limited sunlight (Campos-Salas et al., 2016).

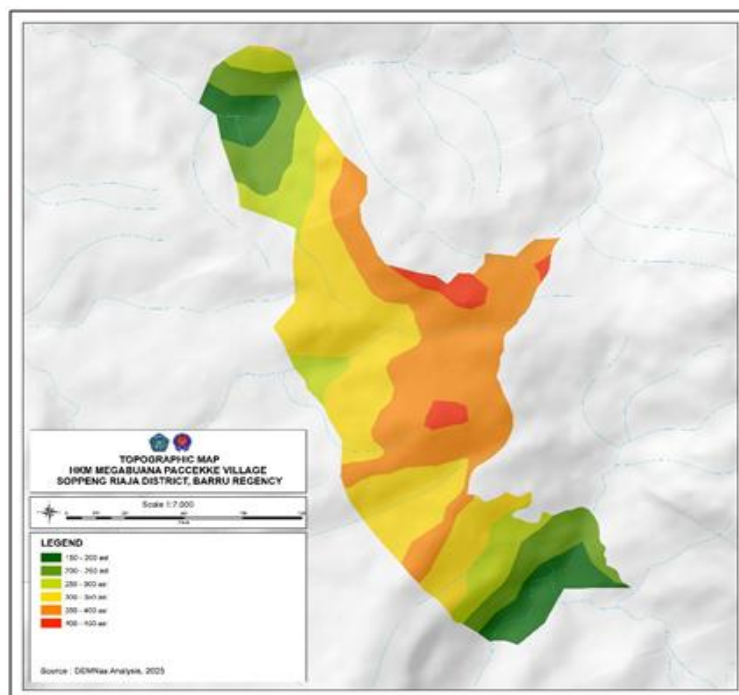


Figure 4. Topography map

Therefore, the variation in altitude in the study site is an important factor in planning agroforestry systems, both in terms of plant species selection and the application of conservation practices that are appropriate to the topographic conditions of each zone. For more details can be seen in table 5.

Table 5. Topography Data

No	Height of Place	Extensive (Ha)	Percentage (%)
1	150 - 200	13,51	8,99
2	200 - 250	18,15	12,07
3	250 - 300	17,31	11,51
4	300 - 350	49,93	33,21
5	350 - 400	46,59	30,98
6	400 - 450	4,85	3,23
Total		150,35	100

Source: SIG Analysis, 2025

Rainfall

Based on annual average rainfall data from 2013 to 2022 in the HKM Megabuana area, Paccekke Village, Soppeng Riaja District, Barru Regency, rainfall patterns show the characteristics of a wet tropical climate with a fairly high total annual rainfall. The months with the highest rainfall generally occur in January and December, with an average of 411.93 mm and 404.27 mm respectively. While the driest months are in August and September with an average rainfall of only 45.89 mm and 46.14 mm. This indicates a distinct seasonal cycle, with the rainy season occurring between November and April, and the dry season spanning from June to September. The results of GIS analysis on rainfall parameters can be seen in Figure 5.

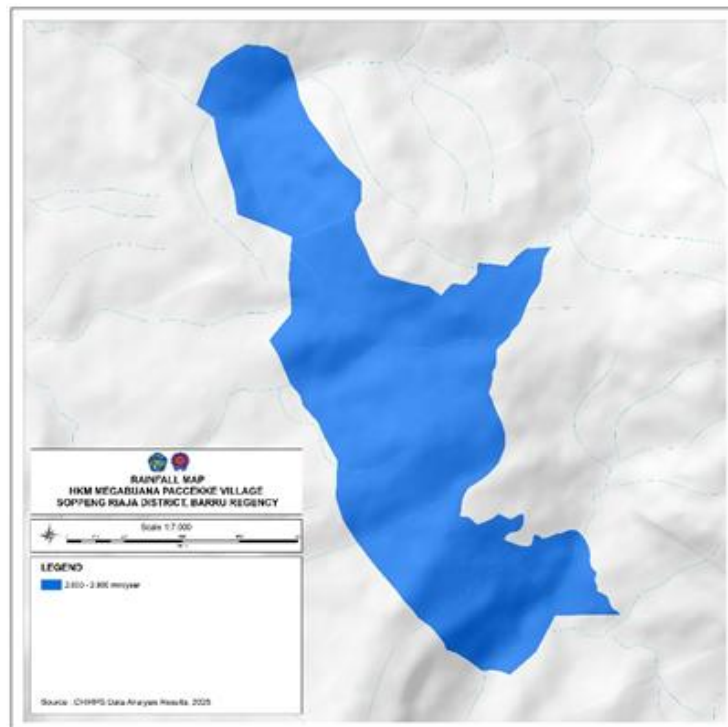


Figure 5. Rainfall map

This rainfall pattern, with an annual average of 2,600–2,800 mm and classified as Schmidt–Fergusson climate type B (wet), greatly influences the planning of agroforestry systems in Social Forestry areas. The long rainy season provides optimal opportunities for planting and growth of forest and agricultural crops, while the relatively short dry season must still be anticipated with water conservation strategies such as planting ground cover crops and constructing roraks or infiltration wells. In addition, high rainfall in the wet season also has the potential to increase the risk of erosion, especially in areas with steep slopes. Therefore, agroforestry practices need to consider these rainfall patterns to optimize sustainability and land productivity (Kumar, M and Singh, H, 2020). The following is rainfall data accessed from NASA Prediction of Worldwide Energy Resources (POWER), 2013–2022 in Table 6.

Table 6: Rainfall Data (mm)

YEAR	JAN	FEB	MAR	APR	MEI	JUN	JUL	AGT	SEP	OKT	NOV	DES
2013	560,89	227,24	233,26	282,4	131,59	220,31	152,86	28,23	19,4	40,2	170,85	466,99
2014	489,22	213,31	280,1	262,73	130,09	146,51	60,91	27,95	0,79	17,56	86,32	364,77
2015	464,52	263,9	206,54	211,35	49,53	88,18	12,25	4,16	2,66	14,46	86,64	394,32
2016	224,96	334,87	190,3	173,35	106,72	138,4	51,99	15,15	82,83	260,72	184,29	296,25
2017	344,44	251,16	242,95	146,72	131,88	160,75	71,67	41,81	73,98	121,63	284,94	524,25
2018	409,68	378,31	315,17	136,54	70,59	121,89	59,48	16,26	14,95	22,84	180,05	392,93
2019	394,2	178,65	261,34	240,76	72,91	94,02	16,63	13,05	8,75	31,4	33,57	154,39
2020	319,24	313,57	231,88	155,97	234,7	101,35	56,32	123,64	53,24	134,35	266	501,28
2021	559,41	257,95	392,01	163,36	97,22	109,13	79,48	114,98	120,91	157,78	309,63	489,85
2022	352,71	391,56	195,66	96,84	298,92	177,87	66,23	73,71	83,89	318,97	312,99	457,66
Average	411,93	281,05	254,92	187	132,42	135,84	62,78	45,89	46,14	111,99	191,53	404,27

Source: NASA Prediction of Worldwide Energy Resources (POWER), 2013 – 2022

Correlation Between Land Suitability Attributes and Degree of Limiting Factors

The aforementioned land characteristics are assessed using land evaluation criteria through a matching approach to identify the correlation between land suitability attributes and the degree of limiting factors, as shown in Table 7.

Table 7. Relationship between Land Suitability Characteristics and Level of Constraints

No	Land Characteristics	Ideal Agroforestry Criteria	Conditions on Location	Suitability Class	Limiting Level
1	Soil pH	5.5 – 7.0	4.18 – 6.26	S2	low pH (acidic)
2	Soil Texture	Loam, sandy loam	Loam to sandy clay loam	S1 – S2	Slightly heavy texture
3	C-Organic (%)	>2.0%	1.71 – 2.30	S2	Low - medium
4	Height of Place	<600 mdpl	150 – 450 mdpl	S1	None
5	Slopes (%)	<25%	Majority >25%	S3	High erosion
6	Rainfall (mm/th)	1.500 – 3.000 mm	2.600 – 2.800 mm	S1	None

Source: Data Analysis Results, 2025

In general, land in the Barru District Social Forestry area is classified as moderately to highly suitable (S1-S2) for agroforestry development based on soil and climate characteristics. However, the low soil pH value (4.18-4.33) is the main limiting factor in the soil suitability classification, as soil acidity reduces the availability of macro nutrients for plants. The organic matter content is also classified as medium with values ranging from 1.71-2.30%, indicating the need to improve soil fertility by increasing the dose of organic fertilizer or utilizing leguminous cover crops.

In terms of topography, land that supports agroforestry growth is at an altitude that supports the growth of various species. Land surfaces with slopes $\leq 25\%$ are classified as steep to very steep. In this case, this condition exacerbates the risk of erosion, especially in the rainy season when rainfall reaches $>2,600$ mm per year. At that time, it is necessary to apply soil conservation technologies such as terracing, planting vegetative strips, and utilizing deep-rooted species. This combination of high climatic potential and limitations on the physical aspects of the land needs to be managed appropriately for a sustainable agroforestry system (Januar et al., 2022).

Agroforestry System Recommendations Based on Land Suitability

According to the land suitability classification and species matching analysis, agroforestry systems can be designed by combining perennial and annual crops. The results of aligning land characteristics with the growth requirements of chosen plant species are shown in Table 8.

Table 8. Land suitability of crop types

Plant Types Based on Site Conditions							
Plant Type	Land Suitability Class	Land Unit					
		I	II	III	IV	V	VI
Coffee (<i>Coffea sp.</i>)	Actual	S3nr	S3nr, fh	S3nr	S3nr, fh	S3nr	S3nr, fh
	Potential	S2nr	S2nr, fh	S2nr	S2nr, fh	S2nr	S2nr, fh
Candlenut (<i>Aleurites moluccanus</i>)	Actual	S3wa	S3wa, nr	S3wa	S3wa, nr	S2wa	S2wa, nr
	Potential	S2wa	S2wa	S2wa	S2wa	S1wa	S1wa
Aren (<i>Arenga pinnata</i>)	Actual	S2nr	S2nr, fh	S2nr	S2nr, fh	S2nr	S2nr, fh
	Potential	S2	S2fh	S2	S2fh	S1	S1fh
Durian (<i>Durio zibethinus</i>)	Actual	S3nr	S3nr, fh	S3nr	S3nr, fh	S2nr	S2nr, fh
	Potential	S2nr	S2nr, fh	S2nr	S2nr, fh	S1nr	S1nr, fh
Mahogany (<i>Swietenia macrophylla</i>)	Actual	S3rc	S3rc, nr	S3rc	S3rc, nr	S2rc	S2rc, nr
	Potential	S2rc	S2rc, nr	S2rc	S2rc, nr	S1rc	S1rc, nr
Merica (<i>Piper nigrum</i>)	Actual	S3tc	S3tc, nr	S3tc	S3tc, nr	S2tc	S2tc, nr
	Potential	S2tc	S2tc	S2tc	S2tc	S1tc	S1tc
Crop Type Recommendations							
Rambutan (<i>Nephelium lappaceum</i>)	Potential	S1	S2fh	S1	S2fh	S1	S1fh
Mango (<i>Mangifera indica</i>)	Potential	S3wa, rc, nr	S3wa, rc, nr, fh	S3wa, rc, nr	S3wa, rc, nr, fh	S2wa	S2wa
Cocoa (<i>Theobroma cacao</i>)	Potential	S3nr	S3nr, fh	S3nr	S3nr, fh	S2	S2
Sengon (<i>Paraserianthes falcataria</i>)	Potential	S3rc, nr	S3rc, nr, fh	S3rc, nr	S3rc, nr, fh	S3rc, nr	S3rc, nr, fh

Description: Wa = Rainfall, Rc = Texture & Permeability, Nr = pH & C-Organic, Eh = Slope

The bulk of the actual crops planted, such as coffee, candlenut, aren palm, durian, mahogany, and peppercorns, fall under the S3 class (marginally appropriate), according to the results of the land suitability evaluation for the six land units. Erosion risk (fh) and nutrient retention (nr) are the main limiting variables. This indicates that the land can still be used for cultivation, but crop productivity may not be optimal without appropriate management interventions. Coffee crops, for example, are actually in the S3nr to S3nr, fh class in almost all land units, but can potentially be improved to S2nr with improvements such as increased organic matter content and soil conservation. Similar conditions also occur in candlenut and durian crops which can increase their suitability from S3 to S2 if the main constraints are controlled. This indicates the potential for developing more sustainable agroforestry systems through land rehabilitation and selection of appropriate conservation techniques. The application of these techniques will enhance crop productivity while also promoting environmental sustainability and improving overall soil health (Neswati et al., 2023).

In terms of recommendations, some crops such as rambutan, mango, cacao, and maize show good potential suitability in some land units. For example, rambutan has suitability classes S1 to S2fh, making it a potential candidate for crop diversification in agroforestry systems. The variation in elevation and slope also opens up opportunities for grouping crop types based on topographic zonation, which can improve the efficiency of land management and reduce the risk of degradation. In general, these results support agroforestry strategies based on conservation and optimization of local potential. Technical recommendations such as minimum tillage, terracing, and cover cropping are necessary to mitigate erosion hazards on steep land (Madenoglu et al, 2024). In addition, organic fertilization and integration of annual and perennial crops can increase productivity, reduce soil erosion while maintaining the sustainability of forest ecosystems (Agegnehu G., & Amede T. 2017) (Choudhury et al, 2022). The land suitability analysis for each plant type offers a basis for recommending appropriate agroforestry systems within each land unit. These recommendations are detailed in the explanation of Table 9.

Most of the regions in the six land units fall into the S3 class (marginally appropriate) for crops like coffee, candlenut, durian, and aren palm, according to the land suitability analysis. This classification is primarily influenced by limitations including low nutrient retention (nr), shallow rooting media (rc), and erosion risk (fh), which are often linked to steep or very steep slopes. These factors significantly hinder optimal plant growth, necessitating technical interventions to enhance productivity. Meanwhile, the assessment of potential land suitability reveals an improvement to the S2 class (moderately suitable) for certain crops, particularly following the mitigation or management of moderate limiting factors. For example, in Land Units I, II, and IV, coffee plants that were originally in the S3nr class can be upgraded to S2nr through organic fertilization and liming treatments. This is in line with the finding that the S3 class can be upgraded to S2 with good land management (Sappe et al., 2022).

Adaptation strategies through agroforestry and crop diversification are important, given that each land unit has a unique combination of characteristics (Thevathasan et al., 2023). For example, the combination of coffee, candlenut and durian in Land Unit I shows good spatial and ecological synergies. Perennials such as candlenut and durian can provide partial shade for coffee, while increasing soil protection from erosion (Cerretelli et al., 2023). Meanwhile, land units with steep topography (IV and V) are in dire need of soil and water conservation treatments, such as roraks, terraces, and ground cover vegetation (Wang et al., 2022). Nutrient retention and soil pH management are prioritized in almost all land units. Low C-organic content and pH below the optimal threshold are the main limiting factors.

Therefore, the addition of organic fertilizers, the use of soil microbes, and bio-fertilization are important recommendations in improving land fertility (Fitriyani et al., 2023). In addition, the analysis of potential crop suitability shows that some species such as rambutan, sengon, mango, and cacao have the potential to be cultivated selectively in certain units. This opens up opportunities for economic diversification for land management communities, especially in the context of Social Forestry, which requires a conservation-based approach and long-term productivity (Murniati et al., 2022).

Table 9: Combination of Potential Crop Types and Recommended Technical Treatments per Land Unit

Land Unit	Combination of Crop Types	Main Limiting Characteristics	Recommended Technical Treatment	Carbon Absorption & Storage Potential
I	Coffee, Candlenut, Durian, Cocoa	Nutrient retention (nr), rainfall (wa), low pH	<ol style="list-style-type: none"> 1) Organic fertilization (compost/manure fertilizer) 2) Planting leguminous ground cover 3) Liming to increase pH 	High – Coffee and durian are perennial species with strong root systems; candlenut contributes woody biomass; cocoa provides long-term carbon sinks.
II	Coffee, Durian, Rambutan	Nutrient retention (nr), erosion (fh), rainfall	<ol style="list-style-type: none"> 1) Contour terraces 2) Terrace reinforcement plants such as vetiver 3) Addition of organic matter and humus 	High – Rambutan and durian are deep-rooted trees with large canopies, enhancing aboveground biomass carbon storage.
III	Candlenut, Mahogany, Aren, Mango	Nutrient retention (nr), soil depth (rc)	<ol style="list-style-type: none"> 1) Balanced fertilization of NPK and organic matter 2) Weed control 3) Planting of ground cover crops (pueraria/chicken's perch) 	Very High – Mahogany is a high-density timber tree; aren palm accumulates substantial biomass; mango and candlenut add fruit + woody biomass.
IV	Coffee, Durian, cocoa, Sengon	Nutrient retention (nr), erosion (fh), soil depth (rc)	<ol style="list-style-type: none"> 1) Erosion control with rorak and guludan 2) Rotation of annual and perennial crops 3) Addition of biochar 	Moderate to High – Sengon grows fast and fixes nitrogen but has lighter wood; combined with durian and coffee, total sequestration is strengthened.
V	Candlenut, Pepper, Corn, Mango	Nutrient retention (nr), low soil pH	<ol style="list-style-type: none"> 1) Liming (dolomite) 2) Cover crops 3) Organic fertilization and addition of soil microbes 	Moderate – Presence of annual crops (corn, pepper) lowers long-term carbon storage, but candlenut and mango contribute to perennial carbon stock.
VI	Coffee, Aren, Rambutan, Cocoa	Nutrient retention (nr), heavy soil texture (tc)	<ol style="list-style-type: none"> 1) Improvement of micro-drainage 2) Addition of fine sand 	High – Combination of coffee, rambutan, and aren palm

3) Soil improver plants such as lamtoro	ensures sustained woody biomass and soil carbon enhancement.
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Thus, crop matching based on land suitability evaluation not only provides a scientific basis for commodity selection, but also encourages integration between conservation approaches and community economic improvement through the utilization of local resources. Moreover, the integration of perennial crops with high biomass accumulation enhances the capacity to absorb and store carbon, thereby contributing to global efforts to mitigate greenhouse gas emissions while improving microclimatic regulation and soil fertility. This dual function positions agroforestry as both a mitigation and adaptation strategy to global warming and climate change, reinforcing its role in achieving environmental sustainability and food security in land management (Osei-Gyabaah et al., 2023). Such an approach is highly relevant to ensuring the long-term resilience and sustainability of Social Forestry landscapes, particularly in this research area.

CONCLUSION

This study aims to design an optimal agroforestry system based on land suitability characteristics in the Social Forestry area of Barru Regency. The results showed that the land characteristics at the research site had considerable variation, both in terms of soil pH which was generally acidic (pH 4.18–6.26), C-organic content ranging from 1.71% to 2.30%, and soil texture dominantly loamy to sandy clay loam. The topography of the area is dominated by steep slopes (25–45%) with land elevations ranging from 150–450 masl. This condition has implications for erosion hazard and soil nutrient availability, which are important aspects in assessing land suitability. The interaction between land characteristics and constraint levels indicates that nutrient retention (nr), rooting media (rc), and erosion hazard (fh) are the primary limiting factors in utilizing the land for agroforestry practices. Most of the land is actually classified in suitability class S3 (marginally suitable), but shows potential for improvement to S2 (moderately suitable) if these constraints are overcome through technical treatments. Based on the analysis, an optimal agroforestry system can be designed by combining main crops such as coffee, candlenut, aren palm, durian, mahogany, and pepper with potential crops such as cacao, rambutan, sengon, and mango. The determination of this crop combination considers the biophysical condition of the land as well as conservation needs to boost soil fertility and limit the risk of erosion. Important tactics to raise the land suitability class include liming the soil, adding organic matter, constructing terraces, and planting ground cover vegetation. In addition to improving ecological functions, agroforestry offers multiple advantages as a strategy for mitigating and adapting to global warming and climate change through carbon sequestration, microclimate regulation, and soil fertility enhancement. At the same time, it provides diversified income sources and strengthens the welfare of farming communities. Thus, this research provides a basis for planning an adaptive, land suitability-based agroforestry system that supports sustainable social forestry management in Barru District while contributing to both environmental resilience and socio-economic development.

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