INTEGRATING LAND SUITABILITY AND SOCIO-ECONOMIC ANALYSISFOR SUSTAINABLE AGRICULTURE IN TASIKMALAYA REGENCY, WEST JAVA, INDONESIA

ABSTRACT

Tasikmalaya Regency possesses a diverse range of land resources with complex physical characteristics, including hills, plains, and valleys distributed across the region. Despite agriculture being the primary livelihood for 41.13% of the population, the productivity of key agricultural commodities such as rice, corn, vegetables, and fruits remains suboptimal, limiting economic profitability. Addressing this issue requires a comprehensive assessment of land suitability and the economic feasibility of agricultural commodities to enhance community income and inform agricultural development strategies. This study evaluates the land suitability and economic viability of 9 major commodities, encompassing food crops, horticulture, and plantation crops: lowland rice, corn, potatoes, carrots, cabbage, tomatoes, cocoa, cloves, and coffee. An integrative methodological approach, combining soil science, climatology, and economics, was employed to identify optimal farming strategies. The research utilized a socio-economic survey of farmer households, employing stratified random sampling based on agro-ecological zones, land map units (SPL), and dominant commodity types. Land suitability was evaluated using the Automatic Land Evaluation System (ALES) and Geographic Information Systems (GIS) with ArcView 3.3 software. Suitability classes were determined by analyzing limiting factors such as slope, rooting conditions, and nutrient availability. The economic feasibility of farming was assessed using the RC ratio to determine the profitability of each commodity. The findings revealed that most areas fall within S2 and S3 land suitability classes, with potential S1 classes identified for lowland rice, potatoes, and carrots following mitigation of limiting factors. Plantation crops, including coconut, cocoa, and coffee, demonstrated higher profitability (RC ratio > 1) compared to horticultural crops. However, certain commodities, such as carrots and cabbage, require socio-cultural adaptation for successful integration. Zoning recommendations include: lowland rice in northern regions; corn and peanuts in central regions; horticulture from northern to central regions on Red-Yellow Podzolic soils; and cloves and plantation crops in central to southern regions. This study underscores the importance of optimizing cropping patterns based on land suitability to enhance agricultural productivity and improve the welfare of farmers in Tasikmalaya Regency.

Keywords: land suitability; agricultural development; economic feasibility; farming commodities; agro-ecological zones

1. INTRODUCTION

Tasikmalaya Regency is characterized by complex physical and environmental conditions, comprising a heterogeneous landscape of hills, plains, mountains, and valleys. These geographical features, distributed irregularly across the region, create a diverse potential for land resource utilization. Elevation and slope variations from the northern to southern parts of the regency further highlight the complexity of its topography. This diversity underscores the substantial agricultural potential of Tasikmalaya Regency's land resources.

The local population demonstrates a strong commitment to agriculture, with 41.13% of residents engaged in the sector, as reported in the Regional Medium-Term Development Plan (RPJMD) of Tasikmalaya Regency. The agricultural commodities commonly cultivated include rice, corn, vegetables, and fruits, which form the foundation of local food security. However, the productivity of these commodities remains low, rendering agricultural activities less economically viable and underscoring the need for targeted interventions.

To address this issue and support the Tasikmalaya Regency government's income improvement program, a thorough evaluation of agricultural productivity and land resource potential is essential. Soil characteristics and environmental factors, which significantly influence plant productivity, must be examined comprehensively. Land suitability assessments for various crops are critical as an initial step toward building a high-productivity agricultural system.

The evaluation of feasible agricultural commodities in Tasikmalaya Regency focuses on three primary crop categories: food crops, horticulture, and plantation crops. Thirteen commodities have been selected for analysis: rice, corn, potatoes, peanuts, soybeans, carrots, cabbage, tomatoes, spring onions, coconuts, cocoa, cloves, and coffee. These commodities will be assessed for their productivity and economic feasibility, leading to the identification of superior agricultural zones and commodity-specific recommendations for the region.

The concept of sustainable intensification plays a pivotal role in increasing agricultural productivity while maintaining environmental integrity. Sustainable intensification emphasizes achieving higher yields without expanding agricultural land, thereby minimizing ecological impacts (Tilman et al., 2011). This approach is particularly relevant for Tasikmalaya, where enhancing agronomic practices and introducing improved crop varieties can sustainably boost the yields of food and plantation crops.

Identifying superior agricultural commodities is a vital component of regional economic development. As Novita et al. (2022) highlight, mapping and prioritizing key commodities can improve agricultural efficiency and competitiveness, particularly in regions with decentralized agricultural policies. This perspective aligns with the need to assess the specific agro-ecological conditions of Tasikmalaya Regency to determine which commodities can thrive while providing economic benefits to the community.

The outcomes of the land suitability and economic feasibility analysis will serve as a valuable resource for agricultural planning. Local government agencies and private sector stakeholders can utilize the structured and comprehensive database generated by this study to optimize land use. Furthermore, these findings provide a foundation for future research on land suitability and agricultural zoning in Tasikmalaya Regency, contributing to the region's sustainable agricultural development.

2. MATERIAL AND METHODS

2.1. Socio-Economical Analysis

The socio-economic component of the study encompasses the following key elements: (1) classification of the research area based on agro-ecological zones, (2) development of a sampling framework and determination of respondent numbers, (3) categorization of respondent farmer households according to the commodity subsectors they cultivate, and (4) application of appropriate data analysis methods. The outcomes of the farming analysis will be integrated with the bio-physical analysis conducted using the Automatic Land Evaluation System (ALES).

The assessment of socio-economic conditions within the farming community involves the use of a structured instrument, the "Farming Business Performance and Farmer Socio-Economics" form. Data collection is conducted through direct interviews with farmers present at the observation sites, ensuring the acquisition of accurate and context-specific information. This approach captures a range of parameters essential to understanding and evaluating farming patterns. Understanding the socio-economic context of farmers can lead to improved agricultural practices and economic performance at the farm level (Buckley & Carney, 2013). The farmers' social networks significantly impact their ability to access and implement innovative practices, which can lead to improved farming outcomes (Villarroel-Molina et al., 2021). Otherwise, Understanding the motives behind diversification strategies in farm businesses can provide insights into how socio-economic conditions shape farmers' decisions and their business outcomes (Miaris, 2023).

The analysis incorporates various socio-economic indicators that influence farming systems, including labor dynamics, income levels, cost structures, and access to resources and markets. A sample questionnaire, tailored to gather detailed agricultural socio-economic data, exemplifies the methodological rigor employed in this study. This comprehensive framework ensures that both quantitative and qualitative dimensions of socio-economic factors are adequately addressed, facilitating a robust understanding of the interplay between farming practices and community welfare.

2.2. Classification Based on Agro-ecological Zones

The classification of land suitability at the district level is conducted in accordance with the General Guidelines for Land Suitability Implementation, using agro-ecological zoning at scales ranging from 1:250,000 for small-scale maps to 1:25,000 for larger-scale maps. This approach aims to identify and select specific locations within defined Farming System Zones (FSZs) that are appropriate for particular agricultural practices. Based on the base map, the study area is divided into three distinct agro-ecological zones: (1) rice fields, including aquaculture ponds, (2) lowland dryland, and (3) coastal and beach land. These zones provide the foundation for determining and selecting representative FSZs that reflect the broader agricultural potential of the region.

The selection of FSZs is guided by several criteria to ensure their suitability for agricultural development. These include identifying areas that serve as centers of agricultural commodity production and are regarded as mainstay areas critical for regional agricultural development. Additionally, FSZs must possess supporting physical infrastructure, such as fertile land, favorable topography, climate, adequate facilities, and reliable water quality. Socio-economic considerations, including community conditions and the presence of agricultural institutions, are also integral to the selection process. By incorporating these criteria, the classification ensures the identification of zones that are both ecologically and socio-economically viable for sustainable farming practices and agricultural planning.

2.3. Sampling Techniques and Number of Respondents

A stratified random sampling method was employed to select respondents, ensuring representation across various strata. The stratification criteria included: (1) characteristics of the agro-ecological zones, (2) land map units (SPL), and (3) the types of dominant commodities cultivated, categorized by subsector and associated land use types. The sample size for each dominant commodity subsector and agro-ecological zone was determined based on the specific requirements of the study, ensuring a balanced and comprehensive representation of the research area's agricultural and ecological diversity.

The study highlighted the importance of this sampling technique in agricultural research, noting that it facilitates a more nuanced understanding of the socio-economic conditions affecting farmers by ensuring that various subgroups are adequately represented (Jumanne, 2024).For instance, Pujiyanto, et al. (2023) utilized stratified proportional random sampling to analyze the participation of farming group members in agricultural development, emphasizing the importance of local context and characteristics in their sampling strategy

2.4. Survey Method

The survey method employed in this study is the land unit approach, also referred to as the free survey method. The implementation of land evaluation activities follows a structured sequence of stages. The initial preparation phase involves the development of a working map, followed by a comprehensive field survey and data analysis. This process culminates in the determination of the actual land suitability class. Once the actual suitability class has been established, further analysis is conducted to identify and address the limiting factors affecting land productivity. The assessment includes recommendations for improvement measures to mitigate these constraints. The study ultimately generates a potential land suitability class, providing a scientifically grounded recommendation for optimal land use to enhance crop productivity.

The spatial data used to determine observation points is derived from a Work Map, which serves as a preliminary land unit map detailing the Soil Map Unit (SUM) as the sample unit for field observation. The Work Map is created by overlaying several maps, including: (1) a slope class map derived from contour interpretations of a 1:25,000 scale topographic map, (2) a soil map at a 1:250,000 scale, and (3) a climate map, specifically a rainfall distribution map. Each SPT contains information on land slope class, soil type, and rainfall characteristics. The overlaying of these maps is conducted using Geographic Information System (GIS) software, specifically ArcView 3.3. This process results in the production of a Soil Unit Map (SUM), which serves as the foundation for field observations. A total of 103 SPTs were generated, representing the samples to be analyzed in the study. Each SPT is labeled according to its unique land characteristics, such as soil type, slope class, and rainfall classification, with all classifications adhering to standardized guidelines. This methodological approach ensures a comprehensive representation of the study area's spatial variability for accurate and systematic field observations.

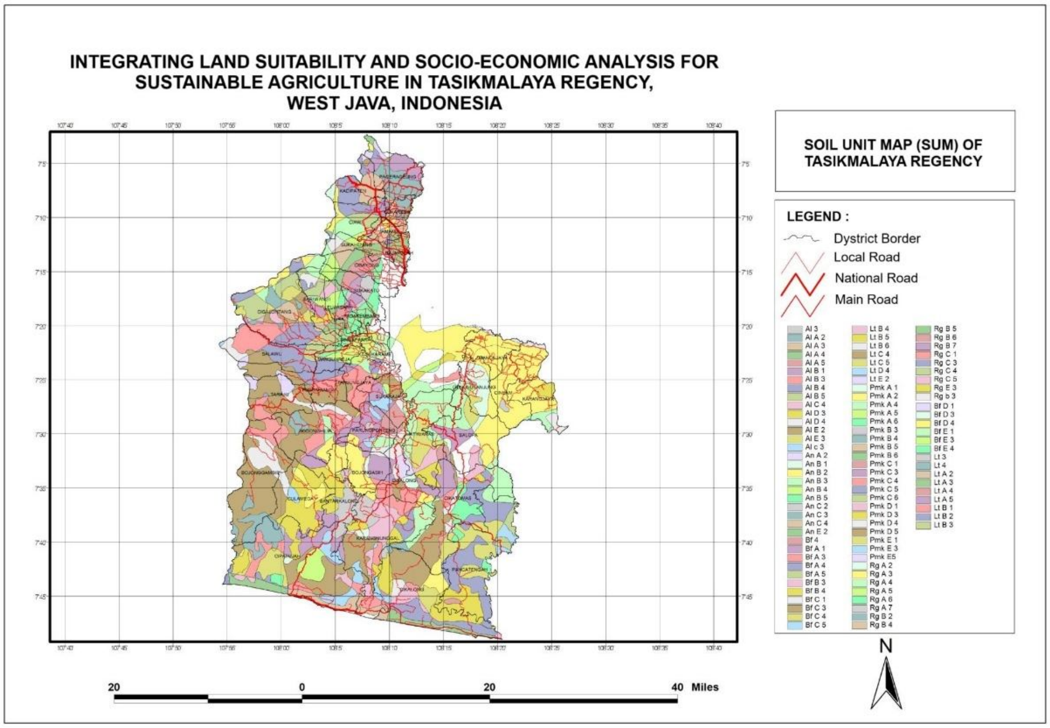

Fig. 1.Soil Unit Map (SUM) of Tasikmalaya Regency (Source: Result of Analysis, 2024)

2.5. Land Suitability Analysis

The land suitability analysis aims to evaluate the appropriateness of specific areas for cultivating particular agricultural commodities. This system is categorized into two primary orders: Suitable (S) and Not Suitable (N). The Suitable (S) order is further divided into three classes: Very Suitable (S1), Moderately Suitable (S2), and Marginally Suitable (S3). The classification process relies on the identification of key limiting or inhibiting factors that affect land productivity. The methodology employs a geo-statistical approach integrated with Geographic Information System (GIS) tools to assess land suitability for essential crops within a given region (Aldabaa& Yousif, 2020). Furthermore, land suitability analysis constitutes a critical component of land resource management, facilitating the determination of optimal land use for various purposes, including agriculture, urban development, and conservation. The evaluation employs multi-criteria decision-making techniques alongside GIS to systematically assess the appropriateness of specific areas for these diverse applications (Kihoro et al., 2013).

Soil condition assessment plays a pivotal role in identifying constraints that hinder soil fertility, enabling the formulation of targeted soil management strategies to mitigate these limitations. Soil fertility is often evaluated using soil analysis or testing methods. This study utilized five soil fertility parameters i.e. Cation Exchange Capacity (CEC), Base Saturation (BS), Organic Carbon (OC) content, and the levels of Phosphorus (P) and Potassium (K) in accordance with technical guidelines for soil fertility evaluation (Hakim, 2023) to determine the fertility status of the soil.

In the classification process, a single subclass may include multiple delimiter symbols, with a maximum of three allowed, prioritizing the most significant limiting factor as the first delimiter. Following established land evaluation protocols, the analysis yields classifications of both actual (A) and potential (P) land suitability. The method integrates biophysical and ecological characteristics of an area to determine its agricultural potential (Hassan et al., 2017). The current land suitability assessment combines empirical field observations and laboratory analysis to provide a comprehensive evaluation of land suitability, offering valuable insights for optimizing land use and enhancing agricultural productivity.

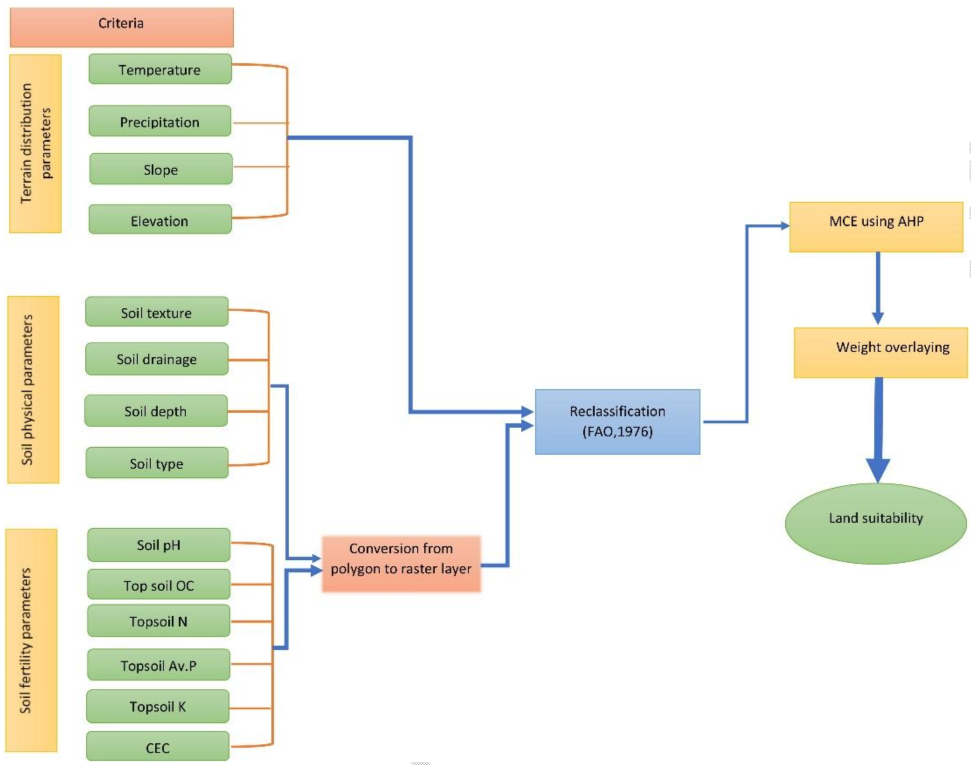

Fig. 2.Land suitability assessment (Source: Nungula, et al., 2024)

3. RESULT AND DISCUSSION

3.1. Land Suitability and Socio-Economical Assessment for Food Crop

Lowland rice farming in Tasikmalaya Regency demonstrates significant potential, with S2 (moderately suitable) land found in Pager Ageung, Ciawi, and Leuwisari, and S3 (marginally suitable) land across most other districts, except Taraju and Salawu. However, challenges such as declining soil fertility, steep slopes, poor rooting media, and over-reliance on chemical inputs reduce productivity. The study conducted by Xu et al. (2021), which emphasizes the importance of soil characteristics in determining rice yield potential. Proper management of soil texture and drainage can significantly enhance the productivity of rice in these areas.While northern and central zones benefit from better irrigation infrastructure and economic viability (RC ratios of 1.32–2.23 for conventional farming and 1.09–1.99 for SRI), the southern zones face weaker institutional support, inefficient marketing chains, and RC ratios as low as 1.07–1.44.The adoption of the System of Rice Intensification (SRI) offers a sustainable solution, improving both economic returns and soil health.

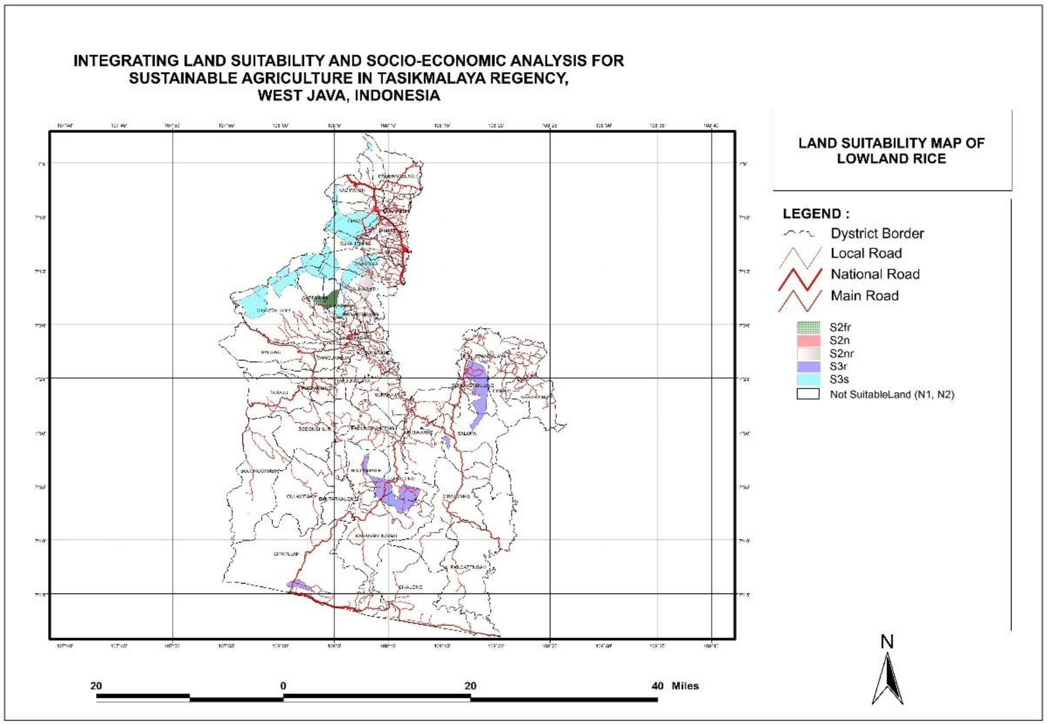

Fig. 3.Land suitability map of lowland rice (Source: Result of Analysis, 2024)

Maize cultivation in Tasikmalaya Regency shows strong potential, particularly in S2 (moderately suitable) land across various districts. However, challenges such as limited planting areas, low technology adoption, inadequate irrigation for dryland farming, and poor access to markets and facilities in southern zones hinder its development.Irrigation infrastructure is another critical factor affecting maize productivity. Effective irrigation systems are essential for maximizing crop yields, particularly in regions where rainfall is inconsistent (Bruun et al., 2016). The lack of adequate irrigation facilities in southern Tasikmalaya limits the potential for dryland farming, making it imperative to invest in irrigation improvements to support maize cultivation. Additionally, irrigation can significantly enhance maize yields, especially in regions facing climatic variability (Wang et al., 2021). While hybrid seeds are commonly used in northern and central zones, traditional varieties dominate in the south. The average RC ratio for maize is 2.11, with northern and central zones performing better economically.To enhance maize farming, irrigation infrastructure, market access, and processing facilities need improvement, especially in the south. Sweet corn and baby corn farming in highland areas like Bojonggambir and Taraju is viable, supported by farmer training, balanced fertilization, and integration with agro-industrial sectors. Improving market access and establishing processing facilities can help farmers capture greater value from their crops, thereby enhancing their economic resilience (Fisher et al., 2015).

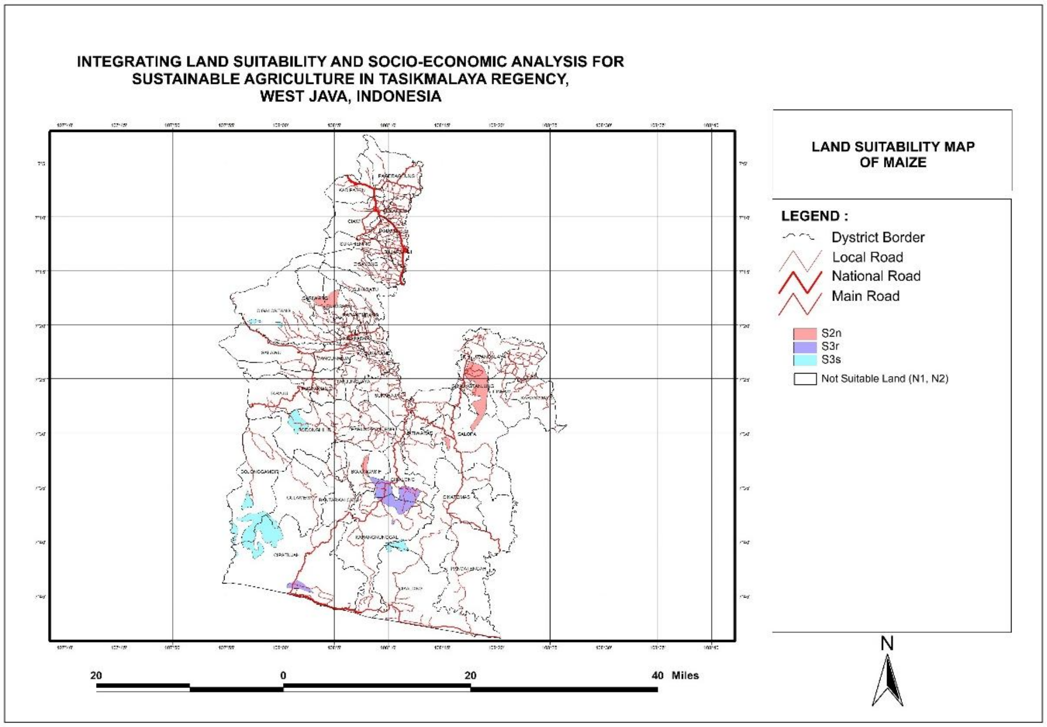

Fig. 4.Land suitability map of maize (Source: Result of Analysis, 2024)

Potato farming in Tasikmalaya Regency shows potential in highland areas like Mount Galunggung, Taraju, and Bojong Gambir (S2 – moderately suitable). However, challenges such as poor nutrient retention, limited infrastructure, and lack of local seed production facilities hinder development. The issue of nutrient retention is critical in potato cultivation, as it directly impacts crop yield and quality. The study emphasized the importance of optimizing soil nitrogen balance through practices such as legume intercropping, which can enhance nutrient availability and retention in potato cropping systems Nyawade et al. (2020).With an RC ratio of 1.56 in highland zones, economic viability is promising, but institutional support and marketing need improvement, particularly in southern areas. Strengthening seed production, introducing balanced fertilization, and enhancing farmer training and market access are crucial for maximizing the region's potato farming potential.This aligns with findings from Sebatta, et al. (2014), who discuss how market participation is influenced by infrastructure and access to resources, which can significantly affect smallholder farmers' economic outcomes.Training can equip farmers with the knowledge and skills necessary to adopt best practices in cultivation, pest management, and post-harvest handling. This is particularly important in the context of increasing demand for potatoes, as highlighted by the growing interest in sustainable agricultural practices (Sukayat, 2023).

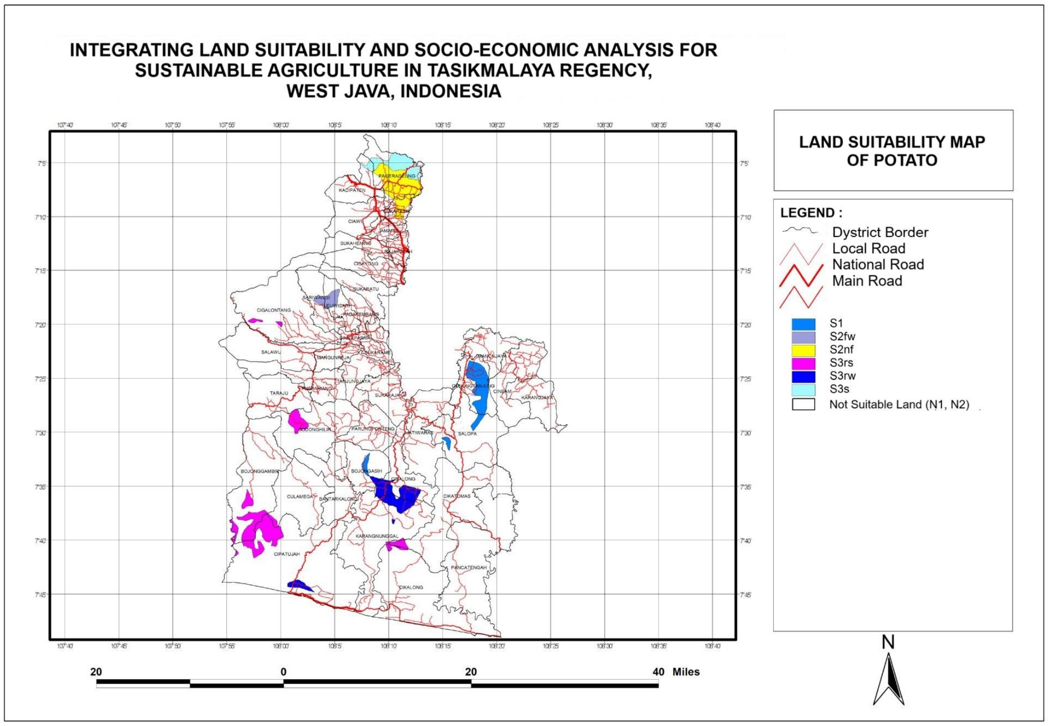

Fig. 5.Land suitability map of potato (Source: Result of Analysis, 2024)

3.2. Land Suitability and Socio-Economical Assessment for Horticulture Crop

Carrot farming in Tasikmalaya Regency is ecologically suitable in highland areas (S2 – moderately suitable) such as Cisayong, Leuwisari, Sariwangi, and Cigalontang in the central and northern zones, and marginally suitable (S3) in southern regions like Bojonggambir and Taraju. Key limiting factors include poor soil retention, steep slopes, erosion risks, and inadequate water availability. Introducing balanced fertilization practices can improve soil health and nutrient retention, thereby increasing productivity (Moudry et al., 2015). Effective irrigation systems can help maintain consistent moisture levels, which are critical for carrot growth and development (Cwalina-Ambroziak, 2022).While carrot farming is a traditional practice for highland farmers, it is less common in lowland and medium-altitude areas due to inefficiency and high environmental risks.Economic feasibility is demonstrated by an RC ratio of 1.69 per hectare per season in highlands, provided infrastructure and inputs are accessible. However, southern zones face challenges such as weak transportation networks and limited irrigation, which reduce profitability. The marketing system for carrots is well-established, with local and external markets readily available, but processing facilities remain underdeveloped, with most carrots sold fresh.The importance of infrastructure in facilitating agricultural productivity is well-documented; improved transportation can enhance farmers' ability to reach markets and sell their produce at competitive prices (Frı́as et al, 2010). WhileThe lack of processing options means that most carrots are sold fresh, which may not maximize their economic value (Gavelienė et al., 2021).

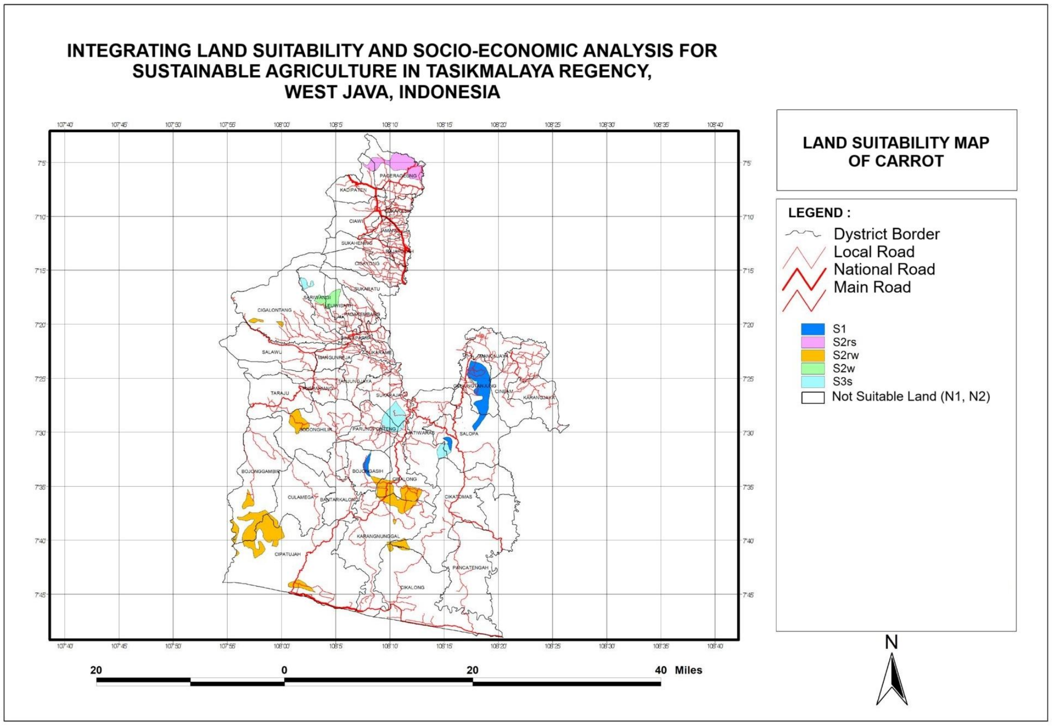

Fig. 6.Land suitability map of carrot (Source: Result of Analysis, 2024)

Cabbage farming in Tasikmalaya Regency is classified as S3 (marginally suitable) and is most viable in highland areas such as Leuwisari, Sariwangi, Cigalontang, and Singaparna, where sufficient infrastructure and farmer practices support cultivation. In medium-altitude zones like Pagerageung and Rajapolah, it can be developed in irrigated areas, but challenges include poor soil retention, steep slopes, and limited water availability.The economic viability of cabbage farming is supported by its established market presence and the practice of crop rotation with other vegetables such as tomatoes and beans. This intercropping strategy not only diversifies income sources but also enhances soil health and pest management Daniel et al. (2023). The study emphasized that optimizing agricultural practices, such as tillage depth and fertilizer application, can mitigate some of these environmental impacts and enhance productivity (Hwang et al., 2019). While cabbage farming is traditionally practiced and economically viable, with an RC ratio of 1.67, southern regions face logistical and marketing constraints due to weaker infrastructure.Cabbage is often grown in rotation with crops like tomatoes and beans, benefiting from established farmer groups and structured vegetable markets. However, marketing inefficiencies and rising input costs hinder profitability.

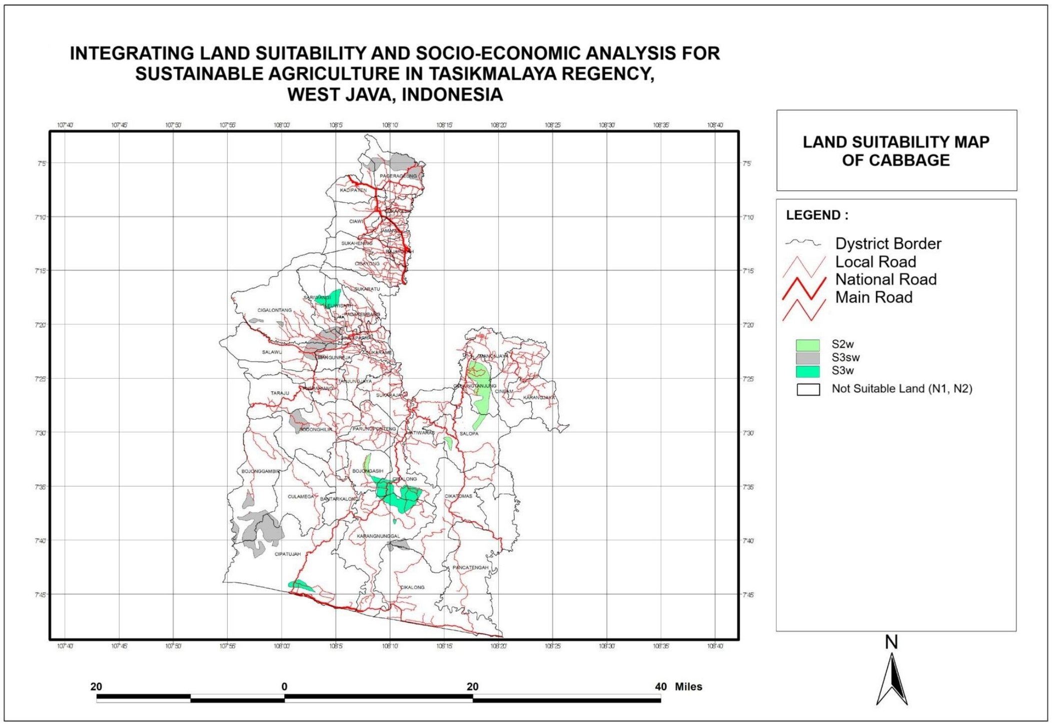

Fig. 7.Land suitability map of cabbage (Source: Result of Analysis, 2024)

Tomato farming in Tasikmalaya is marginally suitable (S3) and thrives in highlands and irrigated lowlands, with challenges including poor soil conditions, limited water supply, and weak infrastructure in southern zones. Research indicates that balanced fertilization is essential for optimizing tomato yields, as nutrient deficiencies can significantly impact plant growth and fruit quality Dutta (2024).While economically viable with an RC ratio of 1.69 per hectare per season, profitability is higher in northern and central areas due to better market access. To enhance sustainability, balanced fertilization, improved irrigation, crop rotation, and stronger marketing institutions are essential, along with support for small-scale farmers through partnerships and agricultural extension services. Implementing crop rotation practices can enhance soil fertility and reduce the buildup of pathogens, which is particularly important in continuous cropping systems (Jin et al., 2021; Cao et al., 2023).The introduction of efficient irrigation systems can help mitigate water scarcity issues and improve yield consistency (Anzalone et al., 2010).

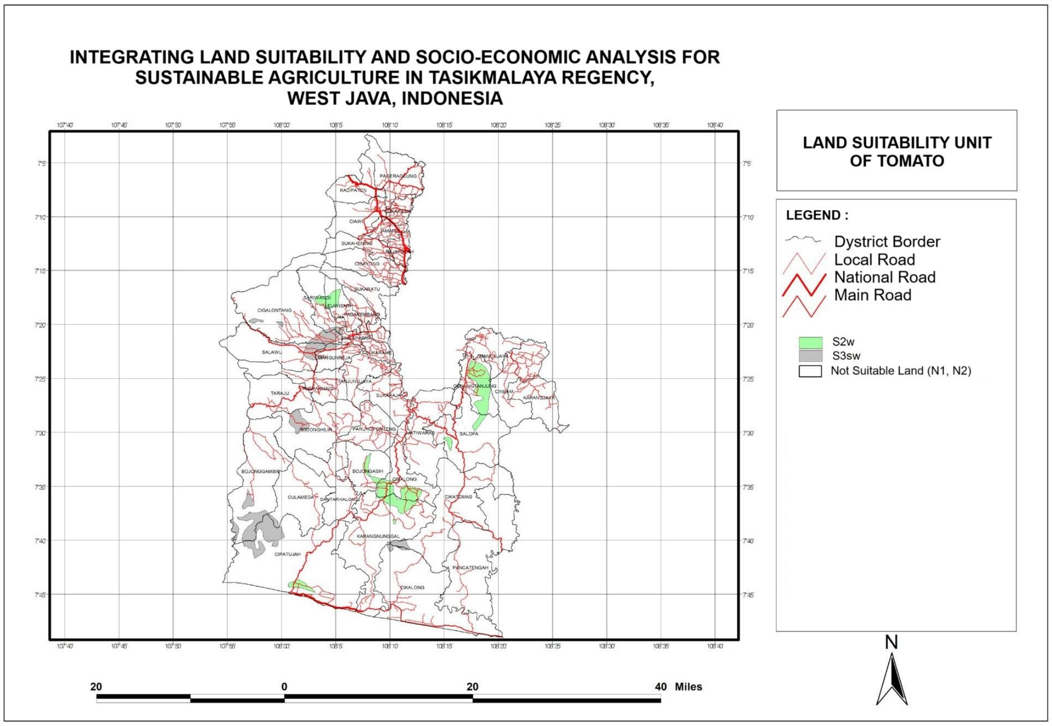

Fig. 8.Land suitability map of tomato (Source: Result of Analysis, 2024)

3.3. Land Suitability and Socio-Economical Assessment for Plantation Crop

Cocoa farming in Tasikmalaya is marginally suitable (S3) and concentrated in southern areas like Salopa and Cipatujah, where dryland and irrigation support its cultivation. Despite strong economic potential, with RC ratios above 2 due to high demand, challenges include steep slopes, erosion, and limited water availability. Expansion requires improved infrastructure, balanced fertilization, and institutional support. Southern zones offer significant agro-industrial potential, while middle and northern zones need socio-cultural empowerment to adopt cocoa farming. Strategic investments in market access and farmer capacity-building are essential for optimizing cocoa agribusiness. The study highlighted that cocoa farms managed by women tend to exhibit higher efficiency levels, suggesting that empowering women through education and capacity-building programs can enhance farm productivity Effendy et al. (2019). This empowerment is crucial in regions like Tasikmalaya, where traditional farming practices dominate, and improving efficiency can lead to increased income for farming families.

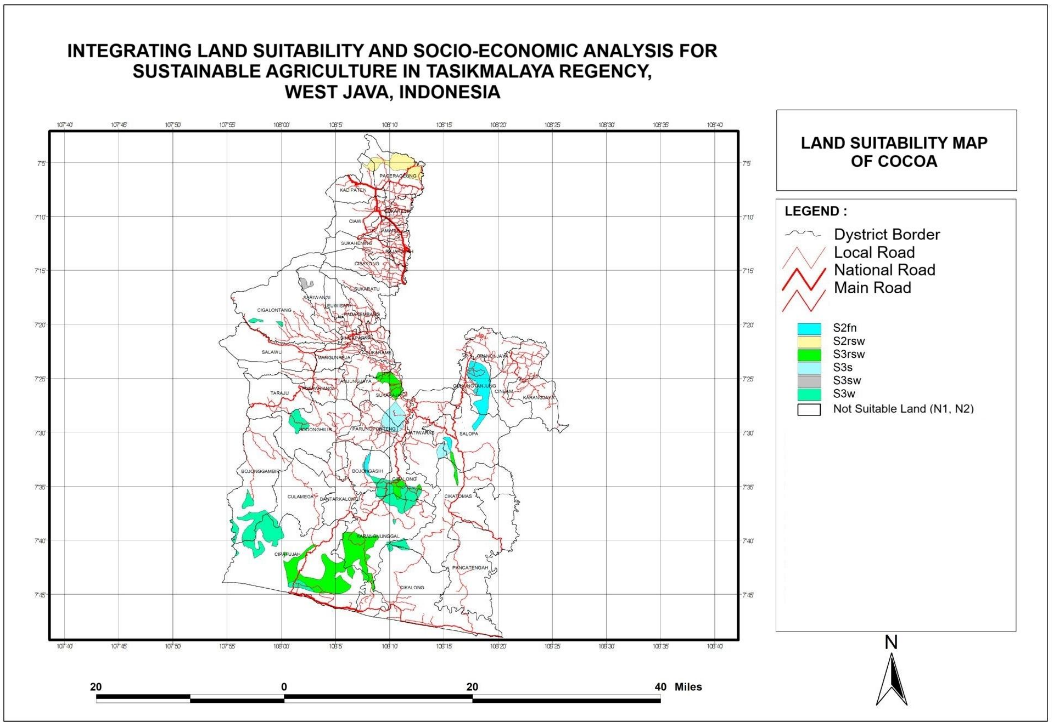

Fig. 9.Land suitability map of cocoa (Source: Result of Analysis, 2024)

Clove farming in Tasikmalaya Regency is marginally suitable (S3) and widely cultivated across areas such as Cisayong, Sukaratu, and Cipatujah. While cloves are resilient to water scarcity, they require moderate irrigation and are vulnerable to soil nutrient limitations, steep slopes, and erosion. The crop benefits from an established market network, primarily supplying the clove-based cigarette industry, though local processing facilities are lacking. Despite an RC ratio consistently above 1, fluctuating prices discourage farmers, leading some to abandon or replace clove plantations.The long shelf life of dried cloves simplifies transportation and storage, but market efficiency is hindered by dependence on intermediaries. To sustain and improve clove agribusiness, integrating local processing industries and fostering partnerships with processing companies are critical. These measures can stabilize prices, enhance profitability, and provide long-term incentives for farmers.

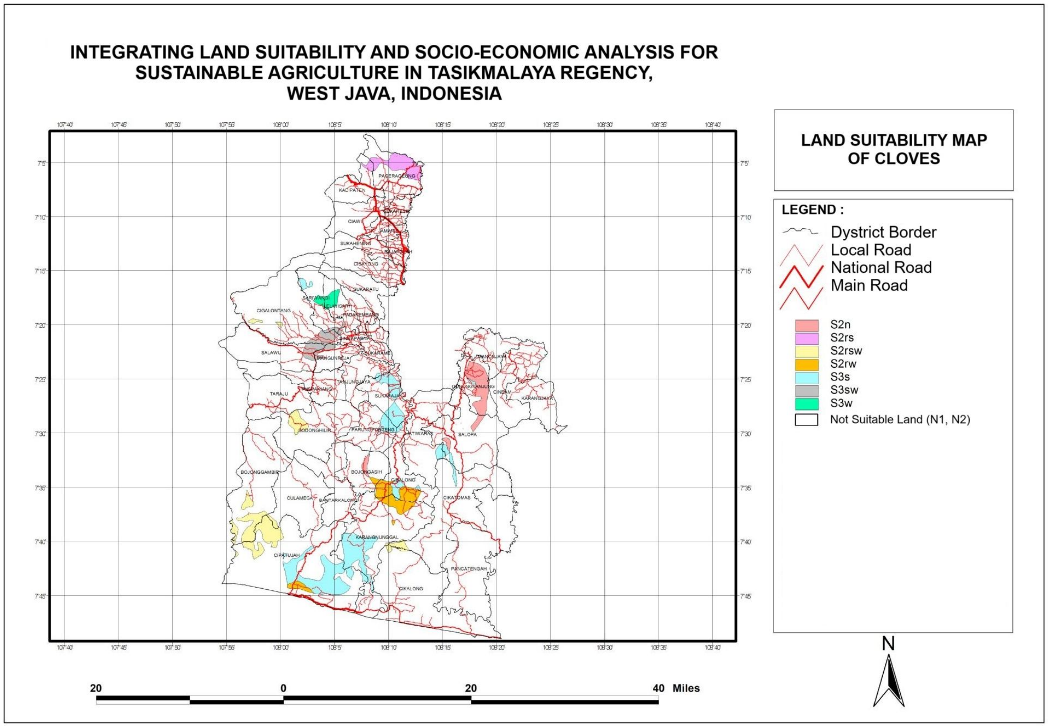

Fig. 10.Land suitability map of cloves (Source: Result of Analysis, 2024)

Arabica coffee farming in Tasikmalaya is moderately suitable (S2) in areas such as Pagerageung, while marginally suitable (S3) in districts like Karangnunggal, Cikalong, and Cipatujah. Key challenges include poor rooting media, steep slopes, erosion risks, and limited access to irrigation. While coffee farming is culturally embedded across Tasikmalaya, most farmers grow coffee for personal consumption rather than commercial purposes, particularly in southern zones where inadequate transport and market access limit profitability.Economic analysis indicates coffee farming is viable, with a Net B/C ratio of 4.01, an IRR of 34.41%, and NPV of 90,794,500 IDR at a 12% discount rate. However, weak farmer associations and limited government support hinder competitiveness. To enhance productivity, balanced organic and chemical inputs are needed alongside improved physical infrastructure, particularly in southern regions.Research has shown that integrated nutrient management can significantly enhance coffee productivity, particularly in regions facing soil nutrient limitations Nangameka (2023). Strengthening farmer groups, developing market networks, and fostering partnerships with processing industries are essential to promote rural agro-industrialization and position coffee as a key agribusiness commodity in Tasikmalaya.This is particularly important given the fluctuating prices that currently discourage some farmers from continuing their coffee plantations (Jesus et al., 2017).The establishment of training programs focused on best practices in coffee cultivation and marketing can further equip farmers with the skills needed to thrive in a competitive market environment (Sihombing, 2023).

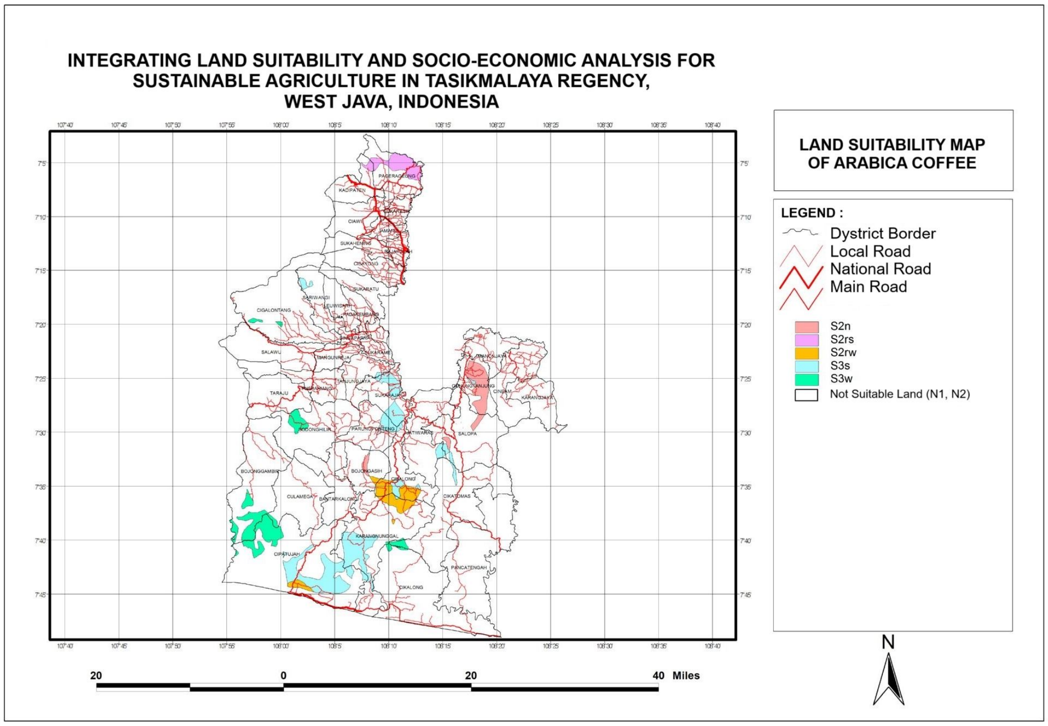

Fig. 11.Land suitability map of Arabica coffee (Source: Result of Analysis, 2024)

4. CONCLUSION

The evaluation of land suitability for agricultural commodities in Tasikmalaya Regency indicates that most areas are classified as S2 (moderately suitable) or S3 (marginally suitable), with potential for S1 (highly suitable) classification for certain crops, such as rice, potatoes, and carrots, provided limiting factors like nutrient retention and availability are addressed. Permanent constraints, including slope steepness, rooting media, and rainfall, cannot be modified, while factors such as erosion risks and soil fertility can be improved through appropriate management practices.

Economic assessments reveal that nearly all commodities are economically viable, as evidenced by RC ratios exceeding 1. Plantation crops, including coconut, coffee, and cocoa, exhibit higher profitability compared to horticultural crops, although newer commodities like carrots, cabbage, and scallions, while profitable, are not yet widely adopted due to limited cultural familiarity.

Zoning recommendations for commodity cultivation are based on biophysical and socio-economic conditions. Rice is best suited for northern regions, while food crops like maize, soybeans, and peanuts are more appropriate for central areas. Horticultural crops, including potatoes, carrots, and tomatoes, are recommended for northern to central zones, particularly on Red-Yellow Podsolic soils with slopes of 0–8% and annual rainfall between 2,500–3,000 mm. Clove cultivation is suitable in the north (e.g., Pagerageung, Kadipaten), where it is culturally established, and plantation crops such as coconut, coffee, and cocoa are better suited for central-southern regions, which offer more favorable environmental and socio-cultural conditions for their cultivation.

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