

Optimizing Agricultural Planning through Land Suitability Mapping: A Case Study on Patchouli in Aceh Jaya

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ABSTRACT

Land suitability is a critical factor in optimizing agricultural productivity and sustainability. This study evaluates the biophysical suitability of land for patchouli (*Pogostemon cablin* Benth.) cultivation in Aceh Jaya, Indonesia, using spatial analysis techniques. The objective was to classify land into suitability categories and identify priority areas for development. Five biophysical parameters—soil type, rainfall, slope, elevation, and land use—were analyzed using a Geographic Information System (GIS), specifically through the union overlay function in ArcGIS 10.5. Each parameter was classified into four suitability levels (S1–N), and then combined into a composite land suitability map. The results revealed that 1,404.94 Ha were classified as very suitable (S1), 92,769.33 Ha as moderately suitable (S2), 251,917.95 Ha as marginally suitable (S3), and 40,353.25 Ha as not suitable (N). The most suitable areas were concentrated in Sampoiniet sub-district, particularly within mixed dryland–shrub farming zones. These spatial insights provide a valuable foundation for land use planning and crop zoning in the region. The study demonstrates that GIS-based land evaluation is an effective approach to support sustainable agricultural expansion, and it can be adapted to other crops and contexts with similar geographic challenges

INTRODUCTION

Land resources play a crucial role in supporting agricultural development, especially in regions with diverse physical characteristics and abundant biodiversity. The strategic utilization of land for crop production must be aligned with the land's inherent potential and physical suitability. For agricultural sustainability and economic resilience, it is essential to identify, assess, and allocate land based on its suitability for specific crops, particularly high-value commodities such as essential oil-producing plants.

Patchouli (*Pogostemon cablin* Benth) is one of Indonesia's primary contributors to the essential oils industry. Known globally as patchouli oil, this product has long-standing importance in global perfumery and aromatherapy markets. In fact, patchouli oil constitutes around 60% of Indonesia's total essential oil exports, underscoring its strategic economic role (Julia, 2019). The dominance of Indonesia as a global supplier of patchouli oil has been well established for over six decades. Among several aromatic crops, patchouli stands out due to its superior oil content, commercial demand, and adaptability to various agroecological zones (Mangun & Waluyo, 2008).

In terms of regional production, the province of Aceh has historically served as a major patchouli cultivation zone, contributing significantly to the national supply chain. Aceh Jaya Regency, in particular, is a prominent site of patchouli agriculture. According to BPS Aceh Jaya (2022), this regency recorded 25 tons of patchouli production in 2017 from 146 hectares of cultivated land. Among its sub-districts, Jaya and Panga lead in production with 7 and 4 tons respectively.

Despite the evident potential, the expansion of patchouli farming often encounters challenges related to unplanned land use, lack of spatial planning, and minimal integration of ecological suitability assessments. Understanding land suitability is pivotal not only for increasing productivity but also for preserving land quality and minimizing ecological degradation. Each land unit has distinct characteristics—such as soil composition, topography, and climatic conditions—which significantly affect the growth and yield of patchouli. In the absence of systematic land evaluation, there is a high risk of suboptimal or even damaging land use practices.

Land suitability assessments provide a scientific framework for evaluating whether land is appropriate for a specific crop based on various physical parameters. These parameters often include soil type, rainfall, elevation, slope, and erosion hazard. According to Nuryani & Emmyzar (2006), the optimal growth of patchouli is closely linked to favorable combinations of these factors. As such, comprehensive biophysical assessments are essential for identifying priority areas for patchouli expansion. When performed at scale, such evaluations guide policymakers, farmers, and agribusiness stakeholders in making informed land-use decisions.

Geographic Information Systems (GIS) have emerged as a powerful technology to support spatial analysis in agriculture. By integrating geospatial data with thematic maps, GIS allows for multi-criteria evaluation of land suitability. This includes the ability to perform overlay analysis, classify land

units, and generate detailed suitability maps that reflect real-world conditions. Arif et al. (2015) demonstrated the value of GIS in web-based land suitability modeling for crops like maize. Similarly, Prahasta (2001; 2005; 2006; 2009; 2015) emphasized the role of GIS in developing spatial decision support systems, particularly in agricultural and environmental applications. These approaches ensure transparency, reproducibility, and scalability of land evaluation processes.

In addition to mapping and visualization, GIS-based models enhance the analytical rigor of land use planning. By incorporating land characteristics as input parameters, researchers can simulate potential zones of high productivity and isolate limiting factors that may impede agricultural development. The union overlay function, in particular, enables the combination of multiple spatial layers to produce an integrative view of land suitability. This function allows each biophysical parameter to be evaluated independently and then combined to determine the overall suitability of each land parcel. This methodology aligns with the land evaluation criteria developed by Djaenudin et al. (2000; 2003), which categorize suitability into classes ranging from very suitable (S1) to not suitable (N).

Although there have been notable efforts in agricultural zoning and spatial modeling in Indonesia, studies specifically addressing patchouli land suitability using GIS remain limited. Existing literature tends to focus on broader plantation commodities or regional development strategies without providing crop-specific recommendations based on physical land parameters. This gap in research is particularly evident in Aceh Jaya, where spatial data are often underutilized in guiding agricultural expansion. Consequently, there is a need for more focused and localized studies that integrate biophysical criteria with spatial technologies to support patchouli development planning.

This study addresses this gap by applying GIS-based overlay analysis to evaluate land suitability for patchouli cultivation in Aceh Jaya. The objective is twofold: (1) to assess the biophysical suitability of land in Aceh Jaya using parameters such as soil type, rainfall, elevation, and slope; and (2) to produce spatial maps indicating areas with high potential for patchouli development. By overlaying these parameters using the union function in ArcGIS, this research identifies land categories ranging from very suitable (S1) to unsuitable (N), enabling targeted interventions in agricultural planning.

The novelty of this research lies in its crop-specific application of GIS-based land suitability modeling using a well-defined set of physical criteria. While GIS has been widely applied in agricultural planning, its targeted use for patchouli land allocation remains underexplored. Moreover, by integrating existing land use data and filtering out unsuitable categories (e.g., urban areas, water bodies), the analysis provides a realistic and actionable framework for local stakeholders. The scope of the study is limited to Aceh Jaya Regency, offering a regional case study that can inform similar analyses in other parts of Indonesia.

In summary, this study contributes to spatial agricultural planning by identifying and mapping areas suitable for patchouli cultivation based on objective biophysical criteria. The integration of GIS with land evaluation

principles ensures a scientifically rigorous approach, while the focus on a high-value crop like patchouli addresses both economic and environmental priorities. Through this study, researchers, policymakers, and agricultural planners can gain insights into the spatial distribution of land suitability and make informed decisions to optimize land use and support sustainable development in Aceh Jaya and beyond.

LITERATURE REVIEW

Understanding land suitability for agricultural development has been a core subject of agronomic and environmental research. According to Vink (1975), land use planning must consider both physical and socio-economic aspects to ensure sustainable crop production. In the context of biophysical suitability, several factors such as soil type, rainfall, elevation, and slope play crucial roles in determining whether a particular land unit can support specific agricultural activities (Djaenudin et al., 2000; Djaenudin et al., 2003).

Patchouli (*Pogostemon cablin* Benth), one of Indonesia's most valuable essential oil crops, requires specific ecological conditions to thrive. Nuryani & Emmyzar (2006) emphasize that patchouli grows best in moderately moist, well-drained soils with sufficient organic content, moderate temperatures, and limited elevation gradients. The crop is sensitive to waterlogging, extreme rainfall, and poor soil structure, which can significantly reduce oil yield and quality.

Indonesia has long held a dominant position in the global patchouli oil market, supplying approximately 60% of global demand (Julia, 2019). Regions such as Aceh, especially Aceh Jaya, have emerged as key production centers. BPS Aceh Jaya (2022) reported consistent patchouli outputs in the region, making it a strategic area for targeted land evaluation and planning.

Geographic Information Systems (GIS) have transformed agricultural land assessment by offering tools that integrate multiple spatial datasets into a cohesive analytical framework. Howard (1996) and Prahasta (2005; 2009) describe GIS as essential in environmental and resource planning due to its capacity for spatial overlay, classification, and thematic mapping. Union overlay methods, in particular, are useful for land evaluation as they allow for the integration of multiple layers – such as soil, slope, rainfall, and land use – into a singular spatial product.

Previous studies have successfully applied GIS for crop-specific suitability analysis. For instance, Arif et al. (2015) demonstrated the use of web-based GIS systems for maize suitability modeling, while Mulyani & Las (2008) applied land evaluation techniques for bioenergy crops. These methodologies have informed multi-criteria decision-making in rural planning and resource management. However, targeted GIS applications for patchouli remain limited, especially at the regency level in Indonesia.

The framework for land evaluation adopted in this study follows the guidelines set forth by Djaenudin et al. (2003), which classify land suitability into four categories: S1 (very suitable), S2 (moderately suitable), S3 (marginally suitable), and N (not suitable). These classifications are derived from quantitative thresholds in soil depth, texture, drainage, slope, and rainfall. By using these

criteria in a GIS environment, researchers can produce maps that are both analytically robust and operationally useful for policymakers.

Additionally, land use data integration is vital for aligning theoretical suitability with practical land availability. This approach ensures that areas identified as suitable are not only biophysically optimal but also realistically accessible for agricultural development. Prahasta (2006; 2015) and Rayes (2007) argue that such integration enhances the decision-making process in spatial planning by accounting for current land utilization and ecological restrictions.

In conclusion, the literature supports the use of GIS and biophysical criteria in assessing agricultural land suitability. Although previous research has laid a strong foundation for land evaluation, this study contributes further by applying these methods specifically to patchouli cultivation in Aceh Jaya. It addresses a significant gap in spatial agricultural planning and offers a replicable model for other high-value crops in similar tropical environments.

METHODOLOGY

Study Area and Duration

This research was conducted in Aceh Jaya Regency, one of the administrative regions in the Aceh Province, Indonesia. Aceh Jaya covers approximately 387,965.36 hectares and is located between 04°22' - 05°16' North Latitude and 95°10' - 96°03' East Longitude. The region includes nine sub-districts, with Sampoiniet and Panga identified as primary zones for patchouli cultivation based on prior production records (BPS Aceh Jaya, 2022).

The research process was carried out over six months, from June 2023 to December 2023. Data processing and spatial analysis were conducted at the Laboratory of SIG and Remote Sensing Development Center, Universitas Syiah Kuala, Banda Aceh.

Materials and Tools

The research relied on both hardware and software tools to perform spatial analysis. The primary software used was ArcGIS version 10.5, particularly ArcMap and its ArcToolBox functions. Hardware requirements included a standard laptop/PC capable of running GIS operations efficiently.

Spatial datasets were gathered in shapefile (SHP) format, including:

Land use map of Aceh Jaya

- Administrative boundary map
- Rainfall distribution map
- Soil type map
- Elevation map
- Slope gradient map

These datasets represent the core biophysical parameters essential for land suitability evaluation for patchouli, as emphasized in prior research on agricultural land assessment (Djaenudin et al., 2000; Nuryani & Emmyzar, 2006). Additionally, a suitability classification table for patchouli was compiled to guide the categorization process.

Data Preparation and Classification

Prior to analysis, all spatial datasets were standardized to ensure compatibility in terms of projection system, resolution, and geographic extent. Each biophysical parameter was classified into four suitability levels based on previously established land evaluation criteria (Djaenudin et al., 2003). These levels include:

- Very Suitable (S1)
- Moderately Suitable (S2)
- Marginally Suitable (S3)
- Not Suitable (N)

For example, rainfall between 2,300–3,000 mm/year was classified as S1, while rainfall exceeding 5,000 mm/year or below 1,200 mm/year was categorized as N. Similarly, soil types such as Latosol were classified as S1, whereas areas with NODA soil were considered unsuitable (N). Elevation and slope gradients were also categorized using thresholds derived from agronomic guidelines specific to patchouli requirements.

These classifications were essential in transforming raw geospatial data into meaningful thematic layers, forming the basis for multi-criteria overlay analysis.

Overlay Analysis using GIS

The central analytical technique employed in this study was overlay analysis using the "union" overlay function available in ArcGIS's ArcToolBox. This method allows for the integration of multiple spatial layers, each representing a specific biophysical parameter. The union function retains the full attribute data from all input layers, enabling a composite view of land suitability.

The analysis was conducted iteratively. Initially, overlay was performed between two parameter layers, such as soil type and rainfall. The resulting layer was then reclassified based on dominant suitability values. This new layer was then overlaid with the next parameter, such as slope, and so on, until all five parameters had been integrated.

This step-wise approach ensured that each parameter contributed equally to the final classification, aligning with the principles of equal weight in multi-criteria evaluation (Howard, 1996; Prahasta, 2005). A dominant-class rule was applied in matching overlapping areas; for instance, if two overlapping parameters both yielded S1 classifications, the resulting unit was retained as S1. If any one parameter indicated a restrictive class (e.g., N), it influenced the final classification toward the limiting factor.

The use of union overlay allowed the generation of a composite map of land suitability, providing a comprehensive spatial representation of suitable areas for patchouli development.

Land Use Filtering and Matching

Following the creation of the composite land suitability layer, a land use filtering process was applied. This step involved excluding areas that, despite being biophysically suitable, were not viable for agricultural activities – such as settlements, bodies of water, or cloud-covered areas. The filtering process was conducted using the "clip" function, which allowed the selective extraction of polygons based on land use attributes.

The filtered suitability map was then matched against actual land use types that are compatible with patchouli cultivation. These include:

- Mixed dryland and bush farming
- Dryland agriculture
- Plantation areas
- Open land

This matching process was crucial in generating a potential land map – one that reflects both physical suitability and current land use compatibility. The goal was to ensure that suitability recommendations were grounded in practical land availability and accessibility, rather than theoretical potential alone.

Ultimately, this method produced a categorized map indicating the spatial distribution of patchouli suitability levels (S1 to N) and the corresponding land use types. It formed the empirical basis for the results and discussion in subsequent chapters.

RESEARCH RESULT

Administrative and Geographic Profile of Aceh Jaya

Aceh Jaya Regency is one of the administrative divisions in the Aceh Province of Indonesia. It encompasses nine sub-districts (kecamatan), 21 mukim, and 172 villages. Geographically, it is situated between 04°22' – 05°16' North Latitude and 95°10' – 96°03' East Longitude. The regency spans a total area of 387,965.36 hectares and has its administrative capital in Calang, located approximately 156 kilometers from Banda Aceh.

Aceh Jaya is bordered by Aceh Besar and Pidie in the north, the Indian Ocean and Aceh Barat in the south, Aceh Barat to the east, and the Indian Ocean to the west. These boundaries frame a diverse topographical and ecological landscape suitable for agricultural analysis and land development planning.

Spatial Distribution of Biophysical Parameters

The land suitability analysis for patchouli cultivation was based on five biophysical parameters: rainfall, soil type, elevation, slope gradient, and land use.

Rainfall

Rainfall data were classified into four suitability levels. The very suitable class (S1) was assigned to areas receiving 2,300–3,000 mm/year, moderately suitable (S2) to 3,000–3,500 mm/year, marginally suitable (S3) to >3,500 mm/year, and not suitable (N) to extreme conditions of >5,000 or <1,200 mm/year. Based on this classification, Aceh Jaya exhibited a wide range of rainfall zones, with most areas falling into the S2 and S3 classes (Figure 1).

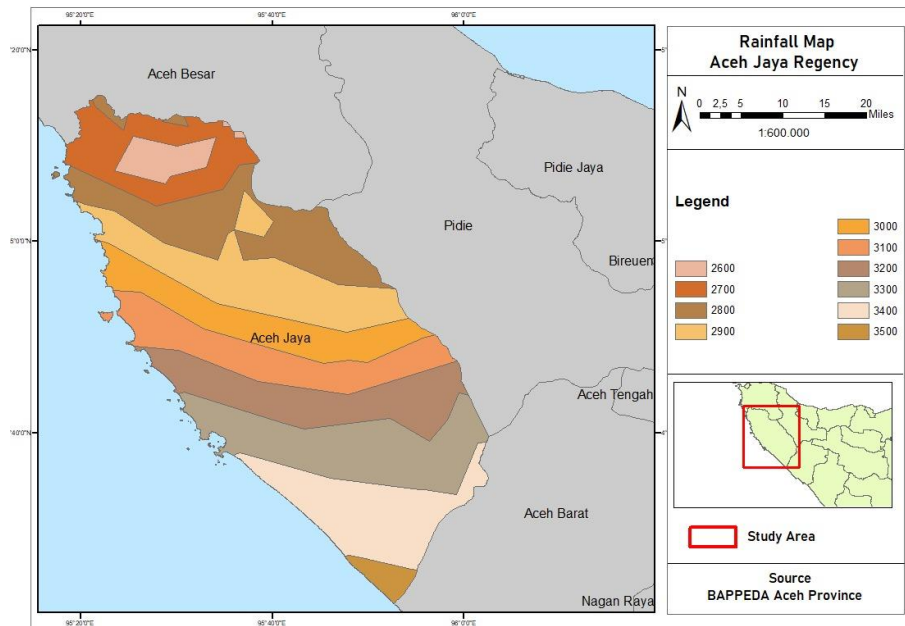


Figure 1. Rainfall Map of Aceh Jaya Regency

Soil Type

Soil in Aceh Jaya was categorized into Aluvial, Latosol, Regosol, Komplek Podsolik, Komplek Rensing, Organosol, and Gle Humus. The most suitable soil for patchouli, Latosol, was assigned S1, while Podsolik Merah Kuning was S2. Soils such as Rensing and Litosol were marked as S3, and NODA-classified soils were deemed unsuitable (N). Overall, S2 was the dominant class across the regency (Figure 2).

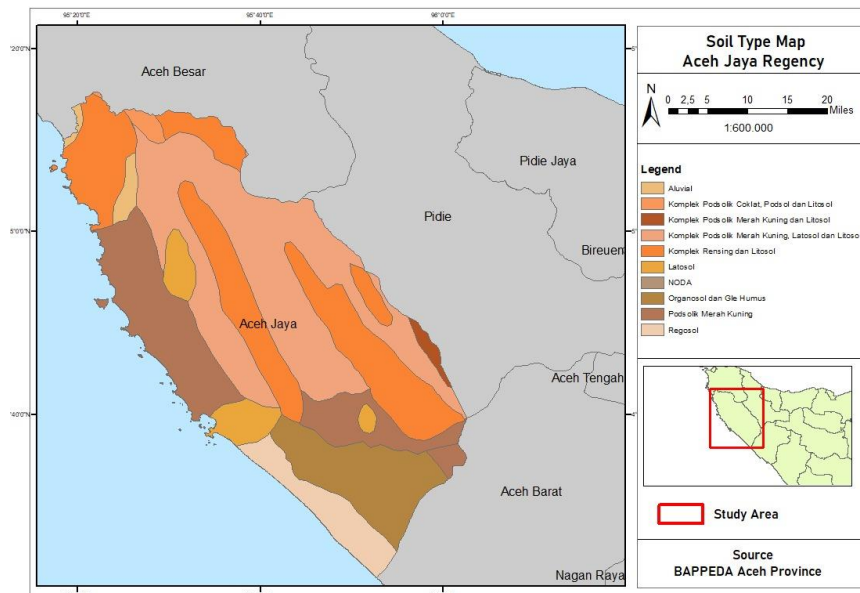


Figure 2. Soil Type Map of Aceh Jaya Regency

Elevation

Elevation in the region varied from coastal lowlands to inland highlands. Suitability was stratified into four classes: 100–400 meters above sea level (S1), 400–700 meters (S2), and >700 meters (S3). This parameter directly impacts temperature and humidity levels critical to patchouli growth (Figure 3).

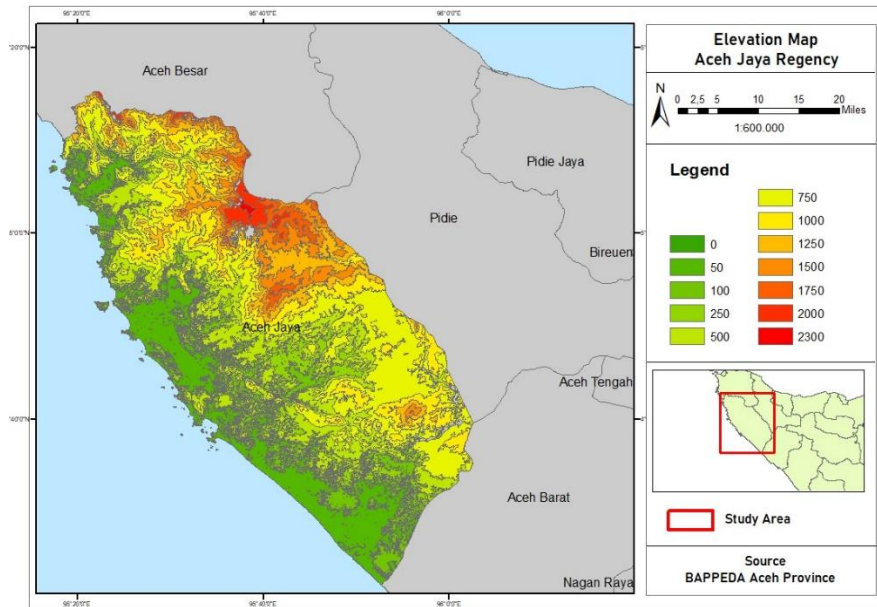


Figure 3. Map of the Altitude of Aceh Jaya Regency

Slope Gradient

Slope was segmented into five classes: flat (<8%), gently sloped (8–15%), moderately steep (16–25%), steep (26–40%), and very steep (>40%). Patchouli performs best on flat or gently sloping terrain. Hence, slopes >25% were considered unsuitable due to erosion risks and cultivation difficulty (Figure 4).

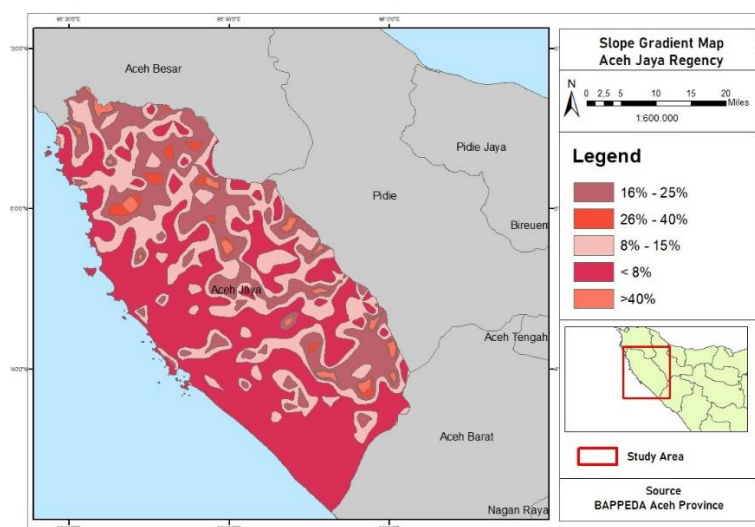


Figure 4. Slope Map of Aceh Jaya Regency

The analysis of these thematic maps shows that most of Aceh Jaya consists of moderately suitable terrain, with certain pockets of very suitable land, particularly in the Sampoiniet sub-district.

Land Suitability Classification

The overlay of all five biophysical parameters using the union function in ArcGIS produced a composite land suitability map for patchouli. The resulting map categorized the region into five classes:

Table 1. Area of Land Suitability Class for Patchouli Plants

| Suitability Class | Description | Area (Ha) |
|-------------------|---------------------|------------|
| S1 | Very Suitable | 1,404.94 |
| S2 | Moderately Suitable | 92,769.33 |
| S3 | Marginally Suitable | 251,917.95 |
| N | Not Suitable | 40,353.25 |
| No Data | - | 799.91 |

Total Area Assessed: 387,245.4 Ha

S1 class was primarily located in Sampoiniet sub-district (1,376.44 Ha), particularly in mixed bush dryland agriculture zones. Conversely, S3 and N classes dominated the terrain, indicating significant limitations in soil, rainfall, or elevation for large parts of the regency.

Land Use Potential and Area-Based Suitability

Following land suitability classification, a secondary analysis was conducted to examine land use compatibility. This step filtered land categories that were practically accessible and agriculturally viable for patchouli farming.

Key land use types and their corresponding suitability area are shown in the table below:

Table 2. Area of Potential Land Suitability for Patchouli Plants

| Land Type | S1 (Ha) | S2 (Ha) | S3 (Ha) | N (Ha) | No Data (Ha) | Total (Ha) |
|----------------------------|---------|-----------|-----------|----------|--------------|------------|
| Dryland Forest (Secondary) | 201.01 | 23,343.28 | 179,100.1 | 34,375.8 | 0 | 237,020.2 |
| Swamp Forest (Secondary) | 0 | 5,007.72 | 1,694.38 | 0 | 0 | 6,702.1 |
| Plantation | 0 | 0 | 3,447.91 | 0 | 0 | 3,447.91 |
| Dryland Agriculture | 471.64 | 18,651.33 | 10,382.25 | 0 | 299.40 | 29,804.62 |
| Mixed Dryland with Shrubs | 732.04 | 28,532.66 | 28,693.12 | 1,141.01 | 0 | 59,098.83 |
| Rice Field | 0 | 1,447.17 | 1,729.86 | 0 | 327.66 | 3,504.69 |
| Shrubs | 0 | 13,309.4 | 17,590.18 | 2,233.6 | 22.35 | 33,155.53 |
| Open Land | 0.24 | 64.69 | 238.85 | 8.56 | 0 | 312.24 |

The most prominent S1 category occurred in mixed dryland–shrub land (732.04 Ha), followed by dryland agriculture (471.64 Ha), and dryland forest (201.01 Ha). These represent the best targets for expanding patchouli cultivation.

DISCUSSION

The spatial evaluation of land suitability for patchouli (*Pogostemon cablin* Benth) cultivation in Aceh Jaya has demonstrated the critical role of biophysical parameters in determining agricultural potential. Using a Geographic Information System (GIS)-based union overlay method, this study integrated five key factors – rainfall, soil type, elevation, slope, and land use – into a composite suitability model. The findings support earlier assertions that patchouli growth is highly dependent on physical land characteristics (Nuryani & Emmyzar, 2006), and that GIS provides an effective platform for multi-criteria spatial analysis in agriculture (Prahasta, 2005; Arif et al., 2015).

The analysis revealed that only a small fraction of Aceh Jaya's land (approximately 1,404.94 Ha or 0.36% of the total area) is classified as very suitable (S1) for patchouli cultivation. These areas are primarily located in Sampoiniet sub-district, a region previously identified as productive based on agricultural records (BPS Aceh Jaya, 2022). This confirms that historical production zones align with areas that have high biophysical compatibility for the crop. It also reinforces the validity of the methodology used in this study for identifying suitable agricultural zones.

Furthermore, the study highlighted the dominance of moderately suitable (S2) and marginally suitable (S3) areas, comprising over 344,000 Ha collectively. These zones present an opportunity for improvement and intervention. Agronomic practices such as terracing, organic soil amendments, or moisture management may enhance their productive potential. However, it must be emphasized that such improvements come with additional input costs and may not always be economically viable for smallholder farmers. Thus, the identification of S1 zones offers a more immediate and sustainable opportunity for patchouli expansion.

One of the study's most important contributions is the link between biophysical suitability and existing land use. By applying a land use filter to the suitability map, the analysis excluded impractical zones (e.g., settlements, cloud-covered areas, water bodies), and focused on agriculturally accessible areas. This ensured that the output map reflected not only theoretical suitability but also realistic implementation potential. The majority of S1-suitable land was found in mixed dryland–bush areas (732.04 Ha), followed by dryland agriculture (471.64 Ha), and dryland forest (201.01 Ha). These results align with the typical ecological preferences of patchouli, which thrives in semi-shaded conditions with moderate moisture and well-drained soils (Harli, 2017).

The importance of elevation and rainfall in defining suitability was particularly evident. Regions located between 100–400 meters above sea level with 2,300–3,000 mm/year rainfall received the highest suitability scores. These ranges provide optimal temperature and humidity conditions for patchouli metabolism and oil biosynthesis, as suggested in previous agronomic studies

(Mangun & Waluyo, 2008; Nuryani & Emmyzar, 2006). Conversely, areas above 700 meters or with rainfall beyond 3,500 mm/year showed declining suitability due to potential issues like waterlogging, erosion, and decreased soil fertility.

Soil classification also played a significant role in shaping the suitability landscape. Latosol soils – classified as S1 – are well-drained and rich in organic matter, ideal for aromatic crops. In contrast, Rensing and Litosol complexes presented limitations in nutrient availability and structure, resulting in their S3 categorization. These findings validate previous land evaluation frameworks (Djaenudin et al., 2000; 2003), which stress the necessity of matching crop requirements with soil characteristics.

Slope analysis revealed that terrain with gradients above 25% were largely unsuitable due to erosion risks and cultivation difficulties. This aligns with studies on land conservation that suggest limiting agricultural activities on steep slopes unless erosion control measures are in place (Arsyad, 1989). Thus, any recommendation for development in such areas must be coupled with soil stabilization strategies.

The integration of all these parameters into a union overlay model demonstrated the analytical power of GIS for agricultural planning. The methodology allowed not only the identification of suitable areas but also the quantification of potential land availability per land use type. These spatial insights are invaluable for regional planners, extension workers, and agribusiness stakeholders.

However, the study is not without limitations. While the use of five biophysical parameters provides a robust base, other important factors – such as pH, temperature variability, organic matter content, and socio-economic accessibility – were not included due to data unavailability. Future studies may benefit from integrating remote sensing data on vegetation indices, or farmer survey data on land management practices, to enhance model accuracy. Additionally, climate change scenarios could be incorporated to anticipate future shifts in suitability zones.

Despite these limitations, the study contributes significantly to spatial agricultural planning in Aceh Jaya. The approach is replicable and adaptable to other crops and regions, offering a framework for evidence-based decision-making. From a policy perspective, the findings could inform zoning regulations, land allocation strategies, and targeted interventions to support sustainable patchouli development.

In conclusion, the spatial analysis confirmed the presence of high-potential zones for patchouli cultivation in Aceh Jaya, particularly in Sampoiniet. Through a combination of biophysical classification and GIS overlay, this study offers practical recommendations for optimized land use and highlights the value of geospatial tools in modern agricultural planning.

CONCLUSIONS

This study has demonstrated that spatial analysis using Geographic Information Systems (GIS) is an effective tool for evaluating land suitability for patchouli (*Pogostemon cablin* Benth) cultivation based on biophysical characteristics. The integration of five parameters – soil type, rainfall, elevation, slope, and land use – enabled the classification of land in Aceh Jaya into distinct suitability classes. The analysis revealed that only 1,404.94 Ha of the total area falls under the 'Very Suitable' (S1) category, predominantly located in the Sampoiniet sub-district, particularly on mixed dryland-bush farmland. The majority of land, however, was classified as moderately (S2) or marginally suitable (S3), with a notable portion deemed unsuitable due to environmental constraints. These findings align with historical production patterns and validate the methodological framework applied. The study provides a scientific basis for targeted agricultural planning and recommends that future research incorporate additional biophysical and socioeconomic variables to further refine the suitability model. Ultimately, this research offers practical implications for regional policymakers, agribusiness actors, and development planners seeking to enhance patchouli production in a sustainable manner.

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REFERENCES

- Agustian, A., & Hartoyo, S. (2023). Analisis Ketergantungan Impor Bahan Baku Pakan Ternak dan Dampaknya terhadap Industri Peternakan Nasional. *Jurnal Ekonomi Pertanian dan Agribisnis*, 7(2), 145-158.
- Akbar, A., Darma, R., Irawan, A., Fudjaja, L., Amandaria, R., & Akzar, R. (2025). An institutional framework for enhanced food security amidst the COVID-19 pandemic: Strategic implementation and outcomes. *Journal of Agriculture and Food Research*, 21, Article 101833. <https://doi.org/10.1016/j.jafr.2025.101833>
- Alamsyah, R. T. P., Wulandari, E., Saidah, Z., & Hapsari, H. (2024). Discovering sustainable finance models for smallholder farmers: A bibliometric approach to agricultural innovation adoption. *Discover Sustainability*, 5(1), Article 107. <https://doi.org/10.1007/s43621-024-00277-4>
- Arifin, B., Nuryartono, N., & Pasaribu, S. H. (2021). *Pembangunan Pertanian dan Ketahanan Pangan Indonesia di Era Disrupsi*. IPB Press.
- Ashari, A., & Saptana, S. (2021). Prospek Pembiayaan Usaha Tani Melalui Kredit Usaha Rakyat (KUR) di Indonesia. *Analisis Kebijakan Pertanian*, 19(1), 21-38.

- Badan Kebijakan Fiskal. (2025). Kerangka Ekonomi Makro dan Pokok-Pokok Kebijakan Fiskal 2026. Jakarta: Kementerian Keuangan.
- Bustos-Terrones, Y. A., Tariq, R., Rangel-Peraza, J. G., Torrónategui-Chávez, G., & Loaiza, J. G. (2025). Sustaining global food security through digitalization. In *Climate change impacts on the water-energy-food nexus: Net zero emissions and sustainability* (pp. 289–302). <https://doi.org/10.1016/B978-0-443-22320-4.00013-X>
- Bustos-Terrones, Y. A., Tariq, R., Rangel-Peraza, J. G., Torrónategui-Chávez, G., & Loaiza, J. G. (2025). Sustaining global food security through digitalization. In *Climate change impacts on the water-energy-food nexus: Net zero emissions and sustainability* (pp. 289–302). <https://doi.org/10.1016/B978-0-443-22320-4.00013-X>
- Chancel, L., Gómez-Carrera, R., Moshrif, R., Piketty, T., et al. (2025). *World Inequality Report 2026*. World Inequality Lab.
- Conway, G., & Wilson, K. (2010). New genetic crops in a global context. In *Successful agricultural innovation in emerging economies: New genetic technologies for global food production* (pp. 39–60). Cambridge University Press. <https://doi.org/10.1017/CBO9781139208475.004>
- Direktorat Jenderal Anggaran. (2025). *Realisasi APBN Per 31 Oktober 2025*. Jakarta: Kementerian Keuangan.
- Hermanto, F., & Swastika, D. K. (2022). Transformasi Digital Sektor Pertanian: Peluang dan Tantangan bagi Petani Kecil di Indonesia. *Forum Penelitian Agro Ekonomi*, 40(1), 1-15.
- Hickel, J., Dorninger, C., Wieland, H., & Suwandi, I. (2022). Imperialist appropriation in the world economy: Drain from the global South through unequal exchange, 1990–2015. *Global Environmental Change*, 73, 102467. <https://doi.org/10.1016/j.gloenvcha.2022.102467>
- Kementerian Keuangan Republik Indonesia. (2025). *Bahan Menteri Keuangan pada acara Rapimnas KADIN 2025: Prospek Ekonomi Indonesia 2026*. Jakarta: Kementerian Keuangan.
- Kementerian Keuangan RI. (2024). *Kerangka Ekonomi Makro dan Pokok-Pokok Kebijakan Fiskal Tahun 2025*. Jakarta: Kementerian Keuangan Republik Indonesia.

- Li, J., Pang, X., Zhai, J., & Wang, S. (2026). Reforming trade governance for sustainable resource flows: Ecologically unequal exchange in Pan-Eurasia. *Environmental Impact Assessment Review*, 118, Article 108247. <https://doi.org/10.1016/j.eiar.2025.108247>
- Marius, J. A., Nurmalinga, R., & Rifin, A. (2024). Sinergi Kelembagaan Pangan Nasional dalam Menjaga Stabilitas Harga Beras. *Jurnal Manajemen & Agribisnis*, 21(1), 45-56.
- Mudzielwana, R. V. A. (2025). Climate-smart food systems: Integrating adaptation and mitigation strategies for sustainable agriculture in South Africa. *Frontiers in Sustainable Food Systems*, 9, Article 1580516. <https://doi.org/10.3389/fsufs.2025.1580516>
- Mudzielwana, R. V. A. (2025). Climate-smart food systems: Integrating adaptation and mitigation strategies for sustainable agriculture in South Africa. *Frontiers in Sustainable Food Systems*, 9, Article 1580516. <https://doi.org/10.3389/fsufs.2025.1580516>
- Nievas, G., & Piketty, T. (2025). Unequal Exchange and North-South Relations: Evidence from Global Trade Flows and the World Balance of Payments 1800-2025. *World Inequality Lab Working Paper Series 2025/11*.
- Nuryanti, S. (2023). Dampak Inflasi Pangan terhadap Tingkat Kesejahteraan Rumah Tangga Miskin di Indonesia. *Jurnal Ekonomi dan Pembangunan Indonesia*, 23(2), 112-129.
- Obe, M. M., Kpadé, C. P., & Singbo, A. (2025). Identifying and overcoming barriers to climate change adaptation innovations among smallholder farmers in developing countries: A literature review and meta-analysis. *Climatic Change*, 178(3), Article 49. <https://doi.org/10.1007/s10584-025-03892-w>
- Obe, M. M., Kpadé, C. P., & Singbo, A. (2025). Identifying and overcoming barriers to climate change adaptation innovations among smallholder farmers in developing countries: A literature review and meta-analysis. *Climatic Change*, 178(3), Article 49. <https://doi.org/10.1007/s10584-025-03892-w>
- Octavia, Z. (2022). Evaluasi Kebijakan Food Estate dalam Mendukung Ketahanan Pangan Nasional: Tinjauan Aspek Lingkungan dan Sosial. *Jurnal Ilmu Lingkungan*, 20(3), 567-578.

- Ramadan, R., & Castet, A. (2025). Past, present and future of food security in Egypt. In *Pathways to African food security: Challenges, threats and opportunities towards 2050* (pp. 49–58). Routledge. <https://doi.org/10.4324/9781032649696-6>
- Regmi, S., & Gheewala, S. H. (2025). Scaling up nature-based solutions for food security and climate resilience in wetlands: Typologies, barriers and opportunities. *Journal for Nature Conservation*, 88, Article 127062. <https://doi.org/10.1016/j.jnc.2025.127062>
- Rosegrant, M. W. (2018). Global and regional perspectives of food economy and policy. *World Food Policy*, 4(2), 7–18. <https://doi.org/10.18278/wfp.4.2.2>
- Rusdiana, S., & Praharani, L. (2023). Dampak Kenaikan Harga Pakan terhadap Usaha Peternakan Rakyat di Indonesia. *Forum Penelitian Agro Ekonomi*, 41(1), 12–25.
- Surmaini, E., Hadi, T. W., & Subagyono, K. (2020). Strategi Adaptasi Perubahan Iklim pada Tanaman Padi di Indonesia: Studi Kasus Kejadian El Nino. *Jurnal Sumberdaya Lahan*, 14(1), 11–24.
- Thobane, J., Ndoro, J., Molepo, S., Serote, B., Hlophe-Ginindza, S., Mpandeli, S., Nhamo, L., & Mokgehle, S. (2025). A review on the adoption of sustainable agricultural practices in Southern Africa: Focus on smallholder farmers. *Agriculture*, 15(20), Article 2125. <https://doi.org/10.3390/agriculture15202125>
- Wibowo, A., & Hidayat, R. (2024). Analisis Dampak Ekonomi Program Makan Bergizi Gratis terhadap Pendapatan Petani Lokal dan Kesehatan Masyarakat. *Jurnal Kebijakan Kesehatan Indonesia*, 13(1), 30–45.