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Review Pape

A Systematic Literature Review on Analysis of Optimal Location for Crop Farming

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Abstract: Crop farming, crucial for global food security, faces challenges like climate change, soil degradation, and resource scarcity. This systematic literature review (SLR) investigated methodologies and technologies for determining optimal crop farming locations, focusing on the integration of Geographic Information Systems (GIS) analysis, Remote Sensing, and Multi-Criteria Decision Analysis (MCDA), particularly the Analytical Hierarchy Process (AHP). The objective was to synthesize findings from peer-reviewed studies to understand how these technologies contribute to sustainable agricultural practices and address global food security challenges. The SLR followed the PRISMA protocol, analyzing data from 69 peer-reviewed studies. Findings highlighted GIS and Remote Sensing as pivotal tools for spatial mapping, land suitability assessment, and real-time monitoring, while MCDA and AHP were instrumental in evaluating multi-dimensional criteria. The analysis explored the strengths and weaknesses of various methodologies and their applications in diverse geographical regions and farming systems. Implications suggest that integrating geospatial technologies and decision-making frameworks is critical for promoting sustainable agricultural practices and addressing global food security challenges. Further research is needed to explore the influence of social and cultural factors on location decisions and to further integrate advanced technologies for diverse contexts.

Keywords: AHP; sustainable agriculture; land suitability analysis; crop farming; GIS; systematic literature review

Introduction

Crop farming, the cultivation of plants for food, fiber, fuel, and other resources, is a cornerstone of human civilization and a critical driver of global food security. It accounts for a significant portion of agricultural output and underpins economic and social stability worldwide. From subsistence farming in developing regions to industrial-scale agriculture in developed nations, crop farming exhibits diverse practices shaped by local climates, soils, cultures and technologies. In 2021, crop farming contributed to feeding the world's population of over 7.8 billion people, with staple crops like rice, wheat and maize providing more than 50% of global caloric intake (FAO, 2021). However, the industry faces numerous challenges, including climate change, soil degradation, water scarcity and the growing demand for sustainable agricultural practices. Emerging technologies such as precision agriculture, genetically modified organisms (GMOs) and regenerative farming are increasingly vital in addressing these challenges and enhancing productivity. Crop farming is also deeply interconnected with global trade. Agricultural exports of key crops like soybeans, coffee and cotton link producers in countries like Brazil, the United States and Vietnam with global markets, impacting food prices, supply chains and rural livelihoods (World Bank, 2020). Moreover, global crop farming practices significantly influence environmental outcomes, contributing to greenhouse gas emissions and biodiversity loss while also offering potential solutions through carbon sequestration and sustainable land management practices.

However, initiatives such as sustainable certification programs and regenerative agricultural practices are being explored to mitigate these impacts. Striking a balance between the economic importance of oil palm and the need for environmental sustainability remains a key challenge. Understanding the suitability of specific regions for oil palm cultivation can help guide policies and practices toward a more sustainable future for this critical crop. The determination of agricultural and plantation locations often relies on location theory, semiotic theory and GIS technology as the primary approaches. Within the framework of location theory, Von Thünen's model (1826) serves as a foundational reference for understanding how distance from refinery factory influences the choice of agricultural land locations. Further studies, such as those by Weber et al. (2012), incorporate modern factors like infrastructure and technology to identify strategic locations for plantation development. These theories provide a robust scientific framework for understanding economic and logistical factors in location selection. On the other hand, semiotic theory adds a social and cultural dimension to location planning. Eco et al. (1999) discussed the role of symbols and cultural meanings in land-use decisions, including societal perceptions of agricultural land. Research by Colchester et al. (2007) highlighted land conflicts between plantation developers and indigenous communities, often stemming from cultural values associated with the land. This semiotic perspective is essential to ensure plantation development respects cultural sensitivities and local community rights. Larsen et al. (2012) supported these findings, offering an in-depth analysis of land-use conflicts in Kalimantan caused by oil palm plantation expansion. Using GIS technology, researchers mapped conflict areas between plantations and indigenous lands, emphasizing factors such as customary land rights and communal land management. The findings revealed that discrepancies between plantation needs and traditional land rights often lead to disputes, affecting productivity and the plantation industry's reputation. This study underscores the relevance of GIS not only for land suitability analysis but also for identifying potential social conflicts before plantation development.

Advancements in geospatial information technologies have significantly transformed the way optimal locations for crop farming are identified and managed, offering systematic and data-driven approaches to address global agricultural challenges. Geographic Information System (GIS) analysis, integrating technologies such as Remote Sensing, GPS, and advanced modeling tools, has emerged as a cornerstone for spatial decision-making in agriculture. These technologies enable the precise mapping, monitoring, and assessment of agricultural lands, supporting sustainable land-use planning and resource management on a global scale (Annuar, 2000; Xaviar, 2001). Remote Sensing, in particular, provides large-scale, high-resolution data for assessing critical factors such as soil fertility, vegetation health, water availability and climate conditions. This capability is invaluable for determining land suitability for crop farming, especially in regions affected by resource scarcity or climate variability (Hudak and Wessman, 1998). GIS platforms integrate these data layers, enabling multi-criteria decision-making that evaluates factors such as environmental risks, accessibility, infrastructure and economic viability. Through spatial modeling, GIS analysis can provide insights that guide sustainable agricultural development and improve productivity. One of the methodologies employed within GIS analysis is the Analytical Hierarchy Process (AHP), which offers a structured approach for incorporating both qualitative and quantitative criteria into land suitability assessments. For example, AHP has been used to evaluate soil quality, water availability, and transportation costs to determine the most viable locations for farming or processing facilities (Kumar et al., 2018). While AHP is an effective tool within GIS, other techniques, such as machine learning algorithms and spatial interpolation models, have also been integrated to enhance predictive accuracy and address complex agricultural scenarios. These approaches allow for real-time decision-making and continuous monitoring of agricultural lands.

The applications of GIS in agriculture extend beyond farming. For instance, GIS has been used in urban land-use planning for waste management, where Saaty and Vargas (2001) demonstrated the integration of environmental, social, and economic factors. Similarly, in agricultural tourism planning, GIS-based analyses have been applied to identify regions with the greatest potential for development, combining factors like infrastructure, accessibility, and regional attractiveness (Yavuz and Ülengin, 2019). These examples underscore the versatility of GIS as a decision-support system for diverse land-use applications, including crop farming. By leveraging GIS technologies and methodologies, agricultural stakeholders can optimize land-use decisions, mitigate environmental risks, and enhance food security. As global food systems face increasing pressure from population growth and climate change, the role of GIS in shaping sustainable and efficient agricultural practices is becoming more critical than ever.

This study's importance stems from its systematic review approach. Unlike other studies that may focus on single methodologies or narrow aspects, this research synthesizes findings from 69 peer-reviewed studies, emphasizing the integration of Geographic Information System (GIS) analysis, Remote Sensing, and Multi-Criteria Decision Analysis (MCDA) for optimal location selection. It highlights the critical role of combining environmental, economic, and social factors for better decision-making in crop farming, addressing the multifaceted challenges of sustainable agriculture and global food security more comprehensively. The study also critically examines the use of GIS, remote sensing, and AHP in combination, and considers both quantitative and qualitative factors in the selection of appropriate locations.

Methodology

1. Review Protocol

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was chosen as the methodology for conducting the systematic literature review (SLR). The SLR was performed based on the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) statement (Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. 2021). It provides a clear framework for our research, covering the whole process from literature retrieval, screening to result reporting. Its advantages lie in the fact that it is adopted by numerous disciplines worldwide, facilitating comparison and communication among different studies and ensuring the transparency and reproducibility of the research. . The SLR process began with the formulation of research questions based on the PICo method. PICo stands for ‘P’ for Problem or Population, ‘I’ for Interest, and ‘Co’ for Context. The document search was then carried out based on three systematic stages: 1) Identification, 2) Screening, and 3) Eligibility.

2. Systematic Searching Strategies

The procedure for selecting the papers was divided into four stages: 1) database selection, 2) paper extraction, 3) abstract screening, and 4) full-text screening. These phases are visualized in Figure 1. Finally, the data extracted from the papers were analyzed using qualitative data synthesis.

3. Formulation of the Research Question

This study uses the PICO method to construct research questions. "P" (Population) refers to Agricultural land suitable for crop farming; specifically, locations where challenges like climate change, soil degradation and resource scarcity are significant. The geographical scope is global, with a focus on regions with oil palm and other major crop production. “I” (Intervention) refers Geographic Information Systems (GIS), Remote Sensing, Multi-Criteria Decision Analysis (MCDA), and Analytical Hierarchy Process (AHP) in combination as tools for determining optimal crop farming locations. “C” Implicit comparison is made to traditional methods of crop location planning that may not incorporate these advanced technological and analytical approaches and “O” refers to Sustainable and efficient agricultural practices; improved decision-making for optimal land-use planning, reduced environmental impact, and enhanced food security. By using the PICO elements, several research questions can be formulated which is how effectively do integrated GIS, Remote Sensing, MCDA, and AHP methodologies support the determination of optimal crop farming locations to promote sustainable agricultural practices and address global food security challenges? And also specific research questions explored include the comparative performance of integrated versus traditional approaches, the most effective combinations of GIS, Remote Sensing, MCDA, and AHP techniques, the influence of social and cultural factors on locational decisions, and challenges in integrating these technologies within diverse contexts. The overarching goal is to understand how these advanced technologies can contribute to more informed and sustainable land-use planning for crop farming.

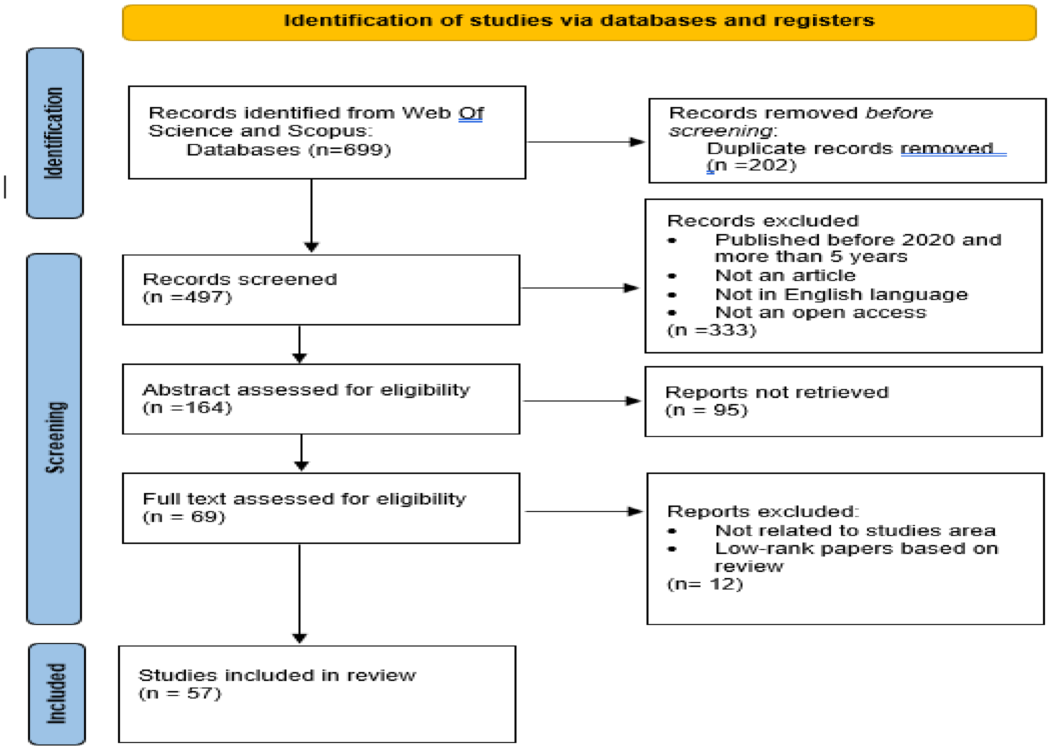

Figure 1. Flow diagram of the process

4. Identification

Identification is the process of locating relevant keywords based on the research questions. Several keywords were used to form search strings for the study. These search strings were applied to the search boxes of the chosen databases. Two databases were selected for the paper search process: 1) Web of Science by Thomson Reuters, and 2) SCOPUS by Elsevier. Table 1 shows the search strings applied during the paper search process.

Table 1. The search strings

Database	**Search strings**
Web of Science	TS=((Plantation) AND (Location OR Optimal Location) AND (Map OR Mapping OR AHP))
SCOPUS	TITLE-ABS-KEY((Plantation) AND (Location OR Optimal Location) AND (Map OR Mapping OR AHP))

5. Screening

The screening process involved removing 202 duplicate papers identified across both databases. Following this, the remaining 497 papers were filtered using the following criteria: 1) publication year, 2) document type (only articles were considered for the SLR), 3) papers written in English, and 4) open-access papers only. As a result of this filtering, 333 papers were excluded, leaving 164 papers to be evaluated in the next stage on the eligibility process.

6. Eligibility

Eligibility involved a manual examination of the papers by the researcher. This process aimed to ensure that all remaining articles met the necessary requirements. It included an abstract assessment to determine whether the papers were appropriate for the review. Following the abstract assessment, 69 papers were selected for the next stage, the full-text assessment, after excluding 95 papers that were unrelated to the study. The selected papers then underwent a full-text assessment, after which only 69 papers proceeded to be ranked through the quality appraisal procedure.

7. Quality appraisal
The quality of the articles was assessed through quality appraisal procedure. The remaining 69 papers from eligibility procedure were examined by two chosen reviewers. The remaining articles were divided into three quality categories which are high, moderate and low. In this last stage of screening, 12 papers were excluded because of 2 reason which is not related to studies area and also low-rank papers based on review.

The Findings

This section presents the key findings derived from a systematic review of 69 peer-reviewed studies investigating methodologies and technologies used to determine optimal locations for crop farming. The review focused on the integration of Geographic Information Systems (GIS) analysis, Remote Sensing, and Multi-Criteria Decision Analysis (MCDA), specifically highlighting the role of the Analytical Hierarchy Process (AHP). The findings are categorized thematically to illustrate the prevalence and effectiveness of different approaches in addressing the complex challenges of sustainable land use planning for crop production in diverse contexts, also considering the limitations and challenges faced. The analysis explores the strengths and weaknesses of various methodologies and their applications in different geographical regions and farming systems, ultimately contributing to a comprehensive understanding of current best practices and outstanding research needs.

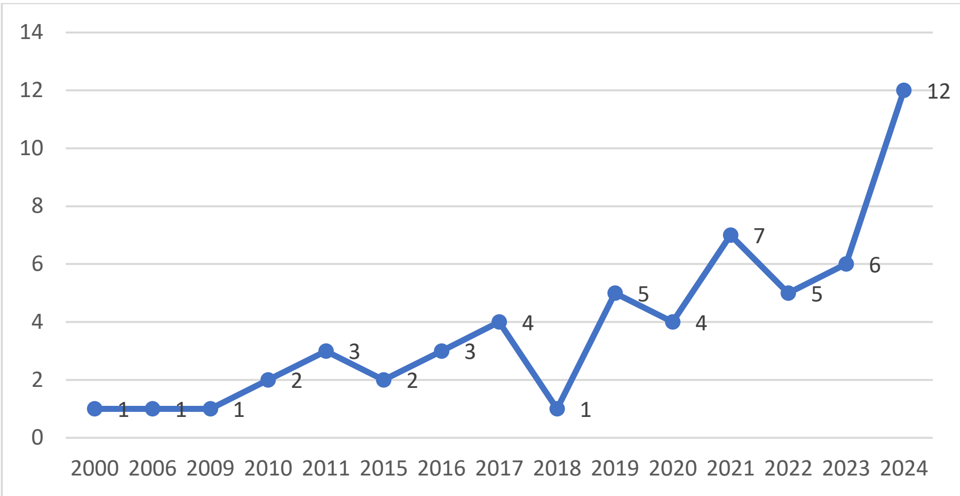

Figure 1. Temporal distribution of the selected articles

The line graph illustrates the temporal distribution of research articles included in a systematic literature review, spanning from 2000 to 2024. Publication rates remained low and relatively stable until 2010, after which a gradual, though fluctuating, increase is observed, culminating in a peak of seven publications in 2021. However, a dramatic surge in research output is evident in 2023 and 2024, with twelve publications in 2024. This substantial increase suggests a recent acceleration in research activity within the field, potentially driven by factors such as technological advancements, heightened awareness of the topic's importance, or increased funding opportunities. Further analysis would be required to fully explain this recent growth.

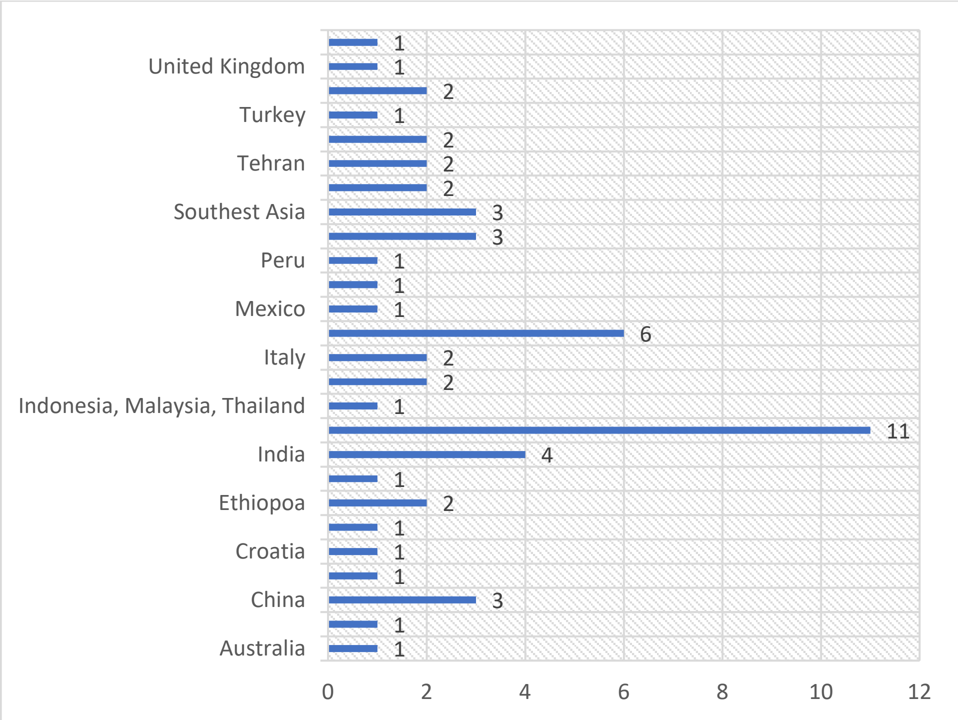

Figure 2. Country distribution of the selected articles

The bar graph displays the country distribution of the selected articles, showing the number of publications originating from each country. Indonesia has the highest number of publications (11), reflecting a significant concentration of research in that nation. Malaysia also shows a substantial number of publications (6), indicating considerable research activity within the country. Other countries, including India (4), China (3), Philippines (3), and several others, are represented but with a fewer number of publications. Many countries only have one or two publications, suggesting a less prominent role in the research output on this specific topic. The geographical distribution of research highlights Indonesia's prominence in the field, along with a noticeable presence of research in Malaysia and a more scattered representation across other regions.

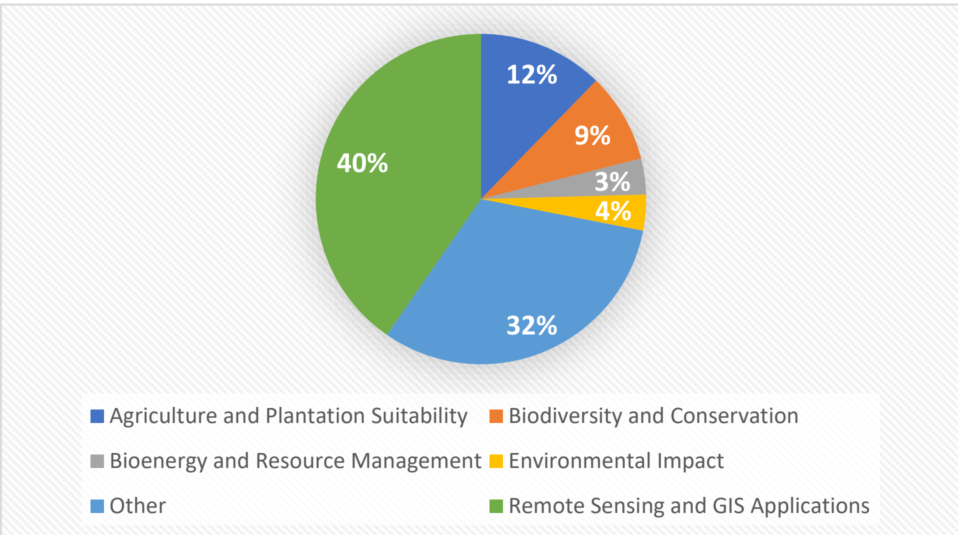

Figure 3. Contextual issue

The pie chart illustrates the contextual issues addressed in the reviewed articles. The largest proportion (40%) focuses on agriculture and plantation suitability, indicating a significant emphasis on optimizing land use for crop production. A substantial portion (32%) addresses other contextual issues, likely encompassing a broad range of topics related to sustainable land management and agriculture. Remote sensing and GIS applications account for 12%, showcasing the considerable interest in using these technologies for spatial analysis and decision-making in agriculture. Biodiversity and conservation constitute 9%, while the environmental impact receives only 4% of attention and bioenergy and resource management only 3%. This distribution suggests a strong focus on optimizing land use for agricultural purposes and leveraging geospatial technologies, alongside considerations for biodiversity and the environmental implications of agricultural practices. However, the "other" category's significant size suggests considerable diversity in research topics beyond those specifically categorized.

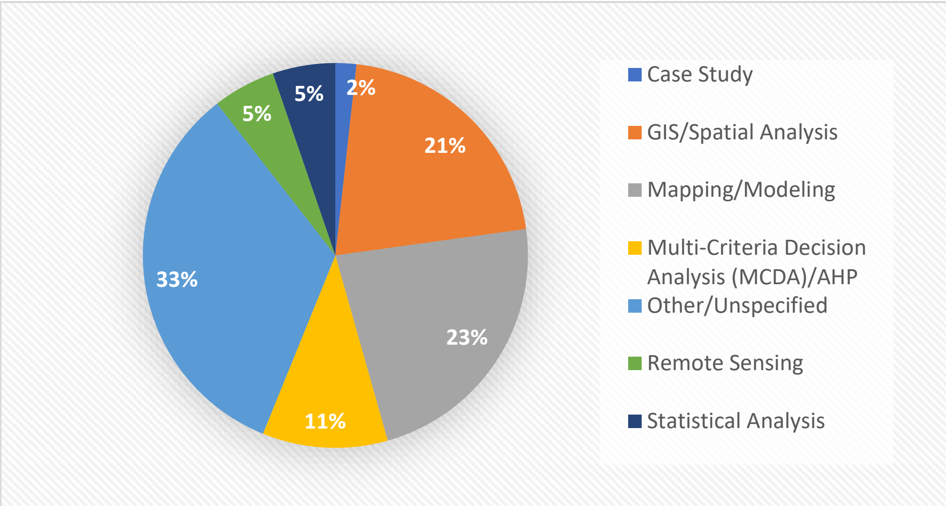

Figure 4. Method used

The pie chart summarizes the methodologies employed in the reviewed articles. GIS/spatial analysis is the most dominant method, accounting for 21% of the studies. Mapping/modeling techniques represent a substantial portion (23%), highlighting the importance of spatial representation and predictive modeling in this research area. Other/unspecified methods constitute a considerable 33%, indicating a diversity of approaches beyond those explicitly categorized. Multi-criteria decision analysis (MCDA)/AHP, a valuable tool for integrating multiple criteria in decision-making, is used in 11% of the studies. Remote sensing and statistical analysis each account for a smaller percentage (5% and 2% respectively), suggesting a less prominent role compared to other methodologies. The substantial proportion of unspecified methods indicates the existence of a range of diverse and potentially innovative approaches not included in the primary categories presented. The prominent role of GIS and spatial analysis, combined with the prevalence of modeling techniques, underscores the field's dependence on geospatial data and technologies.

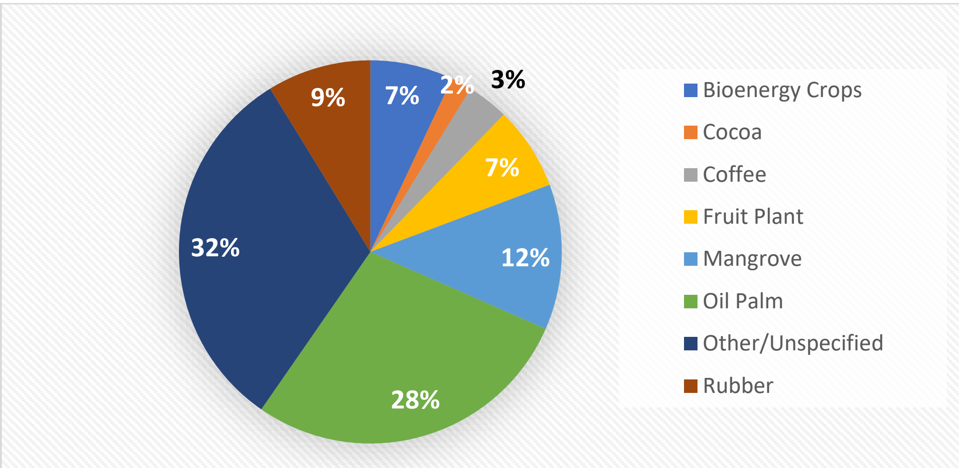

Figure 5. Type of plantations

The pie chart shows the distribution of plantation types across the reviewed articles. Oil palm is the most frequently studied plantation type, accounting for 28% of the articles. A substantial portion (32%) focuses on other or unspecified plantation types, suggesting a diversity of crops beyond those specifically categorized. Mangrove plantations represent 12% of the studies, reflecting the considerable interest in their suitability assessment and sustainable management. Rubber plantations constitute 9%, while cocoa and fruit plants each account for a smaller percentage (7% and 7% respectively). Coffee accounts for 3%, and bioenergy crops only 2%. This distribution highlights the prominence of oil palm and mangrove plantations in the literature, alongside a range of other crops, indicating a diverse scope of research into optimal location determination for various plantation types. The large "other/unspecified" category suggests that several plantation types were not clearly categorized or were less frequently discussed within the reviewed studies.

Thematic Analysis

1. GIS/Spatial Analysis
GIS and spatial analysis are among the most extensively utilized methods in studies related to "Agriculture and Plantation Suitability" and "Biodiversity and Conservation." These methods enable researchers to integrate various geospatial datasets, including land use, topography, soil fertility, and climate data, to determine optimal plantation sites. GIS plays a pivotal role in precise spatial mapping and supports multi-scale analyses. For example, Sahraei et al. (2024), in "Mangrove Plantation Suitability Mapping by Integrating GIS and Remote Sensing," demonstrated how GIS synthesizes spatial data to assess plantation suitability. Similarly, Syahid et al. (2020), in "Determining Optimal Location for Mangrove Plantations in Southeast Asia Using GIS," emphasized the utility of GIS in enhancing plantation planning, particularly in biodiversity-sensitive regions.

2. Remote Sensing and Mapping/Modeling
Remote Sensing, often combined with mapping and modeling techniques, is the most frequently applied methodology in the "Remote Sensing and GIS Applications" category. This approach provides high-resolution data on land cover, vegetation health, and environmental conditions, enabling large-scale assessments of agricultural and ecological systems. Danylo et al. (2021), in "A Map of the Extent and Year of Detection of Oil Palm Plantations in Southeast Asia," utilized Remote Sensing to map the expansion of oil palm plantations. Kalischek et al. (2023), in "Cocoa Plantations Are Associated with Deforestation in West Africa," employed modeling techniques to evaluate the environmental impacts of cocoa plantations. Similarly, Xu and Mola-Yudego (2021), in "Where and When Are Plantations Established? Large-Scale Insights Using Remote Sensing," leveraged satellite imagery to detect land-use changes, showcasing the predictive power of Remote Sensing in plantation studies.

3. Multi-Criteria Decision Analysis (MCDA) and AHP
MCDA, including the Analytical Hierarchy Process (AHP), is a crucial decision-making tool, particularly in studies addressing "Agriculture and Plantation Suitability" and "Biodiversity and Conservation." These methods allow for the integration of multiple criteria, such as soil quality, water availability, environmental risks, and infrastructure, to prioritize optimal plantation locations. Sahraei et al. (2024), in "Mangrove Plantation Suitability Mapping by Integrating GIS and Remote Sensing," employed AHP within their GIS framework to systematically rank suitable areas for mangrove plantations. Similarly, Syahid et al. (2020), in "Determining Optimal Location for Mangrove Plantations in Southeast Asia Using GIS," showcased how AHP could facilitate informed decision-making by balancing quantitative and qualitative criteria.

4. Case Study Approaches
Case study methodologies are employed less frequently but are often applied in "Agriculture and Plantation Suitability" research. These studies focus on localized or specific plantation projects, providing in-depth insights into regional practices, challenges, and opportunities. For instance, Sahraei et al. (2024), in

"Mangrove Plantation Suitability Mapping by Integrating GIS and Remote Sensing," included case studies to validate their findings, highlighting the importance of understanding local contexts.

5. Other Unspecified Methods
Some studies utilize unspecified geospatial or analytical methods, which are concentrated in broader categories like "Remote Sensing and GIS Applications." Danylo et al. (2021), in "A Map of the Extent and Year of Detection of Oil Palm Plantations in Southeast Asia," demonstrate how innovative and flexible methodologies can address large-scale plantation management challenges, particularly in regions experiencing rapid land-use change.

Discussion

Advancements in geospatial analysis methods have significantly contributed to determining optimal locations for crop farming. One of the most prominent methods is GIS/Spatial Analysis, which integrates diverse datasets such as topography, soil properties, water availability and climatic conditions into a unified platform. This enables precise spatial mapping and multi-scale analysis, making it a cornerstone for informed agricultural decision-making. For instance, Sahraei et al. (2024), in their study "Mangrove Plantation Suitability Mapping by Integrating GIS and Remote Sensing," demonstrated how GIS synthesizes geospatial and environmental data to assess plantation suitability. Similarly, Syahid et al. (2020), in "Determining Optimal Location for Mangrove Plantations in Southeast Asia Using GIS," emphasized the role of GIS in biodiversity-sensitive plantation planning. Remote Sensing is another critical tool, providing high-resolution, real-time spatial data for large-scale monitoring of land-use changes, vegetation health and environmental conditions. This method supports both short-term decision-making and long-term strategic planning. Studies like Danylo et al. (2021), in "A Map of the Extent and Year of Detection of Oil Palm Plantations in Southeast Asia," and Xu and Mola-Yudego (2021), in "Where and When Are Plantations Established? Large-Scale Insights Using Remote Sensing," highlight its importance in detecting plantation expansion and identifying suitable agricultural land. The predictive capabilities of Remote Sensing allow researchers to evaluate sustainability practices and forecast future trends effectively.

Multi-Criteria Decision Analysis (MCDA), including the Analytical Hierarchy Process (AHP), offers a structured framework for addressing multi-dimensional criteria in crop farming. These methods are particularly useful for balancing quantitative and qualitative factors such as soil fertility, transportation costs, environmental risks and infrastructure availability. Sahraei et al. (2024) and Syahid et al. (2020) employed AHP within GIS frameworks to prioritize plantation locations by integrating suitability criteria. AHP's hierarchical structure ensures rational and consistent decision-making, with a consistency index validating results and providing confidence in the outcomes.

Mapping and modeling techniques also play a vital role, particularly in understanding current land-use patterns and predicting future scenarios. These methodologies are essential for large-scale studies that quantify spatial relationships and trends. For example, Kalischek et al. (2023), in "Cocoa Plantations Are Associated with Deforestation in West Africa," used modeling techniques to evaluate the environmental impacts of cocoa plantations, while Xu and Mola-Yudego (2021) utilized predictive models to analyze land-use changes and identify areas suitable for plantation establishment. Case study methodologies complement these broader geospatial methods by providing localized and context-specific insights. Although less frequently used, case studies are crucial for understanding regional challenges and refining decision-making processes. For example, Sahraei et al. (2024) incorporated case studies to validate their geospatial analysis findings, emphasizing the importance of on-the-ground data in plantation suitability assessments.

Additionally, some studies employed unspecified or emerging methods, particularly in broad categories like Remote Sensing and GIS Applications. These approaches reflect the adaptability and innovation of geospatial technologies. For instance, Danylo et al. (2021) utilized innovative geospatial methods to address large-scale plantation management challenges in Southeast Asia, showcasing how hybrid methodologies can enhance the accuracy and efficiency of spatial decision-making.

In summary, the integration of GIS, Remote Sensing, MCDA/AHP, mapping and modeling, and case studies forms a robust framework for determining optimal crop farming locations. GIS and Remote Sensing provide foundational tools for spatial analysis and monitoring, while MCDA and AHP address complex, multi-dimensional criteria. Mapping and modeling techniques offer predictive capabilities and case studies ensure localized context is considered. Together, these methods contribute to sustainable and efficient agricultural practices, addressing global challenges such as resource allocation, environmental conservation, and food security.

Recommendations

To address the challenges identified in plantation and land-use research, several recommendations can be made. First, adopting advanced technologies such as GIS and Multi-Criteria Decision Analysis (MCDA) is crucial for land suitability assessments. These tools provide accurate evaluations of environmental and socio-economic factors, enabling better decision-making for plantation expansion. For instance, Sahraei et al. (2024) demonstrated the effective use of GIS in evaluating mangrove plantation suitability. By integrating such tools into planning processes, policymakers can ensure sustainable land use and resource allocation.

Second, integrated conservation strategies should be prioritized to mitigate biodiversity loss caused by plantation expansion. Research by Kalischek et al. (2023) highlighted the importance of biodiversity corridors in protecting threatened species in oil palm landscapes. Similarly, Danylo et al. (2021) emphasized the role of mangrove restoration in improving coastal resilience and carbon sequestration. Governments and stakeholders must implement policies that align agricultural productivity with ecological goals, ensuring a balance between economic development and biodiversity preservation.

Sustainable land-use practices, such as agroforestry systems, are another vital recommendation. Agroforestry has been shown to maintain productivity while preserving ecological integrity (Kalischek et al., 2023). Policymakers should encourage these practices through subsidies, training programs, and market incentives for sustainably produced goods. Additionally, monitoring tools like those described by Xu and Mola-Yudego (2021) can guide the assessment of land-use changes and inform future planning efforts. These measures would help mitigate the negative environmental impacts of plantation expansion.

Leveraging remote sensing technologies combined with artificial intelligence (AI) offers significant potential for enhancing plantation monitoring and management. Syahid et al. (2020) illustrated the value of satellite data, such as Landsat and PALSAR, in mapping oil palm plantations. However, challenges such as data resolution and the need for validation remain. Integrating AI algorithms to process large datasets could improve the precision and scalability of monitoring efforts. Collaboration between research institutions and governments is essential to incorporate these technologies into national land management systems.

Community-inclusive approaches must also be emphasized to address socio-economic issues associated with plantations. Participatory strategies, such as social forestry programs, empower local communities and reduce conflicts over land use. Xu and Mola-Yudego (2021) highlighted the success of such programs in the Batanghari KPHP Area, where community engagement improved rural livelihoods. Governments and NGOs should prioritize equitable benefit-sharing mechanisms and provide platforms for dialogue to address power imbalances and ensure fair compensation for land use.

To meet the growing demand for bioenergy crops, focusing on the sustainability of bioenergy plantations is critical. Xu and Mola-Yudego (2021) identified the potential of utilizing marginal lands for sustainable biofuel production, which avoids competition with food crops. Policymakers should encourage crop diversification and integrate lifecycle analyses into bioenergy policies to ensure long-term sustainability. These measures can help mitigate environmental and food security concerns while supporting renewable energy goals.

Finally, investing in localized research and case studies is essential to tailor plantation strategies to specific regions. For example, Syahid et al. (2020) demonstrated the utility of Landsat data in monitoring citrus plantations, while Xu and Mola-Yudego (2021) explored the potential for rubber plantation expansion in Assam. These case studies provide valuable lessons that can inform practices in similar ecological and socio-economic contexts. Sharing best practices globally could significantly enhance plantation management strategies.

Conclusion

In conclusion, the review of 69 articles demonstrates that sustainable plantation management depends on a multi-dimensional approach. The integration of advanced geospatial methods such as GIS, Remote Sensing, Multi-Criteria Decision Analysis (MCDA), and Analytical Hierarchy Process (AHP), along with mapping, modeling, and case studies, has significantly enhanced the determination of optimal locations for crop farming. GIS and Remote Sensing provide foundational tools for large-scale spatial analysis and real-time monitoring, while MCDA and AHP offer structured frameworks for addressing complex multi-criteria decision-making. Mapping and modeling techniques contribute predictive capabilities, enabling researchers to forecast trends and assess sustainability, while case studies ensure that local contexts are considered. Together, these methodologies form a comprehensive framework for sustainable and efficient agricultural planning, addressing challenges such as land suitability, resource management, and environmental conservation, ultimately supporting global food security and agricultural resilience.

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