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ADVANCEMENTS AND INTEGRATION OF BIOPHYSICAL, SOCIO-ECONOMIC, AND LOCAL KNOWLEDGE IN AGRICULTURAL LAND SUITABILITY ASSESSMENTS: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Land suitability assessments are pivotal for sustainable land use planning, agricultural productivity, and environmental management. Despite substantial advancements, a comprehensive understanding of methodologies, applications, and sustainability challenges across diverse contexts remains limited. This systematic literature review aims to address these gaps by examining advancements, regional practices, and adaptation strategies in land suitability assessments. Using the PRISMA framework, an advanced search of Scopus and Web of Science databases identified 34 eligible studies (n = 34) for analysis. These studies were categorized into three key themes: (1) advancements in methodologies, including GIS-based multi-criteria decision-making (MCDM), machine learning, and hybrid models; (2) applications of land suitability for specific crops and regions, highlighting varying ecological and socio-economic factors influencing implementation; and (3) sustainability and adaptation in land use planning, focusing on the integration of climate resilience and resource conservation. Results indicate that GIS-MCDM approaches dominate, representing 65% of the studies, with machine learning and hybrid methods contributing 20% and 15%, respectively. The review underscores the increasing role of advanced technologies such as remote sensing and IoT in improving precision, yet challenges persist in parameter selection, data quality, and integrating socio-environmental dimensions. This review concludes that while progress in methodologies and applications is evident, future efforts must emphasize sustainability and adaptive strategies to address evolving land use challenges. The findings provide critical insights for researchers and policymakers to enhance land suitability assessments and promote sustainable development practices.

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INTRODUCTION

Land suitability assessment (LSA) is a critical component of sustainable agricultural development, providing a scientific basis for optimizing land use while minimizing environmental impacts (Ahmadi Mirghaed et al., 2020; Han et al., 2021; Montgomery et al., 2016; Wei et al., 2021; Yin et al., 2020). In a rapidly changing world marked by climate variability, population growth, and increasing demand for food security, identifying and utilizing suitable lands for agriculture is of paramount

importance. LSA enables informed decision-making by evaluating the physical, chemical, and socio-economic characteristics of land in relation to specific crop requirements. This systematic approach helps maximize productivity, conserve natural resources, and promote sustainable agricultural practices, making it an indispensable tool for policymakers, planners, and stakeholders in the agricultural sector(Afzal et al., 2021; Amoah & Kwarteng, 2020; Khan et al., 2022; Ngadi et al., 2023; Onegina et al., 2020).

Over the years, significant advancements have been made in LSA methodologies, leveraging advancements in Geographic Information Systems (GIS), remote sensing, and Multi-Criteria Decision-Making (MCDM) techniques(Chughtai et al., 2021; Costa et al., 2018; Perminova et al., 2016; Valiyev & Mirzayev, 2023). Prominent studies have explored the integration of GIS-based tools with MCDM frameworks, such as Analytical Hierarchy Process (AHP) and Weighted Linear Combination (WLC), to evaluate land suitability for various crops. For example, studies have successfully identified optimal sites for crops like rice, wheat, and maize by combining soil quality, topography, and climatic conditions using these advanced methodologies. Additionally, researchers have highlighted the potential of integrating expert knowledge with geospatial data to improve the precision and reliability of LSA results(Insani et al., 2015; Kalogirou, 2002; Maroeto et al., 2022).

Despite these advancements, several gaps and challenges remain in the existing research bodies. One major limitation is the inadequate incorporation of local knowledge and socio-economic factors, which are crucial for context-specific land suitability assessments. Most studies tend to prioritize biophysical parameters, often overlooking the complex interplay between human factors and land-use decisions(Herzberg et al., 2019; Shahpari & Eversole, 2024; Sharifian et al., 2023; Topp et al., 2022). Moreover, existing frameworks sometimes lack robust mechanisms for validating LSA outcomes, raising questions about their accuracy and applicability across diverse agricultural landscapes. Another pressing issue is the lack of standardized criteria for parameter weighting, which often leads to inconsistent and subjective results. These gaps underscore the need for more holistic and integrative approaches to LSA.

This article addresses these unresolved issues by proposing a novel conceptual framework for agricultural land suitability assessment, which systematically integrates expert and local knowledge within a GIS-based MCDM approach, extending beyond prior studies that have focused on individual aspects of these components (Herzberg et al., 2019; Shahpari & Eversole, 2024; Sharifian et al., 2023; Topp et al., 2022). The research question guiding this study is: How can the integration of expert and local knowledge enhance the accuracy and applicability of land suitability assessments for agriculture? The framework seeks to bridge the gap between theoretical advancements and practical applications by emphasizing participatory approaches and robust validation mechanisms.

The objectives of this article are twofold: first, to develop a comprehensive and adaptable framework that integrates biophysical, socio-economic, and local knowledge parameters for LSA; and second, to demonstrate its application through a case study. By addressing these objectives, this study contributes to advancing the field by offering a more inclusive, precise, and scalable approach to LSA. Ultimately,

the proposed framework aims to support sustainable agricultural practices and informed land-use planning, fostering resilience in agricultural systems amid global challenges.

Literature Search

The concept of land suitability frameworks is central to achieving sustainable land use, as it facilitates informed decision-making that considers environmental, economic, and social dimensions. These frameworks have evolved significantly, integrating various methodologies and technologies to assess the potential of land for specific uses. One of the foundational approaches is the FAO framework, which classifies land based on physical characteristics and suitability for agriculture. It uses thematic maps and geographic information systems (GIS) to evaluate factors such as soil, climate, and topography, as demonstrated in a study focused on mango cultivation in Malaysia(Elsheikh, 2016). This review primarily focuses on studies published between 2023 and 2024, while including key foundational works prior to this period to provide essential context for the evolution of land suitability assessment frameworks. Beyond traditional frameworks, more recent approaches integrate multi-criteria decision-making (MCDM) methods to enhance accuracy and scalability. For instance, the Analytic Hierarchy Process (AHP) is widely employed to assign weights to various criteria, aiding in decision support systems. A study by Bojórquez-Tapia S.& Ezcurra, E., (2001) illustrated the use of participatory decision-making in land suitability analysis, incorporating stakeholder inputs to align assessments with local needs. This participatory approach ensures that socio-economic and environmental considerations are harmonized in land use planning.

Another noteworthy development in land suitability frameworks is the application of fuzzy logic and matter-element models, which allow for more nuanced classifications. Traditional Boolean methods often force a binary classification, which may not reflect the inherent variability in land characteristics. Fuzzy logic, as used by (Ahamed K.G.; Murthy, J., 2000), enables the assignment of partial suitability, thus addressing uncertainties and overlaps in classifying land for specific uses. Similarly, Gong and Chen (2012) utilized matter-element theory to classify land suitability in urban-rural areas, offering a framework that effectively balances development needs with environmental constraints.

In urban planning, the Land Suitability Index (LSI) introduced by Marull et al., (2007) offers a modular approach to assess the impacts of developmental land use. This framework incorporates ecological, cultural, and socio-economic factors, providing a holistic evaluation for strategic environmental assessment. The LSI was successfully applied to Barcelona's metropolitan region, highlighting inconsistencies in municipal planning and emphasizing the need for integrative approaches.

A critical aspect of land suitability frameworks is their adaptability to various contexts, from agriculture to urban development. Koomen et al., (2015) proposed an integrated model that combines inductive and deductive methodologies to evaluate utility-based suitability for agriculture and urban land use. This model, which combines hedonic pricing with statistical analysis, highlights the importance of economic valuation in land suitability assessment. It demonstrated significant improvements in accuracy and applicability compared to traditional methods.

GIS-based frameworks remain at the forefront of land suitability analysis due to their ability to integrate diverse datasets and visualize spatial patterns. (Xu H., 2013) incorporated spatially explicit sensitivity analysis into GIS-based MCDM frameworks, enhancing their robustness and reliability. This method, tested in the Yili region of China, provided critical insights into the spatial variability of sensitivity parameters, allowing for more informed planning decisions. Similarly, Roberts and Chiesa (1979) emphasized the utility of GIS in evaluating environmental constraints, enabling planners to assess the implications of land-use changes quantitatively.

The integration of ecosystem services and ecological sensitivity into land suitability frameworks represents another significant advancement. Guo and Gao (2020) developed a framework that evaluates land suitability based on green infrastructure, providing a comprehensive approach to balancing ecological preservation with urban and agricultural needs. This model, applied to Harbin, China, demonstrates how ecosystem services can guide spatial planning to achieve sustainability goals.

Despite these advancements, challenges remain in standardizing methodologies and ensuring their global applicability. For instance, while frameworks like AHP and fuzzy logic offer flexibility, their reliance on expert judgment can introduce subjectivity. Additionally, the integration of socio-economic data with biophysical parameters requires robust data collection and processing capabilities, which may not be universally accessible. However, the continued evolution of GIS and remote sensing technologies promises to bridge these gaps, making land suitability frameworks more accessible and reliable.

In conclusion, frameworks for land suitability have evolved to address the complex interplay between environmental, economic, and social factors in land use planning. From foundational approaches like the FAO framework to advanced GIS-based and participatory methods, these frameworks offer valuable tools for sustainable development. The integration of multi-criteria decision-making, fuzzy logic, and ecological considerations highlights the potential for these frameworks to adapt to diverse contexts and challenges. Future research should focus on standardizing methodologies and enhancing their scalability to ensure their effectiveness across different regions and scales.

Research Question

The PICo framework is a mnemonic style used to formulate research questions, particularly in qualitative research proposed by Lockwood et al., (2015) was applied in this study. Using the PICo framework helps in structuring research questions clearly and systematically by breaking down the key elements of the study into these three components. This approach ensures that the research is focused and the questions are well-defined, making it easier to search for relevant literature or design a study. This study achieved three research question as below;

1. "How do advancements in GIS, multi-criteria decision analysis, and emerging technologies enhance the precision and efficiency of land suitability assessments across diverse applications?"
2. "What methodologies and criteria are predominantly utilized in assessing land suitability for specific crops and how do regional variations influence their application? "

3. "How are sustainability principles and climate adaptation strategies incorporated into land suitability assessments to support long-term agricultural and environmental resilience? "

MATERIALS AND METHODS

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach is a widely accepted standard ensuring transparency, completeness, and consistency in systematic literature reviews (Page et al., 2021). It enhances the rigor and accuracy of analysis by guiding researchers in systematically identifying, screening, and including studies while emphasizing the importance of randomized studies to reduce bias. This review utilized Web of Science and Scopus for their comprehensive coverage and reliability.

PRISMA follows four stages: identification, where databases are searched for relevant studies; screening, where studies are filtered based on predefined criteria; eligibility, where selected studies are assessed for inclusion; and data abstraction, where key data is extracted and synthesized. This structured approach ensures rigorous and reliable reviews, supporting evidence-based research and practice.

Identification

The process began with the selection of keywords and the identification of related terms, drawing on resources such as dictionaries, thesauri, encyclopaedias, and previous studies. All identified terms were consolidated, and search strings were developed to query the Web of Science and Scopus databases (as outlined in Table 1). This initial phase of the systematic review resulted in 1,116 publications relevant to the study topic being retrieved from the two databases.

Table (1): The search strings

Scopus	TITLE-ABS-KEY ("Land suitability" AND (assessment OR evaluation OR judge*) AND agricultur*) AND (LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "SOCI")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (LANGUAGE , "English")) **Date of Access: Jan 2025**
WoS	Refine results for ALL= ((“Land suitability" AND (assessment OR evaluation OR judge*) AND agriculture*)) and 2023 or 2024 (Publication Years) and Article (Document Types) and Environmental Sciences or Green Sustainable Science Technology or Agriculture Multidisciplinary or Agricultural Engineering (Web of Science Categories) **Date of Access: Jan 2025**

Screening

During the screening phase, potentially relevant research items are evaluated to ensure alignment with the predefined research question(s). This stage typically involves selecting research topics related to agricultural land assessment. Duplicate documents are removed as part of this process. From the initial set of publications,

977 were excluded, leaving 139 papers for further analysis based on specific inclusion and exclusion criteria (refer to Table 2). The primary criterion focused on the type of literature, emphasizing primary sources of valuable insights such as book series, book reviews, meta-syntheses, meta-analyses, conference proceedings, and chapters omitted from the latest studies. Only English-language publications from 2023 to 2024 were included in the review. Ultimately, 21 publications were excluded due to duplication.

Table (2): The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2023 - 2024	< 2023
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press
Subject Area	Environmental Science, Agricultural and Biological Science, Social Science	Besides Environmental Science Agricultural and Biological Science Social Science Malaysia

Eligibility

In the third step, known as the eligibility phase, 118 articles were selected for a detailed review. During this stage, the titles and core content of each article were thoroughly assessed to verify their compliance with the inclusion criteria and alignment with the research objectives. Following this evaluation, 84 articles were excluded for reasons such as being beyond the study's scope, having irrelevant titles, containing abstracts unrelated to the research objectives, or lacking full-text availability. As a result, 34 articles were retained for further analysis.

Data Abstraction and Analysis

An integrative analysis was employed in this study as a key assessment strategy to examine and synthesize a variety of research designs, primarily quantitative methods. The primary objective of this approach was to identify relevant topics and subtopics. The process began with data collection, marking the initial step in theme development. As depicted in Figure 1, the authors meticulously analysed a set of 34 publications to extract assertions or materials pertinent to the study's focus areas. This analysis was followed by an evaluation of significant studies related to land suitability assessment, where the methodologies and findings of these studies were systematically reviewed. Collaboration played a critical role in theme development, as the authors worked together to derive themes based on the evidence within the study’s context. Throughout the data analysis process, a log was maintained to document analyses, perspectives, challenges, and insights relevant to data interpretation. To ensure consistency in the theme design process, the results were compared, and any inconsistencies were addressed collaboratively. Notably, any disagreements between concepts were resolved through discussion among the authors, ensuring a cohesive and comprehensive analysis.

Table (3): Number and details of Primary Studies Database

No	Authors	Title	Year	Journal	Scopus	WOS
PS1	(Sathiyamurthi et al., 2024) https://doi.org/10.1007/s43621-024-00471-4	Agricultural land suitability of Manimutha Nadhi watershed using AHP and GIS techniques	2024	Discover Sustainability	×	
PS2	(Akhavan et al., 2023) https://doi.org/10.1080/00103624.2022.2118312	"Use of a GIS-Based Multicriteria Decision-Making Approach, to Increase Accuracy in Determining Soil Suitability", Iran	2023	Communications in Soil Science and Plant Analysis	×	
PS3	(Hayat et al., 2024) https://doi.org/10.3390/crops4030022	Assessing Soil and Land Suitability of an Olive–Maize Agroforestry System Using Machine Learning Algorithms	2024	Crops	×	
PS4	(Dornik et al., 2024) https://doi.org/10.1016/j.iswcr.2024.01.002	Geospatial evaluation of the agricultural suitability and land use compatibility in Europe's temperate continental climate region	2024	International Soil and Water Conservation Research	×	X
PS5	(Mohammed & Suliman, 2023) https://doi.org/10.12911/22998993/163349	Land Suitability Assessment for Wheat Production Using Analytical Hierarchy Process and Parametric Method in Babylon Province	2023	Journal of Ecological Engineering	×	
PS6	(Berhane et al., 2023) https://doi.org/10.2174/0118743315253308230921060221	GIS-based Land Suitability Evaluation for Sesame (Sesamum indicum L.) Production using Agro-climatic Indices in the Semi-arid Areas of Tigray	2023	Open Agriculture Journal	×	
PS7	(Aydın-Kandemir & Sarptaş, 2023) https://doi.org/10.1007/s10098-022-02422-x	Geographic information systems-based land suitability assessment for switchgrass cultivation in marginal lands: a case study for İzmir-Turkey	2023	Clean Technologies and Environmental Policy	×	
PS8	(Azadi et al., 2023a) https://doi.org/10.1134/S1064229322602268	Land evaluation approaches comparing TOPSIS and SAW with parametric methods for rice cultivation	2023	Environmental Monitoring and Assessment	×	
PS9	(Al-Sababhah, 2024) https://doi.org/10.1007/s41651-023-00150-4	Land Suitability and Capability Analysis for Sustainable Allocation of Agricultural Crops and Natural Plants, Northwest Jordan	2024	Journal of Geovisualization and Spatial Analysis	×	
PS10	(Tolera et al., 2023) https://doi.org/10.1007/s13201-023-01883-9	Assessment of land suitability for irrigation in West Shewa zone, Oromia, Ethiopia	2023	Applied Water Science	×	
PS11	(Almayyahi & Al-Atab, 2024) https://doi.org/10.37077/25200860.2024.37.1.16	Evaluating Land Suitability for Wheat Cultivation Criteria Analysis Fuzzy-AHP and Geospatial Techniques in Northern Basrah Governorate.	2024	Basrah Journal of Agricultural Sciences	×	
PS12	(Sadiq et al., 2023) https://doi.org/10.1016/j.indic.2023.100297	Evaluation of land suitability for soybean production using GIS-based multi-criteria approach in Kudan Local Government area of Kaduna State Nigeria	2023	Environmental and Sustainability Indicators	×	
PS13	(Shalaby et al., 2023) https://doi.org/10.1007/s12518-022-00474-8	A GIS-based model for automated land suitability assessment for main crops in north-western desert of Egypt (case study: south of Al-Dabaa Corridor)	2023	Applied Geomatics	×	
PS14	(Yousif & Ahmed, 2024) https://doi.org/10.21608/ejss.2024.260713.1708	Land Evaluation and Assessment of Land Cover Change Using Geospatial Techniques: A Case Study in West Samlout Area, Egypt	2024	Egyptian Journal of Soil Science	×	
PS15	(Gelalacha et al., 2024) https://doi.org/10.1002/ird.2920	Land suitability and crop water requirements for irrigated sugar cane in the Kuraz irrigation scheme, lower Omo basin, Ethiopia	2024	Irrigation and Drainage	×	
PS16	(Ghadirian et al., 2023) https://doi.org/10.1016/j.ecoinf.2023.102129	Area-based scenario development in land-use changes modeling: A system dynamics-assisted approach for mixed agricultural-residential landscapes	2023	Ecological Informatics	×	

No	Authors	Title	Year	Journal	Scopus	WOS
PS17	(Minh, 2024) DOI is not available. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85198548474&partnerID=40&md5=d0abec661d38fce9ea911392faa8d6d6	Assessment of crop-land suitability by the multi-criteria evaluation approach and geographic information system: A scoping review	2024	Agricultural Engineering Internationa: CIGR Journal	×	
PS18	(Delsouz Khaki et al., 2023) https://doi.org/10.1080/03650340.2022.2096878	Comparison of three land suitability evaluation depth scenarios for irrigated paddy fields (case study: North of Iran)	2023	Archives of Agronomy and Soil Science	×	
PS19	(Sarğin & Karaca, 2023) https://doi.org/10.7717/peerj.16396	Land suitability assessment for wheatbarley cultivation in a semi-arid region of Eastern Anatolia in Turkey	2023	PeerJ	×	
PS20	(Mirnasl et al., 2024) https://doi.org/10.1002/tqem.22328	An Integrated Spatial Fuzzy-Based Site Suitability Assessment Framework for Agricultural BMP Placement	2024	Environmental Quality Management	×	
PS21	(Baskaran et al., 2023) https://doi.org/10.1007/s40808-023-01706-5	Modeling the land suitability for agricultural utility in a semi-arid region of Tirunelveli district, South India using multi-criteria and geospatial approach	2023	Modeling Earth Systems and Environment	×	
PS22	Choudhary K.; Boori M.S.; Shi W.; Valiev A.; Kupriyanov A. https://doi.org/10.1016/j.rsase.2023.101051	Agricultural land suitability assessment for sustainable development using remote sensing techniques with analytic hierarchy process	2023	Remote Sensing Applications: Society and Environment	×	
PS23	(Thanh Vu & Minh, 2023) https://doi.org/10.14719/pst.2317	Suitability assessment and recommendations for Urban agricultural development: A case study in Cai Rang District, Can Tho City, Viet Nam	2023	Plant Science Today	×	
PS24	(Uyan et al., 2023) https://doi.org/10.3390/agriculture13091722	Land Use Suitability Model for Grapevine (Vitis vinifera L.) Cultivation Using the Best Worst Method: A Case Study from Ankara/Türkiye	2023	Agriculture (Switzerland)	×	
PS25	(Bazkiaee et al., 2024) https://doi.org/10.1007/s10661-024-12811-y	Multi-criteria GIS-based land suitability analysis for rice cultivation: a case study in Guilan Province, Iran	2024	Environmental Monitoring and Assessment	×	×
PS26	(Azadi et al., 2023b) https://doi.org/10.1134/S1064229322602268	Assessment of Land Suitability for Sugarcane Cultivation Using TOPSIS and Parametric Methods in Southwestern Iran	2023	Eurasian Soil Science	×	
PS27	(Mercan & Acibuca, 2023) https://Doi.Org/10.1007/S10661-023-11899-y	Land Suitability Assessment for Pistachio Cultivation Using GIS and Multi-Criteria Decision-Making: A Case Study of Mardin, Turkey	2023	Environmental Monitoring and Assessment		×
PS28	(El-Basioni & Abd El-Kader, 2024) https://doi.org/10.1007/s10661-024-12483-8	Designing and modeling an IoT-based software system for land suitability assessment use case	2024	Environmental Monitoring and Assessment		×
PS29	(Kiliç et al., 2024) https://doi.org/10.1007/s10668-023-02951-5	An illustration of a sustainable agricultural land suitability assessment system with a land degradation sensitivity	2024	Environment Development and Sustainability		×
PS30	(Wanyama et al., 2024) https://doi.org/10.1016/j.agsy.2024.103937	Evaluation of land suitability for surface irrigation under changing climate in a tropical setting of Uganda, East Africa	2024	Agricultural Systems		×
PS31	(Kalaiselvi et al., 2024) https://doi.org/10.1007/s12524-024-01937-8	Promoting Agricultural Sustainability in Semi-arid Regions: An Integrated GIS-AHP Assessment of Land Suitability for Encouraging Crop Diversification	2024	Journal of the Indian Society of Remote Sensing		×
PS32	(Mallick et al., 2024) Https://Doi.Org/10.1007/S10668-024-05711-1	Land suitability assessment for tea cultivation in Jalpaiguri district of West Bengal, India, using AHP and DEMATEL techniques	2024	Environment Development and Sustainability		×

No	Authors	Title	Year	Journal	Scopus	WOS
PS33	(Nungula et al., 2024) https://doi.org/10.1080/23311932.2024.23333	Multicriteria land suitability assessment for cassava and bean production using integration of GIS and AHP	2024	Cogent Food & Agriculture		×
PS34	(Wahane et al., 2024) https://doi.org/10.1007/s10661-024-12885-8	Geospatial insights into Alphonso mango cultivation: a comprehensive land suitability study in the coastal belt of Maharashtra, India	2024	Environmental Monitoring and Assessment		×

Quality of Appraisal

To ensure the credibility and rigor of this systematic review, a quality appraisal of the selected studies was conducted using standardized criteria. According to the guidelines proposed by Kitchenham and Charters (2007), once we had selected primary studies, we have to assess the quality of the research they present and quantitatively compare them. In this study we apply quality assessment from Anas Abouzahra et al. (Abouzahra et al., 2020) which consist of six QAs for our SLR. The scoring procedure for evaluating each criterion involves three possible ratings: "Yes" (Y) with a score of 1 if the criterion is fully met, "Partly" (P) with a score of 0.5 if the criterion is somewhat met but contains some gaps or shortcomings, and "No" (N) with a score of 0 if the criterion is not met at all.

- QA1. Is the purpose of the study clearly stated?
- QA2. Are the interest and the usefulness of the work clearly presented?
- QA3. Is the study methodology clearly established?
- QA4. Are the concepts of the approach clearly defined?
- QA5. Is the work compared and measured with other similar work?
- QA6. Are the limitations of the work clearly mentioned?

The table outlines a quality assessment (QA) process used to evaluate a study based on specific criteria. Three experts assess the study using the criteria listed, and each criterion is scored as "Yes" (Y), "Partly" (P), or "No" (N). Here's a detailed explanation:

1. **Is the purpose of the study clearly stated?**
   This criterion checks whether the study's objectives are clearly defined and articulated. A clear purpose helps set the direction and scope of the research.
2. **Is the interest and usefulness of the work clearly presented?**
   This criterion evaluates whether the study's significance and potential contributions are well-explained. It measures the relevance and impact of the research.
3. **Is the study methodology clearly established?**
   This assesses whether the research methodology is well-defined and appropriate for achieving the study's objectives. Clarity in methodology is crucial for the study's validity and reproducibility.
4. **Are the concepts of the approach clearly defined?**
   This criterion looks at whether the theoretical framework and key concepts are clearly articulated. Clear definitions are essential for understanding the study's approach.
5. **Is the work compared and measured with other similar work?**

This evaluates whether the study has been benchmarked against existing research. Comparing with other studies helps position the work within the broader academic context and highlights its contributions.

6. Are the limitations of the work clearly mentioned?

Each expert independently assesses the study according to these criteria, and the scores are then totalled across all experts to determine the overall mark. For a study to be accepted for the next process, the total mark, derived from summing the scores from all three experts, must exceed 3.0. This threshold ensures that only studies meeting a certain quality standard proceed further.

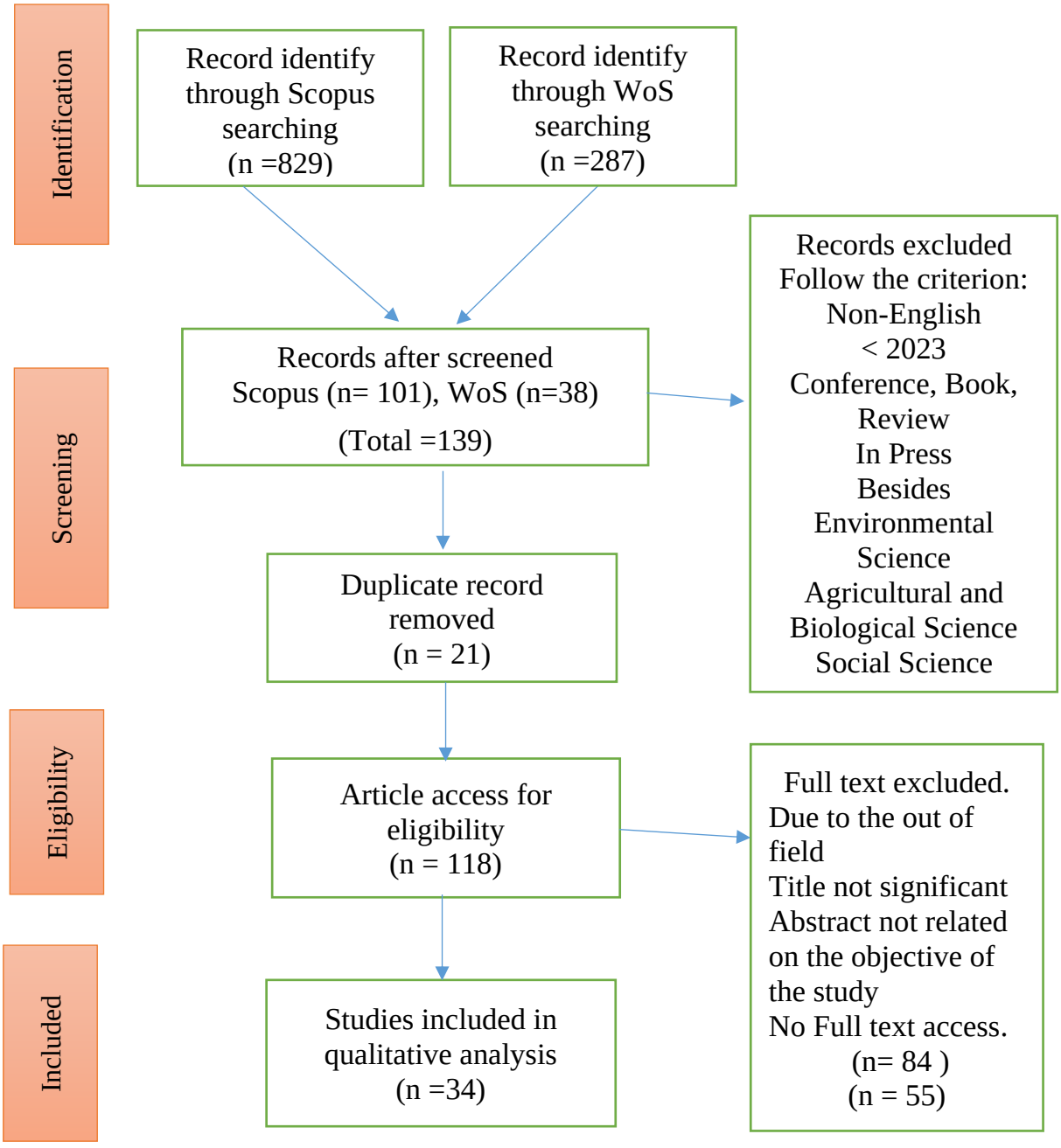

Figure (1): Flow diagram of the proposed searching study [1]

RESULTS AND DISCUSSION

Background of selected study: based on quality assessment, Table 4 shown the result of assessment performance for selected primary studies. The quality assessment of articles PS1 to PS33 demonstrates a consistent focus on employing Geographic Information Systems (GIS) and multi-criteria decision-making techniques, such as Analytical Hierarchy Process (AHP) and fuzzy methods, for land suitability analysis. Most articles clearly state their purpose (QA1) and usefulness (QA2), highlighting the critical role of these methodologies in sustainable land management and agricultural development.

Table (4): Result of Assessment Performance for Selected Primary Studies

PS	QA1	QA2	QA3	QA4	QA5	QA6	Total Mark	Percentage (%)
PS1	Y	Y	Y	Y	P	P	5	83.33
PS2	Y	Y	Y	Y	Y	P	5.5	91.67
PS3	Y	Y	Y	Y	Y	P	5.5	91.67
PS4	Y	Y	Y	Y	P	P	5	83.33
PS5	Y	Y	Y	Y	P	P	5	83.33
PS6	Y	Y	Y	Y	P	P	5	83.33
PS7	Y	Y	Y	Y	Y	P	5.5	91.67
PS8	Y	Y	Y	Y	Y	P	5.5	91.67
PS9	Y	Y	Y	Y	P	P	5	83.33
PS10	Y	Y	Y	Y	P	P	5	83.33
PS11	Y	Y	Y	Y	P	P	5	83.33
PS12	Y	Y	P	P	P	P	4	66.67
PS13	Y	Y	Y	Y	P	P	5	83.33
PS14	Y	Y	Y	Y	P	P	5	83.33
PS15	Y	Y	Y	Y	Y	Y	6	100
PS16	Y	Y	Y	Y	P	P	5	83.33
PS17	Y	Y	Y	Y	P	P	5	83.33
PS18	Y	Y	Y	Y	P	P	5	83.33
PS19	Y	Y	Y	Y	P	P	5	83.33
PS20	Y	Y	Y	Y	P	P	5	83.33
PS21	Y	Y	Y	Y	P	P	5	83.33
PS22	Y	Y	Y	Y	Y	P	5.5	91.67
PS23	Y	Y	Y	Y	P	P	5	83.33
PS24	Y	Y	Y	Y	P	P	5	83.33
PS25	Y	Y	Y	Y	P	P	5	83.33
PS26	Y	Y	Y	Y	P	P	5	83.33
PS27	Y	Y	Y	Y	P	P	5	83.33
PS28	Y	Y	Y	Y	P	P	5	83.33
PS29	Y	Y	Y	Y	P	P	5	83.33
PS30	Y	Y	Y	Y	P	P	5	83.33
PS31	Y	Y	Y	Y	P	P	5	83.33
PS32	Y	Y	Y	Y	P	P	5	83.33
PS33	Y	Y	Y	Y	P	P	5	83.33
PS34	Y	Y	Y	Y	P	P	5	83.33

Methodologies are generally well-documented (QA3), with detailed descriptions of parameters and techniques. Concepts (QA4) are often clearly defined, contributing to replicable and transparent research. However, the comparison with similar studies (QA5) and discussion of limitations (QA6) are less consistently addressed, indicating gaps in contextualizing findings within broader research landscapes. The average scores range between 4.0 (66.67%) and 6.0 (100%), reflecting varying levels of comprehensiveness in addressing the quality criteria.

The highest-scoring articles, such as PS3, PS15, and PS22, achieved near-perfect or perfect scores (5.5 or 6.0). These studies stood out for their robust methodologies, extensive comparisons with similar works, and comprehensive discussions of limitations. For instance, PS15 thoroughly analyzed sugarcane cultivation using GIS-AHP and included a detailed environmental and social implications discussion, earning it a perfect score of 100%. Similarly, PS22 excelled in integrating local farmer opinions with GIS findings, demonstrating a highly practical application of research outcomes. On the other hand, PS12 and PS16 received the lowest scores (4.0 or 66.67%). These articles partly met the methodological and conceptual clarity criteria, but they lacked depth in comparing results with similar studies and addressing research limitations. For example, PS12 focused on soybean suitability in Nigeria but failed to contextualize its findings adequately within broader studies or address limitations, leaving room for improvement in establishing its broader scientific contribution.

This analysis highlights the variability in research quality across studies, emphasizing the need for more rigorous comparisons and acknowledgement of limitations to enhance the utility and relevance of land suitability research.

The produced themes were eventually tweaked to ensure consistency. The analysis selection was carried out by the author and co-author to determine and determine the validity of the problems. The expert review phase ensures the clarity, importance, and suitability of each subtheme by establishing the domain validity. The authors also compared the findings to resolve any discrepancies in the theme creation process. Note that if any inconsistencies on the themes arose, the authors addressed them with one another. Finally, the developed themes were tweaked to ensure their consistency. To ensure the validity of the problems, the examinations were performed by two experts, one specialising in knowledge management and the other in Geographic Information Systems. The expert review phase helped ensure each sub-theme's clarity, importance, and adequacy by establishing domain validity. Adjustments based on the discretion of the author based on feedback and comments by experts have been made.

Advancements in Methodologies for Land Suitability Assessment

The integration of advanced methodologies in land suitability assessments has significantly enhanced the accuracy and applicability of agricultural decision-making. For instance, Sathiyamurthi et al. (2024) applied Geographic Information Systems (GIS) combined with the Analytical Hierarchy Process (AHP) to develop detailed suitability maps for watershed areas, classifying land based on varying levels of agricultural potential. In another study, Akhavan et al. (2023) demonstrated the effectiveness of fuzzy logic and parametric hierarchical models in evaluating wheat production suitability in Iran, with validation through Kappa Cohen coefficients

confirming the robustness of the results. These examples illustrate how the integration of multiple criteria such as climate, soil, and topography within GIS-based systems can be adapted to diverse agricultural contexts, improving land suitability assessments globally. Machine learning (ML) algorithms have further expanded the capabilities of land suitability assessments by enabling more sophisticated analyses. The study on olive-maize agroforestry systems in Pakistan compared Random Forest (RF), Support Vector Machine (SVM), and Weighted Overlay (WOL) techniques, demonstrating RF's superior accuracy for mapping suitability in mountainous terrains (Sathiyamurthi et al., 2024). Similarly, the comparative evaluation of TOPSIS and SAW methodologies for rice cultivation in Iran revealed that TOPSIS outperforms other techniques by efficiently handling multi-criteria decisions (Azadi et al., 2023a). These approaches underscore the potential of ML and multi-criteria decision-making (MCDM) tools to enhance the robustness and reliability of agricultural land assessments.

A review of multi-criteria evaluation approaches identified over 117 parameters crucial for land suitability, ranging from soil properties to hydro-geomorphological factors (Minh, 2024). These parameters form the foundation for tailored methodologies like the FAO framework and depth scenarios for irrigated paddy fields, which offer cost-effective and time-efficient alternatives without compromising on accuracy (Delsouz Khaki et al., 2023). Moreover, spatial fuzzy-based frameworks have addressed the limitations of crisp class boundaries by creating adaptable suitability indices, as demonstrated in the Thames River Watershed for agricultural Best Management Practices (BMP) (Mirnasl et al., 2024).

Remote sensing and Internet of Things (IoT)-based methodologies have further modernized land suitability assessments. The incorporation of remote sensing with AHP has produced detailed land suitability zones, effectively supporting sustainable agricultural practices (Choudhary et al., 2023). Additionally, IoT-driven dynamic systems offer real-time evaluations of soil characteristics, as evidenced by a conceptual model for automating land suitability assessments. These systems integrate web development and digital mapping to enhance decision-making flexibility and cost-efficiency (El-Basioni & Abd El-Kader, 2024).

Finally, sustainability considerations are increasingly integrated into land suitability models. A sustainable agricultural land suitability assessment (SALSA) in Turkey combined soil properties with erosion and climate layers, revealing the critical role of environmental factors in land degradation sensitivity. This integration emphasized a conservation-use balance for both wheat and perennial horticultural crops (Kiliç et al., 2024). Such models highlight the necessity of incorporating ecological and socio-economic factors into land use planning for long-term agricultural viability.

Application of Land Suitability for Specific Crops and Regions

The application of land suitability assessments for specific crops in diverse regions showcases the integration of advanced techniques to enhance agricultural productivity and sustainability. The geospatial evaluation of agricultural suitability in Europe's temperate continental climate region highlights the importance of eco-pedological indicators such as soil texture, pH, and climatic parameters in crop-specific suitability mapping. For instance, within Europe's temperate continental

climate region, wheat and barley were identified as having significant suitability in southern areas such as Romania and Bulgaria, while sugar beet and potatoes were more suited to northern regions including parts of Poland and Germany (Dornik et al., 2024). Similarly, the suitability assessment in Babylon Province, Iraq, employed AHP and parametric methods to evaluate wheat cultivation. This study revealed that using AHP with added soil criteria (e.g., total nitrogen, crop variety) provided more accurate suitability classifications, aligning well with agricultural practices in the region (Mohammed & Suliman, 2023). In Tigray, Ethiopia, agro-climatic variables such as elevation and growing degree days were used to determine land suitability for sesame, identifying highly suitable zones in Humera and other western areas (Berhane et al., 2023).

Several studies emphasized the potential of integrating GIS with multi-criteria decision-making (MCDM) methods to address regional agricultural challenges. For example, in İzmir, Turkey, GIS-based MCDM techniques were applied to assess suitability for switchgrass cultivation, revealing that 69.4% of the land was moderately suitable or higher, indicating significant potential for biofuel production (Aydın-Kandemir & Sarptaş, 2023). In Northwest Jordan, an evaluation for various crops and natural plants demonstrated that a considerable portion of land is moderately or highly suitable for cereals and forests, reinforcing the need for sustainable land use practices to enhance agricultural output (Al-Sababhah, 2024). Meanwhile, in Northern Basrah, Iraq, fuzzy-AHP revealed that the majority of the land was unsuitable for wheat due to high soil salinity and low organic carbon, underscoring the need for improved agricultural management strategies (Almayyahi & Al-Atab, 2024).

Land suitability assessments also highlight specific crop requirements and regional agricultural planning. In the Guilan Province of Iran, AHP-weighted overlay methods identified soil organic matter as the most significant factor influencing rice cultivation suitability, with 91% of the land deemed very suitable (Bazkiaee et al., 2024). The use of TOPSIS in Southwestern Iran for sugarcane cultivation demonstrated the method's efficiency in integrating diverse criteria, resulting in more accurate suitability classifications compared to traditional parametric methods (Azadi et al., 2023b). Additionally, in Turkey's Mardin Province, GIS and MCDM approaches determined that meteorological factors held more significance than soil or economic factors for pistachio cultivation, with high suitability areas validated through Receiver Operating Characteristic (ROC) curves ((Mercan & Acibuca, 2023).

The adaptability of suitability assessments extends to diverse agricultural contexts. In the Jalpaiguri district of India, a combination of AHP and DEMATEL techniques was employed for tea plantation suitability, identifying moderate and marginally suitable areas as predominant, necessitating resilient farming practices (Mallick et al., 2024). For Alphonso mango cultivation in the coastal belt of Maharashtra, India, GIS-AHP integration produced highly reliable suitability classifications, with soil pH, drainage, and cation exchange capacity emerging as key factors (Wahane et al., 2024). Similarly, a multicriteria assessment in Tanzania identified southern regions as highly suitable for cassava and bean production, providing actionable insights for sustainable farming practices (Nungula et al., 2024).

Geospatial evaluation of the agricultural suitability and land use compatibility in Europe's temperate continental climate region.

Sustainability and Adaptation in Land Use Planning

Land suitability assessments are critical for promoting agricultural sustainability and adapting to changing environmental and climatic conditions. Recent studies from diverse regions support this, such as in Ethiopia's West Shewa zone, where GIS-based analytical hierarchy processes revealed that 10.27% of the land was highly suitable for irrigation, while 73.23% was moderately suitable (Tolera et al., 2023) Similarly, the Kuraz irrigation scheme demonstrated significant potential for irrigated sugarcane cultivation (Gelalacha et al., 2024). These studies are particularly insightful as they address challenges common in semi-arid regions, such as soil salinity, slope limitations, and water management. Comparable research in Uganda identified the effects of climate change on irrigation suitability (Wanyama et al., 2024), while studies in Egypt (Yousif & Ahmed, 2024) and India (Kalaiselvi et al., 2024) explored land suitability under environmental stress, reinforcing the importance of adaptive and sustainable planning across various agricultural landscapes.

Remote sensing and spatial analysis techniques have been pivotal in land use adaptation planning. A study in Egypt's West Samlout area utilized multi-temporal Landsat imagery to analyse land cover changes and evaluate suitability for various crops. Results revealed significant expansion in vegetation areas (18.96% increase over a decade) and identified soil salinity and texture as key limiting factors for crop suitability. These findings support the use of geospatial tools for sustainable resource management and agricultural expansion (Yousif & Ahmed, 2024). Additionally, system dynamics-assisted modelling in Iran's Gavkhooni Basin employed coupled models to simulate land use changes, integrating factors like water availability and economic development. This approach highlighted the role of scenario-based planning in managing agricultural and residential land requirements effectively (Ghadirian et al., 2023).

In semi-arid regions, the integration of GIS and multi-criteria decision-making frameworks aids in sustainable land management. For example, in Tamil Nadu, India, land suitability assessments identified soil drainage and texture as critical factors for crop cultivation. Field beans and guava were found to have the highest suitability, while paddy and coconut showed more marginal suitability. Recommendations included tailored land management strategies to enhance productivity and sustainability (Kalaiselvi et al., 2024). Similarly, in Tirunelveli, South India, GIS and AHP integration helped identify 1750 acres of bare land suitable for agricultural conversion, emphasizing the importance of spatial analyses in revitalizing agricultural opportunities amidst urbanization pressures (Baskaran et al., 2023).

Advancements in methodologies for land suitability assessments have substantially enhanced precision and applicability in agricultural decision-making. Geographic Information Systems (GIS) combined with techniques such as the Analytical Hierarchy Process (AHP) and weighted overlay methods have demonstrated their effectiveness in producing detailed suitability maps. These maps classify land based on its appropriateness for specific agricultural uses, integrating

parameters like climate, soil, and topography to support decision-making across diverse agricultural contexts. The use of fuzzy and parametric hierarchical models further enhances these assessments by blending qualitative and quantitative approaches, with accuracy validated through statistical measures like Kappa Cohen coefficients. Machine learning (ML) has expanded the analytical capabilities of land suitability assessments, offering more advanced and accurate evaluations. For instance, studies comparing algorithms like Random Forest (RF) and Support Vector Machine (SVM) have shown RF's superior performance in mapping agricultural suitability in challenging terrains. Similarly, multi-criteria decision-making (MCDM) methods, such as TOPSIS, have proven effective in handling complex agricultural scenarios by integrating diverse factors. These innovations highlight the potential of ML and MCDM tools to enhance the reliability and robustness of agricultural assessments. The identification of over 117 critical parameters, including soil properties and hydro-geomorphological factors, has facilitated the development of tailored methodologies such as the FAO framework. These frameworks offer cost-efficient and accurate solutions for evaluating land suitability, particularly for crops like irrigated paddy. Spatial fuzzy-based frameworks address the rigidity of traditional class boundaries, creating dynamic indices that adapt to varied agricultural requirements, as seen in their application for agricultural best management practices. Technological advancements, including remote sensing and (IoT)-based systems, have modernized land suitability analyses. Remote sensing integrated with AHP produces high-resolution land suitability zones, supporting sustainable agricultural practices. IoT-driven systems, incorporating real-time soil evaluations and digital mapping, enhance decision-making efficiency while reducing costs. These tools exemplify how technology can streamline agricultural planning and resource management. Sustainability has become a central consideration in land suitability models, with an increasing focus on integrating environmental and socio-economic factors. For example, sustainable agricultural land suitability assessments combine soil properties with erosion and climate data to address land degradation sensitivity, balancing conservation with agricultural use. These models underscore the importance of aligning agricultural practices with ecological preservation for long-term viability. Overall, the integration of advanced analytical methods, machine learning, and technological innovations has transformed land suitability assessments. By addressing environmental, economic, and social factors, these methodologies ensure more informed and sustainable agricultural planning, meeting the demands of both current and future agricultural challenges.

CONCLUSIONS

Land suitability assessments have proven indispensable in optimizing agricultural productivity and promoting sustainability by integrating advanced analytical techniques tailored to specific crops and regions. Geospatial evaluations in Europe’s temperate continental climate region underscore the significance of eco-pedological indicators, such as soil texture, pH, and climatic parameters, in crop-specific suitability mapping. For example, wheat and barley were found to thrive in the southern areas, while sugar beet and potatoes were more suited to the northern regions. In Babylon Province, Iraq, combining AHP with parametric methods revealed the importance of additional soil criteria like nitrogen content and crop

variety in accurately classifying wheat suitability, aligning with regional agricultural practices. Similarly, agro-climatic factors, including elevation and growing degree days, were used in Tigray, Ethiopia, to identify highly suitable zones for sesame cultivation, emphasizing the value of localized assessments. The integration of Geographic Information Systems (GIS) with multi-criteria decision-making (MCDM) approaches has been particularly effective in addressing agricultural challenges. In İzmir, Turkey, GIS-MCDM techniques assessed the suitability for switchgrass cultivation, with over two-thirds of the land found moderately or highly suitable, highlighting its potential for biofuel production. Conversely, assessments in Northern Basrah, Iraq, showed a predominance of unsuitable land for wheat due to issues like high soil salinity and low organic carbon, emphasizing the need for better agricultural management. In Northwest Jordan, evaluations revealed significant portions of land suitable for cereals and forestation, reinforcing the necessity for sustainable land use planning. Crop-specific assessments also emphasize critical factors for agricultural planning. In Guilan Province, Iran, soil organic matter emerged as a key determinant for rice cultivation, with a large portion of land classified as highly suitable. Similarly, TOPSIS-based evaluations in Southwestern Iran demonstrated improved suitability classifications for sugarcane, outperforming traditional methods. In Turkey's Mardin Province, meteorological factors were identified as more influential than soil or economic factors for pistachio cultivation, with high-suitability areas validated through advanced statistical techniques. These methodologies extend to diverse agricultural contexts, exemplified by tea plantation assessments in India's Jalpaiguri district, where AHP-DEMATEL identified predominantly moderate and marginally suitable areas, emphasizing the need for resilient farming practices. For Alphonso mango cultivation in Maharashtra's coastal belt, GIS-AHP integration produced reliable suitability classifications, identifying soil pH, drainage, and cation exchange capacity as critical factors. Similarly, a multicriteria assessment in Tanzania identified southern regions as highly suitable for cassava and beans, offering practical insights for sustainable farming. The adaptability and precision of land suitability assessments, supported by geospatial and decision-making tools, highlight their value in agricultural planning. By addressing ecological, climatic, and socio-economic variables, these methodologies provide actionable solutions for enhancing productivity and sustainability across varied agricultural landscapes.

Land suitability assessments have emerged as essential tools for fostering agricultural sustainability and addressing environmental challenges. In Ethiopia's West Shewa zone, GIS-based analytical hierarchy processes identified 10.27% of the land as highly suitable and 73.23% as moderately suitable for irrigation development, highlighting significant potential for agricultural enhancement through strategic irrigation planning. However, factors like soil salinity and slope limitations require attention to optimize productivity. Similarly, the Kuraz irrigation scheme demonstrated considerable potential for irrigated sugarcane cultivation, with 28% of land rated as highly suitable. Nonetheless, concerns related to water usage and soil degradation emphasize the necessity of sustainable agricultural practices. In Uganda, a GIS-based multi-criteria evaluation of irrigation suitability under climate change scenarios revealed a significant reduction in highly suitable land, from 0.9% to

0.046%, illustrating the critical need for adaptive strategies to counteract climate variability.Remote sensing and spatial analysis have played transformative roles in land use adaptation planning. A study in Egypt's West Samlout area utilizing multi-temporal Landsat imagery revealed an 18.96% increase in vegetation coverage over a decade while identifying soil salinity and texture as key constraints for crop suitability. These findings underscore the importance of geospatial tools in managing resources sustainably and supporting agricultural expansion. In Iran's Gavkhooni Basin, system dynamics modelling integrated variables such as water availability and economic growth to simulate land use changes effectively. This approach demonstrated the utility of scenario-based planning for balancing agricultural and residential land needs. In semi-arid regions, GIS and multi-criteria decision-making frameworks have significantly contributed to sustainable land management. For instance, in Tamil Nadu, India, assessments highlighted soil drainage and texture as critical factors for crop cultivation, with field beans and guava showing the highest suitability and paddy and coconut demonstrating marginal suitability. Tailored land management strategies were recommended to enhance both productivity and sustainability. In South India's Tirunelveli region, the integration of GIS and Analytical Hierarchy Process identified 1,750 acres of bare land suitable for agricultural conversion, emphasizing the importance of spatial analyses in rejuvenating agricultural opportunities amid urbanization pressures. Overall, these studies demonstrate the effectiveness of integrating geospatial tools, multi-criteria decision-making techniques, and adaptive planning models to evaluate land suitability comprehensively. By addressing environmental, economic, and social factors, these assessments provide actionable insights for sustainable agricultural development. While challenges such as climate variability, soil degradation, and urbanization persist, the application of innovative methodologies ensures informed decision-making to enhance agricultural productivity and resilience. Future research should focus on standardizing methodologies and enhancing their scalability to ensure their effectiveness across different regions and scales.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest to report regarding the present study.

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التطورات والتكامل بين المعرفة البيوفيزيائية والاجتماعية والاقتصادية والمحلية في تقييمات ملاءمة الأراضي الزراعية: مراجعة منهجية للأدبيات

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الخلاصة

تقييمات ملاءمة الأراضي تعد من الامور الرئيسية للتخطيط المستدام لاستخدام الأراضي، والإنتاجية الزراعية، والإدارة البيئية. وعلى الرغم من التقدم الكبير، لا يزال الفهم الشامل للمنهجيات والتطبيقات وتحديات الاستدامة في سياقات متنوعة محدودًا. تهدف هذه المراجعة المنهجية للأدبيات إلى معالجة هذه الفجوات من خلال دراسة التطورات والممارسات الإقليمية واستراتيجيات التكيف في تقييمات ملاءمة الأراضي. باستخدام إطار عمل PRISMA، حدد بحث متقدم في قواعد بيانات Scopus و Web of Science دراسة مؤهلة (عددها 34) للتحليل. تم تصنيف هذه الدراسات إلى ثلاثة محاور رئيسية: (1) التطورات في المنهجيات، بما في ذلك اتخاذ القرارات متعددة المعايير القائمة على نظم المعلومات الجغرافية (MCDM)، والتعلم الآلي، والنماذج الهجينة؛ (2) تطبيقات ملاءمة الأراضي لمحاصيل ومناطق محددة، مع تسليط الضوء على العوامل البيئية والاجتماعية والاقتصادية المتنوعة التي تؤثر على التنفيذ؛ و(3) الاستدامة والتكيف في تخطيط استخدام الأراضي، مع التركيز على دمج المرونة المناخية والحفاظ على الموارد. تشير النتائج إلى أن مناهج GIS–MCDM هي المهيمنة، حيث تُمثل 65% من الدراسات، بينما تُسهم تقنيات التعلم الآلي والطرق الهجينة بنسبة 20% و15% على التوالي. تُؤكد المراجعة الدور المتزايد للتقنيات المتقدمة، مثل الاستشعار عن بُعد وإنترنت الأشياء، في تحسين الدقة، إلا أن التحديات لا تزال قائمة في اختيار المعلمات، وجودة البيانات، ودمج الأبعاد الاجتماعية والبيئية. وتخلص هذه المراجعة إلى أنه على الرغم من وضوح التقدم في المنهجيات والتطبيقات، إلا أن الجهود المستقبلية يجب أن تُركز على الاستدامة والاستراتيجيات التكيفية لمواجهة تحديات استخدام الأراضي المتطورة. تُقدم النتائج رؤىً بالغة الأهمية للباحثين وصانعي السياسات لتعزيز تقييمات ملاءمة الأراضي وتعزيز ممارسات التنمية المستدامة.

الكلمات المفتاحية: تقييم ملاءمة الأراضي (LSA)، التحليل الجغرافي المكاني في الزراعة، اتخاذ القرارات متعددة المعايير (MCDM)، تقييم الأراضي القائم على نظم المعلومات الجغرافية، التحليل الهجين، PRISMA.

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