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LEVERAGING GIS AND REMOTE SENSING TECHNOLOGIES FOR SUSTAINABLE URBAN PLANNING: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

This study aims to develop a systematic review of the analysis of Land Use Trends Using Geographic Information Systems that has an Implications for Sustainable Urban Planning in Davao City from an international and empirical perspective. The Preferred Reporting Items for Systematic Reviews and Meta-analyzes (PRISMA) is used as a guideline for systematic literature review to collect data. The selected journal timeframe is from 2014 to 2024 with 17 chosen articles meeting the criteria. Analysis of the selected primary studies reveals while urban development brings economic opportunities, it also poses significant threats to the environment, social equity, and overall sustainability. The integration of GIS in urban planning offers a pathway to address these challenges effectively and holistically.

Additionally, this study attempts to develop a more comprehensive concept or model of implications of land use trends to sustainable urban planning using GIS.

Keywords: Land Use Trends, GIS, PRISMA, Systematic Literature Review

1. INTRODUCTION

Urbanization has emerged as a defining global trend, reshaping landscapes and prompting new challenges in sustainable development. The increasing migration to urban centers has accelerated land-use changes, affecting ecological balance, resource allocation, and overall urban sustainability (Wang et al., 2020; Prasad et al., 2022). In Davao City, one of the fastest-growing urban areas in the Philippines, these dynamics are particularly pronounced. Balancing rapid urban growth with sustainable urban planning is critical to addressing environmental and socio-economic challenges (Mallari & Bayod, 2020; Tinoy et al., 2019).

The integration of Geographic Information Systems (GIS) and remote sensing technologies provides an innovative approach to urban planning. These tools enable comprehensive spatial analyses and facilitate data-driven decision-making for sustainable development (Ullah, 2014; Van Maarseveen et al., 2019). This study seeks to systematically review the implications of land use trends using GIS on sustainable urban planning in Davao City. By synthesizing empirical research and international perspectives, the study highlights effective methodologies and strategies for addressing urban challenges.

Guided by the PRISMA methodology and the PICO framework, the review focuses on comparing GIS and traditional land-use analysis methods. It aims to explore how GIS technologies can enhance the monitoring of land-use trends and support sustainable urban planning policies. This review contributes to the growing body of knowledge on urban sustainability and offers actionable insights for policymakers and urban planners (Cochrane Handbook for Systematic Reviews of Interventions, 2023; Santos et al., 2007).

2. METHODOLOGY

The research method followed PRISMA guidelines to produce a systematic review. PRISMA provides a standard methodology that contributes to the quality assurance of the revision and replication process. A systematic review was developed by explaining the article selection criteria, search strategy, data extraction, and data analysis procedures. In general, the PRISMA method is divided into several steps as shows in Figure 1.

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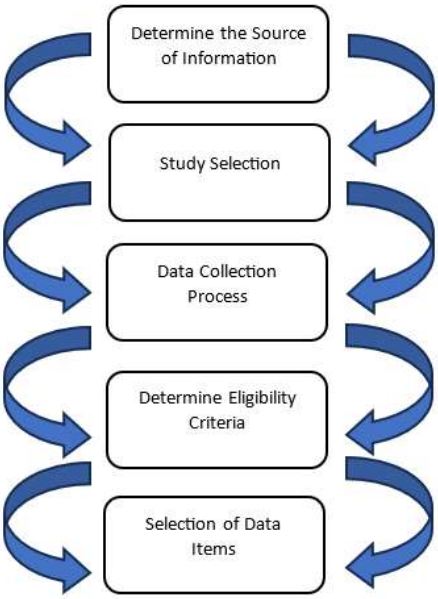

Figure 1. PRISMA Method

Resources and Study Selection

This systematic review was guided by the PICO framework, which provides a structured method for formulating focused and answerable research questions in systematic reviews. Based on this framework, the research question was developed as: *"In urban land use planning in Davao City, how does the use of GIS and remote sensing technologies compared to traditional land use analysis methods influence the monitoring of land use trends and the formulation of sustainable urban planning policies?"*

The PICO framework allowed for the identification of clear search terms and ensured that the systematic review was comprehensive, focused, and aligned with its objectives (Cochrane Handbook for Systematic Reviews of Interventions, 2023; Santos et al., 2007). Using the PICO framework, a detailed search strategy was created to retrieve relevant studies. Key search terms were derived from the framework, including combinations of *"Land Use Trends," "GIS in Urban Planning," "Remote Sensing in Land Use," "Urbanization in Davao City," "Sustainable Urban Planning," and "Land Use Change,"* connected through Boolean operators (*AND, OR*). A systematic search was conducted across well-regarded scientific databases such as Google Scholar, Semantic Scholar, JSTOR, and Science Direct.

Data Collection and Eligibility Criteria

The data collection process was carried out manually by removing duplicates, selected journal timeframe is from 2014 to 2024, and extracting data based on content analysis such as title, topic, year of publication, research methodology, relationship between variables, brief description, and research results in the form of the implications of land use trends to sustainable urban planning using GIS.

The inclusion criteria (IC) that guide the preparation of this systematic literature review are explained as follows in **Table 1.**

IC1	All original and peer-reviewed literature is written in English.
IC2	Research aims to determine the implications of land use trends to sustainable urban planning using GIS.
IC3	Research uses quantitative, qualitative or both methods, namely mixed methods (qualitative and quantitative).

Table 1. Inclusion Criteria

For IC1, all original and peer-reviewed literature is written in English. This criterion ensures the inclusion of high-quality, credible academic work that has undergone rigorous peer review, a standard practice for scholarly reliability (Gasparyan et al., 2015). By restricting to literature in English, the review maintains consistency in language for ease of comprehension and comparability. Although this might exclude non-English studies, English is widely regarded as the global language of academia, enhancing the accessibility and relevance of included research (Ammon, 2012).

Meanwhile, in IC2, Research aims to determine the implications of land use trends to sustainable urban planning using GIS. Geographic Information Systems (GIS) are essential in urban planning, as they enable spatial data visualization and analysis of land use patterns. Incorporating GIS in sustainable urban planning allows planners to assess land use

trends and their environmental, economic, and social impacts effectively (Batty, 2013; Chakraborty et al., 2011). This criterion ensures that selected studies are directly relevant to understanding how GIS-based insights guide sustainable development practices.

Lastly, in IC3, Research uses quantitative, qualitative, or both methods, namely mixed methods (qualitative and quantitative). Including studies with quantitative, qualitative, or mixed methods ensures a comprehensive understanding of the research topic. Quantitative approaches (e.g., spatial modeling) provide measurable data, while qualitative methods (e.g., interviews, case studies) offer contextual insights. Mixed-methods research enhances the depth and breadth of analysis by integrating these approaches, making it particularly valuable for addressing complex issues like urban sustainability and land use trends (Creswell, 2014; Johnson et al., 2007).

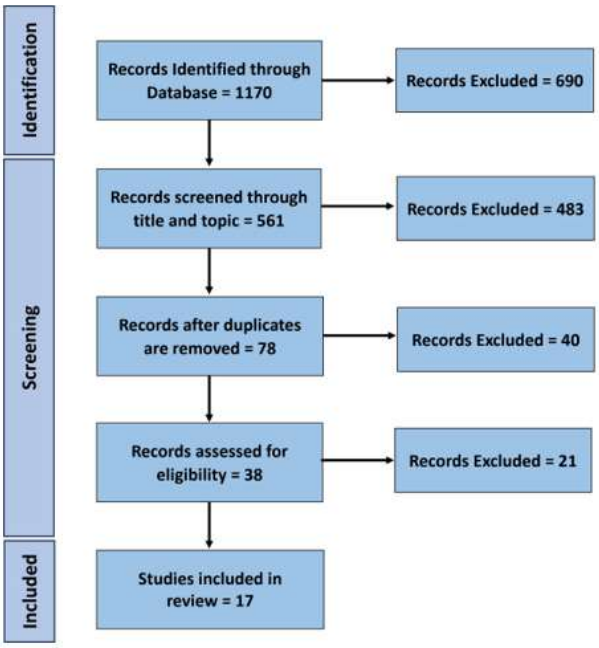

Figure 2. Contextualized PRISMA Model use in the study

Data Items

The distribution of studies sourced from various academic platforms for the systematic review, with the majority retrieved from Google Scholar (12), followed by Semantic Scholar (3), ScienceDirect (2), and JSTOR (1). Google Scholar's prominence reflects its broad coverage and accessibility, making it a primary tool for identifying relevant literature. Semantic Scholar contributes additional context-aware studies, while ScienceDirect provides high-quality, empirically focused research. JSTOR, though yielding only one study, offers valuable theoretical insights. This diverse sourcing ensures a comprehensive review by incorporating both foundational theories and empirical evidence across multiple disciplines. Data items extracted from each article are summarized into the following categories shown in Annex 1 (Cochrane Handbook for Systematic Reviews of Interventions, 2023; Santos et al., 2007).

Table 2. Distribution of Studies from Databases

Database Source	Number
Google Scholar	12
Semantic Scholar	3
JSTOR	1
Science Direct	2

3. RESULTS AND DISCUSSION

Urbanization Dynamics and Impacts

Urbanization and Land Use Changes. Urbanization is driving significant transformations in land use, with impacts that vary across geographic and socio-economic contexts. Wang et al. (2020) documented a 52.47% increase in built-up areas in Kathmandu District over 20 years, emphasizing how rapid urbanization encroaches on agricultural lands and challenges sustainability. Similarly, Prasad et al. (2022) observed a 39.51% increase in urban areas in Vijayawada City

over 15 years, with significant vegetation loss. Vardopoulos et al. (2023) highlighted fragmented urban sprawl in Pafos, Cyprus, where settlement areas expanded by 55% over 28 years. These studies collectively illustrate the strain urban growth places on ecosystems and agricultural resources.

Comparative insights show that urbanization trends are shaped by local governance and policy. For instance, Rahman et al. (2022) used GIS-based multi-criteria decision-making in Rajshahi City to guide sustainable urban expansion, contrasting with Tinoy et al. (2019), who highlighted unmanaged urban heat island effects in Davao City. Similarly, in Dormaa Central Municipality, Ghana, Damoah-Afari et al. (2023) reported a 32% increase in urban land use over 20 years, highlighting deforestation and vegetation loss, mirroring the challenges observed in Rangpur City, Bangladesh, where Naimur Rahman (2019) noted a 17.53% increase in built-up areas over a decade. These findings underscore the importance of proactive land-use policies tailored to regional contexts.

Table 3. **Comparative Table**

Study	Location	Urbanization Trend	Key Impact
Wang et al. (2020)	Kathmandu District	52.47% built-up area increase in 20 years	Loss of agricultural land
Prasad et al. (2022)	Vijayawada City	39.51% urban growth in 15 years	Vegetation loss
Damoah-Afari et al. (2023)	Dormaa Central, Ghana	32% increase over 20 years	Deforestation
Naimur Rahman (2019)	Rangpur City, Bangladesh	17.53% growth in 10 years	Agricultural land conversion

Environmental Impacts of Urban Growth. Urban expansion poses significant environmental challenges. Dumdumaya & Cabrera (2023) predicted that Davao City's urban growth would lead to substantial cropland reductions by 2050, raising concerns about food security. Similarly, Mallari & Bayod (2020) linked deforestation in Davao del Sur to declining watershed resilience. Tinoy et al. (2019) explored urban heat islands in Davao City, emphasizing how impervious surfaces exacerbate thermal impacts.

Comparatively, Rahman et al. (2022) demonstrated the mitigating potential of GIS-based land suitability analysis in Rajshahi City, highlighting the role of technology in addressing urbanization's adverse effects.

Technological Applications in Urban Planning

Geographic Information Systems (GIS) Applications in Urban Planning. GIS has emerged as a critical tool for urban planning, enabling comprehensive spatial analyses and improved decision-making. Ullah (2014) demonstrated the integration of GIS and Analytical Hierarchy Process (AHP) for land-use planning in Dhaka, offering a replicable framework for prioritizing residential and mixed-use development. In Davao, Novero et al. (2018) showcased the potential of LiDAR for bioresource mapping, achieving high spatial accuracy in natural resource assessments.

Ph.D. Sonila Xhafa and Ph.D. Albana Kosovrasti (2015), discusses the transformative potential of GIS in optimizing land use and resource allocation, enhancing decision-making processes for sustainable urban planning. Their study underscores GIS's role in fostering informed urban development strategies and managing the complexities of urban growth.

As seen in Luzorata et al. (2023), the application of machine learning to GIS enhances land-use and land-cover classification, exemplified in Agusan River Basin, where techniques like SVM and RF achieved robust results. Jimenez-Espada et al. (2023) used GIS to assess urban sustainability indicators in Cáceres, Spain, focusing on green space distribution and population density. Van Maarseveen et al. (2019) broadened the perspective, showcasing global GIS applications in transport planning and disaster risk management. These studies illustrate GIS's versatility in addressing localized challenges and its scalability to broader urban contexts.

Technological Innovations in Urban Planning. Technological advancements are transforming urban planning methodologies. Dumdumaya & Cabrera (2023) applied Artificial Neural Networks (ANN) for accurate LULC predictions in Davao City, showcasing its predictive capabilities. Novero et al. (2018) utilized LiDAR for biomass estimation and forest resource classification, emphasizing precision in natural resource mapping. In Rajshahi City, Rahman et al. (2022) highlighted GIS-MCDM as an effective tool for balancing sustainability with urban expansion. These innovations provide scalable methodologies for addressing complex urban challenges.

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Frameworks for Urban Resilience and Sustainability

Sustainable Urban Development Strategies. Efforts to harmonize urban development with ecological preservation have led to innovative strategies. Chen et al. (2023) advocated for targeted densification in Suzhou, China, focusing on underutilized areas with low FAR to enhance land-use efficiency. Fernandez & Schroeder (2023) introduced urban acupuncture in Piura, Peru, transforming small urban spaces into sustainable public areas. In Davao del Sur, Mallari & Bayod (2020) emphasized family-based reforestation programs as a dual solution for land rehabilitation and sustainability.

Comparative insights reveal a spectrum of approaches: compact city planning in Pafos, Cyprus (Vardopoulos et al., 2023) contrasts with broader reforestation initiatives in the Philippines. These approaches demonstrate the importance of tailoring strategies to specific urban and ecological contexts.

Urban Resilience and Risk Mitigation. Building resilience is critical in mitigating environmental and climate-related risks. Mallari & Bayod (2020) proposed a family-based reforestation program in Davao del Sur to address water scarcity. Luzorata et al. (2023) linked LULC changes in Agusan River Basin to water quality degradation, emphasizing sustainable land management. Comparatively, Fernandez & Schroeder (2023) demonstrated how urban acupuncture in Piura enhances resilience through small-scale interventions.

Socioeconomic and Stakeholder Perspectives

Transportation and Accessibility. Transportation systems play a pivotal role in urban sustainability. Bhellar et al. (2023) employed isochrone modeling in Sukkur, Pakistan, to identify accessibility gaps, while Ann et al. (2019) proposed revising TOD guidelines in India to incorporate multimodal transport options. Tinoy et al. (2019) highlighted how transportation infrastructure exacerbates urban heat islands in Davao, advocating for climate-sensitive planning.

Stakeholder Engagement in Urban Planning. Community participation enhances the effectiveness of urban planning. Mallari & Bayod (2020) highlighted the role of stakeholder engagement in reforestation efforts in Davao del Sur. Similarly, Fernandez & Schroeder (2023) demonstrated how local communities transformed illegal dump sites in Piura into sustainable public spaces. Comparatively, Dias et al. (2023) emphasized participatory policy-making as a cornerstone of sustainable urban development.

Advancements and Policy Implications

Methodological Advances in Urban Planning Research. Innovative methodologies are improving urban planning research. Ullah (2014) integrated GIS-AHP for multidimensional land-use analysis, while Luzorata et al. (2023) demonstrated the utility of machine learning for accurate land classification. Rahman et al. (2022) developed GIS-MCDM methods, highlighting their potential to enhance decision-making frameworks.

Policy Implications and Recommendations. Policy frameworks are essential for guiding sustainable urbanization. Ann et al. (2019) advocated for context-sensitive TOD standards in India, while Dias et al. (2023) emphasized integrating resilience measures into global urban policies. Comparatively, Tinoy et al. (2019) highlighted the importance of incorporating climate resilience into urban transport policies, and Rahman et al. (2022) recommended adaptive policies for sustainable urban growth in Rajshahi City.

4. CONCLUSION

The systematic review highlights the pivotal role of Geographic Information Systems (GIS) and remote sensing technologies in addressing the challenges posed by rapid urbanization. Through the analysis of land-use trends, these tools provide actionable insights for sustainable urban planning, particularly in urban centers like Davao City. The integration of GIS facilitates comprehensive spatial analyses, enabling the monitoring of land-use changes, resource management, and informed decision-making processes. Moreover, the findings underscore the potential of GIS and remote sensing in bridging the gap between theoretical frameworks and practical applications, promoting resilience, equity, and environmental sustainability.

While urban development brings economic opportunities, it also poses significant threats to ecosystems, biodiversity, and socio-economic equity. Proactive strategies, supported by advanced technological tools, are essential to mitigate these impacts and guide urban growth toward sustainability. The review also highlights the necessity of aligning policy frameworks with contemporary urbanization trends to ensure effective governance and inclusive development.

RECOMMENDATION

Broader Integration of GIS in Urban Planning. Policymakers and urban planners should prioritize the use of GIS and remote sensing technologies for evidence-based urban planning. These tools enable the creation of detailed spatial datasets that can monitor land-use changes over time, assess environmental impacts, and inform zoning decisions. For example, GIS applications can pinpoint areas of urban sprawl, identify zones at risk of flooding, and track the loss of

green spaces. Remote sensing complements GIS by providing high-resolution imagery and time-series data, enabling the identification of trends and early warning signals. Integrating these technologies into urban planning processes ensures a data-driven approach that can better address current and future challenges.

Policy Alignment with Technological Advancements. Urban policies should reflect the rapid advancements in GIS and remote sensing technologies to effectively respond to urbanization challenges. For instance, policies should mandate the use of these tools in environmental impact assessments, urban heat island mitigation strategies, and climate adaptation plans. By leveraging GIS-based modeling, policymakers can predict the effects of land-use decisions on local ecosystems and develop strategies to counteract deforestation, watershed degradation, and habitat loss. Additionally, urban heat island studies conducted using remote sensing can guide the development of heat-resilient urban designs, such as increased tree canopy coverage and the use of reflective materials in infrastructure. Aligning policy frameworks with these technological capabilities ensures that urban growth is both sustainable and resilient.

Further Research and Innovation. Continued research into the applications of GIS and remote sensing technologies in urban planning is essential to address emerging challenges. Policymakers and researchers should explore integrating these tools with advanced fields like machine learning (ML) and artificial intelligence (AI). For instance, ML algorithms can analyze large datasets to identify patterns in urban growth, predict areas at risk of environmental degradation, and optimize land-use planning decisions. AI-driven scenario modeling can provide insights into the long-term impacts of different planning strategies, helping stakeholders select the most sustainable options. Additionally, innovations in sensor technology and real-time data collection could further enhance the accuracy and applicability of GIS and remote sensing in urban planning. Encouraging interdisciplinary collaborations and investments in research will ensure that these technologies remain at the forefront of sustainable urban development.

Annex 1.

Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
A Family-Based Approach to Reforestation Program Based on a Forecasted Water Availability for the Present and Future Needs: The Case of the Department of Environment and Natural Resources (DENR) Davao del Sur	Archelito Mallari, Rogelio Bayod	2020	Mixed Quantitative and Qualitative	• Water availability in watershed areas • Land cover changes and forest cover • Socio-cultural and economic factors affecting water availability • Impact of human activities on water resources	This study evaluates water availability in the Talomo-Lipadas Watershed in Davao del Sur, Philippines, using GIS and the Brook 90 Hydrological Model. It examines the relationship between land cover, socio-economic conditions, and water availability. The study proposes a family-based reforestation program under the Enhanced National Greening Program (ENGP) to ensure sustainable water management in the region. Findings: Forest cover reduction leads to decreased water availability in watershed areas. Past scenarios showed sufficient water availability, but projections indicate significant decreases by 2080 due to continued deforestation. A family-based approach to reforestation, involving local stakeholders and incentivizing participation, is recommended for effective watershed management and forest restoration.

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Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
Assessment of Land Use Land Cover Classification Using Support Vector Machine and Random Forest Techniques in the Agusan River Basin Through Geospatial Techniques	Juven G. Luzorata, Aljon E. Bocobo, Liahona M. Detera, Neki Jel B. Pocong, Anamarie P. Sajonia	2023	Quantitative	Land Use and Land Cover (LULC) types (agricultural, barren, built-up, forest, grassland, palm plantation, shrubs, water) Water quality parameters (pH, turbidity, total suspended solids) Land cover area changes over time (2000, 2010, 2020)	This study evaluates LULC changes in the Agusan River Basin, Philippines, over two decades (2000–2020) using machine learning classifiers (Support Vector Machine and Random Forest) integrated with Google Earth Engine (GEE). It assesses the relationship between LULC changes and water quality parameters (pH, turbidity, TSS) using spatial analysis techniques, including IDW interpolation and zonal statistics` Findings: Significant LULC changes were observed, with palm plantation areas expanding and shrubland decreasing. Support Vector Machine (SVM) achieved higher classification accuracy (up to 95.61%) compared to Random Forest (RF). Changes in LULC significantly impacted water quality, with decreases in turbidity and TSS attributed to improved land management practices. • The study highlights the importance of geospatial techniques in sustainable land use management and water quality conservation.
Determination of Future Land Use Changes Using Remote Sensing Imagery and Artificial Neural Network Algorithm: A Case Study of Davao City, Philippines	Cristina E. Dumdumaya, Jonathan Salar Cabrera	2023	Quantitative	Land use and land cover (LULC) classifications (water, trees, crops, built-up areas, flood vegetation, bare ground, rangeland, clouds) Elevation and proximity to road networks Projected land use changes for 2030 and 2050	This study utilizes the multilayer perceptron artificial neural network (MLP-ANN) to simulate, predict, and project LULC changes in Davao City. Elevation and road network proximity data were integrated to create predictive models based on 2017–2021 LULC patterns. High classification accuracy (96.68%, kappa index of 0.91) was achieved, enabling reliable projections of land-use dynamics. Findings: Predicted increases in built-up areas (4.50% by 2030, 6.89% by 2050) indicate intensified urbanization.

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					Cropland is projected to decrease significantly (-3.25% by 2030, -3.32% by 2050), highlighting risks to agricultural sustainability. Trees will increase moderately by 2030 (2.31%) but stabilize thereafter. • Recommendations include sustainable land management and integrating environmental considerations into urban planning to mitigate adverse impacts.
Geographic Information Systems (GIS) in Urban Planning	Ph.D. Sonila Xhafa, Ph.D. Albana Kosovrasti	2015	Qualitative	• Spatial data management (archiving, recording, processing) • Urban development patterns (land use, infrastructure distribution) • Population growth and urbanization effects • Decision-making frameworks for sustainable development	This article explores the role of Geographic Information Systems (GIS) in urban planning, emphasizing its application in managing spatial data and modeling urban processes. GIS supports decision-making in urban design, land use management, and infrastructure development. The study highlights how GIS facilitates orderly settlement growth, monitors resource allocation, and models urban transformations based on sustainable development principles. Findings: GIS enables efficient spatial data archiving and analysis, critical for urban planning and resource management. • It improves decision-making through enhanced visualization of spatial relationships and patterns. • Applications of GIS in urban planning address challenges such as population growth, infrastructure demand, and environmental sustainability. GIS promotes the integration of spatial and thematic data, supporting sustainable urban development and planning.
GIS for Sustainable Urban Transformation in Countries With Emerging	Trinidad Fernandez, Stella Schroeder	2023	Mixed Quantitative and Qualitative	Land use and green space availability • Urban population	This study examines the application of GIS for sustainable urban transformation in Piura, Peru, under the Morgenstadt Global Smart Cities Initiative (MGI). It focuses on identifying

Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
Economies: The Case of Piura in Peru				density and access to services Infrastructure and waste management coverage • Flood and pollution risks	and converting small illegal dumpsites into public spaces, addressing urban sprawl, informal housing, and limited green space. Using GIS-based spatial analysis, the study evaluates socio-economic and environmental variables to prioritize sites for intervention, aiming to improve sustainability and resilience in urban planning. Findings: • Eight small illegal dump sites were evaluated, with three prioritized based on population density, accessibility, and vulnerability criteria. • Site 2 was selected for its potential as a public space due to high population density and proximity to schools and economic infrastructure. GIS proved effective in evidence-based decision-making, facilitating resource allocation and urban management improvements. • The initiative highlights the potential of small-scale urban interventions (urban acupuncture) to catalyze broader sustainable urban transformations.
GIS in Sustainable Urban Planning and Management: A Global Perspective	Martin van Maarseveen, Javier Martinez, and Johannes Flacke	2019	Mixed Quantitative and Qualitative	Urban growth patterns Environmental quality indicators Transportation systems and emissions Resilience and compactness of cities	This book provides a comprehensive look at the role of Geographic Information Systems (GIS) in urban planning and management. It covers a global perspective on using GIS to address urban sustainability, inclusiveness, compactness, competitiveness, and resilience. Case studies illustrate GIS applications in analyzing urban risks, developing sustainable cities, and improving decision-making through spatial data. Findings: GIS is instrumental in developing sustainable urban planning strategies by analyzing spatial data.

Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
					Application areas include disaster risk management, urban transport planning, and enhancing urban resilience. • The integration of GIS into planning processes can improve accessibility, reduce carbon emissions, and promote equitable development. • Diverse global case studies demonstrate how GIS supports the creation of compact, resilient, and inclusive urban spaces aligned with the UN's Sustainable Development Goals.
Land Use and Land Cover Change and Sustainability Assessment of Vijayawada City by RS&GIS	Annavarapu Srinivasa Prasad, Chandramohan Ramamurthy, Karnatapu Leela Krishna	2022	Quantitative	Land use and land cover (LULC) categories: vegetation, built-up areas, water bodies, fallow land, and hills Rate of change in LULC from 2005 to 2020 Urbanization trends and spatial distribution	This study analyzes land use and land cover (LULC) changes in Vijayawada City, India, over 16 years (2005–2020) using remote sensing (RS) and geographic information systems (GIS). Satellite imagery from Landsat 5 and 8 was used to detect spatial and temporal changes in urbanization. Maximum likelihood supervised classification was applied to categorize LULC patterns and compute their rates of change. Findings: • Built-up areas increased significantly from 13.71% to 53.22%, primarily at the expense of vegetation and hilly areas. Vegetation cover decreased by 26.58%, with hilly areas also declining by 19.23%. • Fallow land saw an increase, while water bodies showed a minor rise in coverage. The study highlights the need for sustainable urban planning to address resource depletion and environmental degradation caused by urban expansion.
Land Use and Land Cover Change Detection and Prediction in the Kathmandu	Sonam Wangyel Wang, Belay Manjur Gebru, Munkhnasan Lamchin, Rijan	2020	Quantitative	• Land cover types (forest, agricultural land, water bodies, built-up areas, shrub	This study analyzes land use and land cover (LULC) changes in Kathmandu District over a 20-year period (1990–2010) and predicts future changes for 2030 using remote sensing and GIS.

Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
District of Nepal Using Remote Sensing and GIS	Bhakta Kayastha, Woo-Kyun Lee			land, grass land, barren areas) Rate of land use transitions Future land use predictions using CA–Markov model	The research employs the CA–Markov model to project spatial and temporal land use dynamics, highlighting the rapid urbanization and its effects on natural resources. Findings: • Urbanized areas increased by 52.47% from 1990 to 2010 at the expense of forests (-9.28%), agricultural land (-9.80%), and water bodies (-77%). Future projections (2030) indicate further decreases in forests (-14.43%), agricultural land (-16.67%), and water bodies (-25.83%), with urban areas gaining 18.55%. The study emphasizes the need for ecosystem-based urban planning to mitigate the impacts of rapid urbanization on ecosystem services and human well-being.
Re-examination of the Standards for Transit-Oriented Development Influence Zones in India	Sangeetha Ann, Toshiyuki Yamamoto, Meilan Jiang	2019	Mixed Quantitative and Qualitative	Influence zone radii for Transit-Oriented Development (TOD) Walkability and access distances Multimodal transport options Travel patterns in Indian cities	This study critically examines the standards for determining Transit-Oriented Development (TOD) influence zones in India. It highlights the need for adaptability studies specific to the Indian context due to differences in urban density, mobility patterns, and transport modes compared to developed countries. The research evaluates existing TOD guidelines and their applicability, emphasizing multimodal connectivity beyond walking access. Findings: • The influence zones in India should consider multimodal options (e.g., bicycles, auto-rickshaws) instead of relying solely on walking distances (800 meters as a standard). Empirical studies in Indian cities indicate larger influence areas than current policies prescribe. • Recommendations include context-sensitive planning and integrating various mobility

Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
					modes to create accessible and sustainable urban environments. The study provides a framework for re-evaluating TOD guidelines in developing countries with distinct urban characteristics.
Shaping Sustainable Cities: A Long-Term GIS-Emanated Spatial Analysis of Settlement Growth and Planning in a Coastal Mediterranean European City	Ioannis Vardopoulos, Sophia Ioannides, Marios Georgiou, Irene Voukkali, Luca Salvati, Yannis E. Doukas	2023	Mixed Quantitative and Qualitative	Urban sprawl indicators (density, decentralization, fragmentation, polycentricity) • Land use patterns and building density distribution • Population growth and settlement dynamics	This study explores urban sprawl and settlement growth in Pafos, Cyprus, from 1993 to 2021. Using GIS-based spatial analysis, it evaluates urban density, land use distribution, and sprawl characteristics. The research proposes sustainable urban development strategies aligned with compact city principles to address the observed fragmented and dispersed urban patterns. Findings: Urban sprawl led to 55% growth in settlement areas over 28 years, with a gradual reduction in growth rates due to economic challenges. • Density maps revealed high-density cores in the city center and low-density patterns in surrounding areas, emphasizing fragmented development. Sustainable development policies, such as compact city models and mixed land use, are recommended to counter urban sprawl and promote environmental sustainability.
Strategies for Sustainable Urban Renewal: Community-Scale GIS-Based Analysis for Densification Decision Making	Jinliu Chen, Paola Pellegrini, Zhuo Yang, Haoqi Wang	2023	Mixed Quantitative and Qualitative	• Floor Area Ratio (FAR) Accessibility to public transportation • Housing conditions (green space, building quality, infrastructure) Density levels in urban neighborhoods	This study explores urban renewal strategies in Suzhou, China, focusing on densification to optimize land use and enhance urban sustainability. Using GIS-based spatial analysis, the research evaluates 176 resettlement communities built between the 1980s and 2000s. It proposes three strategies for renewal and densification, aiming to balance population growth, resource efficiency, and environmental sustainability. Findings:

Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
					• Renewal is necessary for communities with low FAR, outdated infrastructure, and poor accessibility. Proximity to metro stations and transport hubs increases the potential for successful densification. A mix of approaches, including targeted rebuilding, retrofitting, and compact development, is essential for sustainable outcomes. Densification enhances land-use efficiency, supports economic sustainability, and improves housing quality while reducing agricultural land consumption.
Sustainability Indicators and GIS as Land-Use Planning Instrument Tools for Urban Model Assessment	Montaña Jiménez-Espada, Francisco Manuel Martínez García, Rafael González-Escobar	2023	Mixed Quantitative and Qualitative	• Urban population density Housing density Green areas per inhabitant Public facilities per capita Accessibility to basic services • Building compactness Urban sponging Public parking spaces per dwelling • Cultural heritage integration • Distance to recycling and organic bins	The study analyzes the sustainability of the urban model of Cáceres, Spain, using GIS tools and sustainability indicators at the neighborhood level. The research incorporates both spatial and statistical data to evaluate urban density, accessibility, and land-use efficiency, aiming to identify areas for improvement to meet sustainability goals. Findings: • Central districts exhibit high compactness and public facility access but lack adequate green spaces. Peripheral districts have greater green space availability but suffer from reduced service accessibility. The city struggles with uniform waste management accessibility and has imbalances in parking and heritage site integration. • Recommendations include enhancing green infrastructure, optimizing public facility distribution, and improving waste management proximity.
Sustainable Urban Land-Use Optimization Using GIS-Based Multicriteria	Md. Mostafizur Rahman and György Szabó	2022	Mixed Quantitative and Qualitative	Physical factors (distance from city center, main roads, etc.)	This study develops a GIS-based multicriteria decision-making (GIS-MCDM) approach to optimize land allocation for new residential developments, emphasizing sustainability. The

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Decision-Making (GIS-MCDM) Approach				Sustainability factors (social, economic, and environmental benefits) • Constraints (e.g., land-use restrictions, water body considerations)	methodology integrates physical and sustainability criteria, including social, economic, and environmental benefits, within a decision-support framework. The case study focuses on Rajshahi City, Bangladesh, using ordered weighted averaging (OWA) for suitability mapping and multiobjective land allocation. Findings: Inclusion of sustainability factors in land-use optimization increased total sustainability benefits by 9% compared to traditional approaches. • The "high-risk, no trade-off" strategy provided the highest sustainability benefits. • The study demonstrates the efficacy of GIS-MCDM in addressing sustainability in urban land-use planning, offering a balanced approach for stakeholders.
The Use of Light Detection and Ranging (LiDAR) Technology and GIS in the Assessment and Mapping of Bioresources in Davao Region, Mindanao Island, Philippines	Annabelle U. Novero, Melvin S. Pasaporte, Remie M. Aurelio, Carmel Jean G. Madanguit, Myla Ross M. Tinoy, Marian S. Luayon, John Paul L. Oñez, Emee Grace B. Daquiado, Jose Mari A. Diez, Jesson E. Ordaneza, Louie J. Riños, Neil C. Capin, Brian L. Pototan, Herzon G. Tan, Ma. Dulce O. Polinar, Daryll Ian Nebres, Cleto L. Nañola	2018	Mixed Quantitative and Qualitative	Agricultural resources (crops, irrigation systems) • Coastal resources (mangroves, fishponds) Forest resources (forest cover, biomass, carbon stock)	This study integrates LiDAR and GIS technologies to map and assess bioresources in Davao Region, Mindanao, covering agricultural, coastal, and forest resources. High-resolution LiDAR data (0.5m) enabled the accurate classification of land cover types and resource mapping for sustainable land use planning. The study involved supervised machine learning for land cover classification and field validation to ensure accuracy. Findings: • Agricultural resource maps showed high spatial resolution, with coconut, banana, and rice identified as major crops in the region. Davao Oriental was found to have the largest coastal mangrove coverage (21 sq. km). Forest cover assessments provided detailed classifications, including

Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
					above-ground biomass and carbon stock estimates. LiDAR technology significantly enhanced the accuracy of bioresource mapping, aiding local governments in land use planning and disaster risk management.
Urban Effects on Land Surface Temperature in Davao City, Philippines	M. M. Tinoy, A. U. Novero, K. P. Landicho, A. B. Baloloy, A. C. Blanco	2019	Quantitative	Land Surface Temperature (LST) • Normalized Difference Building Index (NDBI) • Enhanced Vegetation Index (EVI) • Albedo • Particulate Matter 10 (PM10) • Elevation • Population Density	This study analyzes the spatial and temporal dynamics of urban heat islands (UHI) in Davao City from 1994 to 2019. Using remote sensing and GIS, it identifies hot and cold spots of LST and evaluates the impact of various factors like urban density, vegetation, and topography on temperature variations. Regression models were employed to assess predictor variables' significance across different quantiles of temperature distributions. Findings: Urban areas exhibited consistent hot spots, especially in densely populated districts like Poblacion and Talomo. Albedo had the greatest impact on LST, followed by building density (NDBI), elevation, and vegetation (EVI). • The presence of vegetation reduced LST, while urban density and albedo increased it significantly. Quantile regression revealed that at the highest temperature quantiles (31.87°C–33.42°C), all predictors were statistically significant. • Recommendations include integrating higher resolution data and expanding analysis to other urban areas in Mindanao for comprehensive UHI mitigation strategies.
Urban Expansion Analysis and Land Use Changes in	Md Naimur Rahman	2019	Quantitative	Land use and land cover (LULC) changes (built-up areas, water	This study evaluates LULC changes in Rangpur City Corporation (RCC), Bangladesh, from 2009 to 2019 using GIS and remote sensing techniques. It

Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
Rangpur City Corporation Area, Bangladesh, using Remote Sensing (RS) and Geographic Information System (GIS) Techniques				sources, agricultural land, bare soil) Urban sprawl and population growth Environmental impacts of urbanization	examines urban sprawl and its effects on natural resources, highlighting the rapid urbanization of RCC following its transition from a municipal area in 2012. Data from Landsat satellites and field surveys were used for change detection and classification. Findings: • Built-up areas increased by 17.53% (5,670 ha), while agricultural land and bare soil declined by 9.94% (3,208 ha) and 10.19% (3,294 ha), respectively. • Urban expansion led to environmental degradation and reduced agricultural land, affecting food security and natural resources. • Recommendations include improved urban management, zoning for infrastructure expansion, and sustainable use of water and agricultural resources to mitigate the impacts of rapid urbanization.
Urban Land-Use Planning Using Geographical Information System and Analytical Hierarchy Process: Case Study Dhaka City	Kazi Masel Ullah	2014	Mixed Quantitative and Qualitative	Elevation, soil quality, and fault lines Proximity to utilities and facilities (e.g., roads, schools, healthcare centers) Urban land-use categories (residential, industrial, recreational, agricultural)	This master's thesis develops a GIS and Analytical Hierarchy Process (AHP)-based framework for urban land-use planning in Dhaka City. It conceptualizes a geodatabase to address existing data quality issues and applies GIS-AHP for evaluating land suitability. The study identifies criteria influencing urban land use, calculates priority weights using AHP, and creates suitability maps for different land-use zones. Findings: Highly suitable areas (13%) were recommended for residential zones, moderately suitable areas (35%) for mixed-use zones, low-suitability areas (42%) for agriculture and open spaces, and non-suitable areas (10%) for protected uses. • GIS-AHP proved effective in integrating diverse criteria and

Title	Authors	Year	Research Method	Variables Observed	Brief Description and Findings
					generating a strategic urban land-use plan, enhancing decision-making efficiency for sustainable urban development.
Visualizing Travel Accessibility in a Congested City Center: A GIS-Based Isochrone Model and Trip Rate Analysis Considering Sustainable Transportation Solutions	Musrat Gul Bhellar, Mir Aftab Hussain Talpur, Shabir Hussain Khahro, Tauha Hussain Ali, Yasir Javed	2023	Mixed Quantitative and Qualitative	Trip rates across various household categories • Travel distances, costs, and times for different purposes (shopping, business, health, recreation) Accessibility to urban facilities (parks, banks, health services) • Isochronal boundaries for accessibility mapping	This study addresses travel accessibility challenges in Sukkur, Pakistan, by using GIS-based isochrone models and trip rate analysis. The study evaluates travel patterns, costs, and accessibility for various trip purposes, mapping isochronal boundaries to delineate access to urban facilities. The research highlights unplanned urban growth and its impact on transportation efficiency and SDG 11.2 compliance. Findings: Accessibility to essential services is limited in Sukkur due to unplanned urban sprawl and traffic congestion. • Most health facilities are inaccessible within a 6-minute isochrone, whereas parks and religious facilities exhibit better accessibility. High dependency on motorized modes (bikes and cars) increases congestion and reduces travel efficiency. • Recommendations include integrated land use and transportation planning, restricting on-street parking, and promoting walking and cycling.

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