SMARTLAND: DEVELOPMENT OF A GIS-BASED AGRICULTURAL LAND ANALYSIS AND MAPPING SYSTEM FOR E-COMMERCE MARKETPLACE INTEGRATION

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IVAN GABRIEL A. PEÑA
CARLO P. GERBISE
FRANCO LEMUEL A. GARCIA

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ABSTRACT/OVERVIEW

Title:	**DEVELOPMENT OF A GIS-BASED LAND ANALYSIS AND MAPPING SYSTEM WITH MARKETPLACE INTEGRATION**
Developers:	**IVAN GABRIEL A. PEÑA** **CARLO P. GERBISE** **FRANCO LEMUEL A. GARCIA**
Degree:	Bachelor of Science in Computer Science
School:	Cavite State University – Imus Campus
Date:	
Instructor:	Mr. Ramil Huele

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CHAPTER 1

INTRODUCTION

As the global population continues to grow and urban areas expand, effective land management has become essential for promoting sustainable development and addressing the challenges associated with urbanization. SmartLand is a groundbreaking initiative designed to meet this need by combining advanced Geographic Information System (GIS) technology with practical marketplace functionalities. This innovative system serves as a powerful tool for analyzing and visualizing land characteristics, enabling users to make informed decisions regarding land use, investment, and development.

The GIS component of the system allows users to create detailed maps that illustrate various land attributes, such as land use patterns, soil quality, topography, and zoning regulations. By visualizing geographic data, users can better understand the complexities of land resources, identify opportunities for sustainable development, and address pressing issues related to land use conflicts and environmental impacts.

In addition to its robust analytical capabilities, the system features integrated marketplace functionalities that facilitate the buying, selling, and leasing of land. Users can browse listings, compare prices, directly contact land dealer and access market data, all within a single platform. This seamless integration not only streamlines the transaction process but also enhances transparency and accessibility for all parties involved. By connecting potential buyers and sellers with the information they need, the system fosters a more dynamic and efficient real estate market.

SmartLand represents a holistic approach to land management that promotes informed decision-making, sustainable resource utilization, and economic growth. By

providing a user-friendly interface that combines spatial analysis with commercial opportunities, this system aims to empower individuals and organizations to make better choices about land use, contribute to community development, and support the responsible stewardship of valuable land resources. In doing so, it aspires to play a vital role in shaping the future of urban planning and land management in a rapidly changing world

BACKGROUND OF THE STUDY

The integration of Geographic Information Systems (GIS) with marketplace platforms has significantly enhanced land analysis and mapping capabilities. GIS technology enables the visualization, analysis, and interpretation of spatial data, facilitating informed decision-making in land management and real estate sectors. By combining GIS with marketplace functionalities, users can access comprehensive land information, assess property values, and make data-driven decisions (Dangermond, 2023).

An example of this integration is California's use of GIS tools to enhance infrastructure planning and environmental monitoring. According to Jack Dangermond, founder of Esri, GIS technology has revolutionized how spatial data is utilized for decision-making across industries, particularly in managing natural resources and urban planning (Dangermond, 2023).

The integration of GIS with marketplace platforms has also facilitated the development of specialized tools for land analysis. The Land Change Modeler within the TerrSet software suite provides a comprehensive environment for analyzing land cover change and predicting future scenarios. This tool assists in understanding the dynamics of land use, which is crucial for effective land management and planning (Clark Labs, 2020).

Furthermore, the use of GIS in land valuation systems has streamlined property assessment processes. By mapping and analyzing data related to land ownership, land use, and other pertinent factors, GIS-based systems enhance the efficiency and accuracy of land valuation and acquisition management (HexaMap Solutions, 2020).

Open-source tools like PyLUSAT further support land use suitability analysis. This Python toolkit enables urban planners and researchers to conduct various tasks

in a suitability modeling workflow, offering a customizable and automated approach to land use analysis (Wang et al., 2021).

STATEMENT OF THE PROBLEM

The rapid growth of urban populations and the increasing demand for land have led to significant challenges in land management and utilization. Urban planners, real estate professionals, and government agencies often face difficulties in efficiently analyzing land characteristics, assessing market trends, and facilitating land transactions. Existing systems typically lack comprehensive tools for integrating geographic data with real estate marketplaces, resulting in fragmented information that hinders effective decision-making.

To address these issues, SmartLand, a GIS-Based Land Analysis and Mapping System with Marketplace Integration, aims to provide a solution that empowers stakeholders with valuable insights and facilitates efficient land transactions. However, several critical questions need to be addressed:

1. *How can a GIS-based system effectively integrate various land attributes and market data to provide a comprehensive analysis of land suitability for different uses?*
2. *How can SmartLand use a predictive approach to estimate land value based on prevailing land values in a specific geographic location from the data gathered?*
3. *How can the implementation of SmartLand contribute to agricultural planning in improving decision-making processes among land dealerships?*

OBJECTIVES OF THE STUDY

The development of SmartLand, a GIS-Based Land Analysis and Mapping System with Marketplace Integration, aims to address the pressing challenges associated with land management and utilization in rapidly urbanizing areas. To achieve this goal, the study outlines specific objectives designed to respond to the critical questions identified in the statement of the problem.

1. *To integrate agricultural land attributes to market data for comprehensive land suitability and classifying analysis.*
2. *To implement a predictive approach for estimating agricultural land value using Cabanatuan City's municipal records and land dealerships as basis of data.*
3. *To evaluate SmartLand's contribution to sustainable agricultural planning and improved decision-making in land marketing.*

TIME AND PLACE OF THE STUDY

The study focuses on the creation of a GIS-Based Agricultural Land Analysis and Mapping System aimed at integrating e-commerce functionalities. This research will take place from December 2024 to January 2025 at Cavite State University – Imus Campus, under the guidance of Mr. Ramil V. Huele, Professor for Undergraduate Thesis.

SCOPES AND LIMITATIONS

Scope

1. **Geographic Coverage:** The system will focus specifically on Cabanatuan City, allowing for detailed analysis of land attributes and market conditions within this urban area. This localized approach ensures that the system caters to the specific needs and characteristics of Cabanatuan.
2. **Agricultural Land Attributes and Data Integration:** The SmartLand system will integrate various land characteristics relevant to the geographical location.
    - Soil Quality
    - Irrigation
    - Agricultural Land Value Approximation
    - Land Size
3. **Target Users**: The primary users of the system will include local government units, urban planners, real estate professionals, developers, and prospective land buyers or sellers in Cabanatuan. The system will be designed to meet the needs of these stakeholders by offering user-friendly tools for land analysis and transactions.
4. **Functionalities**: The system will provide features such as interactive mapping of Cabanatuan's land, data visualization, land suitability analysis, and marketplace functionalities that enable users to browse property listings, compare and estimate prices with a proper basis from the Municipal records, and access relevant land information seamlessly.

Limitations

1. **Data Availability and Quality:** The effectiveness of the system will depend on the availability and quality of local data sources. Incomplete or outdated information regarding land attributes and market conditions in Cabanatuan may impact the comprehensiveness of the analyses and transactions.
2. **Technical Constraints:** The development and implementation of the SmartLand system may encounter technical challenges related to GIS technology, software integration, and user interface design, which could affect the overall performance and usability of the platform.
3. **Regulatory and Legal Factors:** The system will need to comply with local laws and regulations concerning land use, zoning, and real estate transactions in Cabanatuan. Any changes in regulatory frameworks may influence the functionalities and features of SmartLand.
4. **User Adoption and Engagement:** The success of the SmartLand system in Cabanatuan will depend on the willingness of local stakeholders to adopt and engage with the platform. Resistance to change or lack of familiarity with GIS technology among potential users may limit the system's overall impact.

DEFINITION OF TERMS

Geographic Information System (GIS)

A technology for collecting, analyzing, and visualizing geographic data.

Land Management

The process of planning and regulating land use for sustainable development.

Urbanization

The transformation of rural areas into urban areas due to population growth.

Marketplace Integration

Incorporation of commercial functionalities for buying, selling, and leasing properties within a system.

Land Use Patterns

The categorization of how land is utilized (e.g., residential, commercial, agricultural).

Spatial Analysis

Examination of spatial data to identify trends and relationships.

Zoning Regulations

Laws dictating permissible land uses and development parameters.

Real Estate Professionals

Individuals involved in real estate transactions, such as agents and brokers.

Stakeholders

Individuals or groups with an interest in a project or system.

Sustainable Development

Development that meets present needs without compromising future generations.

Data Visualization

Graphical representation of data to identify trends and patterns.

Property Listings

Advertisements detailing available real estate for sale or lease.

Transparency

Openness and clarity in processes and information.

Community Development

Efforts to improve the quality of life in a community.

Urban Planning

Designing and regulating land use in urban areas.

THEORETICAL AND CONCEPTUAL FRAMEWORK

Geographic Information Systems (GIS) Theory emphasizes the use of spatial data and mapping techniques to facilitate effective decision-making in agricultural practices. GIS technology allows for the integration of various data types, such as soil quality, land use, and crop distribution, enabling stakeholders to optimize land use and improve agricultural productivity. This theoretical framework supports the premise that GIS-based analysis can lead to better resource management, enhance agricultural practices, and contribute to sustainable development.

The Technology Acceptance Model (TAM) provides insight into the factors influencing user acceptance of new technologies, particularly in the context of agricultural stakeholders adopting the GIS-based system. TAM posits that perceived ease of use and perceived usefulness significantly impact an individual's intention to use a technology. This framework is essential for understanding how farmers and other users perceive the benefits of integrating GIS technology into their agricultural practices, which can ultimately influence the success of the SMARTLAND system.

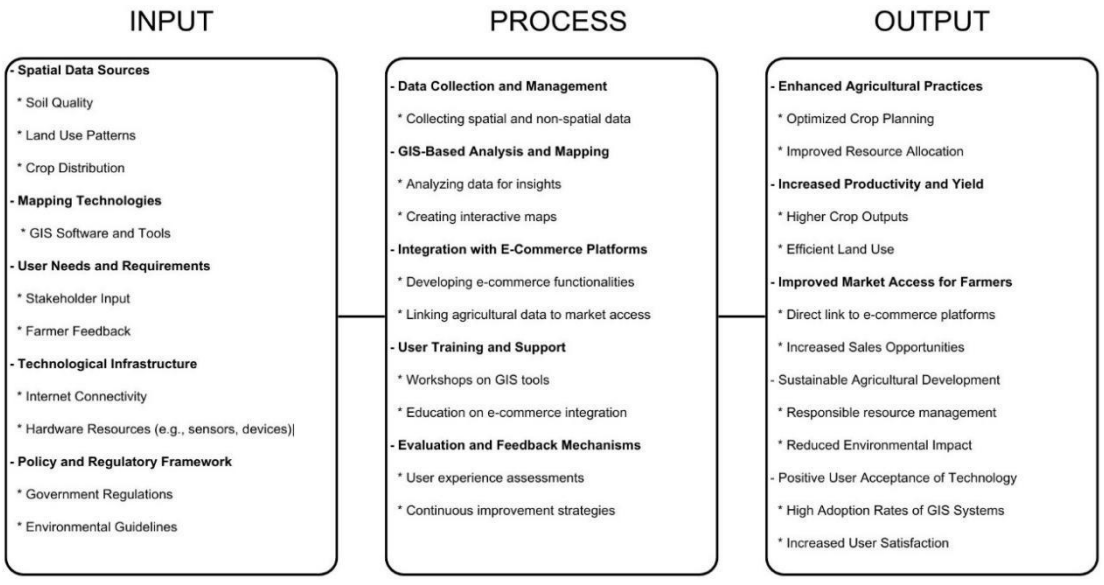

Figure 1: *The Conceptual Framework shows the data inputs, processes, and outputs that the proponent's aims to achieve and provide through the system's capabilities and functionalities.*

CHAPTER II

Review of Related Literatures / Studies Foreign

Urban Vacant Land in Growing Urbanization: An International Review

Song and Wen (2020) conducted an international review exploring the dynamics of Urban Vacant Land (UVL), emphasizing its potential for enhancing urban sustainability. By analyzing typology, morphology, proximate causes, and multiple functions of UVL at parcel, city, and national levels, the study identified critical factors contributing to UVL, including inefficient land use, irregular land parcels, and insufficient investment. Using case studies from cities like Guangzhou, New York, and 65 U.S. cities, the research categorized UVL based on land cover, usage, and ownership, revealing its fragmented and irregular distribution patterns. The study highlights UVL's dual nature: a "gray area" of urban space and a resource for sustainability initiatives. It underscores the importance of GIS-based monitoring, control mechanisms, and revitalization policies to optimize land use and integrate urban planning with marketplace dynamics, ultimately contributing to sustainable urban development.

Land Use and Land Cover Change

In the entry titled Land Use and Land Cover Change by Cutter and Derakhshan (2020), the authors discuss the dynamics of land use and land cover changes and their implications for geographic and environmental analysis. They emphasize the role of GIS and remote sensing in monitoring and analyzing these changes, particularly in understanding the impacts of human activities, such as urban

expansion, agriculture, and infrastructure development, on land use. One of the key findings is that GIS tools are essential for detecting and mapping land use and land cover changes over time, providing valuable insights into trends and patterns that influence land management decisions. The study highlights the significance of integrating temporal data with current land characteristics to improve land suitability analysis. This aligns with the objectives of SmartLand, which aims to use GIS-based analysis to assess land for different uses and predict changes in land value based on environmental, economic, and geographical factors.

Practical Guide for the Use of ICT in Agriculture

In the Practical Guide for the Use of ICT in Agriculture (European Union, 2022), the document provides insights into how information and communication technologies (ICT) can be utilized to improve agricultural practices, focusing on the application of digital tools for land management and decision-making. The guide highlights the role of GIS in managing agricultural land by integrating various data types, such as soil conditions, water availability, and climate factors, to optimize land use for farming. A key finding is that the use of ICT, including GIS-based systems, allows for precise land monitoring, enabling farmers to make data-driven decisions on crop selection, irrigation, and land productivity. The integration of ICT in land analysis is also applicable to urban and real estate planning.

Geospatial Data and GIS Applications in Forestry and Environmental Management

In the article Geospatial Data and GIS Applications in Forestry and Environmental Management by Santos, Lima, and Nascimento (2022), the authors examine the role of geospatial data and GIS applications in managing forest resources and supporting environmental sustainability. The study highlights how GIS enables the integration of diverse data sources, such as topography, soil quality, climate, and forest cover, to create detailed spatial models for forest management

and conservation. A key finding is that GIS provides critical insights into land suitability by assessing environmental factors, which can be extended to other fields such as urban planning and agricultural land management.

A GIS-Based Framework for Land Use and Planning: Integration of Environmental, Economic, and Social Factors

In the article A GIS-Based Framework for Land Use and Planning: Integration of Environmental, Economic, and Social Factors by Hassan and Rahman (2024), the authors explore a GIS-based framework that integrates various environmental, economic, and social factors to aid land use planning. The study emphasizes that GIS tools, when applied in combination with economic and social data, offer a comprehensive approach to land assessment, enabling decision-makers to consider multiple factors, such as soil quality, land accessibility, and socio-economic needs. The authors found that GIS-based land use planning can significantly improve the decision-making process for land development and urban planning by providing clear, data-driven insights into land suitability.

Review of Related Literatures / Studies Local

Transforming Philippine Agri-Food Systems with Digital Technology

In their 2023 study, Briones, Galang, and Latigar explore the role of digital technologies in transforming the Philippine agricultural sector. The research focuses on how tools like advisory apps and online retail networks are enhancing productivity and market access for smallholder farmers. The study identifies the potential of digital agriculture but also highlights challenges, such as the "digital divide" that may leave vulnerable rural populations behind. It emphasizes the importance of government and private sector collaboration to bridge this gap and expand access to digital tools, which could improve land use, productivity, and market integration in agriculture.

Development of the Methodology for Ecosystem Valuation

In this study, Siddica (2023) outlines a methodology for ecosystem valuation, focusing on integrating environmental, social, and economic factors to assess ecosystem services. The methodology provides a framework for sustainable land-use planning by recognizing and quantifying ecosystem benefits, thus offering an effective tool for decision-makers.

Smart Cities and Digital Transformation: Emerging Opportunities and Challenges

In this chapter, Sundararajan and Sharma (2021) explore how digital transformation and smart technologies, including GIS, can shape sustainable urban development. The authors highlight the integration of smart city infrastructure with environmental and market data, facilitating optimized land use and decision-making.

GIS-Based Land Suitability Model for Agricultural Tractors in CALABARZON Region, Philippines

This study developed a GIS-based land suitability model for determining the appropriateness of areas in the CALABARZON region for the use of agricultural tractors. The model evaluates lowland rice areas based on criteria such as slope, road network proximity, and flood risk. The results indicate that a significant portion (81.39%) of these areas is highly suitable for tractor use, with the model providing valuable insights to improve tractor distribution programs by the Philippine government.

GIS for Soil Erosion Risk Assessment in Bukidnon Watersheds

This study applies the Revised Universal Soil Loss Equation (RUSLE) model in GIS for soil erosion risk assessment in the Bukidnon watersheds in the Philippines. By combining factors such as rainfall, soil type, land cover, and slope, the study identifies high-risk erosion zones and supports targeted interventions for soil conservation and sustainable land use management in the region.

Table 1. Table of Comparison

STUDY/ REFERENCE	FOCUS AREA	KEY FINDINGS	RELEVANCE TO PROPOSED SYSTEM
HexaMap Solutions, 2020	Application of GIS technology in land valuation and acquisition management.	Creation of detailed maps, assessment of land value based on various approaches.	Integrating GIS into land valuation systems to enhance efficiency, accuracy, and stakeholder engagement.
Changjie Chen et al., 2021	Development of an open-source Python package dedicated to land-use suitability analysis.	PyLUSAT offers computational efficiency, extensibility, and cross-platform compatibility for conducting suitability modeling.	Incorporating PyLUSAT into the system can provide robust tools for land-use suitability analysis.
European Union, 2022	Utilization of ICT tools, including GIS, in agriculture and agricultural educational training.	ICT applications such as robotics, drones, mobile applications, and GIS in enhancing agricultural productivity and efficiency.	Leveraging technologies like GIS for better data management and analysis.
Siddica, A. 2023	Formulation of methodologies for valuing ecosystem services.	Frameworks for integrating ecosystem service values into national accounts	Incorporating ecosystem valuation methodologies can enhance the system's capability to assess land value

Amongo, R. M., et al., 2023	Mapping and analyzing ecosystem services using advanced remote sensing and machine learning methods	Integrating satellite imagery, GIS, and advanced algorithms to track changes in ecosystems and assess their services	Highlights the utility of remote sensing and machine learning for evaluating land and ecosystem value.

CHAPTER III

Materials

The SMARTLAND system will employ PHP as the primary programming language for backend development and database management, leveraging its efficient server-side scripting capabilities and smooth integration with MySQL for handling and organizing data. PHP will be responsible for processing user inputs, managing geolocation data, and facilitating marketplace transactions. HTML and CSS will be used to design an intuitive and responsive user interface, ensuring that users can easily navigate the system across various devices, including desktops, laptops, and smartphones. MySQL will serve as the relational database management system, storing critical information such as user profiles, geolocation coordinates, agricultural land analysis results, and marketplace listings.

The system will be hosted on a standard Windows environment, ensuring compatibility with readily available hardware and software configurations. The development process will utilize standard desktop or laptop computers equipped with sufficient processing power, memory, and storage to support system coding, debugging, and testing. Additionally, GPS-enabled devices, such as smartphones or GPS modules, will be employed for the accurate collection of geolocation data, allowing precise mapping and analysis of agricultural land areas. These hardware choices ensure cost-efficiency and accessibility for the development and deployment phases.

One of the system's core functionalities is its geolocation-based mapping feature, enabling farmers to register their agricultural land by providing precise GPS

coordinates. SMARTLAND will analyze this data to create interactive maps, displaying detailed information about the land, such as size, location, and potential suitability for specific crops. Farmers can also list their agricultural products on the system, enabling buyers to search for items based on location, crop type, or availability. This functionality not only enhances land analysis but also streamlines the process of connecting producers with buyers, creating a more efficient and transparent agricultural marketplace.

By leveraging PHP, HTML, CSS, and MySQL in a standard Windows environment, SMARTLAND aims to provide an accessible, reliable, and user-friendly system that integrates GIS-based agricultural land analysis with e-commerce, ultimately empowering farmers and fostering economic growth in the agricultural sector.

Experimental Units to Be Used

The experimental units for this project will consist of geolocation data represented as latitude and longitude coordinates, which will be used to map and analyze agricultural land areas. These coordinates will be collected using GPS-enabled devices to ensure accuracy and precision. The system will process this data to generate interactive maps that provide detailed location-based insights, such as the exact positioning of farmlands, their proximity to marketplaces, and their potential for specific agricultural uses. This geolocation data will serve as the foundation for linking agricultural lands to the e-commerce platform, enabling a seamless connection between farmers and buyers.

The primary users of the SMARTLAND system are farmers, who will register their agricultural lands and list their produce on the platform, and buyers, who will use the system to locate and purchase agricultural products based on their location, type, or availability. To ensure the system meets its intended objectives, testing will involve a diverse group of stakeholders. Selected farmers will test the system to ensure that the land registration, mapping, and product listing features are user-friendly and relevant to their needs. Representative buyers will evaluate the platform’s usability and the accuracy of the geolocation-based search functions. This comprehensive testing process ensures that the system is both functional and practical for real-world use.

Planned Experimental Design

REQUIREMENT ANALYSIS	Identifying the needs of farmers, buyers, and other stakeholders in agricultural e-commerce.
SYSTEM DESIGN	Structuring the database schema, geolocation mapping, and user interface layout.
DEVELOPMENT	Implementing the system using PHP, MySQL, HTML, and CSS.
DESIGNING	Performing functionality, usability, and accuracy tests with input from real users and IT experts.
DEPLOYMENT	Launching the system and gathering user feedback for improvements.
MAINTENANCE	Monitoring system performance and addressing issues as they arise.

Figure 2: *Software Development Life Cycle Methodology: ensures a user-centered approach, emphasizing the system's reliability and practicality.*

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