
OPTIMIZATION OF THE USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN MARKET ANALYSIS AND DEVELOPMENT STRATEGIES

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ABSTRACT

This study aims to optimize the use of Geographic Information Systems (GIS) in market analysis and development strategies, focusing on SMEs in West Java. A mixed-method approach was employed, integrating quantitative spatial analysis and qualitative data from surveys and interviews. Primary data were collected through questionnaires administered to 150 business owners and 300 consumers, combined with secondary demographic maps from the Geospatial Information Agency (BIG). Spatial analysis utilized hotspot analysis and buffer analysis in ArcGIS. Key findings include: (1) Three regions identified as potential market hotspots (North Bandung, Central Cimahi, Central Sumedang) with consumer density >50 people/km²; (2) GIS usage showed a significant positive correlation with sales growth ($r = 0.72$; $p < 0.01$), contributing to 58% of sales variation; (3) Main barriers to GIS implementation were licensing costs (45% of respondents) and technological literacy (60%). Strategic recommendations include open-source GIS training (QGIS) and developing an integrated data platform for SMEs. These findings prove that GIS is not only effective for mapping but also as a spatial data-driven decision-making tool that can enhance business strategy accuracy by up to 40%.

KEYWORDS

GIS, market analysis, consumer behavior, SMEs, spatial data.



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INTRODUCTION

Geographic Information Systems (GIS) have evolved from just a conventional mapping tool to a crucial technology in supporting spatial data-driven decision-making. In a global context, GIS is used by multinational

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companies such as Amazon and Starbucks to optimize distribution locations, analyze consumer patterns, and predict market trends with high accuracy. For example, Starbucks combines data on population density, income levels, and transportation access through GIS to determine the location of new stores, thereby reducing the risk of business failure by up to 25% (Rogerson, 2021). In Indonesia, similar potential has not been fully explored. The Central Statistics Agency (2022) noted that 78% of micro and small enterprises (MSMEs) still rely on traditional methods such as manual surveys or intuition in market analysis, even though geospatial data from the Geospatial Information Agency (BIG) is publicly available. In fact, a study by Malczewski (2004) proves that the integration of demographic, economic, and consumer behavior data through GIS is able to increase the effectiveness of marketing strategies by up to 40%. Unfortunately, lack of technology literacy and limited infrastructure are the main obstacles to GIS adoption in Indonesia's business sector, as revealed in his research on the challenges of GIS implementation in developing countries.

This challenge is even more complex when looking at the fragmentation of geographic data in Indonesia. Population density data, for example, is managed by BPS, while land use data is under BIG, and infrastructure information is held by the Ministry of PUPR. This disintegration causes GIS-based market analysis to often be not comprehensive (Widodo et al., 2020). On the other hand, technological advancements such as big data and machine learning should be able to enrich GIS capabilities. Platforms such as ArcGIS Online have enabled real-time analysis of consumer movements through integration with GPS data from ride-hailing apps such as Gojek, but this utilization is still limited to large companies (Goodchild, 2020). A concrete example can be seen from Bali's tourism sector, where GIS is used for mapping tourist destinations, but in-depth analysis such as visit patterns by season or preferences of foreign tourists has not been optimized (Buhalis & Amarangana, 2015). In fact, a study in Malaysia by (Azizan & others, 2021) showed that the integration of GIS with social media data (such as Instagram geotagging) increased marketing targets by 22%, proving that the opportunities for spatial-based market development are huge.

Based on these gaps, this study aims to answer three critical questions: (1) How can GIS be optimized to design adaptive market development strategies? (2) To what extent do geographic variables such as distance to shopping malls or population density affect consumer behavior? (3) How can GIS-based recommendations be implemented by business actors with limited resources? To achieve this, the research uses a mixed-method approach with a focus on spatial analysis and field surveys.

Primary data was collected through a questionnaire of 150 business actors and 300 consumers in three urban areas of West Java (Bandung, Cimahi, and Sumedang), combined with secondary data such as demographic maps from BIG and BPS economic reports. The analysis was carried out in stages: first, mapping of market hotspots using the Kernel Density Estimation technique in ArcGIS Pro; second, a spatial regression test to identify the relationship between geographic variables and purchasing decisions; Third, the formulation of strategic recommendations based on findings. Preliminary results showed that 72% of

regions with economic growth above 5% had a positive correlation between consumer density and marketing strategy success ($r = 0.68$; $p < 0.01$), indicating that GIS is not only a mapping tool, but also a powerful predictive instrument.

This research is expected to make two main contributions: theoretically, developing a Spatial Market Intelligence framework that integrates the principles of geography and business; practically, it provides technical guidance for MSMEs in utilizing GIS with limited resources, including the use of open-source tools such as QGIS and public data from BIG. The long-term implication is to drive the digital transformation of Indonesia's business sector towards an era of data-driven economy, where decisions are no longer based on assumptions, but on accurate spatial analysis. However, ethical challenges such as consumer data privacy and the regulation of PDP Law No. 27/2022 need to be considered, especially in the use of geolocation data from digital platforms. Thus, GIS optimization in market development is not only about technology, but also the balance between innovation and sustainability.

Geographic Information System (GIS) Concept

Geographic Information Systems (GIS) is a technology that combines spatial data (geographic coordinates) with attribute data (descriptive information) to produce multidimensional analyses that support decision-making (De Smith et al., 2018). According to (Chang, 2018), the evolution of GIS can be divided into three phases:

1. Early Phase (1960–1990): GIS is used to a limited extent for basic mapping and inventory of natural resources, such as the Canada Geographic Information System (CGIS) project.
2. Digitalization Phase (1990–2010): The adoption of computer technology allows for complex spatial analysis, such as *buffer analysis* and *network analysis* for urban planning.
3. Integration Phase (2010–present): GIS integrates with *big data*, IoT, and AI for predictive analysis, such as modeling disease spread or predicting market demand (Goodchild, 2020)

In Indonesia, the development of GIS is still lagging behind other ASEAN countries. The BIG report (2022) shows that only 45% of local governments use GIS for development planning, while in Malaysia the figure reaches 78% (Azizan & others, 2021).

Key challenges include limited cloud computing infrastructure and lack of skilled human resources (Widodo et al., 2020). However, initiatives such as GIS Training for MSMEs by Kominfo (2021) are starting to open access for business actors.

Market Development Strategy: Traditional vs. Spatially-Based Approach

Traditional market development strategies generally rely on demographic and psychographic data, such as the age, income, or lifestyle of consumers (Kotler et al., 2016). However, this approach often ignores the geographical factors that are critical in determining the success of a business. For example, a study by (A.B. et al., 2022)(Berman & Evans, 2018) found that 60% of retail location failures are caused by inaccuracies in accessibility analysis and spatial competition. GIS offers solutions through:

1. Hotspot Analysis: Identify the regions with the highest concentration of consumers. Example: Mapping of *smartphone purchase hotspots* in Jakarta using GPS data from e-commerce applications (Kominfo, 2021).
2. Spatial Market Segmentation: Classification of regions based on unique characteristics, such as purchasing power (low-medium-high) and product preferences.
3. Optimal Location Modeling: Determine the location of a new branch taking into account distance to competitors, population density, and road access (Malczewski, 2004).
4. A successful example of the implementation of GIS in market strategy can be seen in the Alibaba company in China. Using GIS algorithms and real-time transaction data, they were able to reduce logistics costs by up to 20% and increase market coverage in rural areas.

GIS Integration in Market Analysis: Global and Local Case Studies

GIS integration has brought transformations across sectors:

1. Retail: Starbucks uses GIS to analyze *walkability index* (ease of pedestrian access) and *drive-time analysis* (vehicle travel time) in determining store locations (Rogerson, 2021). As a result, 85% of their new stores in the U.S. hit sales targets within the first 6 months.
2. Tourism: In Bali, the Central Statistics Agency (2021) mapped priority tourist destinations using GIS, but analysis of tourist behavior (such as duration of visit and travel patterns) is still limited. In fact, a study in Thailand by Srisawat (2022) showed that the integration of GIS with social media data increased the accuracy of the target market of young tourists by 30%.
3. Indonesian MSMEs: Only 12% of MSMEs in West Java use GIS for market analysis, although 65% admit to difficulties in determining strategic locations (BPS, 2022). The main obstacles include the cost of software licensing and lack of training.

Table 1. Comparison of GIS Implementation in the Business Sector

Country	Sector	Technique	SIG Used	Result
AXLE	Retail	<i>Hotspot Analysis</i>		Sales up 25% (Rogerson, 2021)
Malaysia	Tourism	<i>Geotagging + Buffer Analysis</i>		Target pasar naik 22% (Azizan & others, 2021)
Indonesia	MSMEs	Base mapping		45% of MSMEs fail to expand (BPS, 2022)

Theoretical Framework and Analytical Model

This study adapts the Spatial Decision Support System (SDSS) model from Malczewski (2004) which consists of three components:

1. Data Subsystem: Integrates primary (consumer survey) and secondary (BIG demographic map) data.
2. Analysis Subsystems:
 - Spatial Autocorrelation*: Measures the distribution patterns of consumers (randomly dispersed, clustered, or uniform).

Geographically Weighted Regression (GWR): Analyzes the geographic variables that influence purchasing decisions.

3. Visualization Subsystem: Generate thematic maps and interactive dashboards for business recommendations.

The model is enriched with the concept of *Spatial Market Intelligence*, which emphasizes the integration of real-time data (such as GPS data and social media) for dynamic analysis. An example of this model application can be seen in the Gojek company, which uses GIS to predict the demand for *ride-hailing* services based on rush hour traffic patterns (Kominfo, 2021).

Challenges and Opportunities for GIS Development in Indonesia

Despite the huge potential of GIS, its implementation in Indonesia faces structural obstacles:

1. Data Fragmentation: Geospatial data is spread across BIG, BPS, and the Ministry of Public Works without an integrated platform (Widodo et al., 2020).
2. Regulation: PDP Law No. 27/2022 restricts the use of consumer geolocation data without explicit consent.
3. Infrastructure: Only 30% of Indonesia has fast internet access that supports *real-time GIS analysis* (Kominfo, 2021).

The research identifies several key challenges faced by Small and Medium Enterprises (SMEs) in West Java regarding the optimization of Geographic Information Systems (GIS) for market analysis and development strategies. Despite the growing availability of geospatial data, many SMEs still rely on traditional methods such as manual surveys and intuition, limiting their market analysis capabilities. Additionally, issues such as limited technology literacy, high software licensing costs, and fragmented geospatial data further hinder the adoption and effective use of GIS. As a result, these businesses are unable to fully capitalize on the advantages that GIS can offer, such as precise consumer segmentation, location optimization, and strategic market planning.

Furthermore, the fragmented nature of geospatial data in Indonesia, where different agencies control various data sets (e.g., population density, land use, infrastructure), complicates the integration of these datasets for a holistic market analysis. This disjointed data management prevents SMEs from effectively utilizing GIS to identify market hotspots, analyze consumer behavior, and develop targeted strategies for growth. The study aims to address these issues by exploring how GIS can be optimized to create adaptive market development strategies, particularly for businesses with limited resources.

The urgency of this research stems from the increasing need for SMEs in Indonesia to adapt to a rapidly changing business environment. As competition intensifies, particularly with larger firms leveraging technology for strategic decision-making, SMEs must also harness the power of data-driven insights to remain competitive. GIS offers a valuable tool for improving market analysis and decision-making processes, but its adoption remains limited due to technical and infrastructural barriers. Given the significant potential of GIS to enhance business strategies, especially for location-based decisions and consumer targeting, it is critical for SMEs to overcome these challenges in order to maximize their growth potential and maintain their market relevance.

Previous studies have demonstrated the growing importance of GIS in various sectors. Rogerson (2021) highlighted how multinational companies, such as Starbucks, use GIS to optimize the location of new stores by analyzing consumer behavior, population density, and accessibility. Similarly, Azizan et al. (2021) showed how integrating GIS with social media data can significantly improve marketing targeting by 22%, particularly in the tourism sector. These findings indicate the powerful role GIS can play in market analysis and strategic decision-making, providing a competitive edge to businesses that effectively utilize the technology.

In the context of SMEs, GIS adoption has been less widespread. Research by Widodo et al. (2020) noted that while GIS has the potential to transform market strategies, the lack of technological infrastructure and training remains a major barrier for SMEs in developing countries, including Indonesia. The study found that many SMEs continue to rely on traditional methods for market analysis, missing out on the benefits of spatial data integration. The challenges of integrating fragmented data from various sources also hinder the potential of GIS in improving decision-making for SMEs.

Further research by Buhalis & Amaranggana (2015) in the tourism sector of Bali demonstrated the untapped potential of GIS for in-depth market analysis, such as understanding tourist behavior and seasonal visit patterns. Although GIS was used for basic mapping, the deeper, more strategic use of GIS to enhance marketing effectiveness remained underdeveloped. This highlights the broader gap in utilizing GIS for advanced decision-making, particularly among SMEs in Indonesia, and emphasizes the need for further research on its optimization for business development.

Despite the growing recognition of GIS's potential in market analysis, a significant research gap exists in its application among SMEs in Indonesia. While much of the existing literature focuses on large-scale businesses and multinational corporations, there is limited research exploring how GIS can be optimized for SMEs, particularly in developing countries with limited resources. Additionally, the integration of GIS with other business intelligence tools and the use of open-source GIS platforms like QGIS remain underexplored. This study seeks to fill this gap by examining how GIS can be effectively applied to market development strategies for SMEs with limited technical infrastructure.

The novelty of this research lies in its focus on optimizing GIS usage for SMEs, particularly in the context of West Java, Indonesia, where GIS adoption has been limited due to infrastructure and technological challenges. This study integrates spatial analysis with consumer behavior data to propose practical, resource-efficient strategies for SMEs. The research also explores the potential of open-source GIS tools like QGIS, which are more accessible to SMEs with limited budgets, and examines how these businesses can overcome barriers to GIS adoption. By combining spatial data with actionable business strategies, this study offers a fresh perspective on the role of GIS in enhancing business decisions for SMEs in Indonesia.

The main objective of this research is to optimize the use of Geographic Information Systems (GIS) in market analysis and development strategies for SMEs

in West Java. Specifically, the study aims to identify potential market hotspots using spatial analysis, understand how geographic variables affect consumer behavior, and provide actionable recommendations for SMEs to implement GIS-based strategies despite limited resources. By doing so, the research seeks to improve business decision-making, enhance market targeting, and support sustainable growth for SMEs.

This research provides significant theoretical and practical benefits. Theoretically, it contributes to the development of a Spatial Market Intelligence framework, combining geographic data and business strategies to improve market analysis. Practically, it offers SMEs in West Java actionable insights into how to utilize GIS, even with limited resources, to enhance their market development strategies. By focusing on open-source GIS tools and integrating publicly available data, the study offers cost-effective solutions for SMEs to leverage GIS for business growth, ultimately contributing to the digital transformation of Indonesia's SME sector.

RESEARCH METHODS

This study employs a mixed-method approach with quantitative dominance (QUAN-qual), designed to integrate GIS spatial analysis with consumer behavior data. This approach was chosen because it allows triangulation of data, which improves the validity and robustness of the findings (Creswell & Creswell, 2018). The research proceeds in three stages: the first stage is the exploratory phase, where in-depth interviews are conducted with 10 business actors to identify challenges in GIS usage. The second stage involves the quantitative phase, which includes spatial analysis (hotspot and buffer analysis) and statistical tests (correlation and spatial regression) to measure relationships between variables. Finally, the data integration phase synthesizes the qualitative and quantitative findings to formulate actionable strategic recommendations for SMEs.

The population for the study includes MSMEs in West Java, with a total of 1,200 registered businesses. The sample was drawn using purposive sampling for business actors, selecting 150 MSMEs based on recommendations from the Cooperatives and SMEs Office and economic growth maps from BPS. Additionally, random sampling was used to select 300 consumers from urban areas like Bandung, Cimahi, and Sumedang. The inclusion criteria for MSMEs were active businesses using digital technology for transactions, and for consumers, those who made a purchase at least once per month. The sample size was calculated using the Slovin formula with a 5% margin of error to ensure a representative sample.

Data were collected through multiple methods. The primary data sources included surveys with closed-ended questions using a Likert scale (1-5), semi-structured interviews, and field observations. The questionnaires focused on GIS usage and its effectiveness in improving market reach and sales. Interviews with business actors explored the barriers to GIS adoption, while field observations were used to map MSMEs and their proximity to key infrastructure using GPS tools. Secondary data, such as economic reports and demographic maps from BIG and BPS, were also integrated to provide contextual information for spatial analysis.

The study employed ArcGIS Pro and QGIS software to perform spatial analysis, including Kernel Density Estimation (KDE) for hotspot analysis and buffer analysis to determine optimal service zones. Statistical tests, including independent t-tests and spatial regression (GWR), were used to examine the relationships between GIS usage and market effectiveness. To ensure the reliability and validity of the data, the study conducted content validity testing, reliability tests, and accuracy checks for spatial data. Ethical considerations were also addressed, with informed consent obtained from all participants and anonymity ensured for all data. The findings aim to provide practical recommendations for SMEs to optimize their use of GIS despite limited resources.

RESULTS AND DISCUSSION

Description of Demographic and Spatial Data

Characteristics of Business Actors

Of the 150 MSMEs studied:

1. Business Sector:
 - Retail (65%): The majority sell clothing and daily necessities.
 - Culinary (20%): Fast food and café businesses.
 - Services (15%): Car wash, salon, and electronics repair.
2. Technology Usage:
 - 72% use Google Maps for basic location analysis.
 - 28% use GIS (ArcGIS/QGIS) tools, especially medium-scale businesses.
 - Average monthly expenditure on technology: IDR 1.2 million (SD = IDR 350,000).

Table 2. MSME Profile by Location

Location	Sum MSMEs	Average Sales (Rp/month)	GIS Usage (%)
Bandung	53	45.000.000	35%
Summit	41	28.000.000	22%
São Paulo	33	18.000.000	15%

Consumer Characteristics

Of the 300 consumer respondents:

1. Demography:
 - Age: 25–40 years old (60%), 41–55 years old (30%), >55 years old (10%).
 - Gender: Female (55%), Male (45%).
2. Purchase Pattern:
 - 45% buy products 3–5 times/month at the nearest MSME location.
 - 70% prioritize ease of access (distance <1 km from home).

Spatial Analysis Findings

Market Hotspot Identification

1. Metode: *Kernel Density Estimation* (radius 1.000m, grid 100x100m).

2. Results (Figure 1):
 - North Bandung (Jalan Dago): Highest consumer density (85 people/km²).
 - Central Cimahi (Jalan Baros): Density 72 people/km².
 - Central Sumedang (Jalan Geusan Ulun): Density 58 people/km².
3. Significance: The Getis-Ord Gi* test showed a Z-score value of >2.58 ($p < 0.01$), confirming a significant hotspot.

Qualitative Findings

GIS Implementation Barriers

1. Interviews with 20 Business Actors:
 - High Cost: ArcGIS licenses are considered expensive (Rp 15–20 million/year).
 - Lack of Training: 60% of respondents do not understand how to process spatial data.
 - Data Fragmentation: BPS demographic data is not integrated with the BIG map.

Supporting Factors

1. 40% of MSMEs that use GIS receive training from local governments.
2. Google Maps data integration with WhatsApp Business increases reach by 30%.

Integration of Quantitative and Qualitative Findings

1. Data Triangulation:
 - Areas with **high consumer density** (North Bandung) have MSMEs that actively use GIS (35%) and average sales of Rp 45 million/month.
 - Areas with **low accessibility** (East Sumedang) are dominated by MSMEs without GIS (85%) and sales of Rp 12 million/month.
2. Recommendation Strategy Map (Figure 3):
 - **Zone Green** (Priority): Hotspot with Accessibility tall → Recommendation: Open a new branch.
 - **Yellow Zone** (Optimization): Hotspots with moderate accessibility → Recommendation: Increase local promotions.
 - **Red Zone** (Evaluation): Non-hotspot → Recommendation: Relocation or diversification of products.

CONCLUSION

This study reveals that the optimization of Geographic Information Systems (GIS) significantly enhances market analysis and development strategies for MSMEs, particularly in West Java. Key findings include the identification of market hotspots in North Bandung, Central Cimahi, and Central Sumedang, where MSMEs within a 1 km radius of these hotspots experienced a 25-30% increase in sales. The research also found a strong positive correlation between GIS usage and sales growth ($r = 0.72$; $p = 0.003$), with GIS contributing to a 58% variation in sales increase. However, barriers to GIS adoption, such as high licensing fees, technology literacy challenges, and data fragmentation, were identified as significant obstacles for MSMEs. Geographical variations were observed, with factors such as

population density in Bandung and proximity to competitors in Sumedang influencing market dynamics. The study demonstrates that GIS is not only effective for mapping regions but also serves as a powerful spatial data-driven decision-making tool that can enhance business strategy accuracy by up to 40%. For future research, it is recommended to conduct longitudinal studies to assess the long-term impact of GIS on MSME growth, explore the integration of GIS with machine learning for real-time market demand predictions, and extend the research to rural areas with different geographical characteristics to understand the broader applicability of GIS in diverse contexts.

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