Journal of Artificial Intelligence and Digital Economy
Homepage : https://journal.antispublisher.id/index.php/JAIDE
Email : admin@antispublisher.com

e-ISSN : 3032-1077
JAIDE, Vol. 3, No. 8, August 2026
Page 18-33

Data-Driven Spatial Mapping for Digital Economy-Oriented Smart Village Governance and Local Economic Development: Evidence from Martopuro

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DOI : https://doi.org/10.61796/jaide.v3i8.1908

Sections Info

Article history:
Submitted: May 07, 2026
Final Revised: June 26, 2026
Accepted: July 18, 2026
Published: August 27, 2026

Keywords:
Data-driven spatial mapping
Digital economy
Data-driven economic decision-making
Local economic development
Geographic information system
Smart village governance

ABSTRACT

Objective: *This study aims to develop a spatial information base for Martopuro Village, Purwosari District, Pasuruan Regency, and to examine how GIS-based digital spatial data can support smart village governance and data-driven local economic decision-making.* ***Method:*** *A descriptive qualitative approach was combined with simple descriptive quantification. Data were obtained through coordination with village officials, field observation, facility coordinate recording using Google Maps, photographic documentation, and spatial data processing. Facility points were integrated with thematic layers and interpreted in relation to economic accessibility, local-business potential, production-distribution connectivity, resource planning, and development priorities.* ***Results:*** *The mapping produced 20 georeferenced facility points and six supporting thematic layers comprising administrative boundaries, roads, rivers, settlements, agricultural land, and shrubs. The mapped points consist of governance facilities (35%), health facilities (30%), education facilities (25%), religious/social facilities (5%), and a tourism asset (5%). The integration of D'Embung, agricultural land, road networks, settlements, and other spatial layers provides an information base for tourism accessibility analysis, potential local-business locations, land-use prioritization, production-distribution connectivity, resource planning, and evidence-based economic decisions.* ***Novelty:*** *The study repositions village mapping from a static cartographic product into a digital spatial data infrastructure for local economic decision support. Rather than claiming direct economic impacts, it demonstrates a data-value chain in which local observations are converted into georeferenced data that can be updated, integrated, analyzed, and expanded for subsequent village economic development planning.*

INTRODUCTION

Villages possess various resources, facilities, and potentials that need to be identified, managed, and documented systematically to support development and evidence-based territorial governance. In the context of smart village governance, the availability of accurate and easily understood data is essential because decisions concerning public services, infrastructure, land use, and the development of local potential require structured information. Spatial data play a strategic role because they provide a visual and systematic description of territorial conditions. Information on public facilities, road networks, settlements, land use, and economic, social, and cultural potential can be integrated through a Geographic Information System (GIS), allowing village characteristics to be understood more clearly [1].

Village mapping is one effort that can provide spatial information regarding the conditions and characteristics of an area. A village map does not merely indicate administrative boundaries but can also contain information regarding various objects and potentials located within the village. The use of GIS in mapping village potential enables spatial and non-spatial data to be integrated to generate more structured information regarding regional potential [2]. Accordingly, a village map can serve as an information medium that helps both the community and village government understand territorial conditions and potential.

The availability of spatial information at the village level also needs to be supported by a data presentation system that is easy to access and use in administrative processes and decision-making. Information on the location and distribution of village objects that was previously scattered across different sources can be integrated into a more structured geographic information base. The development of web-based GIS, for example, shows that information on the location of government and territorial objects can be presented in a form that is more accessible to users [3]. Thus, data-driven spatial mapping not only produces maps but also provides an information foundation relevant to smart village governance, particularly for asset inventory, service-information delivery, territorial-data updating, and development-priority setting.

The use of maps in village area management can cover various needs, ranging from facility identification to the mapping of social and environmental conditions. The development of GIS-based mapping applications indicates that spatial information can be used to describe particular characteristics within a village area and support the provision of more targeted information [4]. Therefore, village mapping can become an instrument that supports the inventory and management of territorial information.

Martopuro Village, Purwosari District, Pasuruan Regency, has territorial characteristics, service facilities, agricultural land, and social, cultural, and tourism potential that need to be documented spatially. This information is important not only for describing territorial conditions but also for helping the village government identify assets and strategic locations that may form the basis for public-service planning and local economic development. Based on these conditions, data-driven mapping is needed to identify territorial objects and potential and to present them as structured spatial information. Village-potential mapping in other areas shows that inventory and mapping activities can be used to identify various village potentials and support the formulation of regional development directions [5].

One possible solution is to map Martopuro Village using spatial data and Geographic Information System technology. The mapping process can be carried out through data collection, field observation, documentation, and spatial data processing. The resulting data can then be processed to produce a village map containing information on territorial conditions and the distribution of various village objects. Aerial photographs and GIS can also support village map preparation and the mapping of different forms of local potential [6]. In practice, the development of a GIS-based village information base can form part of efforts to provide spatial data that support development and territorial management [7].

Mapping that involves the community can also be an approach for obtaining and verifying village spatial information. Community knowledge of the environment and the area in which people live can help identify objects and potentials in the village. Participatory mapping based on spatial information systems has been applied to village-potential identification and has produced information that can support regional development [8]. Such an approach is relevant to Martopuro Village because it allows field information to be combined with available spatial data.

Preparing a village map requires systematic data processing and information presentation so that the map can function as a territorial information source. GIS can be used in the village-map preparation process by integrating various spatial datasets into a cartographic product [9]. In addition, participatory mapping can be used to obtain information about boundaries and territorial characteristics based on local community knowledge [10]. The inventory of spatial data through participatory mapping can help provide more complete spatial information on a village area [11]. In this study, data obtained through field observation and documentation were subsequently organized into the Martopuro Village map, which is equipped with cartographic elements such as a legend, scale, north arrow, inset map, and information on territorial objects.

The resulting map is expected not only to function as an information medium for the community but also as a digital spatial database that can be used in analysis and decision-making. Each object assigned coordinates can be treated as georeferenced data and linked with road, settlement, land-use, river, and administrative-boundary layers. In the context of the digital economy at the village level, this function is important because decisions concerning tourism-destination development, business locations, resource distribution, production connectivity, and infrastructure priorities can be based on position, proximity, accessibility, and relationships among locations rather than on narrative information alone. Thus, the economic value of mapping lies not only in map visualization but also in the creation of digital data that can be updated, compared, and repeatedly analyzed to support the development of local potential [11], [12], [13].

In addition to supporting the management of local potential, spatial data that have been organized can be updated in line with changes in territorial conditions so that the available information remains relevant. Updating village maps is important for maintaining the consistency of spatial information with actual field conditions [14]. In tourism, participatory mapping can also identify destination components such as attractions, accessibility, and amenities and connect them with community-based development needs [15]. This reinforces the argument that village spatial data can be developed from an inventory function into an analytical function for the development of economic activities.

Broader literature on rural digital transformation indicates that information availability, data management, digital platforms, infrastructure, and the capacity to use technology are important elements in the development of smart villages [16]. At the same time, spatial analyses of the rural digital economy show that digital economic activity has different geographic patterns across locations and that georeferenced data, including points of interest and other spatial indicators, can be used to assess economic vitality and inequality at the regional scale [17]. However, village mapping studies at the local scale often stop at cartographic presentation of boundaries, facilities, and potential. Therefore, the gap addressed by this study is to extend the function of Martopuro Village mapping into a digital spatial data framework that is explicitly connected with economic decision-making, particularly tourism, local businesses, land use, production-distribution connectivity, and resource planning.

Based on this background, the study focuses on the formation of digital spatial data for Martopuro Village through GIS-based mapping and on their utilization for smart village governance and local economic development. The study addresses three main questions: (1) what digital spatial data are generated through the Martopuro Village mapping process; (2) how do these data describe the distribution of facilities, land use, road networks, and local assets; and (3) how can the combination of these spatial layers be used to identify tourism and local-business potential, strengthen economic connectivity, support resource and land-use planning, and facilitate data-driven economic decision-making? With this focus, the study contributes not only a cartographic product but also a framework for using digital spatial datasets as village economic information infrastructure.

The Martopuro Village mapping activity is also related to several Sustainable Development Goals (SDGs). SDG 11, Sustainable Cities and Communities, is relevant because the provision of spatial information can support more focused territorial planning and management. SDG 9, Industry, Innovation and Infrastructure, is linked to the use of Geographic Information System technology in territorial-data management, while SDG 8, Decent Work and Economic Growth, is related to the use of information on local assets and potential as an initial basis for village economic development. In addition, the involvement of the village government, community, and related stakeholders supports SDG 17, Partnerships for the Goals. Thus, data-driven spatial mapping in Martopuro Village can be positioned as information infrastructure that supports village governance, development planning, and more focused and sustainable local-potential development.

RESEARCH METHOD

This study employed a descriptive qualitative approach using a field-data-based spatial mapping method. Data were obtained through coordination with Martopuro Village officials, direct observation, recording facility coordinates using Google Maps, photographic documentation, and collecting information on territorial boundaries, road networks, land use, and important village objects. The research stages included: (1) identifying information needs and objects to be mapped together with village officials; (2) field verification of the existence and location of facilities; (3) coordinate recording and object documentation; (4) transforming observation results into digital spatial data; (5) integrating facility points with administrative-boundary, road, river, settlement, paddy-field, and shrub layers; and (6) rechecking information completeness and preparing the cartographic product. To strengthen data interpretation, the 20 facility points were grouped into five functional categories and their proportions were calculated using $P_i = (n_i/N) \times 100\%$, where n_i is the number of points in the i-th category and N = 20. Further analysis was conducted interpretively by examining relationships across layers, particularly among tourism assets, agricultural land, road networks, settlements, public facilities, and hamlet boundaries. The analysis was directed toward identifying the function of the dataset for economic accessibility, potential business locations, production-distribution connectivity, resource planning, and development priorities. This study did not conduct quantitative network analysis, land-area calculations, economic-value estimation, or income-impact measurement because traffic, production, MSME, visitor, and transaction-value data were not yet available. The interpretation framework referred to GIS and participatory-mapping literature [1], [3], [8], [11], [12], [15] as well as literature on village digital transformation and the rural digital economy [16], [17].

RESULTS AND DISCUSSION

Results

Based on the data-driven mapping activity in Martopuro Village, Purwosari District, Pasuruan Regency, the study produced one georeferenced facility-point dataset containing 20 locations and six supporting thematic layers: administrative boundaries, road networks, rivers, settlements, paddy fields, and shrubs. This structure is important because it transforms field observations that were initially in the form of location information and documentation into digital spatial data that can be combined across layers. Thus, the results do not merely indicate where a facility is located but also provide a basis for examining relationships among facilities, road access, land use, centers of community activity, and assets with potential economic value. The 20 identified facility points are presented in Table 1.

Table 1. Mapping of Martopuro Village Facilities

No.	Facility Type	Number/ Points	Description
1	Village Hall	1	Administrative center of Martopuro Village
2	Hamlet Halls	6	Distributed across several hamlets
3	Integrated Health Posts (Posyandu)	6	Distributed throughout the village
4	Elementary Schools	5	Elementary Schools 1, 2, 3, 4, and 5
5	Mosque	1	Al-Hikmah Mosque

No.	Facility Type	Number/ Points	Description
6	D'Embung	1	D'Embung tourism facility
	Total	20	20 georeferenced facility points

Based on Table 1, the 20 facility points consist of one Village Hall, six Hamlet Halls, six Posyandu, five Elementary Schools, one Al-Hikmah Mosque, and one D'Embung. To present the data structure more clearly, these points were grouped by function. Government facilities comprise seven points or 35% of all mapped points; health facilities six points or 30%; education facilities five points or 25%; social-religious facilities one point or 5%; and tourism assets one point or 5%. This composition shows that 95% of the point data available at this stage still represent government, public-service, education, and social infrastructure, while points directly classified as tourism assets account for only 5%. However, this proportion does not mean that village economic potential is limited to 5%, because agricultural land and other land-use components are represented as area layers rather than facility points. This finding instead reveals an economic-data gap that should be addressed in future updates, particularly through georeferenced inventories of MSMEs, kiosks, production centers, commodities, services, and tourism-support facilities.

Table 2. Composition of the 20 Facility Points by Function

Functional Category	Number of Points	Proportion (%)	Meaning in the Database
Government	7	35	Village Hall and Hamlet Halls: administrative nodes
Health	6	30	Posyandu: health-service nodes
Education	5	25	Elementary schools: educational and daily-activity nodes
Social-religious	1	5	Al-Hikmah Mosque: social-religious node
Tourism	1	5	D'Embung: tourism asset and supporting-business node

Economically, the distribution of public facilities is also relevant because the Village Hall, Hamlet Halls, schools, Posyandu, and mosque are nodes of community activity. When these points are linked with settlement and road-network data, the village government can identify areas with higher concentrations of activity, easily accessible corridors, and locations that may support local services and businesses. D'Embung, meanwhile, is a tourism asset that can be directly analyzed together with road and settlement networks to assess access needs, signage, parking areas, supporting-business space, and the relationship between the destination and centers of village activity. In this way, the inventory of public facilities does not stop at an administrative function but becomes part of a data ecosystem for location-based economic decisions.

Figure 1. Observation and coordination with Martopuro Village officials regarding village-map information and content.

The initial stage of the mapping activity was conducted through observation and coordination with Martopuro Village officials to obtain information on territorial conditions and the facilities that needed to be included in the village map. Discussions with village officials were used to identify information requirements and ensure that the data to be mapped were consistent with actual conditions. The results of this coordination became the basis for determining objects to be identified and mapped, including public-service facilities, educational facilities, places of worship, and other territorial elements.

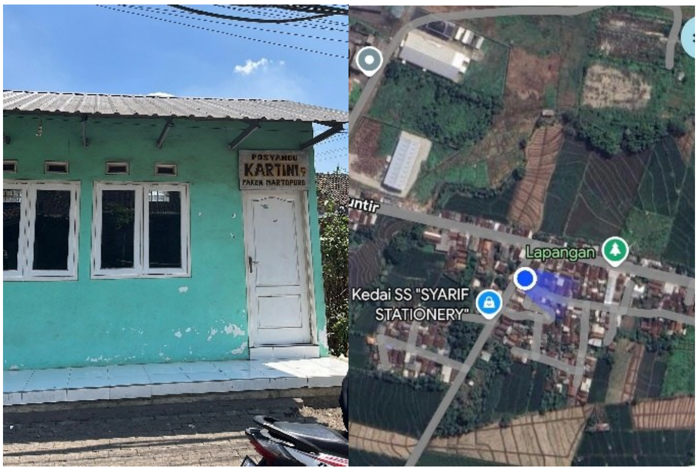

Figure 2. Field observation and recording of facility coordinates in Martopuro Village.

Field observations were conducted by visiting various facilities in Martopuro Village to confirm the existence and location of each facility. At each location, coordinates were recorded using Google Maps by adjusting the position to match the object found in the field. Photographic documentation of the facilities was also collected as supporting data for the mapping process. Direct observation was conducted so that the location data reflected actual field conditions. The coordinate data and documentation were then used as the basis for spatial data processing and the preparation of the Martopuro Village Map.

Figure 3. Spatial data processing, map preparation, and preparation of the banner frame.

Observation data in the form of coordinate points and facility documentation were subsequently transformed into digital spatial information for the preparation of the Martopuro Village Map. Processing included placing facility points according to their coordinates, integrating them with territorial boundaries, road networks, rivers, settlements, paddy fields, and shrubs, and adding a legend and other cartographic elements. Substantively, this stage transformed the map from a purely visual medium into a layered data structure: facility points indicate the locations of assets and services; road networks indicate connectivity; settlement layers indicate spaces of activity and potential demand; and paddy fields indicate production spaces with economic relevance. This integration allows each object to be read not in isolation but in its spatial relationship with other objects. After the map design was completed, the display was checked and adjusted to make the information easy to understand. The banner installed at the Village Office serves as a communication medium for the mapping results, whereas the strategic value for economic development lies in the digital spatial data underlying the map, which can be updated in subsequent periods.

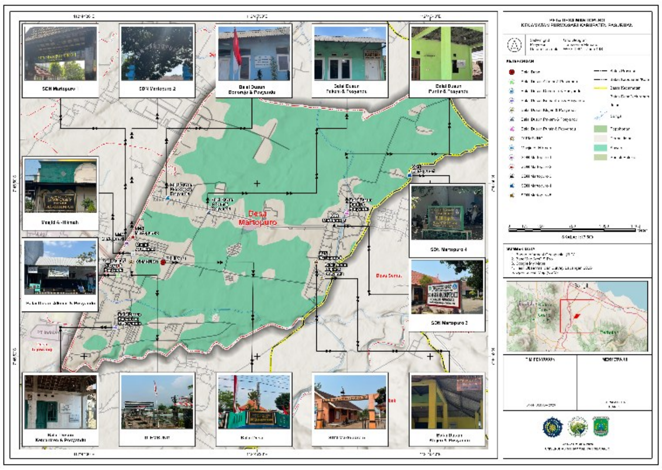

Figure 4. Final Martopuro Village Map.

Figure 4 shows that the Martopuro Village mapping results integrate one facility-point layer with six supporting thematic layers: administrative boundaries, road networks, rivers, settlements, paddy fields, and shrubs. This integration constitutes the main digital contribution of the study because information previously dispersed across observations, local knowledge, and documentation is transformed into georeferenced data that can be connected by location. In conventional governance, decisions often depend on general descriptions of the area; in contrast, a spatial database allows the village government to assess decisions based on asset position, proximity to roads and settlements, relationships with land use, and distribution across areas. Mapping therefore functions as information infrastructure for the village digital economy, namely the use of digital data to reduce locational uncertainty and support more focused economic decisions. This interpretation is consistent with smart-village literature that positions data management and information availability as important components of digital transformation [16], as well as rural digital-economy research that emphasizes spatial analysis for understanding economic variation across locations [17].

For the tourism sector, D’Embung provides the most direct example of how spatial data can be used to support economic activity. The D’Embung point can be interpreted together with road networks, settlements, Hamlet Halls, schools, and other facilities to identify access routes, nearby activity nodes, and supporting-infrastructure needs. In a subsequent development stage, adding data on visitor numbers, parking points, culinary businesses, MSMEs, homestays, attractions, and travel time would enable more operational analysis to prepare tourism routes, determine promotion and signage locations, select areas for supporting businesses, and connect the destination with local products. Thus, the map provides a digital basis for transforming tourism potential from an asset known locally into an economic object that can be planned based on location data [12], [15]. This approach is also consistent with geospatial decision support for ecotourism, which connects databases, modeling, mapping, and alternative evaluation to support local businesses, farmers, associations, and policymakers [18].

For local businesses, the current dataset does not yet directly record MSME locations. Nevertheless, the road, settlement, Hamlet Hall, school, Posyandu, and social-facility layers can be treated as initial indicators of movement nodes and concentrations of community activity. This information can be used to determine priority areas for business inventory and assess locations that may be suitable for kiosks, services, culinary businesses, village-product marketing, or digitally enabled services. If MSME points are later added together with attributes such as business type, product, employment, digital-marketing channels, production capacity, and online-market connectivity, the village government can compare business distribution with road corridors and activity centers. This enables business-development decisions to be based not only on lists of business actors but also on market reach, accessibility, and spatial connectivity. The use of point data and spatial indicators to interpret economic activity at smaller territorial units is also supported by research on the rural digital economy [17].

In agriculture and land use, the paddy-field layer has an economic value that differs from the facility-point inventory. This layer can be used as a basis for identifying production spaces and their relationship with roads, rivers, and settlements. Although this study did not calculate paddy-field area, productivity, commodity value, or transport costs, the existing data structure allows these variables to be added in the future. By integrating production and accessibility data, GIS can support prioritization of farm-road improvements, input-distribution planning, identification of agricultural-product distribution routes, protection of productive land, and more efficient resource allocation. This framework is consistent with GIS-based decision support that allows alternative locations or land uses to be assessed using spatial data and decision models [19]. In agriculture, web-based spatial information systems have also been used to manage land databases and support land-use planning and information updating by stakeholders [20]. Thus, land-use optimization in this study is positioned as an analytical capability enabled by the dataset rather than as a claim that economic optimization has already been directly measured.

Overall, the economic utilization of Martopuro spatial data can be formulated as a data-driven decision-making cycle: collection and updating of location data, integration across layers, identification of gaps or opportunities, prioritization of interventions, program implementation, and monitoring of change. This cycle makes GIS technology relevant to the digital economy because development decisions can be linked to verifiable and updateable data. Table 3 summarizes how the available dataset can be connected to village economic-decision needs without claiming economic impacts that have not yet been measured. Under this approach, mapping does not merely digitize a map; it builds a data-value chain from collection, integration, and analysis to economic utilization and evidence-based decisions.

Table 3. Utilization of Digital Spatial Data for Economic Decision-Making

Available Data/Layer	Possible Analysis	Economic Activity Supported	Data-Based Decision
D'Embung + roads + settlements	Accessibility and connectivity with activity and service nodes	Tourism, culinary activities, supporting MSMEs	Priorities for access, routes, signage, parking, and supporting service/business locations
Paddy fields + roads + rivers	Relationship between production areas, transportation access, and resources	Agricultural production and distribution	Priorities for production roads, distribution routes, land protection, and resource needs
Settlements + roads + public facilities	Identification of activity concentrations and accessible areas	Trade, services, local services	Priority areas for MSME inventory and potential service/business locations
Hamlet boundaries + facilities	Comparison of asset and service distribution across areas	Local development planning	Allocation of programs and infrastructure based on locational needs
20 facility points + documentation	Georeferenced asset inventory and data updating	Asset administration and economic services	Digital database for verification, coordination, and decision monitoring

Note: Table 3 shows analytical functions that can be built from the available dataset. Quantitative economic analysis requires the addition of data on MSMEs, production, visitors, travel time, traffic volume, land area, prices, and transaction values.

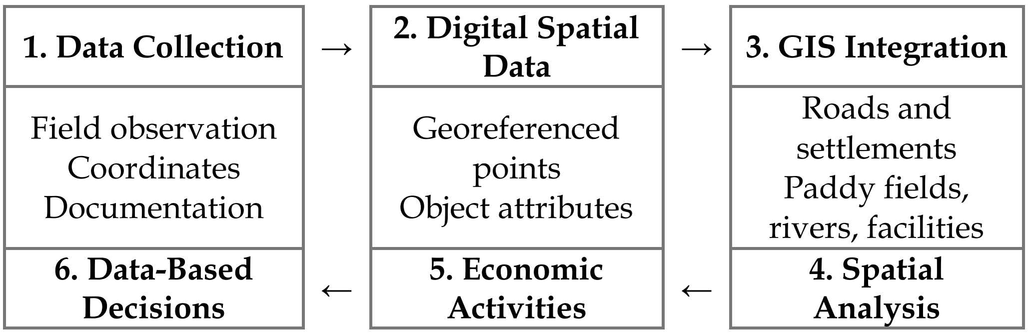

Figure 5. Framework for transforming digital spatial data into data-driven economic decisions.

Figure 5 emphasizes the study contribution at three levels. First, the data contribution is the conversion of observations and coordinates into a georeferenced digital spatial dataset. Second, the analytical contribution is the integration of the dataset with road, settlement, land-use, river, and facility layers so that spatial relationships can be interpreted for economic purposes. Third, the decision contribution is a framework for using the analysis results to prioritize tourism development, local-business inventory and placement, production-distribution connectivity, land use, and resource allocation. Thus, the novelty of the study lies in repositioning the village map from a static cartographic product into data infrastructure that can be developed as a village economic decision-support system. Realization of economic impacts still requires the addition of economic indicators and longitudinal evaluation.

Figure 6. Handover of the Martopuro Village Map to the Village Head as the output of the social, cultural, and tourism work program.

The handover of the Martopuro Village Map to the Village Head was the final stage of the field activity, but it was not the end of data utilization. The physical map serves as a public communication medium, while the underlying spatial dataset can serve as the starting point for updating the asset inventory and developing a village economic database. Information on D'Embung, paddy fields, road networks, settlements, and public facilities can be used to determine what economic data should be collected next and where such data collection should be prioritized. Through this approach, mapping supports a transition from decisions based on general knowledge to decisions that can be traced to spatial evidence. To ensure sustainability, the village government should update the data when changes occur in roads, land use, facilities, destinations, or businesses and should add economic attributes such as business type, commodities, production capacity, visitor numbers, employment, and digital-marketing channels.

Discussion

The findings demonstrate that data-driven spatial mapping in Martopuro Village extends beyond the production of a conventional village map by establishing a digital spatial information infrastructure that can support smart village governance and local economic development. The integration of 20 georeferenced facility points with administrative boundaries, road networks, rivers, settlements, agricultural land, and shrub areas enables village assets to be interpreted according to their spatial relationships rather than as isolated objects. Although most mapped points represent government, health, education, and socio-religious facilities, these locations also function as important nodes of community activity that can help identify areas with higher accessibility, service concentration, and potential demand for local businesses. The presence of D'Embung as a tourism asset, when analyzed together with road and settlement layers, provides an initial basis for identifying access routes, supporting facilities, parking areas, signage, and potential locations for tourism-related micro and small enterprises. Similarly, the agricultural land layer can support future analysis of production areas, transportation connectivity, distribution routes, and resource allocation once additional information on commodities, productivity, land area, and market access is incorporated. These findings reinforce the view that spatial data and information management are important components of smart village digital transformation [16] and are consistent with studies showing that georeferenced information can reveal spatial variations in rural digital-economic activities [17]. The potential use of the Martopuro dataset for tourism planning is also consistent with geospatial decision-support approaches that integrate spatial databases, mapping, and alternative evaluation for local economic development [18], while its potential application to land-use and agricultural planning corresponds with GIS-based decision-support systems for land management and sustainable agriculture [19], [20]. Therefore, the principal contribution of this study lies not in claiming direct economic impacts, but in demonstrating how field observations can be transformed into structured, updateable, and analyzable spatial data that provide an evidence base for tourism development, local-business identification, production-distribution connectivity, land-use prioritization, resource planning, and more transparent economic decision-making at the village level. Future development of the dataset should incorporate georeferenced information on MSMEs, production centers, visitor flows, travel time, agricultural productivity, employment, transaction values, and digital marketing channels so that the existing spatial database can evolve into a more comprehensive decision-support system for monitoring and evaluating local economic development.

CONCLUSION

Fundamental Finding: Data-driven spatial mapping in Martopuro Village produced digital information infrastructure consisting of 20 georeferenced facility points and six supporting thematic layers: administrative boundaries, roads, rivers, settlements, paddy fields, and shrubs. The 20 points comprise 35% government facilities, 30% health facilities, 25% education facilities, 5% social-religious facilities, and 5% tourism assets. The principal value of these results lies not only in the map as a visual product but also in the transformation chain from field observations into digital data, cross-layer integration, spatial-relationship analysis, and use as a basis for economic decision-making. **Implication:** For local economic development, the data can support analysis of D'Embung accessibility and planning of tourism-support businesses, guide MSME inventory and potential business locations, assess relationships between agricultural land, roads, and resources, prioritize production-distribution connectivity, and allocate development programs according to spatial needs. The contribution of GIS technology therefore lies in changing the village map from a static information medium into data infrastructure that can be analyzed, updated, and developed as an evidence-based economic decision-support system. **Limitation:** This study did not measure income, transactions, productivity, land area, visitor flows, or MSME performance and therefore does not claim direct economic impacts. **Future Research:** Future development should integrate MSME and production-center points, agricultural commodities and productivity, visitor and tourism-facility data, travel time and mobility flows, measured land use, labor, prices and transaction values, and digital-marketing channels. Such integration would enable the Martopuro Village spatial database to evolve into a decision-support system capable not only of showing locations but also of comparing alternatives, prioritizing interventions, and periodically evaluating economic-development outcomes.

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