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Participatory Mapping for RT, Dusun, and Village Boundary Delimitation in Dlingo, Bantul, Indonesia

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ABSTRACT

Village, hamlet, and neighbourhood boundary delineation is essential for effective governance, spatial planning, and population administration, yet many rural areas in Indonesia still lack formally recognized boundary maps. This study aims to establish accurate administrative boundaries in Dlingo Village, Bantul Regency, through a participatory mapping approach that integrates field surveys, high-resolution satellite imagery, cartometric interpretation, and GIS-based analysis. Field data were collected using handheld GPS devices and subsequently plotted and digitized to construct preliminary boundary lines. The mapping process was refined through Focus Group Discussions involving village officials, hamlet heads, and neighbourhood leaders, ensuring that spatial interpretations aligned with local knowledge and long-standing territorial agreements. The results show that most village boundaries follow natural landscape features, particularly rivers, which assisted cartometric delineation, although terrain conditions posed challenges during field verification. A comparison between field-surveyed boundaries and OpenStreetMap data revealed significant positional discrepancies, confirming the need for ground-truthing in rural boundary mapping. The final administrative boundary maps reflect both technical accuracy and community consensus, providing a reliable reference for governance, development planning, and the establishment of a village information system. This study demonstrates the effectiveness of combining participatory approaches with geospatial techniques and offers a practical model for addressing boundary ambiguities in other rural regions.

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1. INTRODUCTION

Indonesia operates under a decentralised administrative system that places villages as fundamental territorial and governance units. Administrative arrangements at this level have significant implications for effective public service delivery, spatial planning, and community management. Each village possesses the authority to regulate government affairs and sociocultural functions within the national framework, which highlights the importance of precise administrative boundaries for ensuring legal clarity and community stability (Indra, 2021; Akbar et al., 2021; Fadilah et al., 2022).

The administrative hierarchy within villages includes hamlets (dusun) and neighbourhood units (RT), which serve as functional subdivisions that support governance processes. These units play an essential role in coordinating population data, service distribution, and village-level administration. However, many rural areas still lack formally established boundaries, prompting overlapping claims, spatial ambiguity, and governance inefficiency. These conditions reinforce the urgent need for systematic boundary mapping supported by legal and institutional frameworks (Abdullah et al., 2020; Affandi et al., 2023).

The absence of definitive village, hamlet, and RT boundaries has resulted in administrative conflicts, planning inaccuracies, and challenges in public service implementation. Without clear territorial delineation, it is difficult to implement development initiatives, and jurisdictional responsibilities can become unclear. Such conditions emphasise the importance of adhering to boundary-setting regulations that provide technical and juridical certainty (Fauzi et al., 2022).

Participatory mapping has emerged as a strategic solution to these challenges because it integrates local knowledge with spatial data verification. This method enables communities to actively engage in determining boundary lines while ensuring that the resulting maps reflect the actual field conditions. The combination of community input and technical geospatial analysis enhances the legitimacy, accuracy, and long-term acceptance of administrative boundaries (Akbar et al., 2021; Zuhdi et al., 2024).

Participatory mapping has been widely recognised as an approach capable of generating reliable boundary maps that are aligned with community agreements. Its emphasis on inclusivity and verification helps to strengthen governance capacity at the village level, particularly in areas where formal boundary records have never been established. This approach is increasingly used to minimise disputes and ensure the accuracy of spatial representation (Akbar et al., 2022; Akbar et al., 2021).

Cartometric techniques contribute to boundary delineation by enabling the interpretation of existing base maps through spatial measurements and image analysis. Scientific literature classifies village boundary maps into Boundary Determination Maps, Boundary Confirmation Maps, and Verification Maps, each representing specific stages in formalising territorial limits. These classifications offer structured guidance for achieving accurate and legally recognised boundary outputs (Wahanisa et al. 2021; Xu et al. 2021).

Geographic Information Systems (GIS) enhance this process through tools that manage, analyse, and visualise geospatial information. GIS supports thematic map generation, facilitates spatial decision-making, and assists in the integration of multiple geospatial data sources. Its role is especially critical in administrative boundary mapping and rural spatial planning, where accuracy and clarity are essential (Çelik & Şekeroğlu, 2023; Droj et al., 2022).

Existing research has highlighted the relevance of participatory mapping for boundary determination; however, its application at the micro-administrative levels, such as RT and hamlets, remains limited. Most studies focus on broader district or provincial boundary issues, leaving operational gaps in methodologies applicable to small-scale rural governance contexts (Arifin 2017). This limitation indicates the need for studies that integrate participatory practices directly into the detailed mapping of internal village boundaries.

The reliability of openly available geospatial datasets, such as OpenStreetMap (OSM), also presents a critical challenge. In rural areas, such datasets often lack verification, contain inconsistencies, and deviate significantly from the field conditions. These shortcomings highlight the necessity for boundary mapping methods that incorporate high-resolution imagery, precise GPS-based field surveys, and participatory verification to correct spatial inaccuracies and improve boundary validity (Mapedza et al., 2003; Weil et al., 2019; Wiratmoko et al., 2019).

This study aimed to implement a participatory mapping approach to delineate RT, hamlet, and village boundaries in Dlingo Village, Bantul Regency. This study seeks to integrate field surveys, geospatial analysis, and cartometric interpretation to produce accurate and community-validated administrative boundaries (Study Draft Context). This method ensures that spatial outputs support governance processes, community consensus, and effective rural development planning.

The novelty of this research lies in its multilevel integration of participatory mapping, GIS-based analysis, and cartometric boundary verification. This combination differs from previous studies by directly applying community-centred mapping methods to internal village administrative units rather than only to higher-level boundaries. The scope includes image preparation, spatial data collection, GPS-based plotting, participatory verification with village officials and residents, and GIS-assisted map production, resulting in authoritative boundary maps that improve administrative clarity and planning efficiency.

2. METHOD

2.1. Materials

This research was supported by high-resolution satellite imagery and geospatial tools that are essential for delineating village, hamlet, and neighbourhood boundaries in Dlingo Village. The primary dataset used was the 2015 WorldView-2 satellite image, with spatial resolutions of 1.8 m for multispectral bands and 0.5 m for the panchromatic band. A handheld Garmin E-Trex 10 GPS with an accuracy of 3–5 m was used to collect field boundary coordinates. The OpenStreetMap (OSM) vector data served as the initial spatial reference. ArcMap 10.3.1 was used for geospatial processing, supported by Windows 8.1 as the operating platform. Microsoft Excel was used for attribute preparation and documentation.

2.2. Sample Preparation

The preparation began with the organisation of satellite imagery and arrangement of field survey coordinate data. The imagery was reviewed for clarity, spatial consistency, and usability in terms of boundary interpretation. Field coordinate points collected via GPS were manually transferred into Microsoft Excel owing to software limitations during data download. The points were organised with unique identifiers and supplementary notes to ensure accurate plotting during mapping. This structured preparation minimised the errors during digitisation and spatial analysis.

2.3. Mapping Workflow

The mapping workflow consisted of plotting the field coordinates, interpreting spatial imagery, and digitising the boundaries. The field survey coordinates were imported into ArcGIS and plotted to form initial boundary point distributions. These plotted points were examined for completeness and continuity and then connected sequentially to represent the boundary lines for RT, hamlet, and village units. OSM shapefiles were used only as preliminary guides because inconsistencies were discovered when compared with field-based results.

Digitisation was refined through repeated comparisons between the plotted points and satellite imagery. Once the preliminary boundaries were produced, verification was conducted by printing A3-sized maps for each hamlet. These were reviewed together with the hamlet heads, village chief, and village secretary. Any corrections made during these sessions were transferred back into the GIS environment and re-digitised to ensure that the final boundaries reflected both community agreement and field realities.

2.4. Parameters

Several parameters guided boundary delineation, including spatial accuracy, physical boundary indicators, and administrative validity. Spatial accuracy was assessed by examining the positional differences between the field survey data and OSM references. Physical landscape elements, such as river lines, roads, and vegetation boundaries, were used as natural markers for interpreting administrative limits. Administrative validity was supported through participatory confirmation sessions, ensuring that the mapped boundaries represented both technical accuracy and a collective agreement among local stakeholders. The boundary geometry was also evaluated to ensure consistency and continuity across village subdivisions.

2.5. Data Validation Procedure

The validation procedure cross-checked the field survey coordinates with spatial references and community input. This process overlays GPS points on satellite imagery and OSM lines to identify inconsistencies between field conditions and reference datasets. Positional discrepancies were reviewed to identify segments needing correction, focusing on where boundaries extended beyond natural features or diverged from resident-recognised limits. The differences were summarised by examining directional deviations and offset magnitudes, allowing researchers to classify segments as minor adjustments or major shifts. These findings were presented in participatory sessions, enabling stakeholders to validate boundaries based on technical evidence and local knowledge. Through these discussions, boundary corrections were negotiated, ensuring revisions aligned with administrative practices and social understanding. The validation ensured final maps matched ground conditions and community-verified agreements, producing boundaries accurate and acknowledged by local actors.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Plotting of Field Boundary Coordinate Points

Figure 1 shows the plotted boundary coordinate points obtained from the field surveys. A total of 50 coordinate points were recorded using a Garmin E-Trex 10 GPS to ensure adequate spatial representation for the preliminary boundary construction. The distribution of points shows the alignment of the boundary markers across the terrain.

Figure 1. The result of plotting the boundary coordinate points.

3.1.2. Image Interpretation and Digitization of Village and Hamlet Boundaries

The image interpretation process connected the plotted coordinates to delineate hamlet boundaries using field-surveyed coordinates and WorldView-2 imagery for accurate feature interpretation. Village boundaries from the OSM shapefiles required re-digitisation owing to discrepancies extending beyond territorial limits or failing to follow natural markers. Hamlet boundaries were derived by adjusting digitisation to match field points and village office maps, with boundaries assessed using coordinate distributions and administrative information. In the event of mismatches between the imagery and administrative sketches, the field-surveyed data were prioritised. The integration of field verification, high-resolution imagery, and local knowledge ensured that digitised boundaries reflected spatial accuracy and community recognition, reducing disputes.

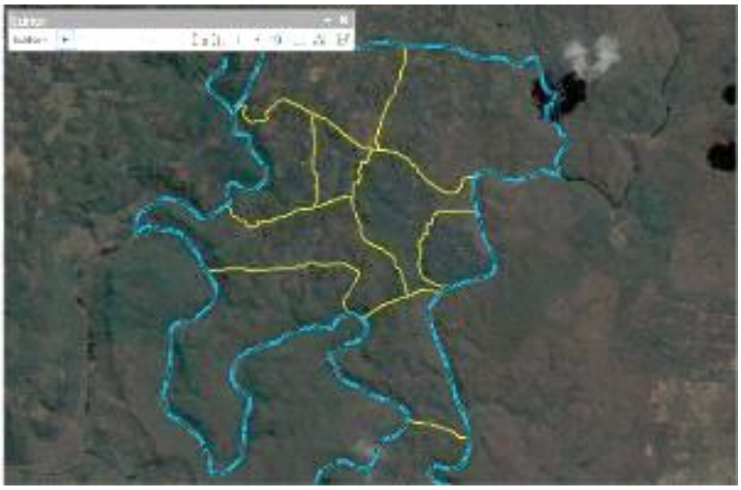

Figure 2. Results of image interpretation and digitization for village and hamlet boundaries.

3.1.3. Hamlet Boundary Delineation

Hamlet boundaries were obtained by integrating the field data and high-resolution imagery. Each boundary was digitised by aligning field-surveyed coordinates with visible landscape features in satellite imagery, allowing the polygons to be refined with precision. During this process, topographic elements such as river paths, road networks, field edges, and settlement clusters served as visual cues for determining territorial extent. Information from local residents and hamlet heads was incorporated to validate boundary locations, particularly where physical markers were unclear or where GPS readings were affected by the terrain. This combination of geospatial data and community knowledge ensured that the hamlet boundaries reflected both measurable field conditions and locally recognised administrative divisions.

Figure 3. Boundary of Hamlets in Dlingo Village.

3.1.4. Village Boundary Mapping

The mapping results for Dlingo Village show that the village boundaries follow the river lines on three sides of the settlement area. These natural features provided clear markers for cartometric delineation, allowing boundaries to be drawn with high spatial confidence using satellite imagery. However, natural boundaries pose challenges during field verification, particularly in areas where access to riverbanks is hindered by steep slopes, dense vegetation, or unstable terrain. These constraints requiresurveyors to navigate difficult paths and sometimes rely on indirect GPS readings from accessible vantage points. Despite these challenges, the combination of cartometric interpretation and field-based adjustments ensured that the final village boundary remained consistent with the physical landscape characteristics and local administrative understanding.

Figure 4. Dlingo Village Boundaries.

3.1.5. Comparison of Field Survey and OSM Boundaries

A comparison between the field-surveyed boundaries and OSM data revealed significant spatial mismatches. The OSM boundaries extended beyond or fell short of the actual surveyed limits in multiple areas. These discrepancies are highlighted in Figure 5, confirming the inadequacy of OSM as the sole reference for administrative boundary determination.

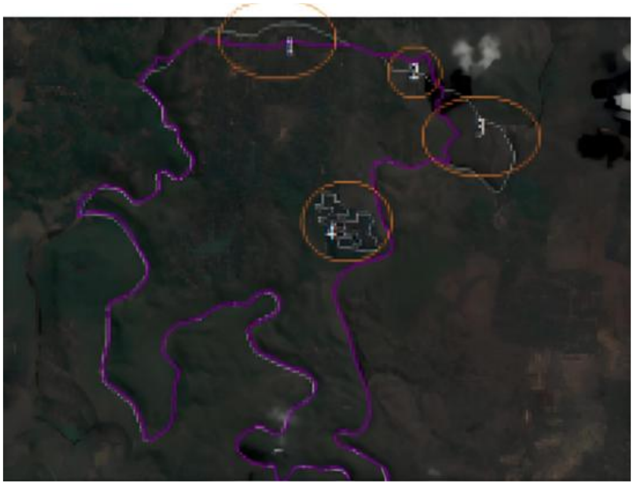

Figure 5. Overlay field survey (purple line) and OSM (white line).

3.1.6. RT Boundary Delineation

RT boundaries were determined using cartometric methods and Focus Group Discussions (FGDs) involving hamlet and RT heads. The cartometric approach enabled the identification of territorial divisions based on spatial indicators visible in high-resolution imagery, such as building clusters, road segments, footpaths, and land-use patterns commonly used by residents as informal reference points. The FGDs served as a platform for validating these interpretations by incorporating local knowledge, particularly regarding social and administrative divisions that may not be visible in imagery alone. During these discussions, the RT heads reviewed printed boundary sketches, provided corrections, and negotiated adjustments for areas with overlapping claims or ambiguous features. This collaborative process ensured that the final RT boundaries reflected both topographic constraints and resident consensus, producing boundary delineations that were technically sound, socially accepted and suitable for administrative implementation.

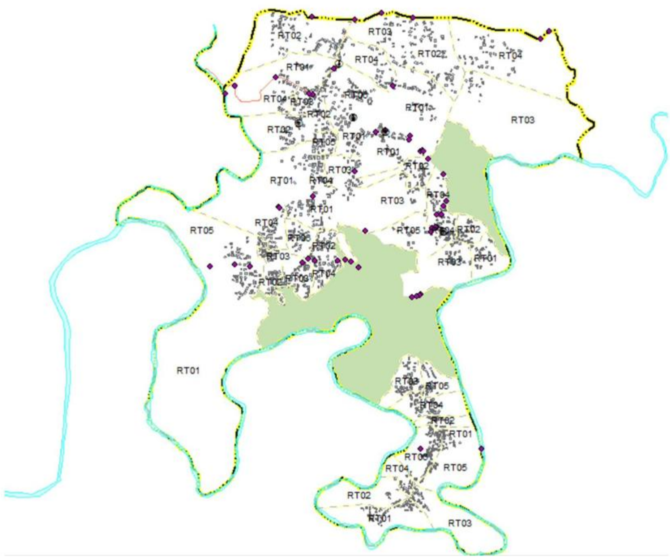

Figure 6. RT boundaries of Dlingo Village.

3.2. Discussion

The results of this study demonstrate that participatory mapping, when combined with cartometric interpretation and high-resolution imagery, is effective in producing administrative boundaries that are both technically accurate and socially legitimate. A comparison between the field survey results and OSM data revealed substantial discrepancies, emphasising that open-source spatial datasets often lack the precision required for formal boundary determination. This supports previous findings that volunteered geographic information requires field verification to avoid inaccuracies, particularly in rural or under-documented areas (Xu et al., 2021). The reliance on field-surveyed coordinates in this study aligns with the argument that ground measurements remain essential for producing authoritative boundary outputs (Asokan et al., 2020; Hettiarachchi et al., 2022).

Natural landscape features played an important role in guiding boundary delineation, as the rivers surrounding Dlingo Village provided clear visual markers that facilitated cartometric mapping. Their prominence as boundary determinants is consistent with the principle that physical features are among the most reliable indicators of spatial demarcation in rural areas (Çelik & Şekeroğlu, 2023). Nevertheless, field verification along these natural boundaries poses challenges owing to steep terrain, dense vegetation, and limited accessibility, requiring surveyors to combine direct observations with contextual knowledge provided by local residents. This reinforces observations in prior research that integrating local knowledge is essential when physical access is constrained and geospatial interpretation becomes ambiguous (Mapedza et al., 2003).

The participatory component of the mapping process, particularly through FGDs, proved crucial in resolving inconsistencies between spatial data and administrative understanding. Community engagement ensured that the resulting RT and hamlet boundaries reflected long-standing territorial agreements and socioadministrative practices. This finding is consistent with studies emphasising that participatory approaches strengthen public involvement and enhance the legitimacy of boundary-making processes (Akbar et al. 2021). Moreover, involving local stakeholders helps prevent misunderstandings, promotes transparency, and reduces the potential for future disputes over territorial claims, as noted in earlier participatory GIS research (Kuźma et al., 2020; Hettiarachchi et al., 2022).

The finalised boundary maps generated in this study have significant implications for governance, administrative planning, and rural spatial management. Accurate boundary information is a prerequisite for effective population administration, service delivery, and development planning, reaffirming the role of geospatial information in accelerating spatial governance (Sari, 2019; Eng et al., 2023; Susiyanti et al., 2025). By combining community participation, field survey validation, and cartometric refinement, this study offers a methodological model that can be replicated in other villages facing similar boundary ambiguities in the future. This hybrid approach aligns with broader perspectives on the importance of GIS-based decision-making in supporting sustainable regional development and public service improvement (Droj et al., 2022; Okamoto et al., 2023). Ultimately, the integration of technical accuracy and social consensus ensures that the resulting boundary maps provide both functional and institutional values for local governance.

4. CONCLUSIONS

This study demonstrates that integrating participatory mapping, field surveys, cartometric interpretation, and GIS analysis effectively delineates RT, hamlet, and village boundaries in Dlingo Village. High-resolution imagery and community involvement ensure that boundary maps achieve technical accuracy and social legitimacy. Field verification corrected substantial discrepancies in open-source datasets, such as OSM, emphasising the importance of ground-truthing. Local leaders' participation strengthened the acceptance of the final boundaries, reducing potential disputes and improving administrative clarity. The maps provide a reliable spatial reference to support population administration, village planning, and information systems. This study demonstrates the value of collaborative approaches in rural spatial governance and offers a model for villages with boundary uncertainties. Future research should focus on enhancing local technical capacity and integrating real-time data collection tools.

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