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SPATIAL DISTRIBUTION AND SERVICE COVERAGE ANALYSIS OF OFFICIAL TEMPORARY WASTE COLLECTION SITES USING GIS AND WEBGIS IN NABIRE DISTRICT

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ABSTRACT

Temporary waste collection sites play an important role in supporting urban waste management services. However, the spatial distribution and service coverage of official temporary waste collection sites in Nabire District have not been comprehensively evaluated. This study aims to analyze the spatial distribution and service coverage of official temporary waste collection sites using Geographic Information System (GIS) and to implement the results in an interactive WebGIS. A quantitative spatial approach was applied using official TPS point data, landfill location data, administrative boundary data, and GIS-based spatial processing. The analysis included location mapping, Nearest Neighbor Analysis (NNA), 500-meter buffer analysis, dissolve processing, and administrative overlay. The results showed that the distribution pattern of official temporary waste collection sites tends to be clustered, with an NNA value of 0.7636 and a Z-score of -2.02. The 500-meter service coverage reached only 13.14 km² of the 205.26 km² study area, equal to 6.40%, while 93.60% remained outside the service range. The novelty of this study lies in integrating spatial distribution analysis, service coverage evaluation, and WebGIS visualization to support district-scale waste facility planning.
Keywords: GIS, WebGIS, spatial distribution, service coverage, temporary waste collection sites

INTRODUCTION

The growth of urban activities has direct implications for the increase in waste generation [1]. Poorly planned waste management can cause various environmental problems, such as soil and water pollution, public health disturbances, and a decrease in the aesthetic quality of the environment. Therefore, an effective and data-based waste management system is an important need to support sustainable development [2].

One of the important components of the waste management system is the availability and distribution of Temporary Waste Collection Sites (TPS). TPS functions as a waste collection point before being transported to the Final Disposal Site (TPA). Uneven distribution of TPS can lead to the accumulation of waste in certain areas, low service affordability, and increased potential for uncontrolled waste disposal [3]. Therefore, analysis of TPS distribution and service coverage is a crucial aspect in waste system planning.

Previous studies have shown that Geographic Information Systems (GIS) can support waste management planning by mapping facility locations, analyzing spatial distribution, and evaluating service coverage areas. Several studies have also applied buffer analysis, overlay analysis, and spatial accessibility methods to assess the adequacy of public facilities and waste collection services. In addition, WebGIS has been used to present spatial information interactively and support decision-making in environmental and public service management [4].

However, most previous studies tend to focus separately on GIS-based spatial analysis or WebGIS application development. Studies that integrate official temporary waste collection site distribution analysis, service coverage measurement using a 500-meter buffer, administrative overlay analysis, and WebGIS-based visualization at the district scale remain limited. In the context of Nabire District, such an integrated spatial evaluation of official temporary waste collection sites has not been widely documented. Therefore, this study aims to analyze the spatial distribution and service

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coverage of official temporary waste collection sites in Nabire District and to implement the results in an interactive WebGIS. The contribution of this study lies in providing an integrated spatial evaluation framework to support data-driven waste facility planning at the district level.

Nabire District as the center of activity in Nabire Regency has relatively high socio-economic activity compared to the surrounding area. This condition has the potential to increase the volume of waste produced every day. Although the government through the Environment Agency has provided an official TPS, it is not known for sure whether the distribution of the TPS has been evenly distributed and is able to reach the needs of community waste services. In addition, there has been no spatial study that specifically analyzes the affordability of TPS to residential areas in Nabire District [5].

Based on these problems, this study aims to analyze the spatial distribution and level of official TPS service coverage in Nabire District using the Geographic Information System approach. The analysis was carried out through TPS distribution mapping, the application *of Nearest Neighbor Analysis* to identify distribution patterns, the creation of a *500-meter radius buffer to measure service coverage, and* spatial *overlays* to identify the areas served more accurately [6]. The results of the analysis were then implemented in the form of WebGIS to support interactive visualization of TPS distribution and service coverage. With this approach, this study is expected to provide a comprehensive spatial overview of the distribution and service coverage conditions of TPS in Nabire District and become a basis for consideration in planning waste management that is more effective, efficient, and based on spatial data [7].

LITERATURE REVIEW

Geographic Information Systems (GIS) have an important role as a tool for analyzing and visualizing location-based data [8]. GIS allows integration between spatial data, such as TPS locations, regional boundaries, and road networks, with non-spatial data, such as waste volume and TPS capacity, so that it can produce more comprehensive information. In this study, GIS is used as a basis for analyzing the distribution of waste facilities and evaluating the spatial service coverage of the area [9].

One of the analysis methods used in GIS is *buffer analysis*, which is the creation of zones with a certain radius of a point to measure the service coverage to the surrounding area. In the context of this study, *buffer* is used to determine the coverage of official TPS services for residential areas in Nabire District. In addition, *overlay analysis* is used to combine various spatial layers so that it can help identify areas that are within the range of TPS services more accurately.

To analyze the distribution pattern of temporary waste collection sites, this study uses *Nearest Neighbor Analysis* (NNA). This method is used to find out whether the distribution of facility points tends to be clustered, random, or evenly distributed. Through this analysis, the distribution pattern of temporary waste collection sites can be identified quantitatively so that the results of the study do not only depend on the visual interpretation of the map [10].

Previous Studies and Research Gap
Several previous studies related to GIS-based waste management, service coverage analysis, and WebGIS implementation are summarized in Table 1. These studies show that GIS and WebGIS have been widely used to support spatial analysis, facility mapping, service coverage evaluation, and spatial information visualization.

Table 1. Related Works on GIS, WebGIS, and Waste Facility Service Analysis

No	Study	Method	Focus	Gap
1	[5]	GIS analysis	Waste facility mapping	No WebGIS visualization
2	[11]	GIS mapping	Waste generation mapping	No 500 m TPS buffer
3	[10]	NNA and overlay	Facility distribution analysis	Not focused on waste TPS

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4	[7]	WebGIS	Waste governance platform	Limited spatial coverage analysis

Based on the related works, GIS has been widely applied for mapping waste facilities, analyzing spatial distribution, and evaluating service coverage. In addition, WebGIS has been used to support interactive spatial visualization and decision-making. However, previous studies generally discuss GIS-based spatial analysis and WebGIS implementation separately. The integration of Nearest Neighbor Analysis, 500-meter buffer-based service coverage evaluation, administrative overlay analysis, and WebGIS visualization for official temporary waste collection sites at the district scale remains limited. Therefore, this study fills the gap by combining these components to evaluate the distribution and service coverage of official temporary waste collection sites in Nabire District [7].

A number of previous studies have utilized Geographic Information Systems in the management of public facilities and urban infrastructure, including waste management. The results of these studies show that the GIS approach can be used to map the location of waste facilities, evaluate their distribution, and support spatial-based service analysis. Some studies emphasize more on equitable distribution of facilities, mapping the locations of official and illegal temporary waste collection sites, comparing the capacity of temporary waste collection sites with waste generation, or evaluating the distribution patterns of waste facilities in various urban areas.

On the other hand, there are also studies that develop WebGIS applications to support location-based waste management, but focus more on system development and data visualization without in-depth spatial analysis of TPS distribution and service coverage. Based on these conditions, it can be seen that the integration between official TPS distribution analysis, service coverage measurement using standardized radius buffers, and the implementation of analysis results in the form of WebGIS at the administrative district scale is still limited, especially in the context of Nabire District. Therefore, this study positions itself as a development of previous studies by combining spatial distribution analysis, service coverage evaluation, and WebGIS implementation in one research framework.

RESEARCH METHODS

3.1 Data Collection and Processing

This study uses a quantitative approach with spatial analysis based on Geographic Information System (GIS) [6]. The research location is in Nabire District, Nabire Regency, with the research object in the form of official temporary waste collection sites (TPS) registered with the Environment Agency [5]. The data used consists of spatial data in the form of TPS locations, landfill locations, and administrative area boundaries, as well as non-spatial data in the form of information on waste volume and TPS capacity [9].

Data collection was carried out through literature study and documentation of official TPS data [13]. Spatial data was then processed using GIS software through the process of data input of TPS points, integration of administrative boundaries, and the incorporation of supporting attributes at each TPS point [14]. The spatial data were prepared by ensuring coordinate system consistency before further analysis. The TPS point data, landfill location data, and administrative boundary data were processed in GIS software to generate spatial layers required for distribution analysis, 500-meter buffer analysis, overlay analysis, and WebGIS visualization.

3.2 Distribution and Service Analysis of TPS

The analysis of the distribution of temporary waste collection sites was carried out through mapping the distribution of temporary waste collection sites and *Nearest Neighbor Analysis* (NNA) to identify spatial distribution patterns [5]. The index value of the nearest neighbors was used to determine whether the distribution pattern of temporary waste collection sites tended to be clustered, random, or evenly distributed [12]. The Nearest Neighbor Analysis (NNA) result was interpreted using the nearest neighbor index value. An index value of less than 1 indicates a clustered pattern, a value close to 1 indicates a random pattern, and a value greater than 1 indicates a dispersed pattern.

The service analysis was carried out by creating *a buffer* radius of 500 meters at each TPS point to measure the service coverage to the surrounding area [16]. All *buffers* were then combined using a *dissolve* process to avoid double calculations on overlapping areas [17].

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Furthermore, *an overlay* was carried out between the *buffer* of the dissolved results and the boundaries of the village administrative area to identify the areas served more accurately [13]. The 500-meter buffer was used as a service coverage indicator to estimate the area that can be reached from each official temporary waste collection site. The dissolve process was applied to merge overlapping buffer areas and avoid double calculation of the served area. Furthermore, overlay analysis was conducted to identify the administrative areas that fall within the service coverage more accurately.

3.3 WebGIS Implementation

The final stage of the research is the implementation of the analysis results into the form of interactive WebGIS based on HTML, CSS, JavaScript, and Leaflet.js [18]. The spatial data from GIS processing is exported into GeoJSON format so that it can be dynamically visualized through WebGIS [17]. The research flow chart is used to illustrate all stages of research from problem identification to conclusion drawn.

The research flow diagram describes the stages of research ranging from problem identification and literature study, data collection, spatial data processing, TPS distribution analysis, TPS service coverage analysis using a 500-meter buffer, overlay analysis of the served area, implementation of WebGIS, to conclusion [18]. The research flow diagram can be seen at Figure 1.

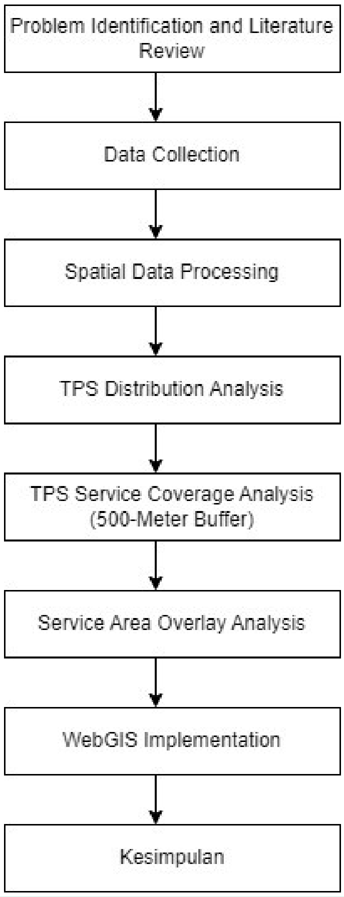

Figure 1. Research Flow Diagram

RESULTS AND DISCUSSION

4.1 Official TPS Spatial Distribution

The mapping results showed that the distribution of official Temporary Waste Collection Sites (TPS) in Nabire District was not even in all study areas [8]. Visually, TPS points tended to be concentrated in certain areas, especially in areas with relatively higher community activities, while some other parts of the region still did not have adequate TPS facility support. This condition shows the inequality of distribution of waste facilities between regions.

To strengthen the visual analysis, *Nearest Neighbor Analysis* (NNA) was conducted to identify the pattern of TPS distribution quantitatively [16]. The results of the analysis showed that the nearest neighbor *index (R)* value was **0.7636** with *a Z-score* of **-2.02**. *An R* value of less than 1 indicates that the distribution pattern of official temporary waste collection sites in Nabire District tends *to be clustered*, while a negative *Z-score* reinforces that the grouping pattern is statistically quite real.

These findings show that the placement of

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official TPS is still focused on certain areas and has not been spread proportionally to all study areas. The distribution pattern that groups has implications for the formation of service concentrations only around certain points, so that some other areas have the potential to not have optimal access to waste services [9]. Thus, the results of the spatial distribution analysis show that the distribution of existing TPS is still uneven and needs to be a concern in the evaluation of waste services in Nabire District.

The clustered distribution pattern is consistent with the low service coverage percentage. When TPS locations are concentrated in certain areas, the resulting service coverage also overlaps around the same zones, while other areas remain uncovered. This means that the main issue is not only the number of TPS facilities, but also their spatial placement across the district.

The spatial distribution of official temporary waste collection sites in Nabire District is shown in Figure 2.

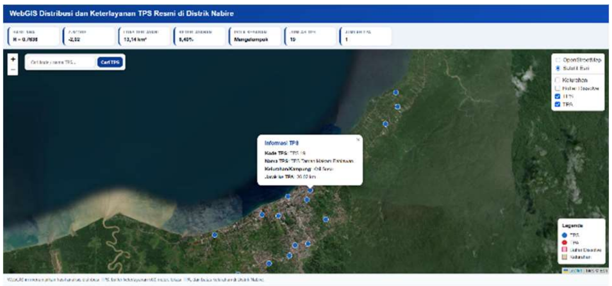

Figure 1. Spatial Distribution of Official TPS in Nabire District

4.2 TPS Service Coverage Based on 500-Meter Buffer

The service analysis was carried out using *a buffer* radius **of 500 meters** from each TPS point to measure the service coverage to the surrounding area [11]. At the processing stage, all *buffers* are combined using a *dissolve* process so that overlapping areas are not calculated repeatedly [18]. This step is important to produce a more accurate area of the served area and represent the total service coverage of the entire TPS.

The results of the analysis show that the area served by the official temporary waste collection sites in Nabire District is only **13.14 km²** out of the total study area of **205.26 km²**. Thus, the percentage of areas that are within the service range of the temporary waste collection sites is only around **6.40%,** while around **93.60% of** the other areas are still outside the service range. These findings show that the level of official temporary waste collection sites service in Nabire District is still low.

The low level of service coverage indicates that the distribution of TPS has not been optimal in reaching all residential areas. People who are outside the *500-meter buffer range have the potential to travel longer distances to dispose of waste. This condition can reduce the effectiveness of waste services and in the long term has the potential to trigger uncontrolled waste disposal practices* [19]. In the context of urban infrastructure services, facilities such as TPS should be placed with coverage distances in mind so that they can be accessed more fairly and efficiently by the community.

Spatially, the low coverage of this service also strengthens the results of previous distribution analysis which shows that the distribution pattern of temporary waste collection sites tends to be clustered. When temporary waste collection sites are concentrated in certain areas, the service areas formed are only dominant in zones adjacent to the location of the temporary waste collection sites, while other areas remain unreached. This shows that the main problem in this study is not only the number of temporary waste collection sites, but also the unbalanced placement pattern between regions.

With service coverage only reaching **6.40%,** it can be concluded that the need for additional TPS in Nabire District is still relatively high. Areas that are outside the 500-meter buffer range need to be prioritized in planning the placement of new TPS. Through this approach, the management of waste facilities can be improved not only in terms of quantity, but also in terms of equitable distribution of service access spatially.

In addition, the use of spatial analysis in this study provides a more objective approach in identifying areas that have been and have not been served. The Geographic Information System-based approach allows service coverage evaluation to be carried out in a measurable manner through the integration of data on the location of temporary waste collection sites, service coverage areas, and administrative boundaries [20]. Thus, the results of the study are not only descriptive, but can also support spatial data-based

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decision-making.

This result indicates that the existing official temporary waste collection sites have not adequately covered the study area. The service coverage of only 6.40% shows that most parts of Nabire District are still outside the service range of official TPS facilities. This condition suggests that waste service accessibility is still limited and unevenly distributed across the study area. In this study, the 500-meter buffer is used as a service coverage standard to represent a reasonable walking distance to access temporary waste collection sites. Based on this standard, areas located within the 500-meter buffer are considered served, while areas outside the buffer are considered not adequately served. Therefore, the finding that 93.60% of the study area remains outside the service range indicates that the current distribution of official TPS facilities has not met the expected spatial service coverage.

The service coverage area generated from the 500-meter buffer analysis is shown in Figure 3.

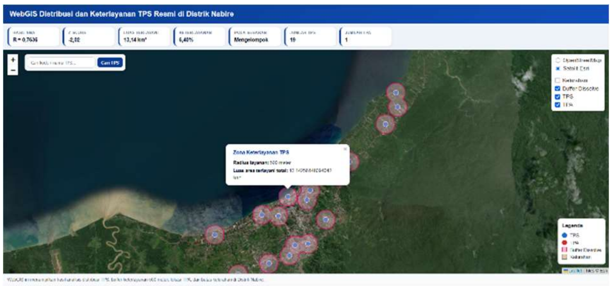

Figure 2. TPS Service Coverage Based on 500-Meter Buffer

A summary of the TPS service coverage analysis is presented in Table 2.

Table 2. Results of TPS Service Analysis in Nabire District

No	Indicator	Value
1	Area of study	205,26 km²
2	Area served	13,14 km²
3	Percentage of areas served	6,40%
4	Percentage of unserved territories	93,60%

4.3 WebGIS Implementation

The results of the spatial analysis were then implemented in the form of interactive WebGIS as a medium for visualization and presentation of information [15]. This implementation provides added value because the results of the distribution of temporary waste collection sites, landfill locations, 500-meter service buffers, and administrative area boundaries can be displayed in an integrated manner in one platform that is easier for users to understand [14].

The WebGIS developed displays several main layers, namely the location of the temporary waste collection sites, the 500-meter service buffer, the location of the landfill, and the boundaries of the village [21]. This system is also equipped with information *popups*, *control* layers, *basemap options*, temporary waste collection sites search features, and map legends. With these features, the results of the analysis of the distribution and service coverage of the temporary waste collection sites are not only presented in the form of static maps, but can also be explored in a more interactive manner.

In the context of this study, the implementation of WebGIS shows that GIS-based spatial analysis can be further developed into a communicative and applicative information system. Thus, the research does not stop at the stage of identifying distribution patterns and the service coverage of TPS, but also produces information presentation media that can be used to support the evaluation and planning of waste facilities in Nabire District.

The WebGIS interface developed to visualize the distribution and service coverage of official temporary waste collection sites is shown in Figure 4.

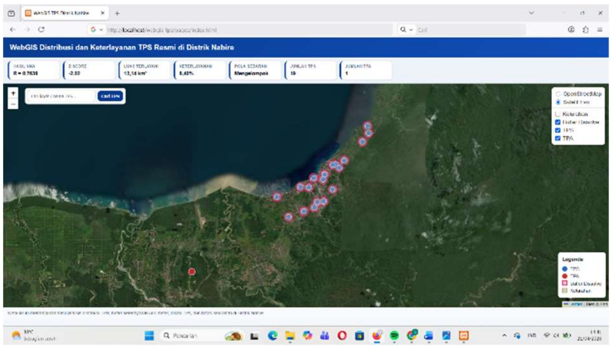

Figure 3. Implementation of WebGIS Distribution and Service of TPS in Nabire District

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CONCLUSION

Conclusion

Based on the results of the analysis that has been carried out, it can be concluded that the spatial distribution of official temporary waste collection sites in Nabire District tends to be clustered, which is shown by the Nearest Neighbor Analysis (NNA) value of 0.7636 with a Z-score of -2.02. These results show that the distribution of temporary waste collection sites is not even in all study areas.

A service analysis using a *500-meter radius buffer showed that the area served by the official TPS was only* 13.14 km² **out of the total study area** of 205.26 km²**, or around** 6.40%, **while** the other 93.60% **of the area was still outside the service range. This condition shows that the level of service of the official TPS in Nabire District is still low and has not been optimal in reaching all residential areas.**

The results of the spatial analysis were subsequently successfully implemented in the form of **interactive WebGIS** which displays the TPS location layer, landfill location, *service buffer*, and administrative area boundaries. This implementation shows that GIS and WebGIS can be used not only to analyze the distribution and service coverage of TPS, but also to present the results of the analysis in a more communicative and interactive manner to support evaluation and decision-making.

The scientific contribution of this study is the integration of Nearest Neighbor Analysis, 500-meter buffer-based service coverage analysis, administrative overlay, and WebGIS implementation in evaluating official temporary waste collection sites at the district scale. This integrated approach can support spatial data-based decision-making for waste facility planning.

Suggestions

Based on the results of the research that has been conducted, there are several suggestions that can be proposed. First, it is necessary to add new TPS points in areas that are still beyond the service range so that the level of waste service coverage in Nabire District can increase. Second, further research can use additional data such as road networks, waste generation, or regional socio-economic data so that the analysis of service coverage becomes more detailed. Third, the WebGIS that has been developed can be improved by adding advanced analysis features, periodic data updates, and integration with waste management operational data so that it can be used more optimally by related parties.

Future research can improve the analysis by using road network data, population distribution, waste generation volume, and TPS capacity data. These additional data can provide a more detailed evaluation of waste service accessibility and support more accurate recommendations for new TPS placement.

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