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Analysis Hierarchy Process and Geospatial in Determination of the Alternative Locations for Temporary Disposal Site in Sumbersari District, Jember

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Abstract: Sumbersari District, one of the urban areas in Jember, meets the problems of a limited number of temporary disposal sites (TDS). The paper aims to determine an alternative location for a new temporary disposal site (TDS) in the Sumbersari District by combining the Analysis Hierarchy Process (AHP) and Geographic Information System (GIS) methods. The AHP method is applied to determine the priority land with predetermined variables and the GIS method is applied for weighting physical aspects and spatial to make decisions through buffering and overlay techniques. The results of the study show that AHP weighting obtains priority to land, namely areas that are dominated by land with ownership rights of the State, Property Rights, and Use Rights, land that has a distance of more than 1000 m from the existing TDS, and land that has existing TDS conditions with a storage capacity of more than 100 %. Meanwhile, based on the GIS method through buffering and overlay techniques on physical and priority land aspects, 10 alternative location points were obtained with a value of 26 (Quite feasible and priority). These points were then carried out by eld observations, resulting in 2 suitable locations, namely A1 in the Antirogo Village and K1 in the Kranjingan Village.

Keywords: AHP; alternative locations; overlay; temporary disposal site

Introduction

A temporary disposal site (TDS) is a facility that accommodates waste from settlements or agencies to be sorted according to the type and characteristics of waste.

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Then, the residual results are transported by trucks to the final processing site (landfill site) as the final stage of waste management (Act of the Republic of Indonesia Number 18 of 2008). However, its function is not optimal and negatively impacts it unless it is in good site planning (Dhokhikah and Trihadiningrum, 2012), inadequate collection places in terms of facilities and size, improper collection methods, and scarcity of TDS facilities. Therefore, it is necessary to determine the location of TDS by considering several supporting factors to get the best alternative location. Suk-Eng (2021) explained several variables that determine the TDS location, including distance from the community, water resources, road, slope, digital elevation model, and land use. It showed that there is a theoretical gap. Thus, the following variables are added, including the existing TDS service capacity and land ownership.

Sumbersari District is one of the urban areas that faces the threat of decreasing the quality of municipal waste services. The observations illustrate that the current TDSs in Sumbersari District have various physical conditions. The location of some TDs is not based on the boundaries of surrounding facilities or land uses, such as the TDS in Karimata and Mastrip, which have a road border of 20-100 cm. They cause congestion during the collecting and operating hours. The Sukorejo TDS has no border with the Sukorejo Market, which can cause unpleasant odors and susceptibility to the spread of disease from the TDS to cooking ingredients or active residents in Sukorejo Market.

Based on the results of the calculation of waste generation using the SNI 193964-1994 method, it shows that the feasibility conditions of existing TDS in Sumbersari District, Jember Regency, on average, have a <100% space, but the Karimata TDS has a more than 100% space or has a storage condition that exceeds the capacity of the TDS which causes some waste not to be transported. This condition is influenced by the dimensional capacity of the TDS to accommodate waste generation. Meanwhile, each TDS service coverage cannot serve the waste generation area. In addition, compared to the Regulation of the Minister of Public Works of the Republic of Indonesia number 03/PRT/M/2013, each temporary disposal site, on average, exceeds the maximum service range of a radius of 1 km. TDS coverage services are considered not optimal due to the limited number of temporary disposal sites in the waste generation source area that exceeds 1 km from the existing TDS. The villages not optimally served by the existing TDS are Kranjingan, Antirogo, and Wirolegi Village. Therefore, it is necessary to plan the construction of TDS in waste source areas not served by existing TDS.

This fact is reinforced by the urgency stated in the Strategic Plan of the Department of Environment Jember Regency for 2021-2026, namely the evaluation of the performance achievements of the previous year's targets. More optimal efforts are needed within the next five years, one of which is handling waste management through increasing the number of TDS due to the minimal availability of TDS. This indicates that waste services in the Jember Regency have not run optimally to manage waste, especially in providing TDS infrastructure. The Jember Regency Government has not yet determined the location for the construction of TDS due to limited strategic land.

To anticipate the declining TDS services, handling efforts are needed in determining the location for additional capacity and adding new temporary disposal sites in the Sumbersari District. This study aims to analyze alternative temporary dumping sites (TDS) with the scope of services of Sumbersari District. This research uses spatial analysis and Analytical Hierarchical Processes. Spatial analysis was chosen because of the ease of making decisions through the physical criteria of the TDS construction site so that the necessary information can be captured, modified, and managed quickly and in an appropriate way, and spatially referenced data can be correlated and analyzed with the same platform (Singh, 2019).

Research Method

The study is in Sumbersari District, an urban district of Jember Regency with an area of 3677.88 ha. This research used a qualitative approach using the Analytical Hierarchy Process (AHP) and a quantitative approach using spatial analysis through GIS applications. The AHP determines the priority land for TDS development by filling out questionnaires by respondents, who are chosen using Purposive sampling techniques. The total respondents are five, including two from the Department of Environment Jember Regency, two from the Regional Planning and Development Agency Jember, and one from Muhammadiyah University. The hierarchy in AHP is shown in Figure 1.

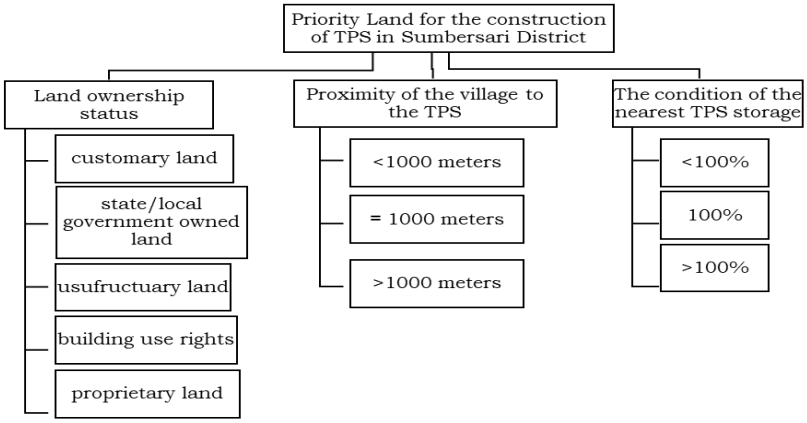


Figure 1. Hierarchy of AHP

Meanwhile, the spatial analysis uses buffering and overlay techniques to determine the location based on overlapping physical conditions and priority land results. The research variables used were adapted from Siregar (2019), Hanafiah (2008), and Anwari et al. (2021), including land use classification, land slope classification, distance to routes, distance to sources of waste generation, distance to water sources, and land ownership data are shown in Table 1.

Table 1. Variables and Parameters of Physical Aspects of Research

Indicators	Parameters	Expected Value	Value
Distance to Waste Generation Center	● 0-250 meters	● Very Low	1
	● 250-500 meters	● Keep	3
	● 500-750 meters	● Tall	4
	● 750-1000 meters	● Very High	5
	● >1000 meters	● Low	2
The distance of TDS to the Garbage Transport Route	● 0-50 meters	● Very High	5
	● 50-100 meters	● Tall	4
	● 100-150 meters	● Very Low	1
	● 150-200 meters	● Low	2
	● >200 meters	● Keep	3
Land Use for TDS Locations	● Vacant Land	● Very High	5
	● Rice fields, moor, garden	● Keep	3
	● Settlements, Housing	● Tall	4
	● Offices, trade and services	● Very Low	1
	● Forest, thicket	● Low	2
Land slopes	● 0-11%	● Very High	5

Indicators	Parameters	Expected Value	Value
	● 12-23%	● Tall	4
	● 24-35%	● Keep	3
	● 36-45%	● Low	2
	● >45%	● Very Low	1
Distance to a river or water source	● >100 meters	● Very High	5
	● 84-100 meters	● Tall	4
	● 67-83 meters	● Keep	3
	● 51-66 meters	● Low	2
	● <50 meters	● Very Low	1

This research identifies the problems in solid waste management, particularly in the TDS location, where improper loading activities from garbage carts into a dump truck. The TDS location is on the roadside, and there is no spare space for the dump truck to park safely, and the number of garbage carts fulfills the road. Fortunately, the unloading and loading activities start from 04.00 until 06.00, when traffic is still low. The research flowchart is shown in Figure 2.

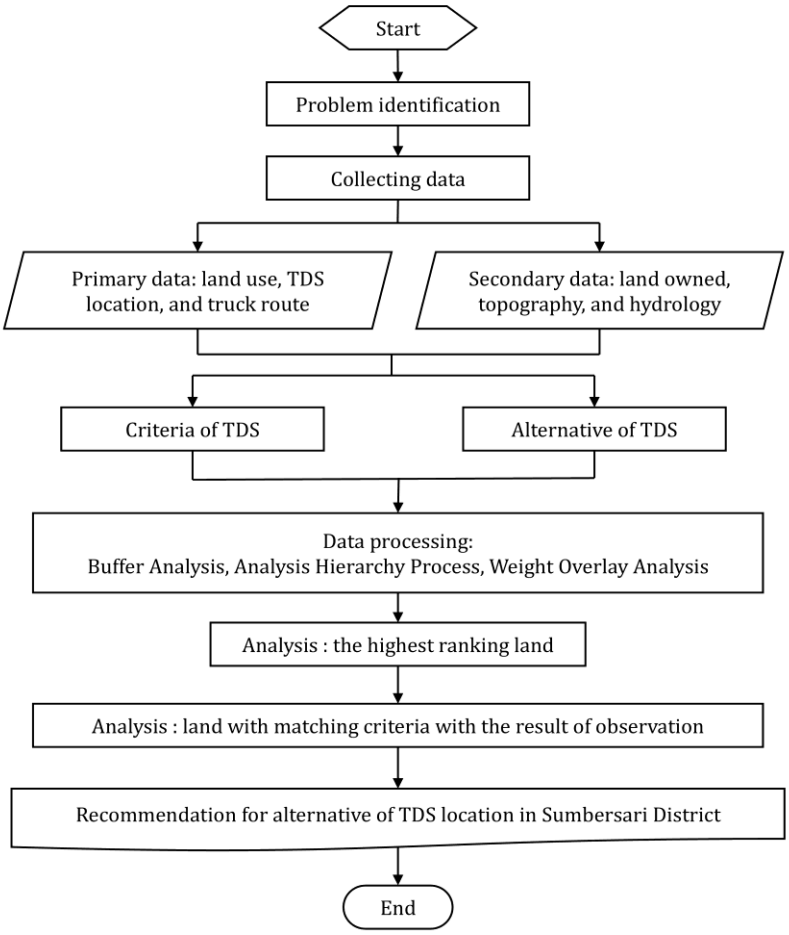
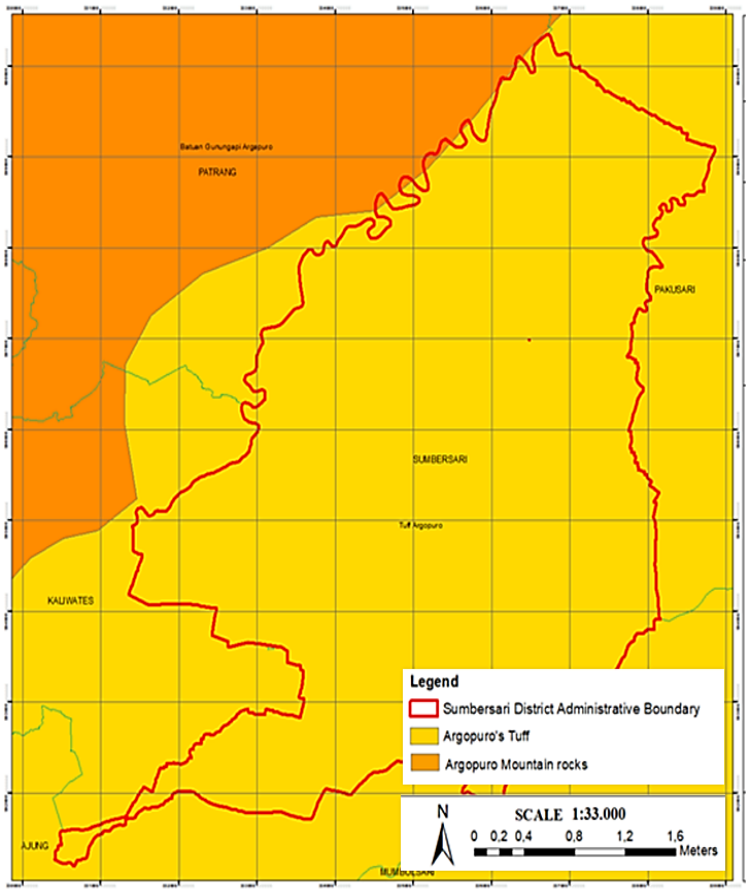


Figure 2. Research Flow

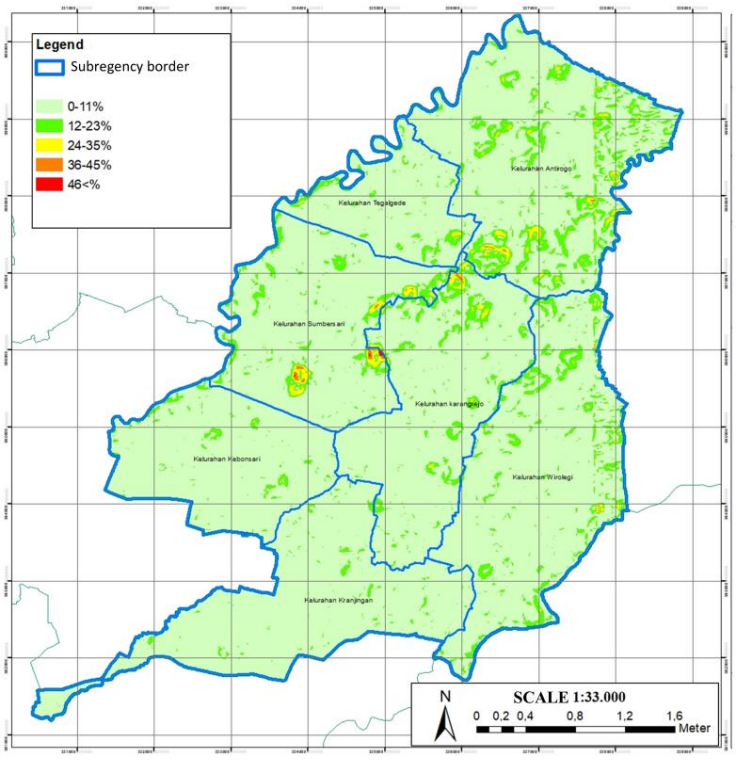
In general, Sumbersari District can be described through physical conditions, population, and land ownership it. Sumbersari sub-district consists of 7 sub-districts, with the largest sub-district area being the Antirogo sub-district, and the sub-district center is in the Sumbersari sub-district. Sumbersari District is dominated by geology in the form of Mount Argopuro Rock and Argopuro Tuff, which causes the soil texture to experience water

and soil pollution easily (Febriarta et al., 2021). The hydrological distribution has a parallel pattern dividing Sumbersari District with the density of tributaries in Kranjingan Village. These geological and hydrological conditions are a consideration for determining the location of TDS, so it is better to avoid areas adjacent to water so that the remaining pollutants of TDS activities do not pollute the hydrological area. The topography of Sumbersari District is at an altitude ranging from 140-180 meters above sea level and is dominated by slopes of 0-11%, with a stable distribution of slopes in Kranjingan Village, Kebonsari Village, and Antirogo Village. Land with such slopes is more recommended in development. Rice fields and residential areas dominate the land use conditions of Sumbersari District. No land use was found for vacant land types, shrubs, and RTH, so the study used the remaining land use types. The condition of the garbage transportation route is on a road with Collector and Local functions, which has a road width ranging from 6-8 m and asphalt pavement to facilitate the movement of garbage transporters. Sumbersari District is dominated by land status in the form of real estate / customary land in all villages. Meanwhile, land ownership in the form of state/state-controlled land has a limited number of 7 location points and is only spread in Sumbersari Village, Wirollegi Village, and Antirogo Village. The physical picture of the condition of the Sumbersari District is shown from Figure 3 to Figure 13.



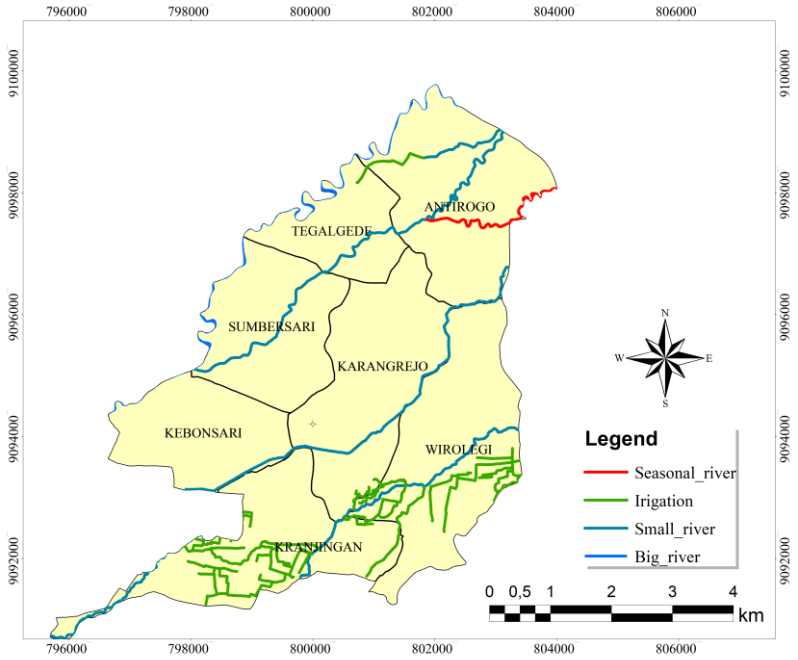
Source:RBI, 2022

Figure 3. Geologic Map of Sumbersari District



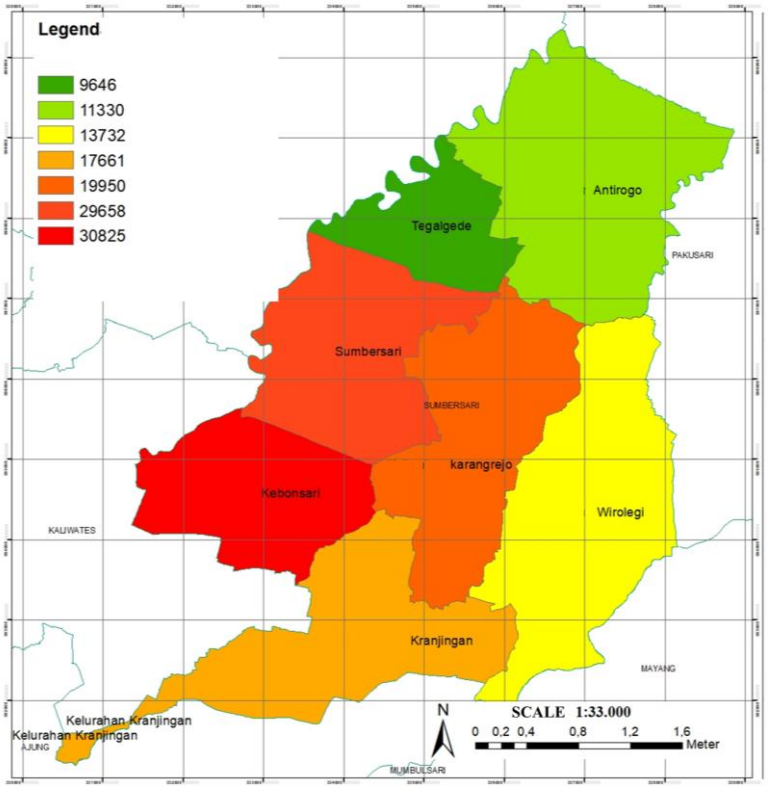
Source: RBI, 2022

Figure 4. Land Slope Classification Map of Sumbersari District



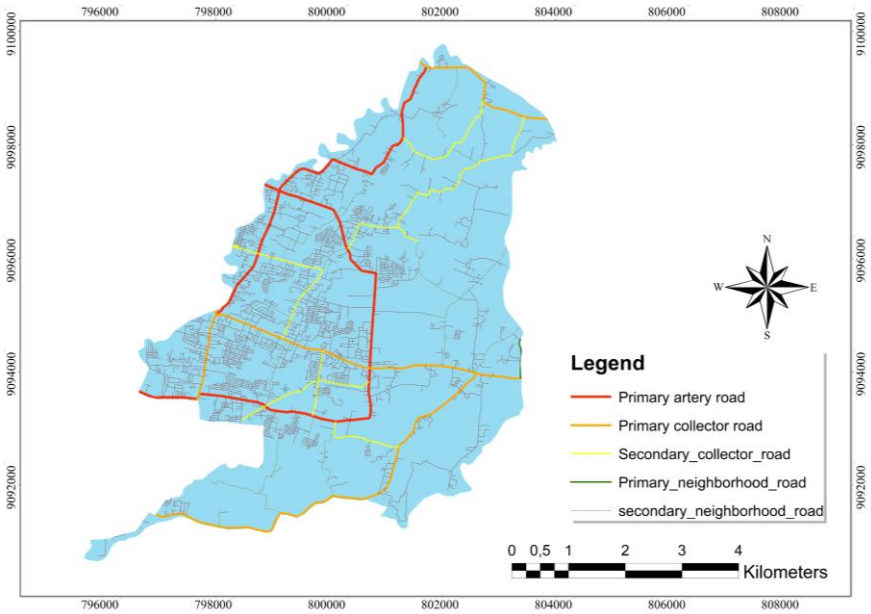
Source: Public Works, Road and Bridge, dan Water Resources Office of Jember Regency

Figure 5. Hydrological Distribution Map of Sumbersari District



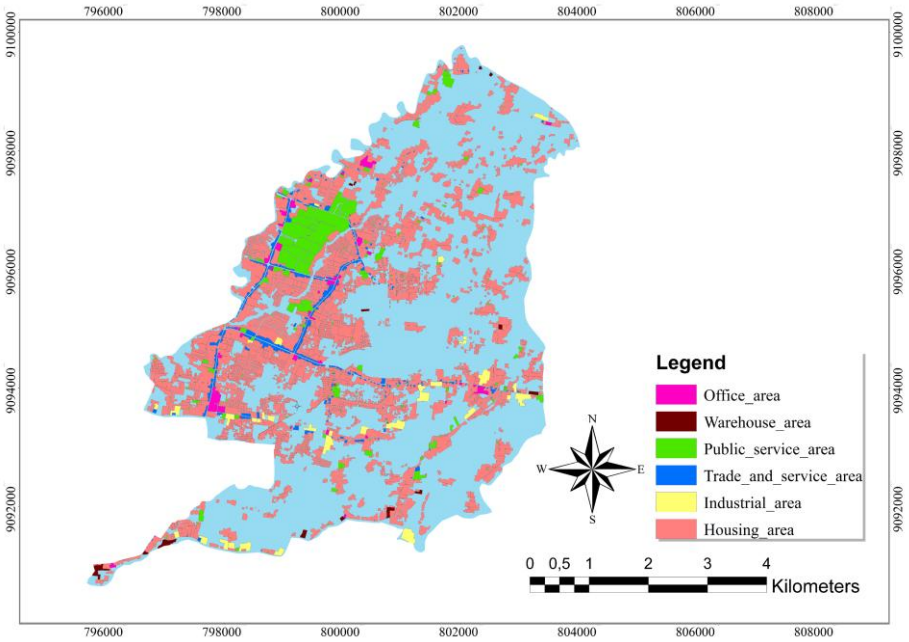
Source:Statistics Jember Regency, 2022

Figure 6. Map of The Total Population of Sumbersari District



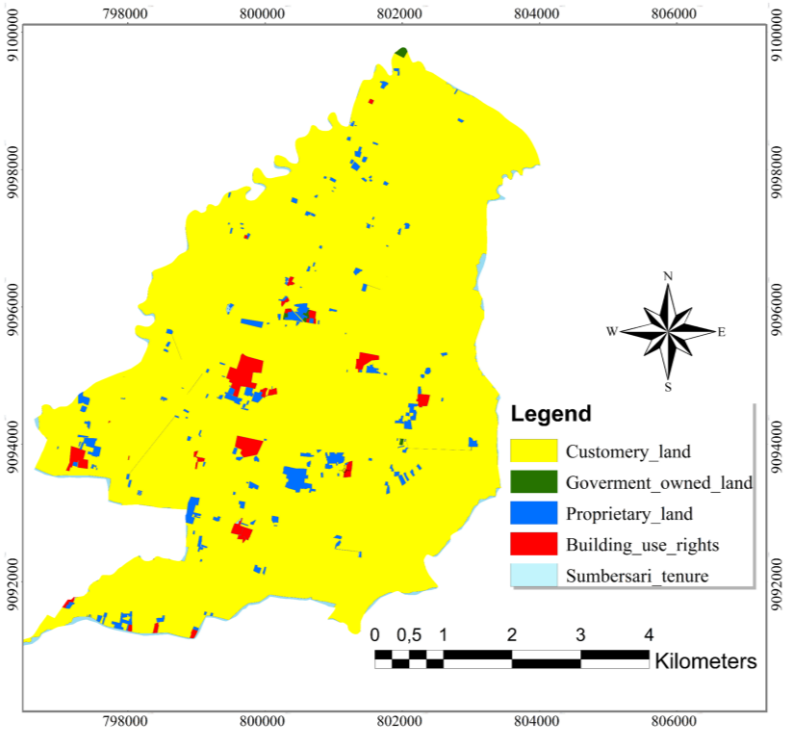
Source: Public Works, Road and Bridge, and Water Resources Office of Jember Regency

Figure 7. Road Network Map of Sumbersari District



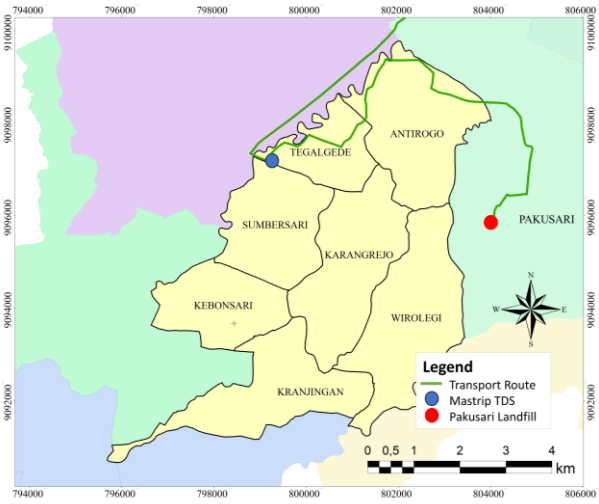
Source:Public Housing, residential areas, and Human Settlements Office of Jember Regency, 2022

Figure 8. Land Use Map of Sumbersari District

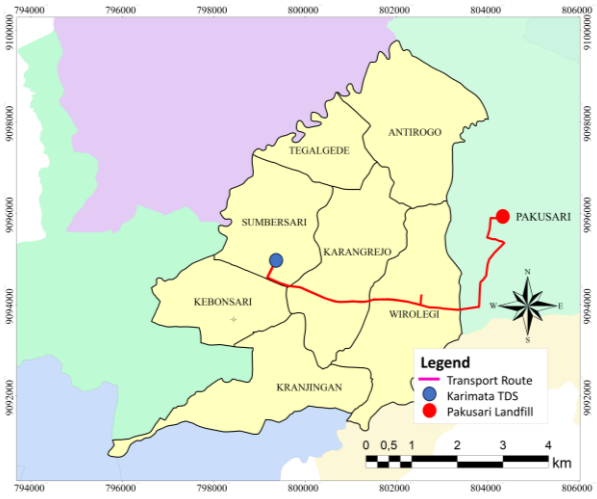


Source: Agrarian Affairs and Spatial Planning Agency of Jember Regency, 2022

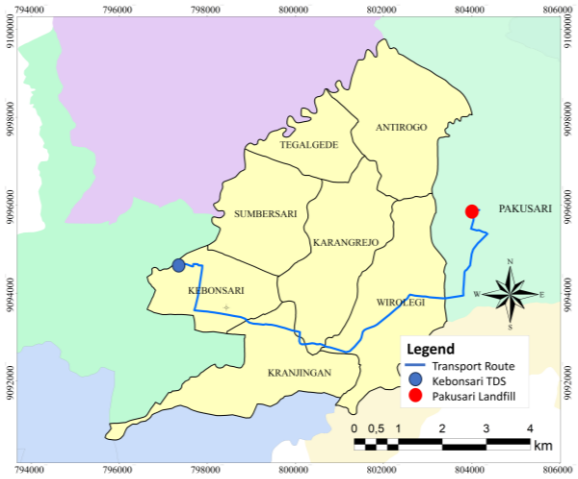
Figure 9. Map Of Land Tenure Status of Sumbersari District



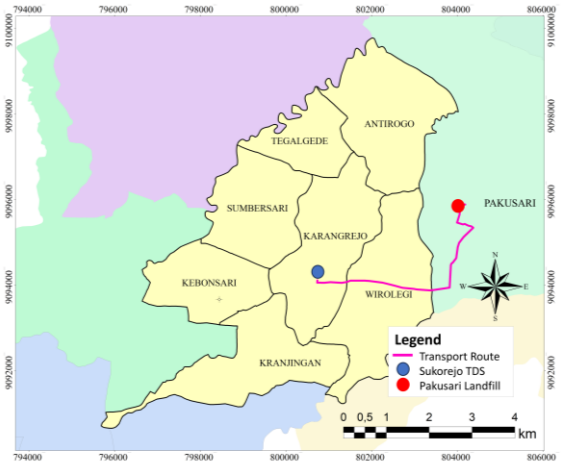
(a) Mastrip



(b) Karimata



(c) Kebonsari



(d) Sukerejo

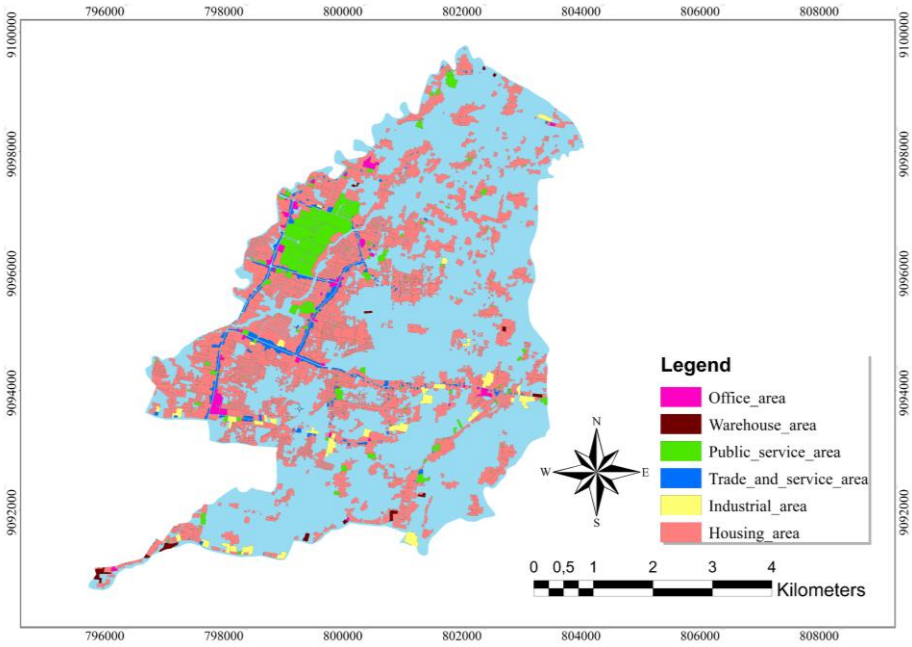
Source: Khomsa, 2022

Figure 10. Map TDS Garbage Transport Route

Results and Discussions

Spatial Analysis of Physical Aspect Variables and Criteria for Determining TDS Zoning in Sumbersari District

This stage aims to determine the zoning map of the feasibility of physical aspects according to their level so that the analysis results can be used to determine the zoning of the strategic location of TDS in the Sumbersari District. Figure 11, Figure 12, Figure 13, Figure 14, and Figure 15 show the study buffering and classification on physical aspect maps of the Sumbersari District.



Source:Regional Planning and Development Agency of Jember Regency

Figure 11. Land Use Classification Map of Sumbersari District

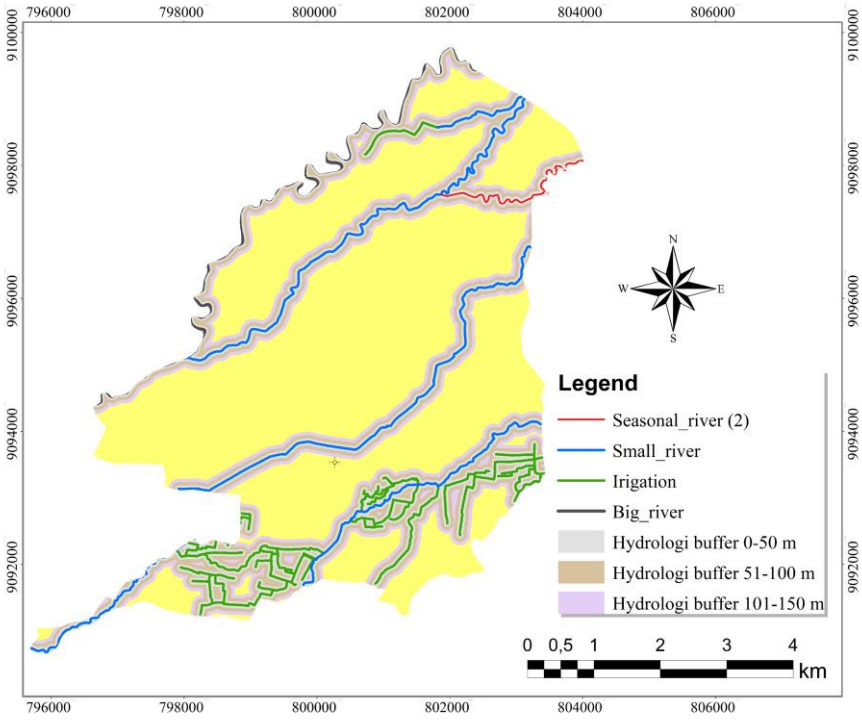


Figure 12. Hydrological Distribution Buffering Map of Sumbersari District

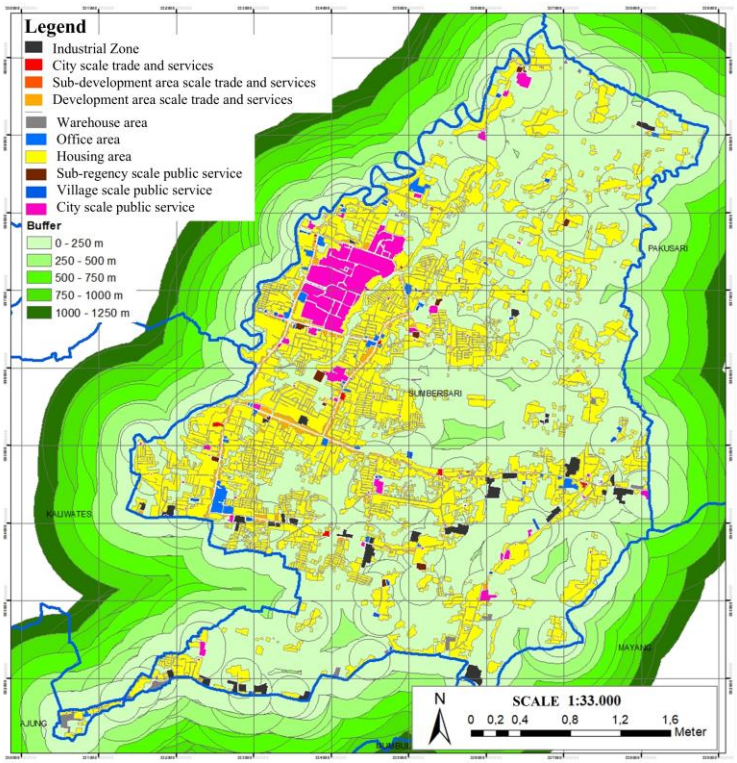
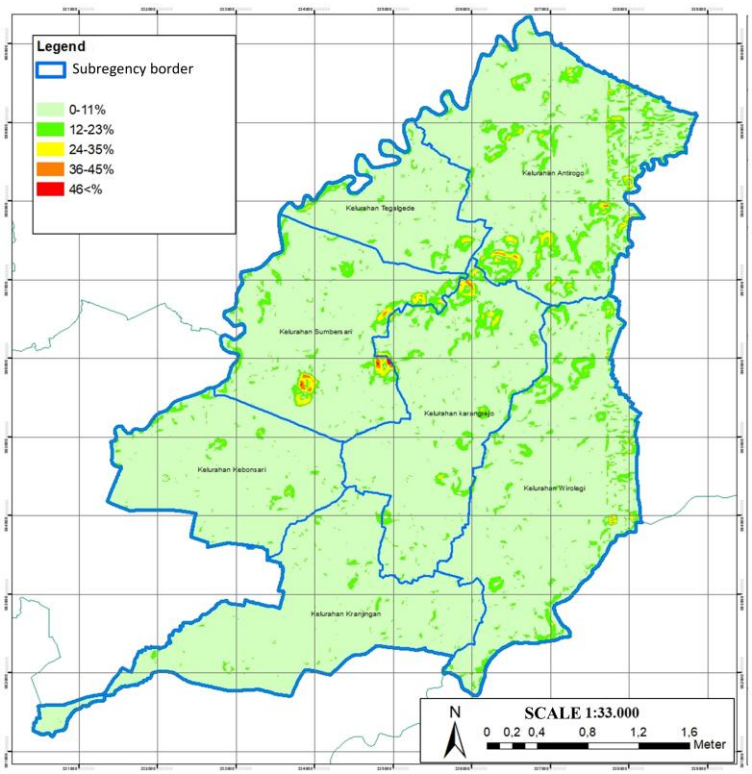


Figure 13. Land Use Buffering Map of Waste Generation Source of Sumbersari District



Source:RBI 2022

Figure 14. Land Slope Classification Map of Sumbersari District

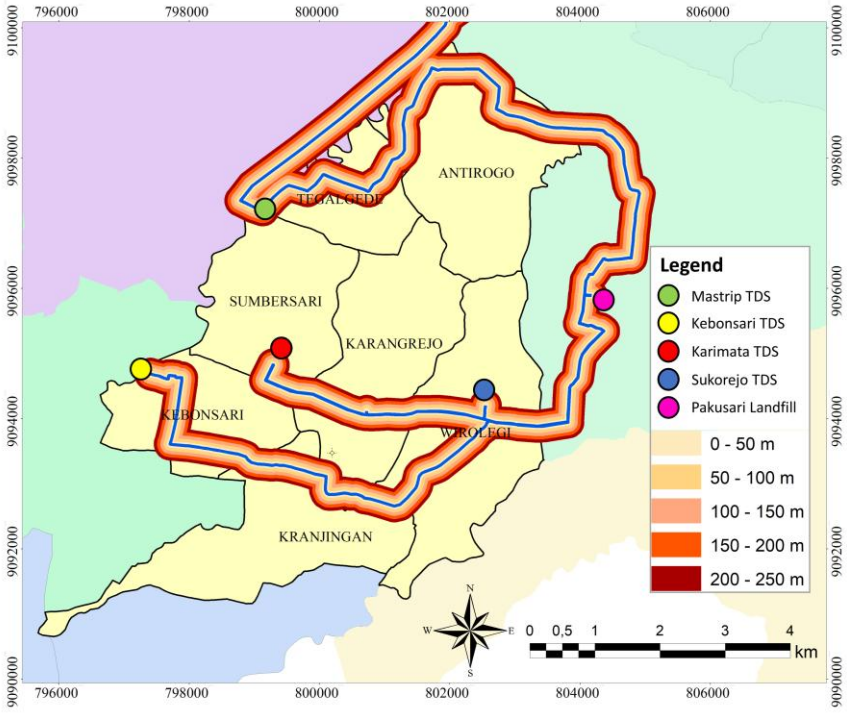


Figure 15. Buffering Map of Garbage Transport Route of Sumbersari District

The existing condition analysis based on the results of the physical aspect ranking is shown below.

1. Buffering aspects of land use (housing, office, and trade) illustrates that almost all areas in Sumbersari District are at a very low level, namely 0-250 meters and a medium level of 250-500 meters. This happens because waste-producing land use areas have high density in urban areas.
2. Buffering the hydrological aspect illustrates that the hydrological distribution map has a high density in Kranjingan Village, so it is necessary to consider the construction of TPS so that it has boundaries not to pollute the hydrological flow.
3. Buffering of the aspect of the waste transportation route by the fleet shows that the highest service is at a distance of 0-50 meters from the waste transportation route. Most of the land not served by the waste transportation route is in the northern part of Sumbersari Village, the southern part of Antirogo Village, the northern part of Karangrejo Village, and the southern part of Kranjingan Village.
4. The ranking of land slopes in Sumbersari District, which is scattered, is dominated by slopes of 0 - 11%, with a stable distribution of slopes in Kranjingan Village, Kebonsari Village, and Antirogo Village. Land with such slopes is more recommended in development.
5. The ranking of land use classifications suitable for TDS development is considered not to meet the recommendations of Hanafiah (2008) by showing the absence of vacant land and green open space.

After buffering and classification functions on physical aspect data, a process was carried out using Weight Overlay on variable zoning maps of physical aspects to determine the location of temporary disposal sites in Sumbersari District. The scoring process on the Weight Overlay method produces the highest value of 25 and the lowest of 5. Furthermore,

the determination of the number and range of classes resulted in the following classification:

1. Values 5 to 11 are zoning that is considered unsuitable for the placement of temporary disposal site locations
2. Values 12 to 18 are medium zoning to be used as temporary disposal site locations
3. Values 19 to 25 are considered suitable for use as a temporary disposal site location.

Spatial analysis of physical variables produces maps presented in Figure 16.

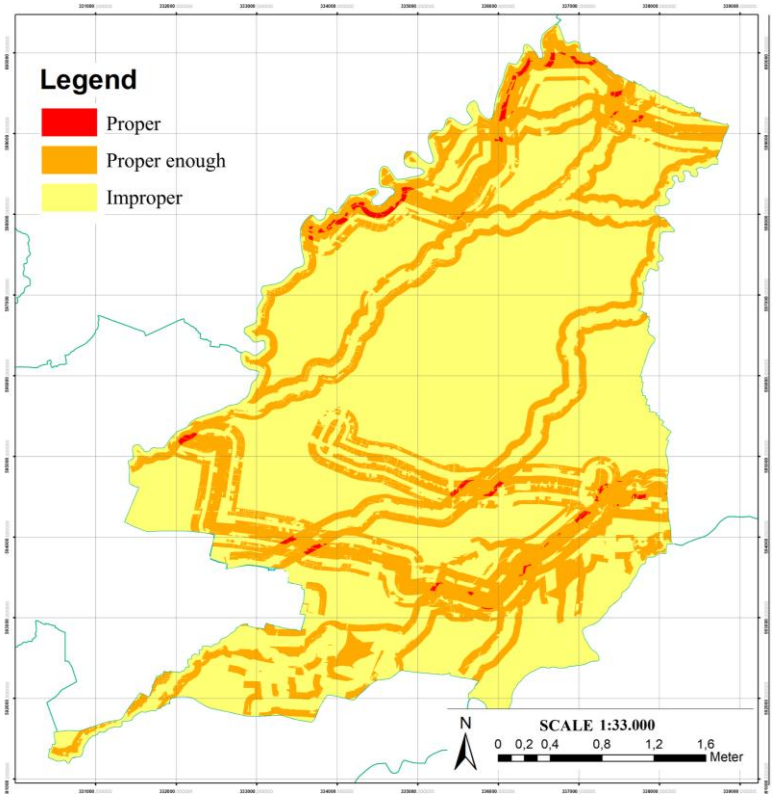


Figure 16. Feasibility Map of Physical Aspects for TDS Construction in Sumbersari District

Figure 5 shows that areas with feasibility for constructing TDS based on physical aspect variables are generally around main roads or waste transportation service routes by truck fleets. This illustrates that accessibility factors are more important than other factors.

Analysis of Priority Land Determination using the AHP Method

The stages of AHP analysis are used to obtain land prioritized in constructing TDS through AHP analysis with predetermined criteria and sub-criteria. The acquisition of scores on each criterion and sub-criteria was carried out using a matrix filled in by five selected respondents, namely two respondents from the Department of Environment Jember Regency, two respondents from the Regional Planning and Development Agency Jember Regency, and one respondent from a lecturer in Environmental Engineering at the University of Muhammadiyah. The result of this stage is three priority values through the weighting of the Expert Choice application with an inconsistency value of 0.00003, which states that the weighting results are feasible to use. The weighting results are shown in Figure 20.

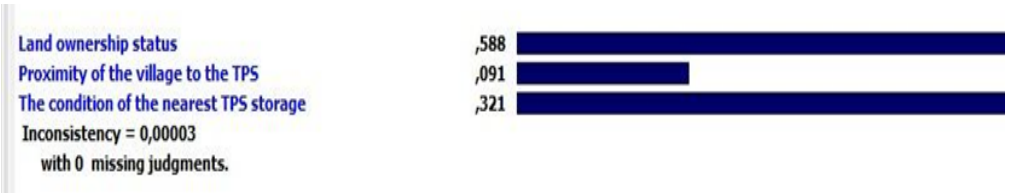


Figure 17. Land determination based on the priority values

Based on the results of the Expert Choice weighting, it can be seen that the first priority is land ownership with a value of 588, the second priority is the condition of the TDS reservoir closest to the village with a value of 321, and the third priority is the distance between the village and the existing TDS with a value of 91. The following are the results of calculating indicators on each criterion to determine priority land for TDS development:

1. Land Ownership Variables

Land tenure variables consist of several types of land ownership status. The results of the Expert Choice weighting show that the first priority is State land with a value of 551, the second one is freehold land with a value of 273, and the third one is right-of-use land with a value of 109. The weighting results are presented in Figure 18.

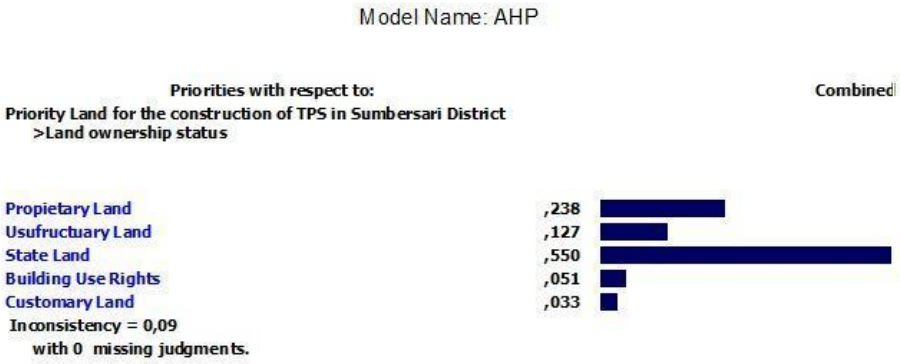


Figure 18. Land Tenure Variable Weighting Chart

2. Variable distance of villages that cause waste to existing temporary disposal sites

The variable distance of the village that causes waste to the existing temporary disposal site consists of several types. The results of the Expert Choice weighting show the first priority, which is >1000 m, with a value of 733. This shows that villages that have a longer distance from the existing TDS are chosen so that the construction of new TDS can reach waste transportation services in villages that have not been served by existing TDS. The weighting results are presented in Figure 19.

Figure 19. Variable Weighting Diagram of Village Distance Conditions to the Nearest Existing TDS

3. Variable condition of existing TDS reservoir

The variable condition of existing TDS reservoirs around the village consists of several types, including >100% storage (TDS capacity exceeds capacity), =100% storage (sufficient TDS capacity), and <100% storage (TDS capacity still has space to accommodate waste). The results of the Expert Choice weighting show the first priority, which is >100% with a value of 674. This shows that existing TDS have waste storage conditions exceeding their ability to be selected so that the construction of new TDS can accommodate excess waste generation at existing TDS and accommodate waste in villages that have not been served by existing TDS. The weighting results are presented in Figure 23.

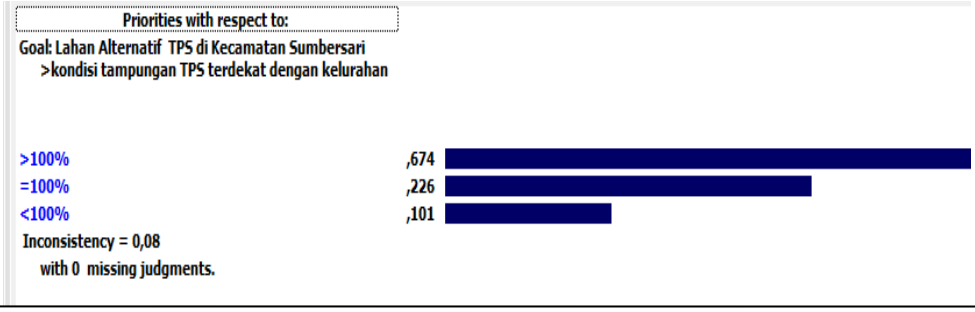


Figure 20. Variable Weighting Chart of Nearest Existing TDS Reservoir Conditions

The results of calculating the three priorities will then be converted to spatial using the Weight Overlay method with the results presented in Figure 24.

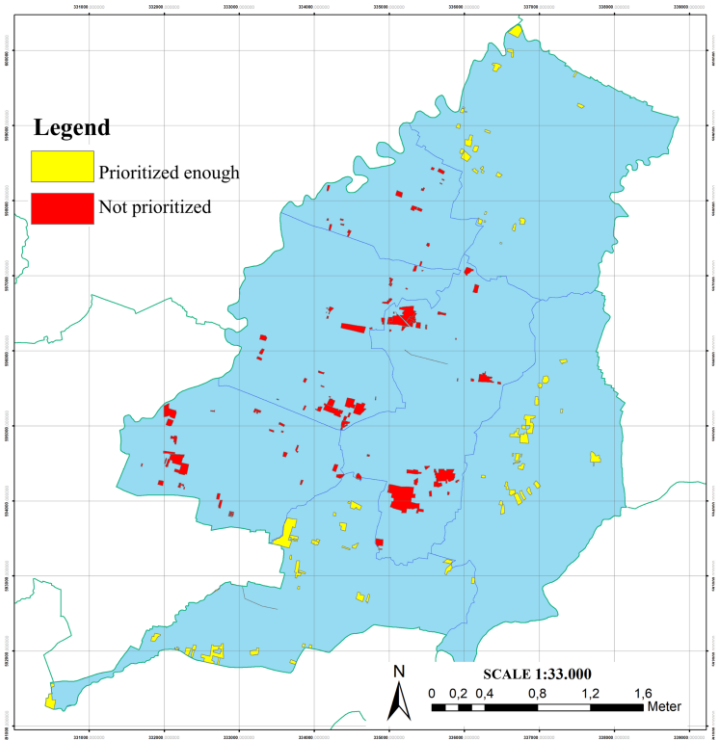


Figure 21. TDS Development Priority Land Map based on AHP Weighting Results

Figure 21 shows land conditions with a reasonably prioritized category dominating villages far from existing temporary disposal sites, namely Antirogo Village, Kranjingan Village,

Karangrejo Village, and Wirolegi Village. Some of these villages are underserved by existing TDS, so they are prioritized for development.

Spatial Analysis on Zoning Feasibility of TDS Location in Sumbersari District

The method used at this stage is the Weight Overlay function on variable zoning maps for determining the location of temporary disposal sites based on physical aspects in Sumbersari District and priority land maps based on AHP results. The results at this stage will be used as a general assessment tool for the current location of temporary disposal sites and strategic site plans for developing temporary disposal site facilities in Sumbersari District. The scoring technique is used to obtain the zoning class of the TDS location in Sumbersari District through summation based on the value of the location determination criteria in Table 1. The calculation yields a high value of 40 and a low. Furthermore, the determination of the number and range of classes was carried out to produce the following classification:

1. Values 6 to 17 are zoning that is considered inappropriate for the placement of temporary disposal site locations
2. Values 17 to 29 are medium zoning to be used as temporary disposal site locations
3. Values 30 to 40 are zoning that is considered suitable for use as a temporary disposal site location.

This analysis stage produced a zoning map of the location of temporary disposal sites in Sumbersari District with 28 priority location points and 10 locations with the highest value. The results of the spatial analysis of variables of physical aspects and land priorities according to the AHP method are presented in Figure 22.

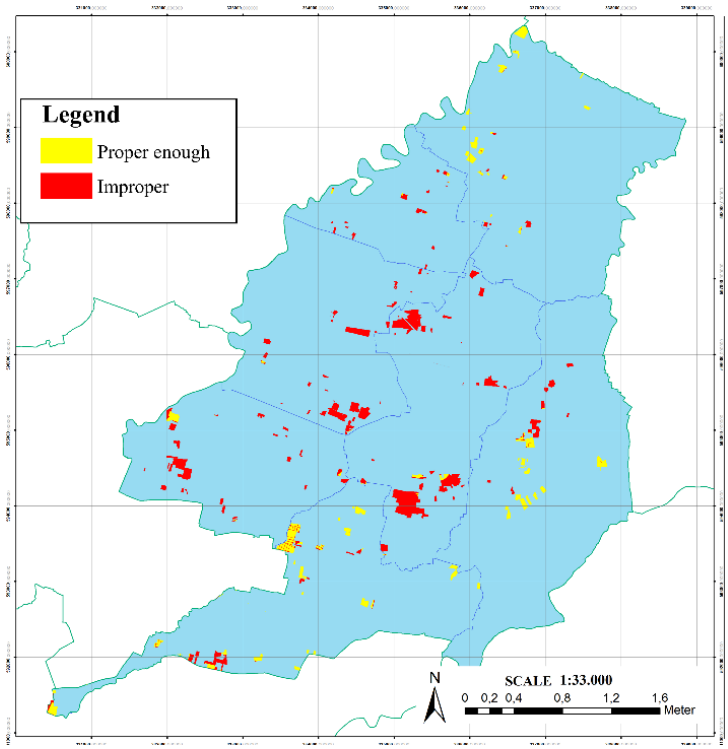


Figure 22. Location Zoning Map for TDS Development in Sumbersari District

Alternative New Temporary Disposal Site Locations in Sumbersari District

The results of spatial identification, based on the feasibility of physical aspects and AHP analysis, can be found as many as 11 feasible location points with the top ranking to build new temporary disposal sites in Sumbersari District, Jember Regency. The distribution of locations is present in Figure 23.

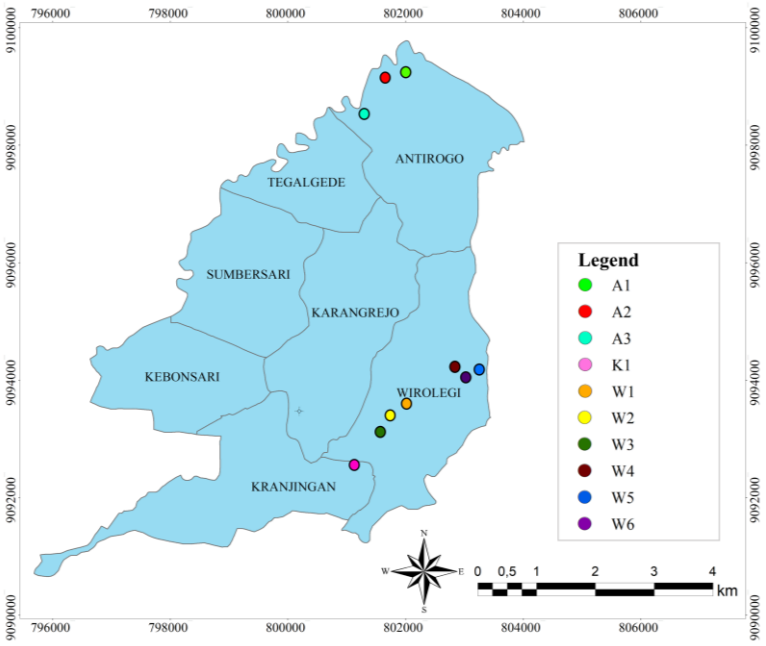


Figure 23. Map of Locations with The Highest Scores in Recommended TDS Locations

The results of these observations illustrate that the zoning of the average temporary disposal site location differs from land use planning by the Regional Planning and Development Agency in the RTRW of Jember Regency in 2015-2035. The condition of each piece of land determines its suitability for the construction of TDS. Land A1 is a densely populated residential land with the availability of vacant land in front of the residential area. This land is considered unsuitable for the developer's residential area because the construction of TDS in the front of the residential area will reduce the aesthetic image. A2 land is a former paddy field that has low productivity. This is evidenced by the absence of irrigation and traces of food plants planted on the land. This land is considered suitable for the construction of TDS because of its location in the source area of waste generation. However, this land needs to be cleared because access from the main route to land A2 is covered by semi-permanent building street vendors. Land A3 is in the boarding house area which makes this land considered unsuitable for the construction of TDS. The construction of TDS in the middle of a built-up area will cause unpleasant odor disturbances for residents of boarding houses around the TDS. K1 land is a paddy field that is still planted with food plants. However, this land is not traversed by technical irrigation infrastructure and this land is planned as residential land based on the 2015-2023 Jember Regency RTRW plan so that the land is considered potentially suitable for TDS development. W1, W2, W3, and W4 land are land with existing conditions as industrial land. The allocation of industrial land is considered unsuitable for the construction of public TDS because the industry has certain types of waste generation so that independent and separate waste management is needed by related industries. W5, W6, and W7 land are residential lands that are far from the main

access and do not have access to land, so the land is considered unsuitable for TDS development. Based on this description, the land recommended for TDS development is K1 and A2. Planning directions are presented in Table 2 and Figure 24.

Tabel 2. The land recommended for TDS development

Village Name	Land Code	Referral
Kranjingan	K1	a. Land leveling is required b. Increasing the landing area at the temporary disposal site is recommended because the road around the land cannot be used for a U-turn. c. It is recommended that the construction of Type I TDS with the type of depot transfer consider the amount of waste generation that has not been served.
Antirogo	A2	a. It is necessary to clear land by evicting street vendors in front of the land. b. The construction of temporary disposal sites must pay attention to the boundaries of surrounding buildings. c. It is recommended that the construction of Type I TDS with the type of depot transfer consider the amount of waste generation that has not been served.

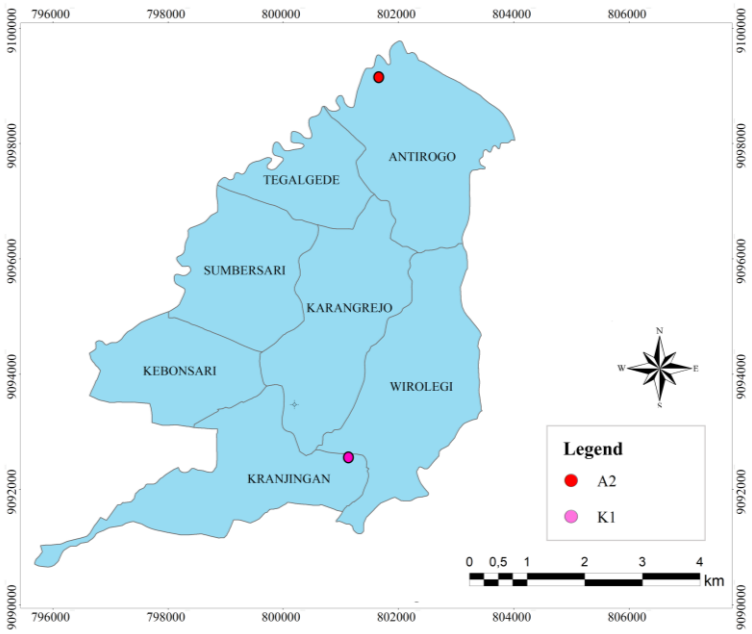


Figure 24. Map of Recommended Alternative Temporary Disposal Site Locations in Sumbersari District

Comparison between this research and the previous research

The gap between this study and previous research includes:
1. Differences in variables that determine the location of alternative TDS
In this study, the most influential spatial variable in determining the location of the alternative TDS is the distance to the existing waste transportation route. Meanwhile, in the Suk-eng (2021) study, the most influential spatial variable in determining the location of TDS is the distance to the location of the waste source.

2. Differences in the implementation of the AHP method in determining the location of TDS construction.

This study implements the AHP method to determine land priorities based on aspects of land ownership, distance to waste sources, and existing TDS space capacity. The determination of priority land is carried out on a physical aspect scoring map. The results of the AHP stated that land ownership was the most influential variable. On the other hand, Suk-eng's research (2021) implements the AHP method to determine the physical aspect variables that are most influential in determining the location of TDS. The results of the AHP stated that land use was the most influential variable.

Conclusion

The goal purpose of this study is to determine alternative land for waste disposal in Sumbersari District. This research is based on spatial analysis methods, including buffering and weight overlay, using GIS and AHP methods. Spatial analysis of physical aspect variables using buffering techniques and Weight Overlay so that areas that have feasibility according to physical aspects are found around the accessibility of waste transportation routes. While the analysis of determining priority land using the AHP method using data processing techniques through the Expert Choice application and weight Overlay techniques in the ArcGIS application, it was found that areas with priority land were areas dominated by land with ownership of State Rights, Property Rights, and Use Rights, land that had a distance of >1000 m from the existing TDS, and land that had existing TDS conditions with a reservoir of >100%. The land is spread across Antirogo Village, Wirollegi Village, and Kranjingan Village. The land was selected through the highest ranking of 28 points, leaving 10 location points for TDS planning. Furthermore, field observations were carried out to determine the suitability of field conditions with the construction of TDS to produce two suitable locations, A1 in Antirogo Village and K1 in Kranjingan Village.

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