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Original Article

Spatial Feasibility Evaluation of Landfill Site Policy within the National Activity Center Area of Sleman Regency's Spatial Plan for 2021–2041

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ABSTRACT
Sleman Regency does not have a landfill after the issuance of the Piyungan Landfill Decentralization Letter. According to Government Regulation No. 81 of 2012 Article 23, the Regency/City Government is required to provide a landfill in accordance with the RTRW and meet technical requirements. In Sleman Regional Regulation No. 13 of 2021 concerning RTRW, the PKN area is conditionally permitted to build a landfill. This research aims to evaluate the feasibility of landfill locations designated in the RTRW based on the parameters outlined in Article 23 paragraph (3) of the Government Regulation. The spatial analysis method involved overlaying and assigning scores to each parameter. Secondary data were used, obtained through agency surveys and literature studies. The results showed that the PKN area does not have a site feasible for a landfill. The research findings can be used as input in reviewing the landfill location policy.

KEYWORDS
Final Processing Site, Regional Spatial Plan, Spatial Evaluation

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INTRODUCTION

In developing countries, waste management pays little attention to environmental impacts, with waste often being disposed of directly in landfills without going through the waste cycle process (Ferronato & Torretta, 2019). The inability of landfills to meet the required parameters will have a negative impact on the surrounding area. For example, research in Kudus Regency states that landfill activities can cause aesthetic disturbances, odors, noise, waste spillage, and social conflicts (Azizi et al., 2022). Another study in Bangalore, India, found that landfills can only collect 60% of the total waste generated, resulting in rampant illegal dumping and burning of waste (Nalladiyil et al., 2023). Poor waste management, even for the provision of waste facilities in the community, can lead to a decline in public health, as has been studied in Kota Agung Subdistrict, Tenggamus Regency (Utami et al., 2019). Other impacts of not meeting the technical requirements of landfills can result in water, air, and soil pollution; landslides; fires; and methane gas explosions as stated in Article 31 paragraph (2) of Government Regulation Number 81 of 2012. Therefore, in Indonesia, the operation of landfills must comply with applicable technical requirements, and if they do not meet these requirements, the landfill must be closed and/or rehabilitated in accordance with Article 24(2) of Government Regulation No. 81 of 2012.

In 2010, Indonesia became one of the countries that had a negative impact on public health and the environment due to pollutants from illegal waste disposal (Maalouf & Mavropoulos, 2023). By 2024 in Indonesia, unmanaged waste amounted to 40.13% of the total waste entering landfills, according to a report from the National Waste Management Information System (2024). In fact, waste generation continues to increase rapidly (Wowrzeczka, 2021) as the population grows (Diani et al., 2024). This can be seen from the results of a study by Voukkali et al. (2024), which states that the amount of waste always increases on holidays due to the presence of tourists. In addition, the increase in the amount of waste is also influenced by the high purchasing power of the community (Manulangga, 2022) and the lack of sustainability of *local wisdom* regarding waste management, such as *kerigan (*Nurpratiwiningsih & Juhadi, 2024).

Article 23 paragraph (1) of Government Regulation (PP) of the Republic of Indonesia Number 81 of 2012 concerning Management of Household Waste and Household-like Waste, 2012), states that the

Regency/City Government is obliged to provide and operate its waste by determining the location of the landfill in accordance with the RTRW and must comply with the aspects of the PP. The delegation of policy to local governments regarding independent waste management can lead to protests from the community if it fails, as in previous studies that revealed that *the* Piyungan landfill *stakeholders* were unable to manage the Piyungan landfill (Lodan et al., 2022). The National Waste Management Information System (SIPSN) states that *the stakeholders* of the Piyungan landfill are a collaboration between the Yogyakarta City Government, the Bantul Regency Government, and the Sleman Regency Government. Another study states that the amount of waste entering the Piyungan landfill has been increasing every year due to economic activity and community consumption, and now the Piyungan landfill can no longer accommodate waste.(Nugroho et al., 2025). The inability of the Piyungan landfill has led to a decentralization policy for waste management as stated in the Yogyakarta Special Region Governor's Letter Number 658/11898, resulting in the relevant city/regency governments experiencing serious problems in waste management (Governor of the Special Region of Yogyakarta, 2023).

Sleman Regency, which previously used the Piyungan landfill, faced serious problems in managing its waste. In addition, another study mentioned that many universities in Sleman Regency were driving migration, resulting in the population of Sleman Regency exceeding the optimal population (Ariani & Susilo, 2022). Based on Article 48 paragraph (2) letter b number 1 of Sleman Regional Regulation Number 13 of 2021 concerning the 2021-2041 Spatial Plan for Sleman Regency, landfills are permitted to be built on the condition that they are located within the National Activity Center (PKN) area. In the Regional Regulation, the National Activity Center (PKN) is defined as an area developed for Meetings, Incentives, Conventions, and Exhibitions (MICE), education, trade and services, as well as integrated tourism and urban areas. Considering the policy of Article 23 paragraph (1) of Government Regulation Number 81 of 2012 and the fact that the Piyungan landfill cannot accommodate waste, this study aims to evaluate the spatial feasibility of the landfill location in the PKN area as mentioned in Article 48 paragraph (2) letter b number 1 of Sleman Regional Regulation Number 14 of 2021 concerning the Spatial Plan of Sleman Regency in meeting the technical requirements used.

Research on determining landfill sites in Indonesia often uses criteria from SNI 03-3241-1994 as guidelines and technical requirements to assess suitable land. GIS technology is used to help spatially identify land that can be used for landfills by assigning scores to each criterion (Ngwijabagabo et al., 2020). For example, in determining the location of a landfill using the criteria from SNI 03-3241-1994, this study was conducted in the Kartamantul area (Yogyakarta City, Sleman Regency, and Bantul Regency) and found that there were 5 highly suitable locations and 4 locations with a suitable class (Sustanugraha & Purwantara, 2016). Another study in

Bandar Lampung City still used the criteria from SNI 03-3241-1994 accompanied by *ground checks* as field validation of the latest and authenticity of data, resulting in 3 areas suitable for landfills (Anggara et al., 2021). Over time, modifications to the criteria or parameters have been made to adapt to regional conditions and/or for more practical and flexible application (Saragih, 2023). Research on determining the location of a landfill in Pekalongan City adopted the criteria from SNI 03-3241-1994 and modified them so that the results obtained were locations suitable for landfills (17.33%), less suitable (40.35%), and unsuitable (42.32%) (Maharani et al., 2024). Therefore, as a novelty of this research, the author refers to the aspects mentioned in Article 23 paragraph (3) of Government Regulation Number 81 of 2012 as technical requirements and criteria for evaluating the suitability of landfill sites.

The aspects or criteria for the location of a landfill site mentioned in Article 23 paragraph (3) of Government Regulation No. 81 of 2012 have different criteria from SNI 03-3241-1994. The difference is in the addition of parameters, namely that the landfill site must be located at least 1 km from the landfill site and the landfill site must not be located in a volcanic hazard zone. Research in Ethiopia confirms that landfills should not be located in or near residential areas to avoid the risk of odor and pollution from landfill waste (Balew et al., 2022). In addition, residential areas near landfills have another risk, namely the emergence of diseases caused by bacteria that breed in waste piles (Axmalia & Mulasari, 2020). Research in Kurdistan, Iraq, adds the parameter that landfills should not be located near infrastructure for the safety of activities around the infrastructure (Manguri & Hamza, 2022). Meanwhile, if the landfill site is located in a volcanic hazard area, it is considered unsuitable because volcanic flows can cause damage to the landfill infrastructure (Aditama & Burhanudin, 2022). Research on determining the location of landfills in Southeast Minahasa Regency also includes volcanic hazards as a parameter that must be met (Merry N. M. Kosakoy et al., 2022). Therefore, it is important to identify the characteristics of PKN areas before scoring or evaluating the suitability of landfill locations.

METHOD

Research Location

Based on Article 48 paragraph (2) letter b number 1 of the Sleman Regency Spatial Plan, the PKN (National Activity Center) area is conditionally permitted to build a landfill. Therefore, the PKN area became the population and research location, which covers an area of 11,765 ha with a total of 17 villages (Figure 1). The PKN Area is designated for MICE (Meetings, Incentives, Conferences, and Exhibitions) and thus has complete infrastructure to support such activities. The National Activity Centers mentioned in Article 8 letter (2) of the 2021-2041 Sleman Regency Spatial Plan include: Depok District: Maguwoharjo Village, Condongcatur Village, Caturtunggal Village; Ngaglik District: Sariharjo Village, Sinduharjo Village, Minomartani Village; Mlati District: Sendangadi Village. Sinduadi Village; Godean District: Sidoarum Village; Gamping District: Trihanggo Village, Nogotirto Village, Banyuraden Village, Ambarketawang Village; Ngemplak District: Wedomartani Village; Kalasan District: Purwomartani Village; Berbah District: Kalitirto Village, Tegaltirto Village.

Research Approach

This study aims to evaluate the feasibility of the landfill site in PKN in the Sleman Regency Spatial Plan (RTRW) based on Article 23 paragraph (3) of Government Regulation No. 81 of 2012 as technical requirements that must be met by all parameters. These guidelines were chosen due to the novelty of previous studies that used SNI 03-3241-1994 as a guideline in determining landfill locations. The data used is secondary data with various types of data obtained through institutional surveys and literature studies. To determine feasibility, each data point is given a score of 1 if it meets 1 parameter. Therefore, a location suitable for building a landfill is one with a total score of 10, as there are 10 parameters that must be met. The accuracy and authenticity of the data were tested using *Google Earth* and *Groundcheck*.

Research Procedure

This procedure involves four stages, as shown in Figure 2. The first stage is to collect secondary data according to the parameters used, then visualize it in the form of *a shapefile*. The second stage is to identify location characteristics by analyzing each data using *tools* available in *ArcMap* 10.8 *software*. The third stage is to combine all data and score data that meets the parameters/criteria/aspects/technical requirements mentioned in Article 23 paragraph (3) PP Number 81 of 2012 to evaluate locations suitable for landfill construction. A location can be considered suitable for the construction of a landfill if it meets all parameters. The final stage involves testing the accuracy and currency of secondary data through validation using a combination of *Google Earth* and *ground checks*

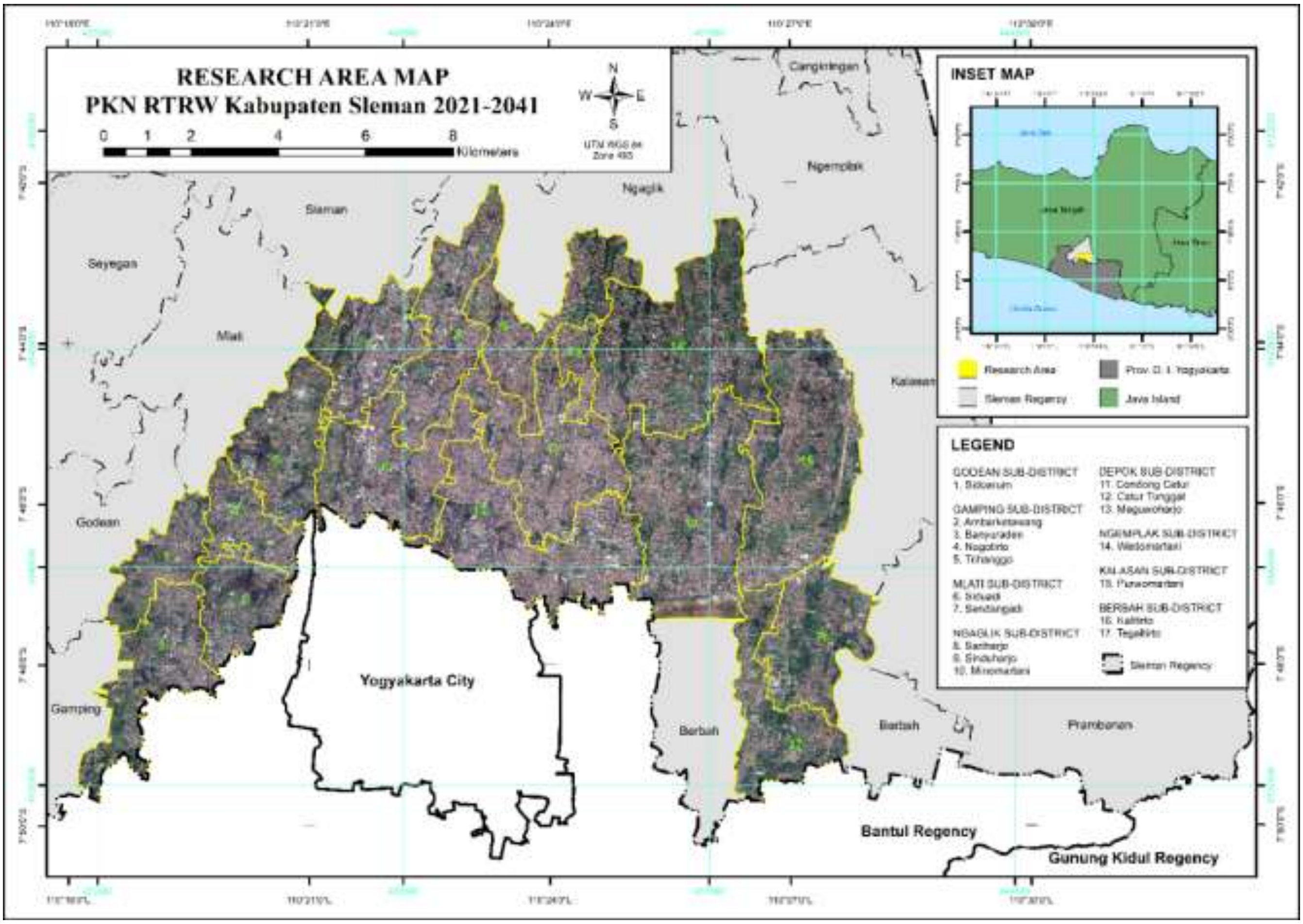

Figure 1. National Activity Center (PKN) Area/Research Area Map
Source: Author's Data Analysis, May 2025

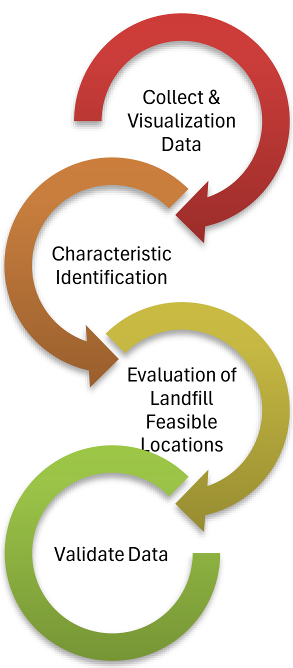

Figure 2. Research Flow Chart
Source: Author's Data Analysis, May 2025

Data Collection Techniques

The data required for this study is data that will be assessed using the parameters of Article 23 paragraph (3) of Government Regulation No. 81 of 2012. This data can be secondary data of various types, such as *vector* data, *raster* data, and information from documents. Data collection was carried out by requesting data from the relevant agencies ( ), while data that was not available from these agencies was obtained by conducting a literature study of previous research. The data sources used in this study are presented in Table 1. The various types of data obtained need to be converted into *shapefiles* with WGS 84/UTM Zone 49s projection so that all data can be overlaid. *Vector* data can be visualized directly because it is already in *shapefile* format.

This data includes water body data in the form of irrigation in Sleman Regency in 2018, the Adisucipto Airport area, and land cover in Sleman Regency in 2018. *Raster* data that will be converted into *shapefiles* must first be analyzed separately for each parameter. Raster data includes soil type maps, water body maps in the form of water resource networks, DEMNAS data, spatial planning maps, and flood hazard *layers*. Information obtained from agencies can be in the form of report documents, so when visualized, it is similar to *raster* data.

Table1. Data for Landfill Site Feasibility

Data	**Data Source**
Faults & Earthquake Hazards	KRB Sleman 2021-2025 (BPBD Sleman)
Volcanic Eruption Hazards	Sleman Disaster Risk Reduction Plan 2021-2025 (Sleman Disaster Management Agency)
Groundwater Level (GWL)	Report on MAT Levels in the 2022 Monitoring Well Network (DPUESDM DIY)
Soil Classification	Soil Type Map (Sleman Spatial Plan 2021-2031) & Research by Sustanugraha & Purwantara (2016)
Water Body	Irrigation *Shapefile* 2018 (DPUESDM) & Water Resource Network Map (RTRW Sleman 2021-2041)
Slope Gradient	DEMNAS (BIG)
Airport	Airport Land *Shapefile* Adisucipto (Bhumi, ATR/BPN)
Settlements	2022 Land Cover *Shapefile* (DPTR)
Protected Areas	Spatial Planning Map (RTRW Sleman 2021-2041)
Flood Hazard	Flood Hazard *Layer* (Inarisk, BNPB)

Source: Article 23 paragraph (3) of Government Regulation Number 81 of 2012

Data Analysis Techniques

Data analysis was performed on each data set to identify location characteristics and when the data had *been unioned* or combined for the evaluation of suitable landfill sites. The analysis for identifying location characteristics certainly varies due to different data sources and types (Table 1). The data used to identify location characteristics is data that can be measured using the parameters set out in Article 23 paragraph (3) of Government Regulation Number 81 of 2012 (Table 2). The aspects mentioned in Article 23 paragraph (3) of Government Regulation No. 81 of 2012 include geological aspects, hydrogeological aspects, zone slope, distance from the airport, distance from residential areas, non-protected areas, and non-flood areas with a 25-year recurrence interval. The geological aspect includes parameters of fault occurrence and earthquake hazard level, as well as volcanic eruption hazard level. Data analysis for this aspect is done by filling in the attributes of each sub-district with the prevailing hazard class in the KRB document. The hydrogeological aspect includes parameters of MAT elevation, soil permeability value, and distance from water bodies. The MAT elevation parameter uses information from the MAT position report on the monitoring well network, so the information is converted into data points and analyzed using *the IDW tool*. The soil permeability level parameter is analyzed by interpreting the soil type map with previous research (Sustanugraha & Purwantara, 2016). The parameter of distance from water bodies was analyzed using a 100 m *buffer tool* on irrigation *polyline* data and water resource network data. The slope aspect used DEMNAS data and was analyzed using *the slope tool,* then divided into two classes, namely <20% and >20%, using *the reclassify tool*. The aspect of distance from the airport was analyzed using *a buffer tool* with a radius of 3 km from the Adisucipto airport land data. *The buffer tool* was also used on attributes such as settlements and built-up land from the land cover data ( ) to analyze the aspect of distance from settlements within a radius of 1 km. The aspect of non-protected areas was obtained through direct interpretation so that areas that were not included in the protected areas on the spatial plan map could be identified. The final aspect, namely non-flood areas with a 25-year recurrence interval, was obtained from *the* flood hazard *layer* data using *the raster to polygon tool* to standardize the data types so that they could *be overlaid* and directly interpreted to identify which areas had a certain flood hazard class.

After each piece of data has been analyzed and the characteristics of the location identified, the data *is overlaid* into a single data set using *the union tool* for the landfill site feasibility evaluation stage. It can be said that this stage uses derivative data from the location characteristics identification stage. The evaluation stage is the stage of scoring location characteristics that meet the requirements as stated in Article 23 paragraph (3) of Government Regulation Number 81 of 2012 (Table 2). Scoring for an area is done by giving a score of 1 to location characteristics that meet the parameters. The Government Regulation also states that a location suitable for the construction of a landfill is one that meets all parameters or has a total score of 10. To test the currency and accuracy of the data, validation can be carried out *using Google Earth* in combination with *ground checks*. *Google Earth* can be used to validate data on water bodies, airfields, and settlements, while *ground checks* are used to help validate data on soil types and slope gradients.

Table 2. Feasibility Requirements for Landfill Sites

Parameters	**Landfill Site Requirements**
Fault Zone & Earthquake Hazard	Not located in these areas
Volcanic Eruption Hazard Zone	Not located in the area
Groundwater Level (GWL)	Must not be less than 3 m
Soil permeability	Must not exceed 1^{0-6}cm/second
Distance from Water Body	Must not be less than 100 m
Slope Gradient	Must not exceed 20%
Distance from the airport	Must not be less than 3000 m
Distance from residential areas	Must not be less than 1000 m
Protected area	Not located in that area
Flood Hazard Area	Not located in that area

Source: Article 23 paragraph (3) Government Regulation Number 81 of 2012

RESULTS AND DISCUSSION

Results

The PKN area is mentioned in Article 48 paragraph (2) letter b number 1 of the 2021-2041 Sleman Regency Spatial Plan, which allows for the conditional construction of a landfill, but after spatial evaluation, the entire PKN area is not suitable for landfill construction (Figure 3). This is because there are no *sites* that can meet the aspects mentioned in Article 23 paragraph (3) of Government Regulation Number 81 of 2012. The largest reduction in the PKN Area is the distance from densely populated settlements, covering an area of 11,764.99 ha or 100% of the PKN Area. After *overlay* analysis, the average class in the PKN Area was 5.08 with a total of 2,795 sites; the highest class was 8; and the lowest class was 3. Further details are provided in the discussion sub-section.

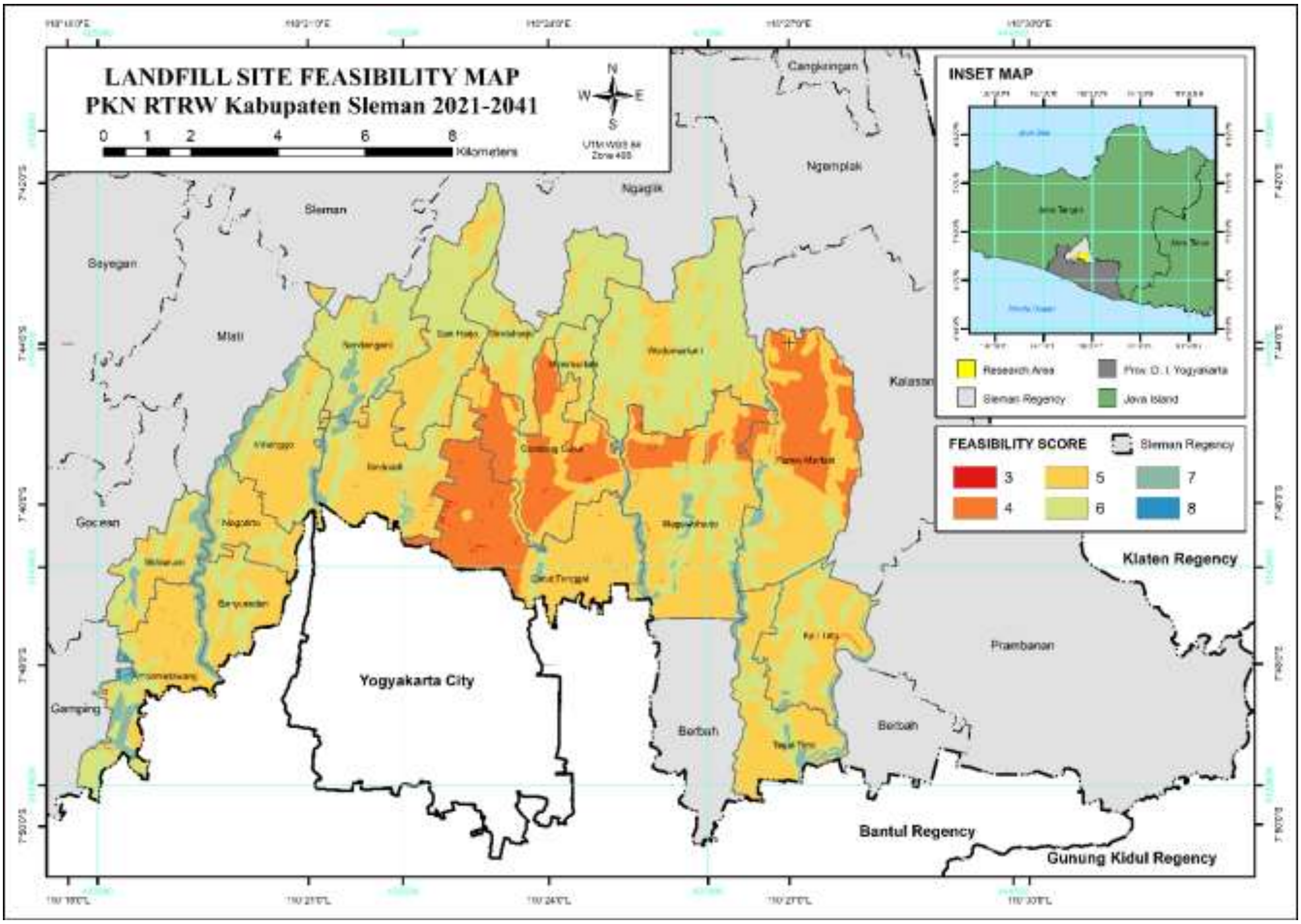

Figure 3. Feasible Landfill Site Map
Source: Author Data Analysis, May 2025

Discussion

Earthquake hazard (Figure 4a) in the PKN area with a high hazard class (5,467.98 ha) dominates the western side and a moderate hazard class (6,927.01 ha) dominates the eastern side of the PKN area. The earthquake hazard level increases towards the southeast due to a fault line stretching from Bantul Regency to Prambanan District, Sleman Regency, along a 45 km length (Fandayati et al., 2024). This can be proven by research on earthquake vulnerability in Bantul Regency, which is an area directly adjacent to the PKN Area in the southeast, which found that the entire Bantul Regency has a high vulnerability class (Tidiesya et al., 2025). The determination of landfill locations must ignore areas that are prone to earthquakes based on research in Najran, Saudi Arabia (Elkhrachy et al., 2023). However, in another study, the determination of a landfill site after an earthquake in Kahmramanmaras, Turkey, was carried out while still considering other parameters (Mete & Biyik, 2024). Therefore, areas with a high level of hazard are ignored or not allowed to have landfill sites built.

Sleman Regency is located close to Mount Merapi and often experiences moderate eruptions that cause the danger zone to extend 10 km from the source of the eruption (Mastrolorenzo et al., 2017). The results of the map analysis (Figure 4b) show that the PKN area is dominated by no eruption hazard class (11,566 ha) and low hazard class or KRB I (199 ha). In the context of volcanic eruptions, Disaster Prone Zone I (KRB I) is an area that can be a river and is potentially affected by lava floods and the possibility of hot clouds spreading. If the government sets a safe radius of 20 km when Mount Merapi erupts, the PKN area that could be at risk of lava floods due to eruptions is the KRB I area, namely the Boyong River and the Kuning River with a buffer area of 1 km (Wigati et al., 2023). Other studies on the vulnerability risk of Mount Merapi eruptions show that the PKN area is in 3 vulnerability classes, namely: low (Gamping District and Godean District), medium (Mlati District, Depok District, and Kalasan District), and high (Ngaglik District, Ngemplak District, and Berbah District) (Wachidatullailiya et al., 2025). However, based on the dominance of hazard classes, all subdistricts in the PKN Area are not at risk of volcanic eruptions (3b) and are only slightly affected, so it can be said that the construction of a landfill is permissible

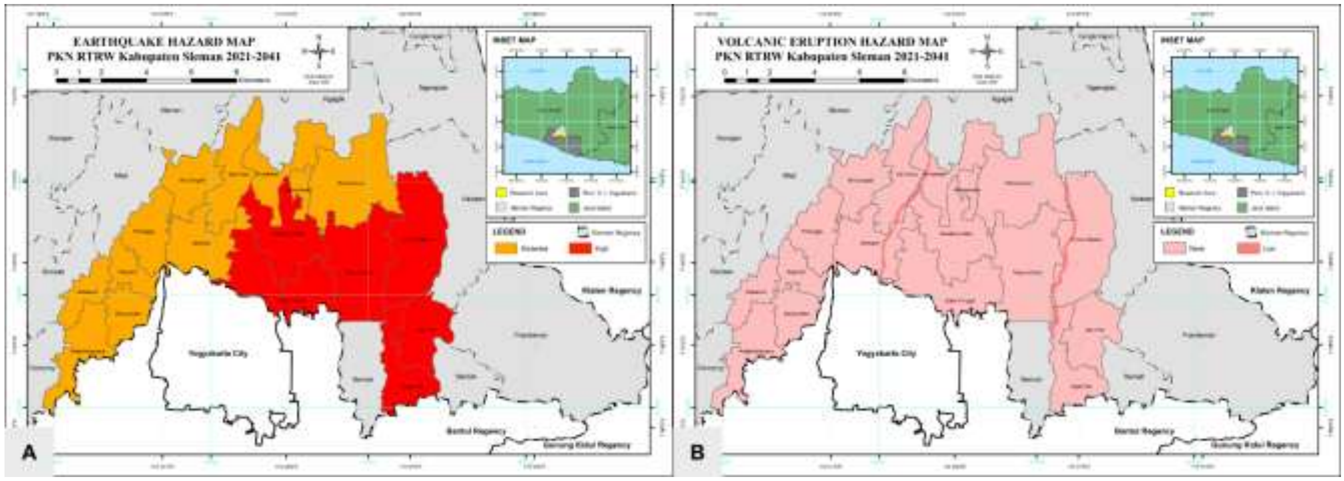

Figure 4. Thematic Maps: (a) Earthquake Hazard Map, (b) Volcanic Eruption Hazard Map
Source: Author Data Analysis, May 2025

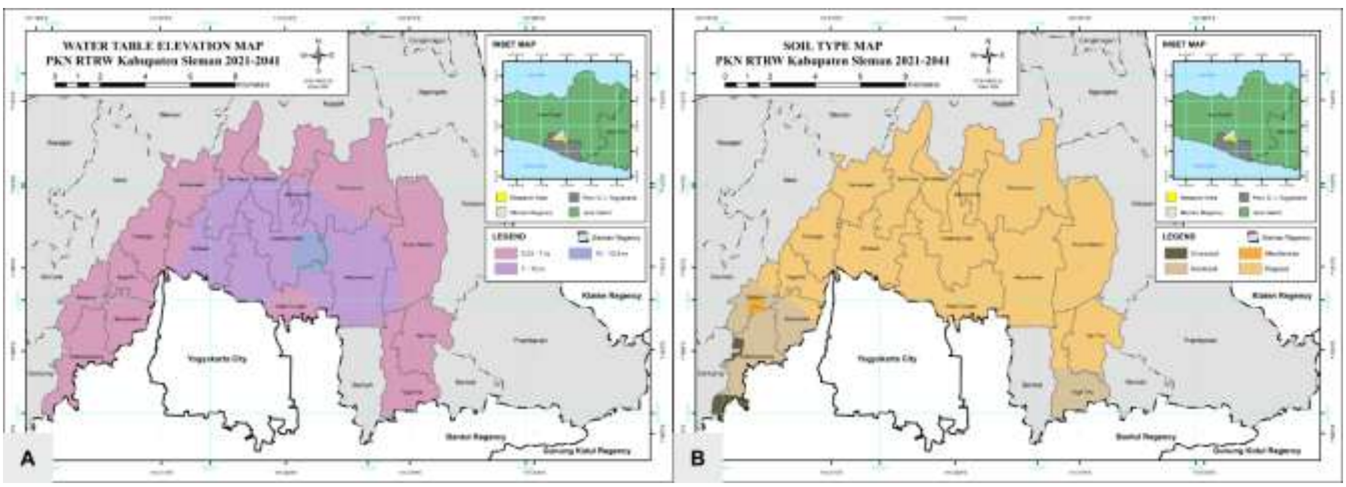

Figure 5. Thematic Maps: (a) Water Table Elevation Map, (b) Soil Type Map
Source: Author Data Analysis, May 2025

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The MAT elevation in the PKN area meets the requirements for a landfill site because the entire PKN area has a MAT elevation of >3 m (Figure 5a). The analysis results show that the MAT elevation decreases towards the eastern side of Condong Catur. The deeper or lower MAT elevation may be caused by land conversion with groundwater exploitation (Abidin et al., 2008; Iskandar et al., 2025). However, the deeper the MAT elevation, the more suitable it is considered to be, as it is related to the rate of leachate absorption into the soil. Other studies mention that poor landfill management contributes to accelerating the leachate absorption process due to waste accumulation, causing it to seep into the soil and contaminate groundwater (Chaturvedi et al., 2025). Therefore, it is important to have a system that can monitor the groundwater in the surrounding area in order to determine the ability to manage leachate from waste accumulation (Pasalari et al., 2019). The types of soil in the PKN area are diverse (Figure 5b). Based on a literature study, the types of soil that do not meet the requirements are regosol (10,178.87 ha), kambisol (1,405.91 ha), and mediterranean (61.38 ha), while the only type of soil that meets the requirements is grumusol (118.84 ha) (Sustanugraha & Purwantara, 2016). This is because only grumusol soil has a permeability of $10^{(-6)}$ -$10^{(-9)}$ cm/second with a clay texture (Widaryanto et al., 2022). Other soil types include sandy regosol (1-$10^{(-2)}$cm/second), dusty clayey kambisol (5x$10^{(-4)}$-$10^{(-}$

$^{5)}$cm/second), and clayey Mediterranean soil (5x10($^{-}$ $^{(4)}$-10(-$^{)}$ $^{(5)}$cm/second). Another study explains that soil types increasingly dominated by sand fractions have high permeability, so that regosol, kambisol, and mediterranean soils can easily help leachate seep into the ground (Ghoushchi & Nasiri, 2022). Therefore, locations with grumusol issuitable for building landfills, as stated in the research in Jordan at , which states that soil types with low permeability values can overcome the entry of leachate into the soil (Arabeyyat et al., 2024).

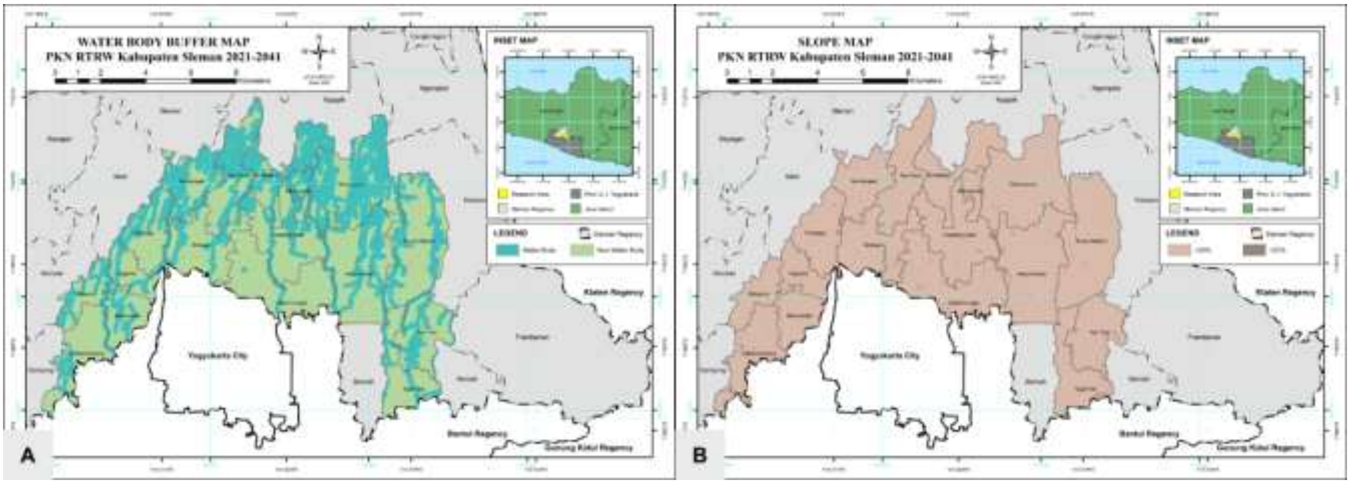

Figure 6. Thematic Maps: (a) Water Body Buffer Map, (b) Slope Map
Source: Author Data Analysis, May 2025

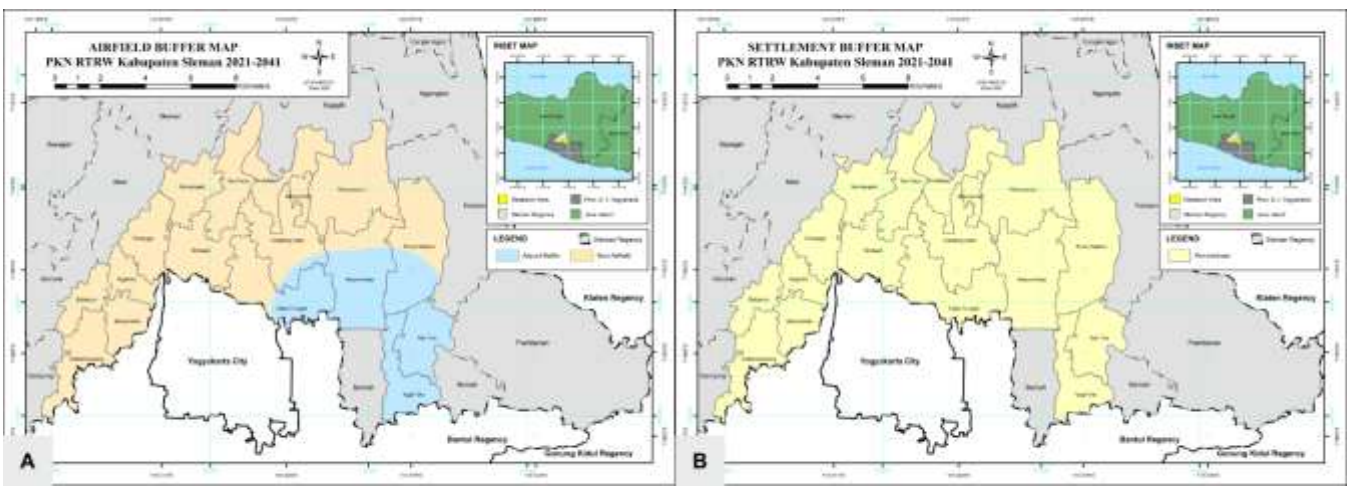

Figure 7. Thematic Maps: (a) Airfield Buffer Map, (b) Settlement Buffer Map
Source: Author Data Analysis, May 2025

Research in Kurdistan, Iraq, shows that landfills are not allowed to be located near lakes due to the potential for contamination from landfill activities (Othman et al., 2021). In addition, research in Harar, Ethiopia, shows that landfills are not allowed to be located near water sources (Asefa et al., 2021). An example of such pollution can be seen in research on the Piyungan landfill site, where the Opak River, located 99.10 m from the Piyungan landfill site, is used as a drainage channel and has now experienced a decline in quality with a pollution index of 12.46 (Astuti et al., 2023). The results of the *buffer* analysis of the water body *polyline* (Figure 6a) dominate the northern side of the PKN area with an area of 5,108.02 ha, while the area that is not a water body has an area of 6,656.97 ha. The water bodies are denser in the north and sparser in the south, indicating that the further north, the more water sources (*recharge areas)* there are. Therefore, there is an area of 6,656.97 ha that does not pollute water bodies, which include rivers, lakes, reservoirs, irrigation, and others.

Research in western Ethiopia indicates that gentler slopes can reduce the risk of erosion and costs (Burayu &

Shiferaw, 2022). In addition, gentle slopes have a low risk of surface runoff, thereby minimizing the risk of soil erosion and water pollution downstream (Tella et al., 2024). Another study in Kebonagung Village, Sawahan District, Nganjuk Regency shows that slopes with a gradient of >25% have the potential for landslides (Rahmawati, 2024). The slope inclination (Figure 6b) in the PKN area is dominated by slopes of <20% with an area of 11,632.48 ha, while the area with slopes of >20% has an area of 132.51 ha. This is also confirmed by the slope data, which shows that the further north, the higher and steeper the slopes are because the northern side of Sleman Regency is the slope of Mount Merapi. If a landfill is built in a location with a slope >20%, it can cause risks to the stability of the landfill and the area below it. It can be said that the PKN area, which has a slope <20%, is suitable for the construction of a landfill.

Research in Polatli, Ankara, Turkey, states that the distance parameter from the airport is not a limiting factor because it is not close to the airport (Öner et al., 2025). However, in the PKN area, there is Adisucipto Airport, and *buffer* analysis is used to avoid disturbances and even work accidents affecting airport activities due to the existence of the landfill. Research at the Kampung Duiran landfill in Aceh Tamiang found that many storks come to eat fly larvae in the waste piles (Parliansyah et al., 2023). Indirectly, landfills become habitats for certain species of birds and can endanger aviation activities if they are located near airports due to bird activity flying near the airport. Research in Tonekabon, Iran, suggests that landfills should be built at least 3 km away from airports (Yazdani et al., 2015). After conducting a *buffer* analysis of 3 km (Figure 7a), Adisucipto Airport has an area of 8,615.41 ha, so the remaining safe area for landfill construction is 3,149.58 ha.

Landfills built less than 1 km from residential areas increase the risk of environmental pollution, disease spread, noise and odor, property value decline, and human-wildlife conflict (Sisay et al., 2025). For example, in a settlement within a 500 m radius of the Piyungan landfill, residents experienced diarrhea and skin diseases due to inadequate sanitation facilities (Farahdiba et al., 2021). Another study in Danang City, Vietnam, found a strong correlation between the perceptions of residents living within a 1 km radius of a landfill regarding the risk of diseases such as cough, sinusitis, diarrhea, and eczema originating from environmental pollution generated by landfill activities (Hoang et al., 2022). However, the results of *the* residential *buffer* showed the greatest reduction because all residential areas were affected by *the 1* km *buffer* (Figure 7b). This shows that the PKN area is a high-density residential area, so there is no suitable location to build a landfill.

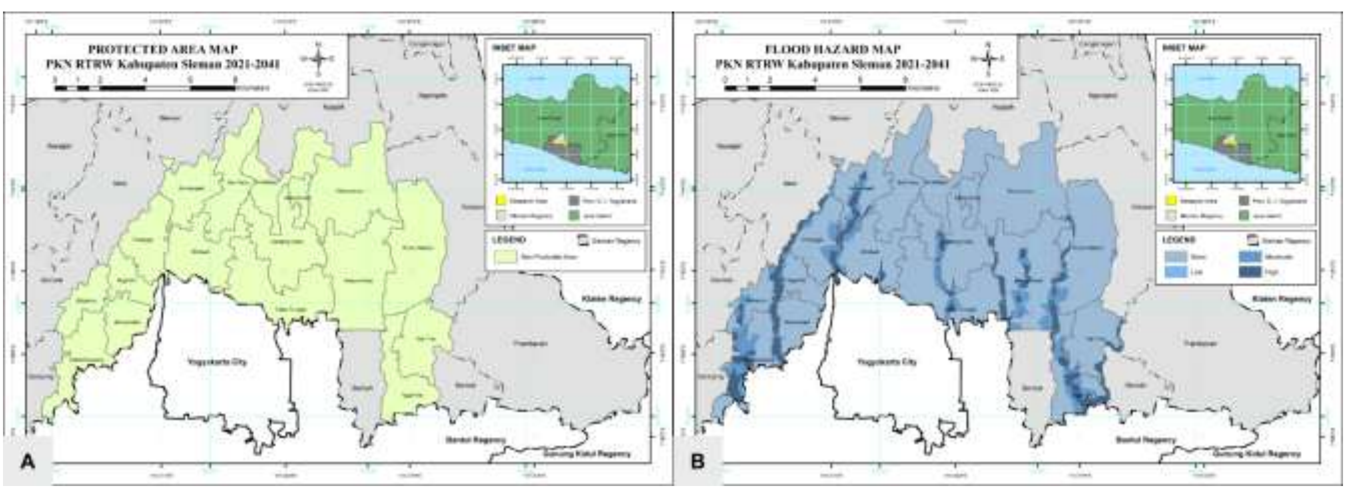

Figure 8. Thematic Maps: (a) Protected Area Map, (b) Flood Hazard Map
Source: Author Data Analysis, May 2025

Protected areas are not allowed to have landfills because they serve to protect and preserve biodiversity, which has high ecological value (Barzehkar et al., 2019). Research at the Kuchyňky landfill in Croatia found that between 2007 and 2015, native plant species experienced fluctuating declines, while new species experienced constant increases (Vaverková et al., 2019). Based on the spatial plan map, the interpretation results show that there are no protected areas in the PKN Area (Figure 8a). This is in contrast to the distance parameter from residential areas, where the PKN Area is suitable for the construction of a landfill based on the protected area parameter. This difference is also due to the fact that the PKN Area has a different function from a Protected Area. The absence of protected areas in the PKN Area, according to Guha et al (2023), means that a landfill is more suitable to be built on vacant land, but the PKN Area is dominated by land cover in the form of settlements. Therefore, there is no suitable location to build a landfill in the PKN Area.

The PKN area is dominated by no flood hazard with an area of 9,783.72 ha, low class 8.31 ha, medium class 1,027.24 ha, and high class 945.72 ha (Figure 8b). The flood hazard level increases towards the south due to the slope gradient, where water will more easily accumulate in flat areas. This can be seen from research in the Gajah Wong River sub-segment, specifically in Umbulharjo District, Yogyakarta City, which shows that in a 25-year recurrence period with a rainfall intensity of 165.33 mm, flooding occurred with a maximum discharge of 155.18 m3/second. This is because it exceeds the canal's discharge capacity of 106.97 m3/second (Sari et al., 2025). The areas prone to flooding based on research in Varbilau, Romania, are low-lying areas with high population density (Popescu & Bărbulescu, 2023). When flooding occurs, pollutants in waste spread rapidly and cause instability in waste piles due to prolonged submersion in water (Laner et al., 2009).

Table 3. Tabulation of Landfill Location Feasibility Scores per Village

Subdistrict	Village	Total of Sites	Maximum Site Area (Ha)	Total Score	Maximum Score	Mean Score
Berbah	Tirto River	162	197.45	902	7	5.57
	Tegal Tirto	157	124.46	879	7	5.60
Depok	Catur Tunggal	300	442.36	1,298	7	4.33
	Condong Catur	200	128.10	905	7	4.53
	Maguwoharjo	315	135.51	1,595	7	5.06
Gamping	Ambarketawang	283	201.80	1,502	8	5.31
	Banyuraden	93	70.30	462	7	4.97
	Nogotirto	73	118.07	393	7	5.38
	Trihanggo	106	238.67	564	7	5.32
Godean	Sidoarum	160	42.21	852	7	5.33
Kalasan	Purwo Martani	282	321.90	1,360	7	4.82
Mlati	Sendangadi	126	258.12	674	7	5.35
	Sinduadi	197	266.30	1,033	7	5.24
Ngaglik	Minomartani	17	71.68	91	6	5.35
	Sari Harjo	56	271.40	285	6	5.09
	Sinduharjo	76	227.98	406	7	5.34
Ngemplak	Wedomartani	192	569.17	987	7	5.14
PKN Area		2,795	**-**	14,188	-	5.08

Source: Author Data Analysis, May 2025

The analysis results presented in Table 3 show that no site meets all 10 parameters, and it can be said that there are no *sites* suitable for landfill construction. The table shows the number of *sites* owned by each village, the largest *site* area, total score, and average score. The average score obtained by the PKN area is only 5.08, which means that 17 villages can only meet approximately 5 parameters. Tegal Tirto Village, Berbah Subdistrict, has the highest average score of 5.60, which is still not enough to be considered suitable for the construction of a landfill. In fact, the highest score obtained in the PKN Area, which is 8, was obtained by 4 *sites* in Ambarketawang Village, Gamping Subdistrict, but they are still considered unsuitable for the construction of a landfill. This highest score was achieved because only Ambarketawang Village has grumusol soil and meets the requirements for a landfill site. Meanwhile, Maguwoharjo Village, Depok District, has the most *sites,* namely 315 *sites,* but the average score obtained is only 5.10 with the highest score being 7, so it is not feasible to build a landfill there. The fact that it has the most *sites* shows that Maguwoharjo Village has very complex characteristics. The largest *site* is located in Wedomartani Village, Ngemplak District, with an area of 569.17 hectares, but this *site* only has a score of 6. From this, it can be concluded that there is *no site* in the PKN area that can be used as a landfill.

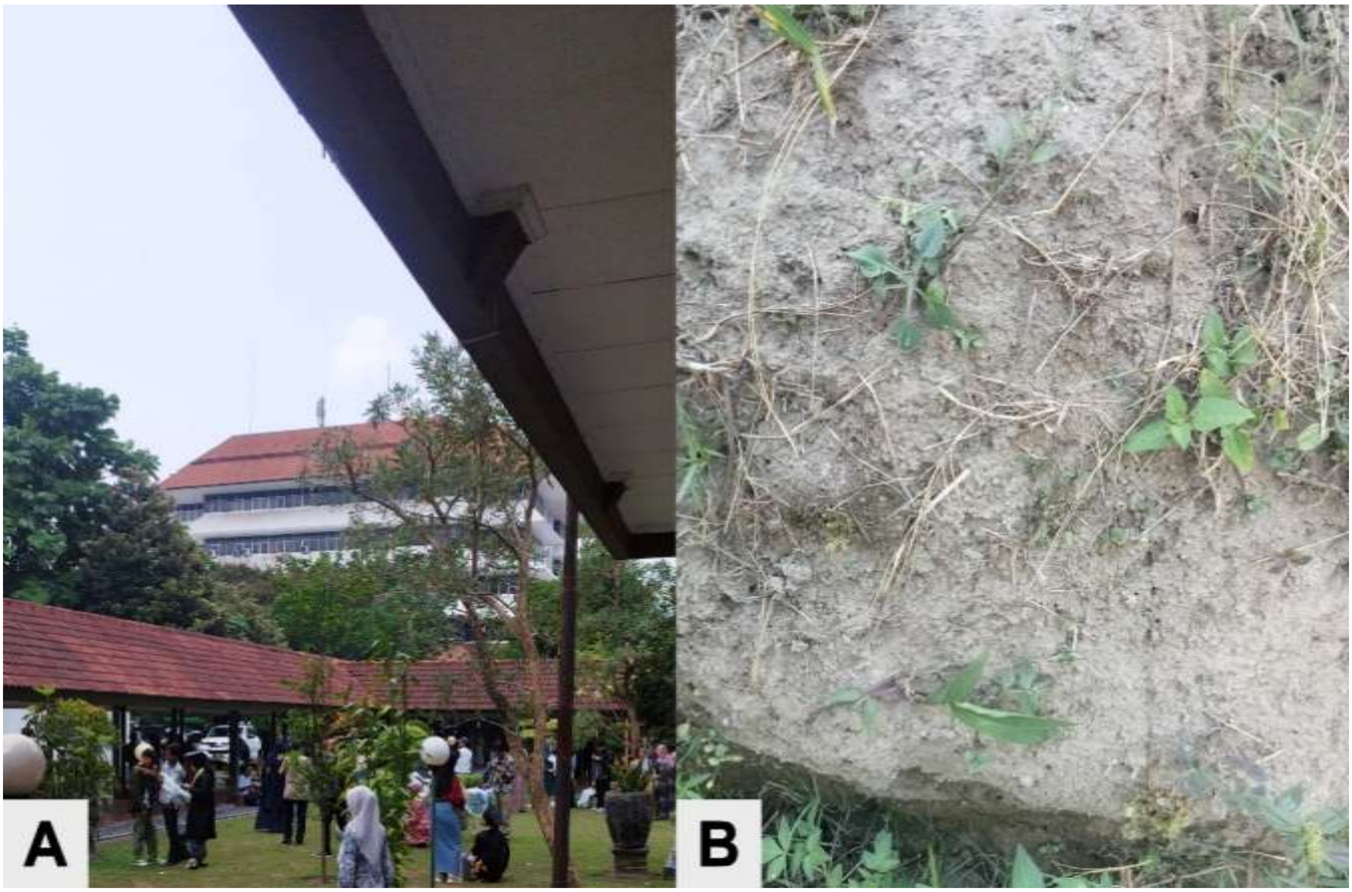

Figure 8. Reducing Factor: (a) College Activity at UPNVY, Condongcatur (b) Regosol Soil, Trihanggo
Source: Author Documentation, May 2025

Based on the results of the characteristic identification, the analysis of the unsuitability of the PKN Area for the construction of a landfill site is due to two location reduction factors that exceed 50% of the PKN Area. The first limiting factor is that after analyzing *a* 1 km *buffer* on secondary settlement data, it was found that there is no space to build a landfill site, or in other words, the PKN Area has a dense population. Furthermore, after validation through *Google Earth* and *ground checks,* the PKN Area is full of built-up land, for example in Depok District, where there are many universities (Figure 9a). Therefore, if a landfill is built near universities, it will disrupt learning activities. The second reducing factor is the dominance of regosol soil types, which have a sandy texture with a permeability of 1-10$^{(-)\ (2)}$cm/second. Soil with a permeability value close to 1 should be avoided so that leachate cannot be directly absorbed into the soil. After conducting *a ground check* in Trihanggo Village, Gamping District, it was found that the grumusol soil type has the same characteristics as the results of secondary data analysis through literature studies (Figure 9b). These characteristics include a sandy texture and high permeability, so that water easily seeps into the soil.

The failure to meet the parameters specified in Article 23 paragraph (3) of Government Regulation No. 81 of 2012 means that the PKN Area, where the construction of a landfill is permitted under Article 48 paragraph (2) letter b number 1 of the 2021-2041 Sleman Regency

Spatial Plan, does not have *a site* that meets the parameters for the construction of a landfill. However, in addressing the current waste problem in Sleman Regency, Article 26 paragraph (1) of Government Regulation No. 81 of 2012 states that the regency/city government ( ) may establish a waste management institution, partner with business entities or the community, and collaborate with other regency/city governments. Several solutions can be implemented, such as reducing plastic use, conducting education and supporting programs related to waste awareness, and increasing the number of TPSTs and waste management facilities. If these solutions are implemented, they can reduce the amount of waste that cannot be processed and then dumped in landfills, so that relevant *stakeholders* can work together with other regency/city governments to dump their unprocessable waste. This is considered preferable to constructing landfills in unsuitable locations, which could lead to closure/rehabilitation as stipulated in Article 24(2) of Government Regulation No. 81 of 2012.

CONCLUSION

Article 23 of Government Regulation No. 81 of 2012 states that city/regency governments are required to provide and operate landfills (1) with locations selected in accordance with the Spatial Plan (RTRW) (2a) and locations that meet all the aspects mentioned (3). Based on Article 48(2)(b)(1) of the 2021-2041 Sleman Regency Spatial Plan (RTRW), the PKN Area is permitted to be developed as a landfill site under certain conditions. However, it was found that the PKN Area is not suitable for use as a TPA location based on spatial analysis utilizing GIS technology and using the parameters of Article 23 paragraph (3) of Government Regulation No. 81 of 2012.

In general, the PKN Area has an average score of 5.08 with a score range of 3 to 8. This average indicates that the sites located in the PKN Area are only able to meet approximately 5 technical requirements due to the different characteristics between *sites*. This diversity of characteristics means that the 17 villages included in the PKN Area have 1,274 *sites* with different characteristics. However, there is not a single *site* that meets all 10 mandatory parameters. This is because there are two parameters whose characteristics do not match the parameters and dominate all *sites*. The characteristic of dense settlements is the largest reduction, accounting for 100% of the total area of the PKN Area, while the characteristic of soil type is the second largest reduction, accounting for 86.52% of the total PKN Area. Considering Article 23 paragraph (3) of Government Regulation Number 81 of 2012, which states that the location of a landfill must meet all these parameters, it can be concluded that the PKN Area is not suitable for a landfill because it does not meet the aspects mentioned in the article. The inability of the PKN Area to meet the 10 parameters indicates that not all areas can be used as landfill sites. Therefore, Article 26 of Government Regulation No. 81 of 2012, paragraph 1, letter c, applies, which is to cooperate with other regency/city governments.

This study has limitations, namely limited spatial data and information on the distribution of floods with a 25-year recurrence interval in the PKN area of Sleman Regency, thus requiring further research. Referring to the results that there are no areas suitable for landfill construction in the PKN area of Sleman Regency, the recommendation for further research is to find alternative sustainable waste management methods. The benefits of this research are as a reference for research on the evaluation or determination of landfill locations using GIS to avoid environmental damage. This research is also beneficial to *stakeholders* so that they can be more careful in planning the location of the landfill to be built. If there is no suitable location for a landfill in the area, the solutions that can be offered are to create a policy to reduce plastic bags, provide education about waste, add waste facilities, TPST, and collaborate with other regency/city governments.

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