

Study of Capacity and Technical Design for the Arrangement of Sungai Dua Landfill in Tanah Bumbu Regency South Kalimantan Indonesia

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DOI: <https://doi.org/10.52403/ijrr.20250215>

ABSTRACT

Waste management is a significant challenge faced by cities worldwide. With the increasing population and economic activities, the volume of generated waste also rises significantly. To address this issue, landfills have become crucial facilities in waste management systems. This research aims to analyze the existing condition and capacity of Sungai Dua Landfill in facing the increasing waste volume.

The research methodology includes field observation and data analysis through calculations of waste generation and composition, population projection, and land requirements at Sungai Dua Landfill. The research found that the waste generation entering Sungai Dua Landfill is 0.50 kg/person/day with a waste volume of 2.33 liters/person/day. The total area of Sungai Dua Landfill is approximately 2.163 hectares, with ± 0.8 hectares (or 8,000 m²) designated as the active area for accommodating waste generated by residents within the service area and transported to the landfill.

The solid waste management system at Sungai Dua Landfill uses the controlled

landfill method. If a waste reduction of 70% is implemented, the remaining land and service life of Sungai Dua Landfill can still accommodate the incoming waste until 2035. With a 70% reduction, only residual waste enters the landfill, thus the required land in 2035 is estimated to be 0.7 hectares.

Keywords: capacity, existing conditions, Sungai Dua Landfill

INTRODUCTION

A landfill is a facility used for the final disposal of waste, typically after it has undergone collection, transportation, and initial treatment stages. The primary role of a landfill is to ensure that waste that cannot be recycled or further processed is handled safely and does not harm the environment or public health (Tchobanoglous et al., 1993). Landfills are crucial in preventing negative impacts from waste, such as groundwater, air, and soil contamination, which can threaten human health and surrounding ecosystems. Waste management processes at landfills include various steps, such as waste sorting, composting, recycling, landfilling, leachate management, and methane gas management. Each of these steps aims to

minimize environmental impact and maximize the reuse of resources contained within the waste (Christensen, 2001). However, landfill management faces numerous challenges. One of the greatest challenges is the often-limited capacity of landfills, while waste volume continues to increase.

Landfill design must consider various technical and environmental aspects to ensure effective and safe waste management. The use of geosynthetics in landfill design can enhance landfill performance by extending its lifespan, increasing stability, and reducing carbon emissions (Koerner & Gilson, 2022). A bottom liner system consisting of multiple layers, including a clay liner and a synthetic geomembrane, serves to prevent leachate infiltration into the ground. Leachate management systems involve collection ponds and leachate treatment facilities to ensure that this liquid does not contaminate groundwater or surface water (Townsend et al., 2022).

The Landfill in Tanah Bumbu Regency is an essential facility designed to manage waste effectively to mitigate negative impacts on the environment and public health. With the increasing population and economic activity, waste volume in Tanah Bumbu Regency continues to grow. According to data from the Tanah Bumbu Regency Central Bureau of Statistics, the generated waste volume reached 171.87 tons per day in 2023 (SIPSN, 2023), with an average annual increase of 5% over the past five years (BPS Kabupaten Tanah Bumbu, 2023). The design and layout of the landfill in Tanah Bumbu Regency consider various technical and environmental aspects. The facility is equipped with a bottom liner system consisting of a clay layer and a synthetic geomembrane to prevent groundwater contamination by leachate. Additionally, the leachate management system includes collection ponds and treatment facilities to ensure that this liquid does not pollute the surrounding environment. Methane gas management, which is generated from the decomposition of organic waste, is carried

out through pipe installations and gas wells to collect and utilize or flare this gas to reduce greenhouse gas emissions (Lukita, C. W., & Fadilah, K., 2023).

MATERIALS & METHODS

This study was conducted through field observation and data analysis through calculations of waste generation and composition, population projections, and land requirements and the Sungai Dua Landfill. Determination of waste generation and composition was carried out through measurement and analysis of data obtained from waste collection at certain locations. Population projections were used to estimate future increases in waste volume. The landfill planning method focused on determining land requirements and strategies to increase capacity and added value of waste management. Data calculations were then data processed and presented using Microsoft Excel.

RESULT

General Overview of the Area

Tanah Bumbu Regency is located at the southeastern tip of Kalimantan Island, in South Kalimantan Province, Indonesia. Geographically, the regency lies between 2°52' – 3°47' South Latitude and 115°15' – 116°04' East Longitude, covering an area of 5,066.96 km², representing 13.50 percent of the total area of South Kalimantan Province. It is bordered by Kotabaru Regency to the north and east, the Java Sea to the south, and Banjar Regency and Tanah Laut Regency to the west.

Tanah Bumbu Regency comprises 12 districts. The largest district is Kusan Hulu, encompassing 31.76 percent of the regency's total area, while the smallest is Kuranji, with an area of 110.42 km², or 2.18 percent of the total regency area. The districts of Teluk Kepayang and Kusan Tengah were established in 2021, adding to the regional diversity and development potential of the area.

Tanah Bumbu Regency was established in 2003 as a result of the division of its parent

regency, Kotabaru Regency. Tanah Bumbu possesses abundant natural resources, spanning from highlands (upland) and midlands (middle land) to lowlands situated in coastal areas. Consequently, the regency encompasses three main watersheds: the Batulicin Watershed, the Kusan Watershed, and the Satui Watershed. A significant advantage is that the entire course of these watersheds, from upstream to downstream, lies within the regency's administrative boundaries, allowing for unified administrative control and management. This contrasts with the Riam Kanan and Martapura Watersheds, which originate in the Meratus Mountains and flow downstream to the Barito River, traversing three regencies/cities (Banjar, Banjarbaru, and Banjarmasin).

Table 1. Districts, District Capitals, and Area

| Districts | District Capitals | Area(km ²) |
|--------------------|----------------------|------------------------|
| Kusan Hilir | Pagatan | 74.56 |
| Kusan Tengah | Saring Sungai Binjai | 214.45 |
| Sungai Loban | Sari Mulya | 383.91 |
| Satui | Sungai Danau | 877.87 |
| Angsana | Angsana | 195.95 |
| Kusan Hulu | Binawara | 249.73 |
| Kuranji | Giri Mulya | 114.64 |
| Teluk Kepayang | Teluk Kepayang | 1.253.51 |
| Batulicin | Batulicin | 135.16 |
| Karang Bintang | Karang Bintang | 201.4 |
| Simpang Empat | Kampung Baru | 293.48 |
| Mantewe | Mantewe | 895.64 |
| Tanah Bumbu | | 4.890.30 |

Sumber: BPS Kabupaten Tanah Bumbu, 2023

Existing Waste Management Conditions

The current waste management system in Tanah Bumbu Regency faces numerous challenges, including suboptimal management in terms of service provision, operational and maintenance costs, institutional capacity, regulations, and public participation in waste processing. These issues require serious attention and appropriate, integrated operational and management techniques.

Currently, waste processing in Tanah Bumbu Regency still utilizes a controlled landfill system, which involves dumping waste at the landfill without regular compaction and covering. Consequently, waste management relies heavily on waste collection vehicles, resulting in high operational costs. The current waste management service coverage in Tanah Bumbu Regency is approximately 50%.

The Sungai Dua Landfill, covering an area of approximately 8 hectares, began operations in 2011, making its current operational lifespan around 7 years. Although designated as a controlled landfill, its operation currently resembles open dumping, with approximately 14 trucks making two trips per day. Located 14 km from the city, the landfill is owned by the Tanah Bumbu Regency Regional Government.

The Sungai Dua Landfill has facilities such as an office, a sorting warehouse, a clean water source (borehole), a leachate treatment plant (IPLT), fencing, and electricity. Waste entering the landfill undergoes sorting, shredding, and composting before final disposal.

Residential waste collection systems in Tanah Bumbu Regency are divided into two categories. First, residents directly dispose of their household waste into designated temporary collection points or containers provided by the Tanah Bumbu Regency government. Second, residents collect their waste in receptacles placed in front of their homes, which is then collected by contracted personnel assigned by the Tanah Bumbu Regency Environmental Agency. This collected waste is subsequently transported to the designated or government-owned containers.

The transportation vehicles used are primarily waste carts/Tossa vehicles with a capacity of approximately 1 m³ or ±150 liters. Waste collection in urban residential areas occurs daily. Waste transportation is carried out directly from the waste source using dump trucks and employs a transfer depot system to the final disposal site (landfill), utilizing a hold container system.



Figure 1. Existing Conditions of Sungai Dua Landfill

Existing Conditions of Sungai Dua Landfill

The Sungai Dua Landfill currently lacks a waste processing system capable of significantly reducing the volume of waste it receives, resulting in minimal waste reduction. Solid waste management at the Sungai Dua Landfill primarily relies on a controlled landfill method on the disposal site. This leads to the majority of generated

waste simply entering the landfill and subsequently accumulating without further processing. The Sungai Dua Landfill is located in Simpang Empat District, Tanah Bumbu Regency. This research focuses specifically on the service area of the Sungai Dua Landfill, which includes Mantewe District, Karang Bintang District, Simpang Empat District, and Batulicin District.

Based on sampling data from the Solid Waste Management Master Plan of Tanah Bumbu Regency, the waste generation rate is 0.50 kg/person/day, with a volume of 2.33 liters/person/day. The total waste generation from the population served by the Sungai Dua Landfill, transported to the landfill over the past 10 years since its initial operation, was calculated by multiplying the population by the waste generation rate and volume based on the sampling results. This data is detailed in **Table 2** below.

Table 2. 10-Year Waste Accumulation at Sungai Dua Landfill

| Year | Population | Waste quantity (ton/year) | Volume (m3/year) |
|--|------------|---------------------------|--------------------|
| 2013 | 183.610 | 33508.825 | 156151.1245 |
| 2014 | 197.344 | 36015.28 | 167831.2048 |
| 2015 | 203.153 | 37075.4225 | 172771.4689 |
| 2016 | 208.877 | 38120.0525 | 177639.4447 |
| 2017 | 214.408 | 39129.46 | 182343.2836 |
| 2018 | 219.706 | 40096.345 | 186848.9677 |
| 2019 | 223.549 | 40797.6925 | 190117.2471 |
| 2020 | 201.379 | 36751.6675 | 171262.7706 |
| 2021 | 190.770 | 34815.525 | 162240.3465 |
| 2022 | 194.970 | 35582.025 | 165812.2365 |
| 2023 | 200.224 | 36540.88 | 170280.5008 |
| TOTAL WASTE INPUT OVER 10 YEARS | | 408433.175 | 1903298.596 |

Based on **Table 2**, the waste input since the Sungai Dua Landfill began operations has shown an increasing trend each year. However, a decrease was observed during the pandemic. Currently, waste input is increasing again due to population growth and the influx of new residents in the landfill's service area. Population projections, conducted using the arithmetic method, were used to project waste input from 2024 to 2035, as detailed in **Table 3** below.

Table 3. Sungai Dua Landfill Waste Projections (2024-2035)

| Year | Population | Waste quantity (kg/o/h) | Volume (m3/year) |
|------|------------|-------------------------|------------------|
| 2024 | 271.200 | 49494 | 230642.04 |
| 2025 | 278.494 | 50825.155 | 236845.2223 |
| 2026 | 285.900 | 5217.75 | 243143.655 |
| 2027 | 293.430 | 53550.975 | 249547.5435 |
| 2028 | 301.081 | 54947.2825 | 256054.3365 |
| 2029 | 308.862 | 56367.315 | 262671.6879 |
| 2030 | 316.780 | 57812.35 | 269405.551 |
| 2031 | 324.835 | 59282.3875 | 276255.9258 |
| 2032 | 333.032 | 60778.34 | 283227.0644 |
| 2033 | 341.381 | 62302.0325 | 290327.4715 |
| 2034 | 349.885 | 63854.0125 | 297559.6983 |
| 2035 | 358.547 | 65434.8275 | 304926.2962 |

The active landfill area, with a size of 8,000 m², is assumed to be a rectangular area measuring 80m × 100m. The slope of the landfill is set at 30°, in accordance with the regulations outlined in the Ministry of Public Works Regulation No. 3 of 2013. According to the Ministry of Public Works (2013), the maximum slope for waste landfills is 30°, as stipulated in the Regulation of the Minister of Public Works of the Republic of Indonesia Number 03/PRT/M/2013. In this study, each cell lift is assumed to have a height of 3 m, with terracing of 1 m wide to facilitate the operation of heavy equipment. The landfill is

designed with 6 lifts or 6 levels, resulting in a total landfill height of 18 meters (6 lifts x 3 m/lift). The estimated capacity of the active landfill area at Sungai Dua Landfill, with an area of 8,000 m² (0.8 ha) and a landfill height of 18 meters, is calculated to be 58,509.76 m³.

To calculate the remaining lifespan or remaining service life of the landfill, the projected waste input volume is compared with the available cell volume. The remaining lifespan of Sungai Dua Landfill can be seen in Table 4 and further detailed in **Table 5**.

Table 4. Estimated Remaining Service Life of Sungai Dua Landfill

| Year | Existing Capacity (m3) | Compacted waste accumulation(m ³) | Accumulated volume of compacted waste and cover soil (m ³) | Spare capacity (m3) |
|-------------------------------------|------------------------|---|--|---------------------|
| 2024 | 58.509.76 | 117858 | 7993.50 | 50.516.26 |
| 2025 | 58.509.76 | 121028 | 16201.99 | 42.307.77 |
| 2026 | 58.509.76 | 124246 | 24628.76 | 33.881.00 |
| 2027 | 58.509.76 | 127519 | 33277.48 | 25.232.28 |
| 2028 | 58.509.76 | 130844 | 42151.71 | 16.358.05 |
| 2029 | 58.509.76 | 134225 | 51255.28 | 7.254.48 |
| 2030 | 58.509.76 | 137666 | 60592.23 | -2.082.47 |
| The landfill has been filled | | | | |
| 2031 | 58.509.76 | 141167 | 70166.60 | -11.656.84 |
| 2032 | 58.509.76 | 144729 | 79982.57 | -21.472.81 |
| 2033 | 58.509.76 | 148357 | 90044.63 | -31.534.8 |
| 2034 | 58.509.76 | 152053 | 100357.33 | -41.847.57 |
| 2035 | 58.509.76 | 155817 | 110925.35 | -52.415.59 |

Table 5. Impact of 70% Waste Reduction on the Remaining Lifespan of Sungai Dua Landfill

| Year | Existing Capacity (m3) | Compacted waste accumulation(m ³) | Accumulated volume of compacted waste and cover soil (m ³) | Spare capacity (m3) |
|------|------------------------|---|--|---------------------|
| 2024 | 58.509.76 | 117788 | 1141.93 | 57.367.83 |
| 2025 | 58.509.76 | 120958 | 2314.57 | 56.195.19 |
| 2026 | 58.509.76 | 124176 | 3518.39 | 54.991.37 |
| 2027 | 58.509.76 | 127449 | 4753.93 | 53.755.83 |
| 2028 | 58.509.76 | 130774 | 6021.67 | 52.488.09 |
| 2029 | 58.509.76 | 134155 | 7322.18 | 51.187.58 |
| 2030 | 58.509.76 | 137596 | 8656.03 | 49.853.73 |
| 2031 | 58.509.76 | 141097 | 10023.80 | 48.485.96 |
| 2032 | 58.509.76 | 144659 | 11426.08 | 47.083.68 |
| 2033 | 58.509.76 | 148287 | 12863.52 | 45.646.24 |
| 2034 | 58.509.76 | 151983 | 14336.76 | 44.173.00 |
| 2035 | 58.509.76 | 155747 | 15846.48 | 42.663.28 |

With a 70% waste reduction, the remaining landfill space and lifespan of Sungai Dua Landfill are projected to accommodate incoming waste until 2035. The waste entering the landfill will consist only of residue, requiring only 0.7 hectares of land

by 2035. Currently, the waste management technique employed is open dumping with a lift division method and daily compaction by excavators to maximize land use. Based on Table 4, the landfill capacity of the currently used Sungai Dua Landfill shows a negative

value in 2030, indicating that the available landfill will be full in 2030 and unable to accommodate waste in subsequent years. Therefore, sustainable waste management or landfill expansion is required to accommodate the waste generated by the population in the following years. Currently developing and highly recommended waste treatment technologies aim not only to dispose of waste but also to recover materials and/or energy contained within it.

Effects of Expanding the Service Coverage on Sungai Dua Landfill Operations

The current service area of Sungai Dua Landfill encompasses six sub-districts: Sungai Loban, Kusan Hilir, Batulicin, Simpang Empat, Kuranji, and Karang Bintang. However, the service area will expand to include four additional sub-districts: Kusan Hulu, Kusan Tengah, Mantewe, and Teluk Kepayang. This expansion of the Sungai Dua Landfill's service area will impact its operations, including an increase in waste handling capacity, a greater volume of incoming waste, and a corresponding increase in required land area.

In a different context, service expansion will optimize waste management, such as by improving facilities and infrastructure, including temporary waste collection points and waste transportation vehicles. Furthermore, other environmental impacts can be minimized to reduce waste pollution and unpleasant odors, which also affect the health of the surrounding community. This service expansion is expected to raise public awareness about the importance of proper waste management and encourage active public participation in maintaining environmental cleanliness. Another impact of service expansion on landfill operations concerns the waste transportation stage, which utilizes specific transportation means to convey waste to the final disposal/processing site. This stage also involves personnel who, at specific intervals, transport waste from temporary waste collection points to the landfill. At the final

disposal/processing stage, the waste undergoes physical, chemical, and biological processing until the entire process is completed. Waste management, especially in urban areas, faces various complex challenges. These challenges include high waste generation rates, low public awareness (human behavior), and issues related to final waste disposal, which consistently present unique problems.

DISCUSSION

Sungai Dua Landfill currently faces significant challenges in managing increasing waste volumes, primarily due to limited land availability. The implementation of a more effective and efficient landfill management system is necessary to optimize land use and mitigate the negative impacts of waste disposal. The increasing waste generation and the limited waste processing capacity within the Tanah Bumbu Regency result in a small amount of waste being managed or recycled, leading to the majority of waste ending up at the final disposal site (landfill). The diverse waste streams generated by communities exhibit varying degrees of complexity, ranging from simple household organic waste to complex industrial hazardous waste, necessitating appropriate treatment to mitigate negative impacts on environmental quality. A Final Processing Site represents the culmination of the waste management process. The waste management cycle encompasses several stages: generation at the source, collection, transportation/transfer, processing, and final disposal. Modern landfills are designed not merely as dumping grounds, but as facilities for processing waste through various methods, such as composting, recycling, and controlled landfilling, before final disposal to minimize environmental impact. Landfills are designated areas for waste disposal, separated from residential areas to prevent detrimental impacts on the surrounding environment. The continuously increasing volume of waste in landfills each year is a significant factor contributing to environmental damage.

The expansion of Sungai Dua Landfill's service area, in addition to impacting landfill operations, necessitates the implementation of spatial planning strategies to enhance the landfill's capacity. Site selection for the expanded service area must meet specific criteria, such as distance from settlements, water bodies, and soil conditions, to minimize environmental pollution and public health impacts. Infrastructure development, such as the construction of adequate facilities at the landfill, including access roads, drainage systems, and environmental protection facilities like embankments and leachate treatment systems, is crucial. Well-maintained landfill infrastructure contributes to maintaining efficient and environmentally sound landfill operations. The current waste management system undergoes planned evaluation and monitoring, enabling more effective waste compaction and reducing the volume of waste requiring handling.

CONCLUSION

Waste management in Tanah Bumbu Regency currently faces numerous challenges, including suboptimal management in terms of service provision, operational and maintenance costs, institutional capacity, regulations, and public participation in waste processing. By 2030, the landfill capacity of the currently used Sungai Dua Landfill is projected to reach a negative value, meaning that by 2030, the available landfill space will be completely full and unable to accommodate any further waste in subsequent years. This necessitates sustainable waste management strategies or landfill expansion to accommodate the waste generated by the population in the following years.

Declaration by Authors

Acknowledgement: None

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Rizqi Puteri Mahyudin, Yusari Ridhayah, Akbar Rahman, Fitriani Ridzeki, Fathurrahman. Study of capacity and technical design for the arrangement of Sungai Dua Landfill in Tanah Bumbu Regency South Kalimantan Indonesia. *International Journal of Research and Review*. 2025; 12(2): 128-134. DOI: <https://doi.org/10.52403/ijrr.20250215>
