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PLANNING OF INTEGRATED WASTE PROCESSING SITE (TPST) IN LHOKNGA DISTRICT, ACEH BESAR REGENCY

Fathul Mubarak*

Department of Environmental Engineering, Faculty of Science and Technology, Ar-Raniry State Islamic University, Banda Aceh, Indonesia

**Email Correspondence : atulbarak0@gmail.com*

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ABSTRACT

Waste management remains a critical issue in Lhoknga Sub-district, Aceh Besar, due to limited facilities, inadequate collection systems, and low community participation. This study aims to plan an Integrated Waste Processing Facility (TPST) as a sustainable long-term waste management solution. A quantitative approach was applied through waste generation and composition sampling over eight consecutive days in accordance with SNI 19-3964-1994, covering both domestic and non-domestic sources. Fishbone analysis was employed to identify key factors influencing waste management performance. The findings indicate that organic waste, particularly food waste, dominates the waste composition. The proposed TPST is designed to manage 83.78 m³/day of waste projected until 2043, based on national standards and regional planning policies. This study contributes scientifically by offering a data-driven TPST planning framework that can be replicated in coastal and tourism-oriented regions facing similar waste management challenges.

Keywords : Integrated waste processing place, Waste management, Waste facilities and infrastructure

ABSTRAK

Pengelolaan sampah di Indonesia masih menjadi permasalahan, termasuk di Kecamatan Lhoknga, Kabupaten Aceh Besar, yang ditandai dengan keterbatasan TPS, tidak adanya rute pengangkutan, dan rendahnya partisipasi masyarakat. Penelitian ini bertujuan merencanakan Tempat Pengolahan Sampah Terpadu (TPST) yang berkelanjutan sebagai solusi pengelolaan sampah jangka panjang. Metode penelitian menggunakan pendekatan kuantitatif melalui pengambilan sampel timbulan dan komposisi sampah selama delapan hari berturut-turut berdasarkan SNI 19-3964-1994, mencakup sampah domestik dan non-domestik. Analisis fishbone digunakan untuk mengidentifikasi faktor utama permasalahan pengelolaan sampah. Hasil penelitian menunjukkan bahwa sampah organik, khususnya sisa makanan, merupakan komponen terbesar. TPST dirancang untuk mengelola timbulan sampah sebesar 83,78 m³/hari hingga tahun 2043 dengan mengacu pada regulasi nasional dan dokumen perencanaan daerah. Kontribusi ilmiah penelitian ini berupa penyediaan model perencanaan TPST berbasis data timbulan dan komposisi sampah lokal yang aplikatif untuk wilayah pesisir dan kawasan wisata.

Kata kunci : *Tempat pengolahan sampah terpadu, Pengelolaan sampah, Sarana dan prasarana persampahan*

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Introduction

Waste management problems persist due to limited waste processing facilities (Kurniawan & Santoso, 2020). Population growth and increased consumption have raised waste generation, while reliance on landfills accelerates overcapacity. The absence of Integrated Waste Processing Facilities (TPST) limits upstream waste treatment. Therefore, TPST development is a strategic solution to reduce landfill dependency through integrated processing and material recovery. Inefficient management systems contribute to waste accumulation and declining landfill performance (Kurnia & Sholihah, 2020).

Based on data from the National Waste Management Information System (SIPSN) of the Ministry of Environment and Forestry (KLHK), Indonesia generated 31.9 million tons of waste between 2023 and July 24, 2024, with 35.67% remaining unmanaged. This condition indicates limited waste processing capacity at the local level. A similar situation occurs in Lhoknga Sub-district, where the absence of integrated waste processing facilities causes waste to be directly disposed of without prior treatment. Therefore, the development of an Integrated Waste Processing Facility (TPST) in Lhoknga is an urgent and relevant local response to national waste management challenges (Sakinah, 2024).

According to Fauziah (2024) Aceh Besar Regency has an area of 2,903.49 km^2 with mostly land and several islands, where about 10% of villages are located in coastal areas. Lhoknga Subdistrict has an area of 87.95 km^2, consisting of 4 mukims and 28 villages, with Mon Ikeun Village as the administrative center (Usman, 2021).

Field observations conducted in July 2024 indicate that waste management in Lhoknga Sub-district remains suboptimal, despite the involvement of the Aceh Besar Regency Environmental Agency (DLH) and support from PT. Solusi Bangun Andalas (PT. SBA). The existing problems are not limited to inefficient management systems but also include low public awareness in maintaining cleanliness and caring for available facilities. However, there is still a lack of technical studies that comprehensively integrate existing conditions, waste generation characteristics, and integrated waste processing facility planning as a long-term solution at the sub-district level. This research gap underlines the necessity of conducting a TPST planning study in Lhoknga Sub-district.

The lack of temporary storage facilities (TPS/containers) and the absence of regular transportation routes are major obstacles. The long distance between Lhoknga District and the Blang Bintang Regional Landfill also increases operational costs, so that some people choose to burn or dump their waste into the nearest river, causing new environmental impacts.

In addition, waste in this area is dominated by coconut shell waste from tourism and household activities. Waste transportation efforts by the Aceh Besar District DLH are often hampered by delays in payment of fees by businesses, resulting in operational disruptions. Although PT. SBA has provided several containers, some of these facilities have been sold by the community for personal use, causing the transportation system to be ineffective.

Given these conditions, it is necessary to plan an Integrated Waste Management Facility (TPST) in Lhoknga District as a solution for effective, efficient,

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and sustainable waste management. The technical planning refers to the governs the technical requirements and management of household waste infrastructure, focusing on collection, transport, processing, and disposal (landfills). Concerning the implementation of infrastructure and facilities for household waste and similar household waste. The construction of this TPST is an urgent need, considering that Lhoknga District is one of the leading tourist areas in Aceh, such as Lampuuk Beach and Kapuk Island Beach, which are the main sources of economic activity for the surrounding community.

Methods

This research was conducted in Lhoknga Sub-district, Aceh Besar Regency (5º02'–5º08' N and 95º80'–95º88' E). The area was selected due to existing waste management problems and its characteristics as a coastal tourism area with potential future environmental impacts, making it relevant for TPST planning. This subdistrict consists of four mukims (Kueh, Lamlhom, Lampuuk, and Lhoknga) with a total of 28 villages (BPS Aceh Besar, 2023). This research will be conducted over approximately ten months, beginning with a literature review, followed by preliminary observations in July 2024, and concluding with the preparation of the final report in April 2025.

This research adopts a quantitative approach because TPST planning requires measurable data on waste generation, composition, and growth projections. This approach enables the design of an Integrated Waste Management Facility (TPST) that is appropriate for the characteristics of Lhoknga District and community needs based on numerical data analysis.

The data used in this planning consists of primary data, in the form of field observations, sampling of waste generation and composition based on SNI 19-3964-1994, and photographic documentation of existing conditions. Secondary data includes population data sourced from BPS (projected for the next 20 years), topographic maps and land use maps sourced from PUPR Aceh Besar, RTRW and RPJMD sourced from Bappeda Aceh Besar, and technical regulations sourced from the BPK RI website.

The method of sampling waste generation and composition was to conduct sampling for eight consecutive days in two source categories, namely domestic (high, medium, and low income settlements) and non-domestic (shops, markets, schools, offices, public facilities).

a. Data analysis

Data analysis in this study comprises three primary components: the assessment of existing conditions, the analysis of waste generation data, and the analysis of land requirements for the TPST.

The analysis of existing conditions was conducted using the Fishbone method to identify the root causes of problems at the research site. Although this method has limitations due to its reliance on researcher interpretation and field observations, which may introduce subjectivity, it remains effective in systematically organizing problems by categorizing technical, institutional, and social factors. The process includes identifying the main problem, brainstorming potential causes, developing the

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Fishbone diagram, and analyzing dominant factors to determine priority corrective actions. This structured approach provides a strong foundation for effective TPST planning.

Waste generation data were analyzed to determine daily waste quantity and composition in Lhoknga Sub-district as a basis for Integrated Waste Processing Facility (TPST) planning. Sampling was conducted for domestic and non-domestic sources to define land requirements, processing systems, equipment specifications, and appropriate technologies. The sampling procedure followed SNI 19-3964-1994 using a proportional stratified random sampling method, with household samples classified into high-, middle-, and low-income groups. Sampling was carried out for eight consecutive days, and all data were analyzed using Microsoft Excel. The results were used to project waste generation over a 20-year period (2023–2043) based on average waste generation rates and population growth projections, where this projection is not part of the research period but serves as a long-term estimation.

Further analysis includes calculating the Recovery Factor (RF) to identify reusable waste, such as organic materials suitable for composting and inorganic materials like plastics and metals. The Loading Rate is also calculated to ensure efficient and sustainable TPST processing capacity. The main analytical components include daily waste weight and volume per capita, compaction factor, waste composition based on weight and volume, and the determination of the weight of each waste type.

Land requirement analysis for the TPST was carried out using a scoring method based on SNI 03-3241-1994, which evaluates geological characteristics, distance from residential areas, accessibility, and the availability of buffer zones. The design criteria are applied in the TPST pollution control systems, residue handling units, supporting facilities, and designated buffer zones.

Table 1. Technical Specifications of TPST Planning

No.	Planning Stage	*Output*
1	Sampling	Volume and composition of waste
2	Population Projections	Population growth projections for the next 20 years
3	Location Determination	Identifying the right location for the construction of the TPST
4	Determining the land area required for TPST construction	Having a land area that is appropriate for the needs
5	Desain *layout* TPST, denah dan desain bangunan	TPST layout design, floor plan and building design TPST design drawings include. 1. Reception area 2. Waste sorting area 3. Organic waste storage and processing area 4. Inorganic waste storage and processing area 5. Hazardous waste storage area 6. Residue processing area 7. TPST administration room 8. Warehouse 9. Toilets

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No.	Planning Stage	*Output*
		10. Prayer room 11. Security post 12. Parking area
6	Calculating the RAB	RAB for the planning of the Lhoknga Subdistrict TPST

Results and Discussion

a. Existing Conditions

The main causes of waste management problems in Lhoknga Sub-district, Aceh Besar Regency, are classified into four key factors: regional conditions, infrastructure, community participation, and other supporting factors. In terms of regional conditions, the problems arise from a limited workforce and funding for waste management, Lhoknga's status as a tourism area that increases waste generation, and the absence of specific waste management programs at the village level. From an infrastructure perspective, waste collection is not optimal due to limited equipment and low participation in fee payments, the lack of temporary storage facilities (TPS), damage to waste management facilities, and the long distance to the final disposal site (TPA), which increases operational costs. Community participation remains low due to limited education and awareness regarding the importance of waste management, as well as the perception that waste management is solely the responsibility of the government. In addition, the absence of waste management programs at the regency level, the use of vacant land and PT. SBA mining areas are used as informal dumping sites, and easy access to mining roads further exacerbates waste management conditions in the area.

Based on sampling results, the average waste generation in Lhoknga District reached 83.78 m^3/day, with organic waste accounting for 75.57 m^3, inorganic waste 3.08 m^3, and residual waste 5.13 m^3. This composition is consistent with the characteristics of coastal and tourist areas, where food waste and coconut shells are the most dominant types of waste.

Mon Ikeun Village
(643,64 m^2)

Meunasah Karieng Village
(1.372,76 m^2)

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Naga Umbang Village
(313,36 m^2)

Mon Ikeun Village
(65,52 m^2)

Figure 1. Documentation of Waste Accumulation Sites

Based on projection results, waste generation in Lhoknga District, with a population of 19,715, is estimated at 3,154 kg/day by weight and 83.8 m^3/day by volume. This projection serves as the basis for determining the capacity and facility requirements of the TPST to handle waste over the next 20 years.

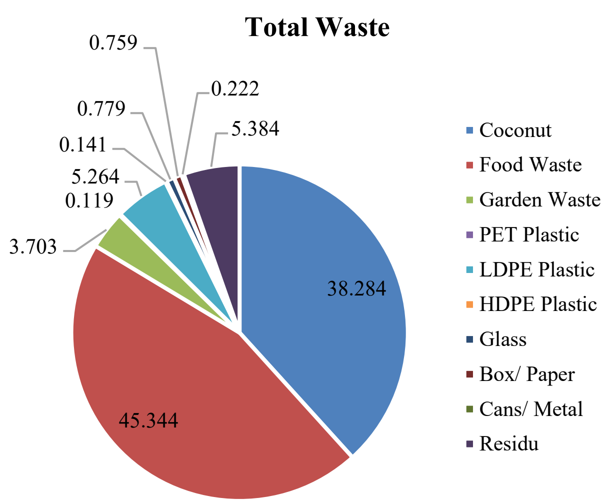

Figure 2. Percentage of Waste Generation Amount

Based on waste sampling data, Figure 1 shows the percentage according to waste composition. The results of waste projection in terms of mass and volume in Lhoknga District, Aceh Besar Regency, for the next 20 years are shown in Table 5.

Table 2. Projection of Waste Generation by Composition

Waste Composition	Population (Souls)	Weight of Waste (kg/Person/day)	Weight of Waste (Kg/day)	Volume of Waste (L/Person/day)	Volume of Waste (L/day)	Volume of Waste (m^3/day)
Coconut	19.715	0,061	1.205	3,892	76.731	76,731
Food Waste		0,072	1.427	0,109	2.140	2,140
Garden Waste		0,006	117	0,030	601	0,601
PET Plastic		0,000	4	0,007	136	0,136

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LDPE Plastic		0,008	166	0,122	2.396	2,396
HDPE Plastic		0,000	4	0,004	72	0,072
Glass		0,001	25	0,004	72	0,072
Box/ Paper		0,001	24	0,021	420	0,420
Cans/ Metal		0,000	7	0,007	145	0,145
Residue		0,009	169	0,054	1.064	1,064
Total		**0,16**	**3.147**	**4,25**	**83.775**	**83,78**

b. TPST Planning

Determination of TPST Location

The results of the regional feasibility analysis show that all three TPST location options meet the basic requirements of SNI 03-3241-1994 regarding geological conditions and distance from water bodies. However, several differences were observed in terms of distance from residential areas, agricultural land, and administrative boundaries. After further assessment using a scoring system for ten indicators of regional feasibility and placement feasibility, the total weight for each location was obtained: Option 1 scored 17, Option 2 scored the highest at 19, and Option 3 scored 16. Based on the highest weight, Option 2 was determined to be the most feasible location for TPST planning in Lhoknga District.

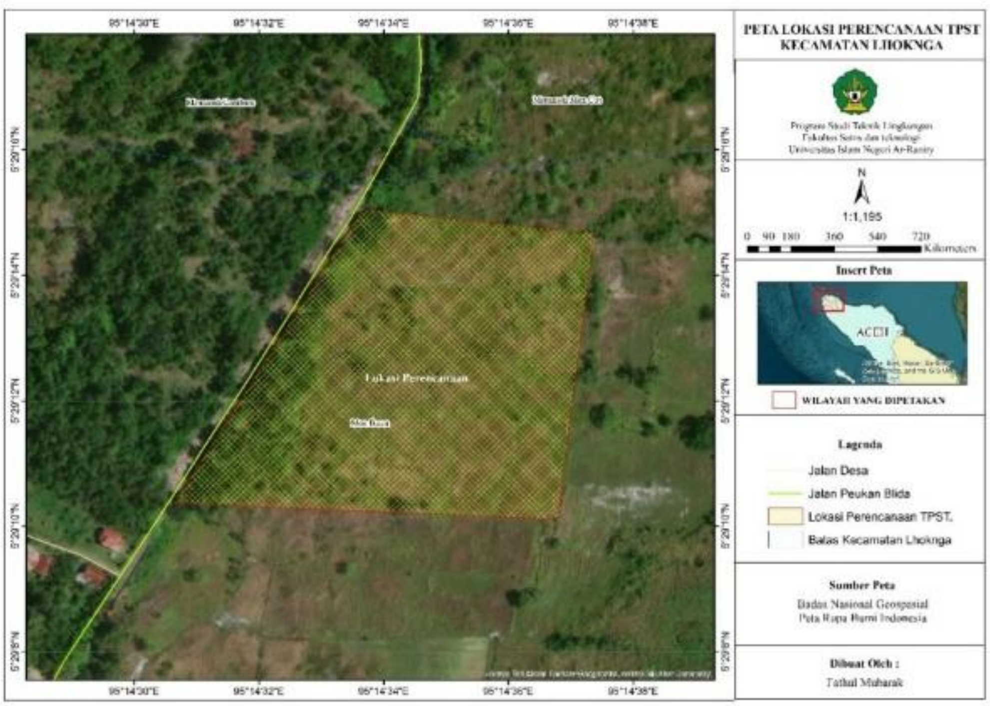

Figure 3. TPST Planning Location

This location is at coordinates Lat 5.48713° and Long 95.242567°, precisely on Jl. Peukan Blida, Gampong Mon Ikeun. The selected land is former rice fields that

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are no longer used and are now vacant with shrub and grass vegetation, so it is considered suitable for the construction of TPST facilities.

Table 3. Assessment of TPST Location Selection

Indicator				
Geological conditions of the land	**Distance from water bodies**	**Distance from residential areas**	**Distance from agricultural areas**	**Distance from administrative boundaries**
Not located in an active fault zone	1.316,82 m	166,75 m	416,53 m	3.989,75 m

The assessment of the selected locations is shown in Table 4, while the map of the selected locations is presented in Figure 2. The table summarizes the main eligibility criteria, and Figure 2 provides an overview of the spatial position of the locations within the study area. Both pieces of information support the designation of these locations as the most suitable options for the construction of the TPST.

Planning of Waste Management and TPST Building Details

Based on the mass balance of TPST Lhoknga with a projected population of 19,715 in 2043, waste generation is estimated at 83.78 m³/day, of which 5.13 m³/day (8%) of residue is planned to be treated using an incinerator. The incinerator is classified as environmentally friendly as it uses high-temperature-resistant materials from an ISO 9001–certified manufacturer, complies with emission standards under the Minister of Environment and Forestry Regulation No. P.70/2016, and has obtained Environmental-Friendly Technology Registration from KLHK. All waste is handled according to the TPST's operational schedule, which runs for 8 hours per day, from 08:00–12:00 WIB, paused until 14:00 WIB, and continued until 18:00 WIB.

Mass balance analysis shows that 83.78 m³/day of incoming waste is separated into several major categories, including coconut waste, food waste, yard waste, plastics (PET, LDPE, HDPE), glass, paper or cardboard, metals, and mixed residues. Each category produces two streams: recoverable materials and residual materials. Most waste categories demonstrate high recovery potential. Coconut waste, as the dominant fraction, contributes the largest volume to the processing stream. Food waste, glass, and metals can be fully recovered, while plastics and paper generate small amounts of residue. All recoverable materials flow into the processing line, totaling 78.64 m³/day.

Residual materials from all waste categories amount to 5.13 m³/day and are directed to the incineration unit. Overall, mass balance results illustrate that the TPST's sorting system operates efficiently, maximizing the volume of waste that can be processed and minimizing the quantity requiring final disposal.

All waste will be processed based on its composition, with the processing flow and results shown in the Material Flow Analysis (MFA) (Figure 3).

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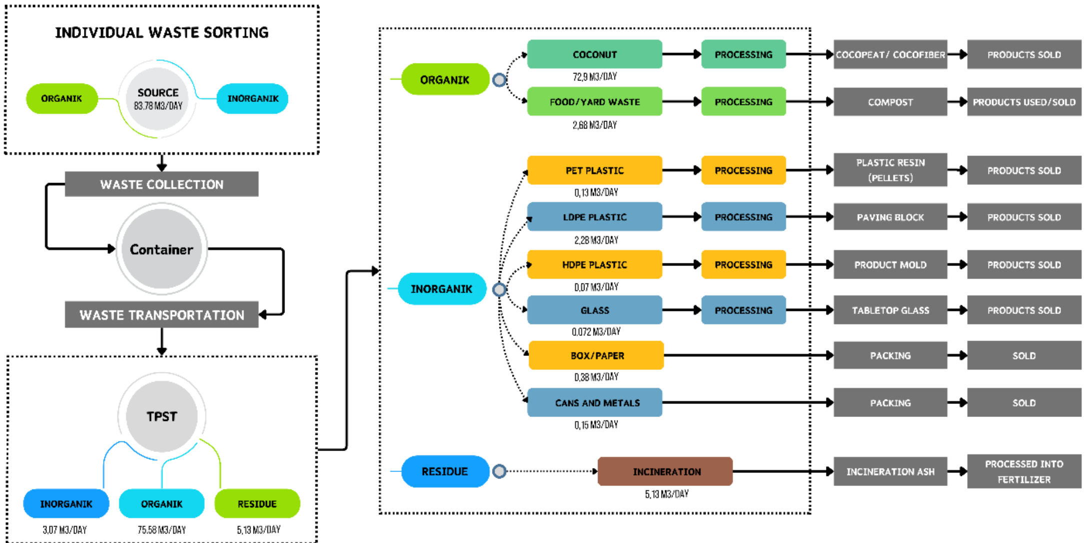

Figure 4. Material Flow Analysis (MFA) of Lhoknga District TPST

The waste management system in Lhoknga District is designed in an integrated manner, covering the stages of collection, transportation, sorting, and final processing at the TPST. Collection is carried out individually in accordance with SNI 19-2454-2002, where each household uses two 40-liter bins to separate organic and inorganic waste. Sorting at the source supports more efficient operations at the TPST, with organic waste placed in 6 m³ containers and inorganic waste stored in 660-liter dustbins.

The transportation stage applies the Hauled Container System (HCS) pattern supported by 11 containers and 2 arm roll trucks operating daily at 07.00 WIB. Waste is transported to the TPST, received at the loading area, and manually sorted in the sorting zone using a conveyor belt and magnetic metal separator.

Hazardous waste is not processed at the TPST, but it is temporarily stored in accordance with the Ministry of Environment and Forestry Regulation No. 9 of 2024 in four color-coded containers before being transferred to the Blang Bintang Regional Landfill for further treatment. Residual waste, around 8% of the total input, is incinerated every three days using an environmentally friendly incinerator compliant with ISO 9001 standards to ensure no waste remains unmanaged.

All activities in this system are regulated in the Lhoknga TPST design, which was developed in accordance with the Minister of Public Works Regulation No. 3 of 2013, ensuring that the waste management system operates effectively, environmentally friendly, and sustainably. The three-dimensional design for the TPST building plan in Lhoknga District is presented in Figure 4.

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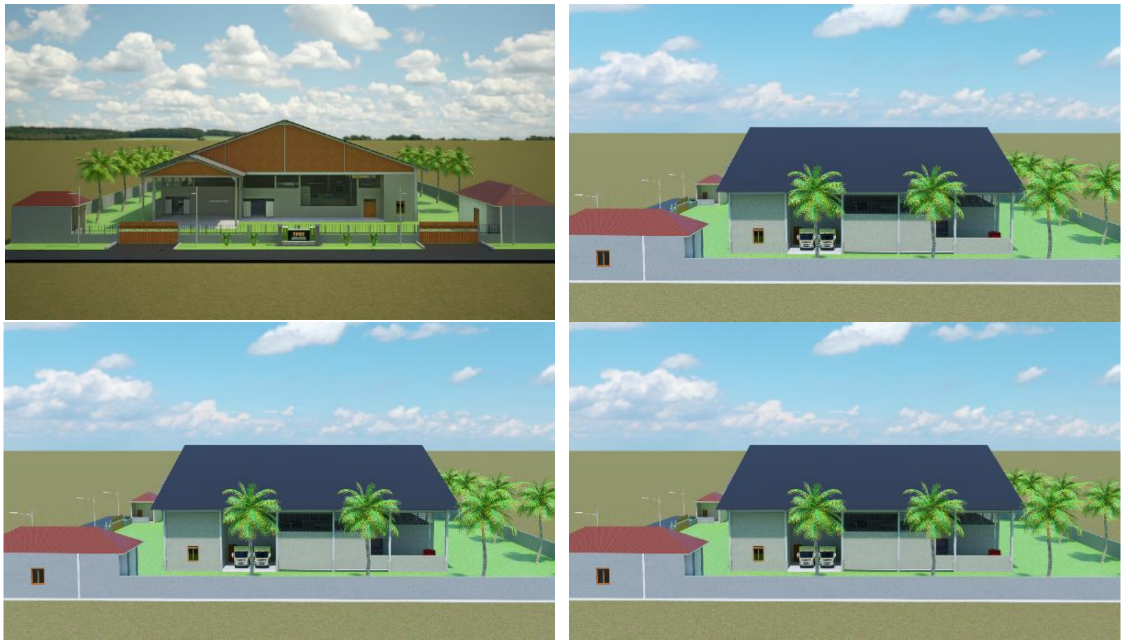

Figure 5. 3D Image of the Lhoknga District Landfill

Based on the TPST building layout shown in Figure 6, the processing stages and design calculations for the TPST in Lhoknga District cover the entire workflow, starting from waste reception and sorting to final waste processing. Each area is designed according to spatial requirements and equipment capacity to ensure an efficient operational flow. Processing is carried out in an integrated manner, including composting of organic waste, recycling of inorganic waste, and residue incineration using environmentally friendly incinerators. This design was developed by considering operational effectiveness, worker comfort, and environmental sustainability in accordance with applicable technical standards.

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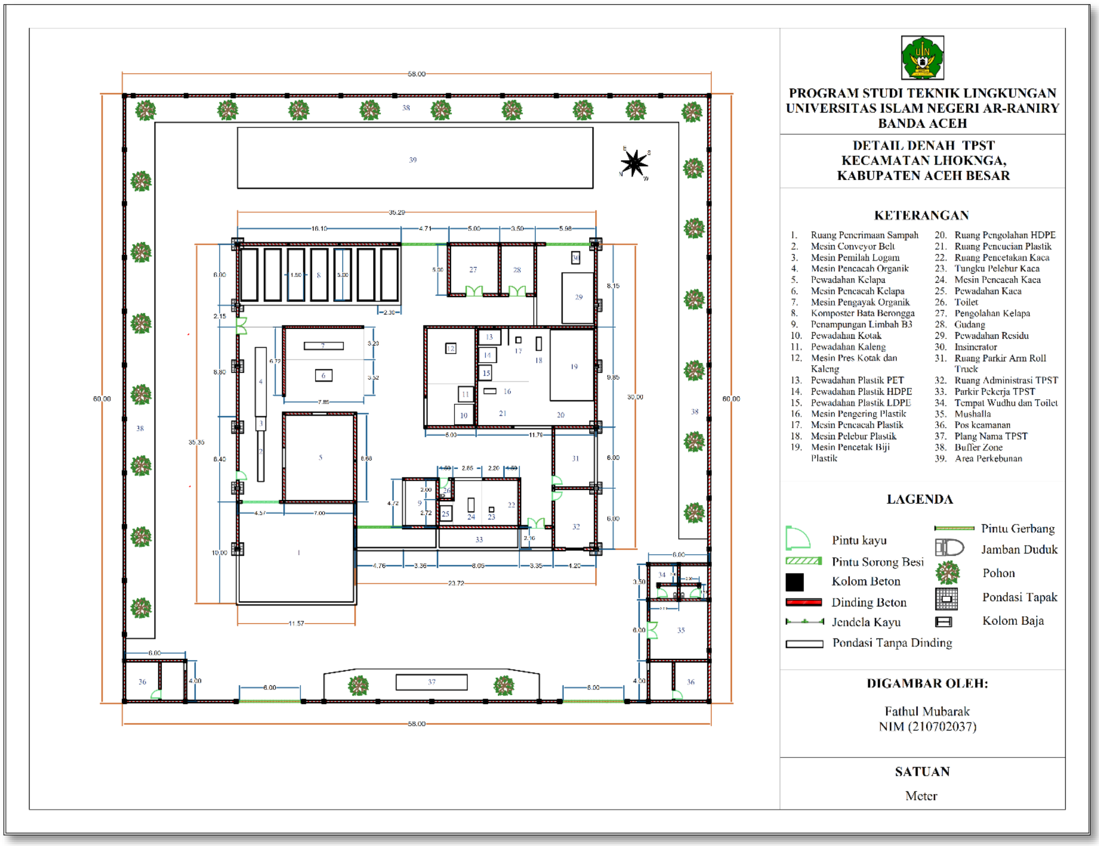

Figure 6. Detailed Layout of the Lhoknga District Landfill

Based on the layout shown in Figure 5, the TPST design in Lhoknga District covers all waste processing stages, from reception and sorting to final treatment. Each area is designed according to space requirements and equipment capacity to ensure an efficient workflow. The integrated system includes organic waste composting, inorganic waste recycling, and residue incineration using an environmentally friendly incinerator, with consideration given to operational efficiency and environmental sustainability in accordance with applicable technical standards.

1. Reception and Sorting Area

The detailed calculation of the waste reception and sorting area is as follows:

Maximum pile height = 0.7 meters

Planned pile width = 10 meters

Waste reception area size $= \frac{\text{Total Waste Volume (m}^3\text{/day)}}{\text{Planned Pile Height (m)}}$ .... (1)

$= \frac{83{,}78\ (\text{m}^3/\text{day})}{0{,}7\ (\text{m})}$

$= 119{,}68\ \text{m}^2$

Length of waste reception area $= \frac{\text{Area of waste reception area } (m^2)}{\text{Planned width } (m)}$ .... (2)

$= \frac{119{,}68\ (m^2)}{10\ (m)}$

$= 11{,}97$ m

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The waste reception area is known to be 119.7 m² with a length of 11.97 meters and a width of 10 meters. The total area is then combined with the waste sorting area according to the machine dimensions. To facilitate worker activities, each side of the equipment is provided with additional workspace, so the machine placement location has adjustments in length and width according to operational needs.

- Conveyor belt = (5 + 2) × (0,6 + 3,97) m = 31,99 m^2 ..... (3)
- Metal Separator Machine = 1,4 × (0,97 + 3,6) m = 6,4 m^2 .... (4)

Therefore, the total area of the reception and sorting location is as follows.

Total area = 119,7 m^2 + 38,8 m^2 ……………………………………… (5)
= 158,08 m^2

2. Organic Waste Processing

Organic waste amounting to 2,676.76 kg/day is processed into the following products:

- **Coconut waste** is processed into two main products, namely cocopeat and cocofiber. The process begins with shredding using a coconut shredder, then the results are sieved to separate the cocopeat and cocofiber so that each can be processed according to its intended use.

Planned pile height = 1.2 meters
Planned width = 7 meters

$$\text{Coconut storage area} = \frac{\text{Total Coconut Volume (m}^3\text{/day)}}{\text{Planned Pile Height (m)}} \quad \ldots\ldots\ldots\ldots (6)$$

$$= \frac{72{,}9\ (\text{m}^3/\text{day})}{1{,}2\ (\text{m})}$$

$$= 60{,}75\ \text{m}^2$$

$$\text{Length of coconut storage area} = \frac{\text{Storage Area } (m^2)}{\text{Planned Width } (m)} \quad \ldots\ldots\ldots\ldots (7)$$

$$= \frac{60{,}75\ m^2}{5\ m}$$

$$= 8{,}68\ \text{m}$$

The area of the coconut storage is known to be 60.75 m² with a length of 8.68 meters and a width of 7 meters. This total area is combined with the coconut processing area according to the machine dimensions in Table 5.3. To facilitate worker activities, each side of the equipment is added with a working space of 0.6 meters, so that the final size of the machine placement area adjusts to the addition.

- Coconut shredding machine = (1,64 + 6,21) × (1,12 + 2,4) m = 27,63 m^2 …... ……………………………………………… (8)
- Sifting machine = (3,85 + 4) × (0,7 + 2,5) m = 25,12 m^2 ………..... (9)

Therefore, the total area of the coconut storage and processing site is as follows.

Total area = 60,75 m^2 + 52,75 m^2 …………………………………… (10)
= 128,52 m^2 ………………………………………………. (11)

.

- **Food waste** will be processed into compost using hollow brick composters. Therefore, the required land area and number of hollow bricks are as follows.

Composting time = 30 days
Base channel height = 0.2 meters

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Total composting volume = composting time × waste volume per day ……... (12)
= 30 × 2,14 m^3/day
= 64 m^3/day

Determination of the number of brick boxes

Compost pile volume = P × L × (box height – base channel height)) …………… (13)
= 5 × 1,5 × (1,5 – 0,2)
= 5 × 1,5 × 1,3
= 9,75 m^3

Number of boxes required $= \frac{\text{Total composting volume } (m^3)}{\text{Compost pile volume in boxes} (m^3)}$ ………………….. (14)
$= \frac{64\ m^3}{9{,}75\ m^3}$
= 6,56 ~ 7 brick boxes

Determining the space requirements

Length per box unit = distance from end A + box length + distance from end B + length of brick pair ……………………………………….. (15)
= 0,4 + 5 + 0,4 + (2 × 0,1)
= 6 m

Width per box unit = width of box + distance between right and left ends + width of brick pair …………………………………………….. (16)
= 1,5 + 0,3 + 0,3 + (2 × 0,1)
= 2,3 m

Space per box unit = Length × Width ……………………………………... (17)
= 6 × 2,3 = 13,8 m^2

Total space requirement = Number of boxes × space per box unit …………………….. (18)
= 7 × 13,8 m^2
= 96, 6 m^2

The area of the organic composting area is known to consist of 7 brick boxes, each measuring 6 meters × 2.3 meters, with an area of 13.8 m² per unit. The total space requirement for organic composting is 96.6 m². This area is then combined with the organic shredding area according to the machine dimensions in Table 5.4. To facilitate worker activities, each side of the equipment is given additional working space so that the processing runs more efficiently.

- Organic shredding machine = (1,1 + 3,47) × (6,8 + 2) m = 40,21 m^2 ... (19)

Therefore, the total area for composting and coconut processing is as follows.

Total area = 96,6 m^2 + 40,21 m^2 …………………………………………….. (20)
= 136,81 m^2

3. Inorganic Waste Management

Inorganic waste amounting to 218.2 kg/day will be processed separately according to type. The space required for storing and processing PET, LDPE, and HDPE plastics is as follows.

PET plastic storage space

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PET shredding time = every 30 days
Planned pile height = 1.2 meters
Planned width = 1.5 meters

Total shredding volume = Shredding time × waste volume per day .... (21)
$= 30 \times 0{,}13\ \mathrm{m^3/day}$
$= 3{,}9\ \mathrm{m^3/day}$

PET storage bin area $= \frac{\text{Total PET volume (m}^3\text{/day)}}{\text{Planned pile height (m)}}$ .... (22)
$= \frac{3{,}9\ (\mathrm{m^3/day})}{1{,}2\ (\mathrm{m})}$
$= 3{,}25\ \mathrm{m^2}$

PET storage tank length $= \frac{\text{Storage bin area (m}^2\text{)}}{\text{Planned width (m)}}$ .... (23)
$= \frac{3{,}25\ \mathrm{m^2}}{1{,}5\ \mathrm{m}}$
$= 2{,}17\ \mathrm{m}$

LDPE storage space

LDPE collection time = once a day
Planned pile height = 1.2 meters
Planned width = 1.5 meters

Total collection volume = collection time × daily waste volume .... (25)
$= 1 \times 2{,}28\ \mathrm{m^3/day}$
$= 2{,}28\ \mathrm{m^3/day}$

LDPE storage bin area $= \frac{\text{Total LDPE Volume (m}^3\text{/day)}}{\text{Planned Pile Height (m)}}$ .... (26)
$= \frac{2{,}28\ (\mathrm{m^3/day})}{1{,}2\ (\mathrm{m})}$
$= 1{,}9\ \mathrm{m^2}$

Length of LDPE storage bin $= \frac{\text{Storage bin area } (m^2)}{\text{Planned width } (m)}$ .... (27)
$= \frac{1{,}9\ m^2}{1{,}5\ m}$
$= 1{,}27\ \mathrm{m}$

HDPE storage space

HDPE collection time = once every 30 days
Planned pile height = 1.2 meters
Planned width = 1.5 meters

Total collection volume = collection period × daily waste volume .... (28)
$= 30 \times 0{,}07\ \mathrm{m^3/day}$
$= 2{,}1\ \mathrm{m^3/day}$

HDPE storage bin area $= \frac{\text{Total HDPE Volume (m}^3\text{/day)}}{\text{Planned Stockpile Height } (m)}$ .... (29)
$= \frac{2{,}1\ \mathrm{m^3/day}}{1{,}2\ (\mathrm{m})}$
$= 1{,}75\ \mathrm{m^2}$

Length of HDPE storage bin $= \frac{\text{Storage bin area } (m^2)}{\text{Planned width } (m)}$ .... (30)

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$$= \frac{1{,}75\ m^2}{1{,}5\ m}$$
$$= 1{,}17\ m$$

After determining the area of the plastic storage location, each has a length of 2.17 meters, a width of 1.5 meters, and an area of 3.25 m2 for PET storage. The LDPE storage has a length of 1.27 meters, a width of 1.5 meters, and an area of 1.905 m2, while the HDPE storage has a length of 1.17 meters, a width of 1.5 meters, and an area of 1.75 m2. The total area of the plastic storage is 6.905 m². Therefore, the total area of the plastic storage is added to the plastic processing area with the dimensions of the machines used in Table 5.5. To make it easier for workers to do their jobs, the area on each side of the equipment used is added, so that the machine location will have the following area.

- Plastic shredder
  $= (0{,}55 + 5{,}075) \times (0{,}5 + 1{,}5)\ m = 11{,}25\ m^2$ .... (31)
- Plastic melter
  $= (1{,}3 + 6{,}125) \times (0{,}5 + 1{,}25)\ m = 12{,}9\ m^2$ .... (32)
- Plastic pellet molding machine
  $= (7 + 0{,}5) \times (4{,}25 + 0{,}75)\ m = 37{,}5\ m^2$ .... (33)
- Plastic drying machine
  $= (1{,}2 + 3{,}97) \times (0{,}5 + 0{,}75)\ m = 6{,}46\ m^2$ .... (34)
- PET storage area
  $= (2{,}17 + 1) \times (1{,}5 + 0{,}375)\ m = 5{,}94\ m^2$ .... (35)
- LDPE storage area
  $= (1{,}27 + 1{,}9) \times (1{,}5 + 0{,}25)\ m = 5{,}54\ m^2$ .... (36)
- HDPE storage area
  $= (1{,}75 + 1{,}45) \times (1{,}5 + 0{,}25)\ m = 5{,}54\ m^2$ .... (37)

Therefore, the total area of the plastic storage and processing site is as follows.

Total area $= 17{,}02\ m^2 + 99{,}47\ m^2$ .... (38)
$= 116{,}49\ m^2$

4. Glass Waste Processing

Glass waste is processed into recyclable products with commercial value through a melting process based on color, then molded into glass sheets such as tabletops. The space required includes an area for glass storage and processing.

Glass crushing time = every 30 days
Planned pile height = 1.2 meters
Planned width = 1.5 meters
Total shredding volume = Shredding time × daily waste volume …............. (39)
$= 30 \times 0{,}07\ m^3/day$
$= 2{,}1\ m^3/day$

Glass storage bin area $= \frac{\text{Total glass volume } (m^3/day)}{\text{Planned pile height } (m)}$ .... (40)
$= \frac{2{,}1\ (m^3/day)}{1{,}2\ (m)}$
$= 1{,}75\ m^2$

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Length of glass storage bin $= \frac{\text{Storage tank area } (m^2)}{\text{Planned width } (m)}$ …………………………….. (41)

$= \frac{1{,}75 \text{ m}^2}{1{,}5 \text{ m}}$

$= 1{,}17$ m

The area of the glass storage tank is known to be 1.75 m² with a length of 1.17 meters and a width of 1.5 meters. This total area is combined with the glass processing area according to the machine dimensions in Table 5.6. To facilitate worker activities, each side of the tool and storage tank is given additional space, so that the final size of the machine placement area is adjusted to the result of this addition.

- Glass crusher machine $= (1{,}35 + 3{,}37) \times (0{,}6 + 2{,}25)$ m …………. (42)
  $= 13{,}45 \text{ m}^2$
- Glass melting furnace $= (0{,}45 + 4{,}27) \times (0{,}45 + 1{,}75)$ …………... (43)
  $= 10{,}38 \text{ m}^2$
- Glass storage tank area $= (1{,}17 + 0{,}33) \times (1{,}5 + 1{,}22)$ m …………. (44)
  $= 4{,}08 \text{ m}^2$

Therefore, the total area of the glass storage and processing site is as follows.

Total area $= 4{,}08 \text{ m}^2 + 30{,}91 \text{ m}^2$ ………………………………………….. (45)

$= 34{,}9 \text{ m}^2$

5. Box/Cardboard Storage

Box or cardboard waste at the TPST is not processed, but around 10% is used as fuel for incinerators, while the rest is sold. Before being sold, this waste is packaged using a press machine according to type and color to facilitate the sales process. The space required includes an area for the storage and packaging of cardboard.

Cardboard box/cardboard sale time = every 15 days
Planned pile height = 1.5 meters
Planned width = 2 meters

Total sale volume = sale period × daily waste volume ………………………. (46)

$= 15 \times 0{,}38 \text{ m}^3/\text{day}$

$= 5{,}7 \text{ m}^3/\text{day}$

Cardboard box storage bin area $= \frac{\text{Total box volume } (m^3/day)}{\text{Planned stack height } (m)}$ ………………… (47)

$= \frac{5{,}7\ m^3/day}{1{,}5 \text{ m}}$

$= 3{,}8 \text{ m}^2$

Cardboard box storage bin length $= \frac{\text{Storage bin area } (m^2)}{\text{Planned width } (m)}$ ……………………… (48)

$= \frac{3{,}8\ m^2}{2\ m}$

$= 1{,}9$ m

After determining the area of the box/cardboard storage bin with a length of 1.9 meters, a width of 2 meters, and an area of 3.8 m2. Therefore, the total area of the box/cardboard storage plus the box packaging area with the machine dimensions used in Table 5.7. To make it easier for workers to do their jobs, the area on each side of

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the tool and storage bin used is added, so that the location of the machine and bin will have the following length.

- Press Machine = (1 + 4,6) × (1 + 4) m …………… (49)
  = 28 m^2
- Cardboard box/carton storage bin = (1,9 + 3,1) × (2 + 0,375) m …….. (50)
  = 11,87 m^2

Therefore, the total area of the box/cardboard storage and packaging location is as follows.

Total area = 11,87 m^2 + 28 m^2 ……………………………………………. (51)
= 39,87 m^2

6. Cans and Metal Storage

Cans and metal waste at the TPST are not processed, but are sold directly. Before being sold, this waste is packaged using a press machine according to type and color to facilitate the sales process. The space required includes an area for metal storage and packaging.

Cans and metal sales time = every 15 days
Planned pile height = 1 meter
Planned width = 1.5 meters
Total sales volume = sales period × daily waste volume ……………... (52)
= 15 × 0,15 m^3/day
= 2,25 m^3/day

Area of cans and metal storage location $= \frac{\text{Total Volume of cans/metals (m}^3\text{/hari)}}{\text{Planned Stockpile Height (m)}}$. …………………………………….. (53)

$= \frac{2{,}25\ \text{m}^3\text{/day}}{1\ \text{m}}$

= 2,25 m^2

Length of storage location $= \frac{\text{Storage location area (m}^2\text{)}}{\text{Planned width (m)}}$ …………………. (54)

$= \frac{2{,}25\ m^2}{1{,}5\ m}$

= 1,5 m

After determining the area of the can and metal storage location with a length of 1.5 meters, a width of 1.5 meters, and an area of 2.25 m2, the can or metal packaging location will be carried out on the same press machine as the box/cardboard packaging area. To make it easier for workers to do their jobs, the area on each side of the storage bin used is added, so that the bin location will have the following length.

Area of the can or metal storage location = (1,5 + 0,375) × (1,5 + 3,5) m …... (55)
= 9,375 m^2

7. Hazardous Waste Management

Hazardous waste is not included in the waste sampling results in Lhoknga District. However, in accordance with Minister of Public Works Regulation No. 03/PRT/M/2013, the construction of a solid waste management facility (TPST) must provide hazardous waste storage facilities, either for processing at the TPST site or by

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a third party. This waste is stored in 240-liter Krisbow bins. The land required for hazardous waste storage, with an additional 0.6 meters on each side of the bin, is as follows.

Width of hazardous waste storage location = 4 × (Bin width + 0,6 m) ……….. (56)
= 4 × (0,58 m + 0,6 m)
= 4,72 meter

Length of hazardous waste storage location = Bin Length + 0,6 m …………..... (57)
= 0,76 m + 0,6 m
= 1,36 m

Planned transportation area = Length 2 meters × width of storage location ……………………………………………… (58)
= 2 × 4,72 m
= 9,5 m^2

After obtaining the required area for B3 waste storage with an area of 6.42 m², it is added to the planned transportation area as follows.

Total Area = 6,42 m^2 + 9,5 m^2 ……………………………………………... (59)
= 15,92 m^2

8. Residue Processing

Residue is waste that cannot be recycled and must be processed. At the TPST, it is processed by incineration using an environmentally friendly incinerator every three days. The amount of residue processed reaches 5.13 m³ per day, with the space requirements adjusted for the residue storage bin.

Planned pile height = 1 meter
Planned width = 5 meters
Total residue volume = 5.13 × 3 = 15.39 m^3/day

Residue storage tank area $= \frac{\text{Total Residue Volume } (\text{m}^3/\text{hari})}{\text{Planned Pile Height } (\text{m})}$ …………….......... (60)
$= \frac{15{,}39\ (\text{m}^3/\text{hari})}{1\ (\text{m})}$
= 15,39 m^2

Length of residue storage tank $= \frac{\text{Storage area } (\text{m}^2)}{\text{Planned width } ((\text{m})}$ ………………………... (61)
$= \frac{15{,}39\ (m^2)}{5\ (m)}$
= 3,08 m

After determining the area of the residue storage tank with a length of 3.08 meters, a width of 5 meters, and an area of 15.4 m2, the total area of the storage area is added to the combustion area using an incinerator with the dimensions used in Table 5.10. To facilitate the workers in performing their tasks, the area on each side of the equipment and storage area used is added as follows.

- Incinerator = (1,2 + 0,725) × (0,78 + 5,747) m ………. (62)
= 12,57 m^2
- Storage tank area = (3,08 +3,297) × 5 m …………………… (63)
= 31,89 m^2

Therefore, the total area of the reception and sorting location is as follows.

Total area $= 31{,}89\ m^2 + 12{,}57\ m^2$ ………………………………………… (64)
$= 44{,}46\ m^2$

Based on the calculations for all storage, processing, and operational support areas, the land requirements for the construction of the TPST in Lhoknga Subdistrict are presented in Table 8.

Table 4. Total Land Area Required for TPST

No.	Space	Land Requirements
1	Waste reception and sorting room: a. Waste reception room (T, 0.7 m) b. Waste sorting room	 11,97 × 10 m = 119,7 m² 4,57 × 8,4 m = 38,38 m²
	Total	158,08 m²
2	Organic Waste Processing Room: a. Coconut storage room (T, 1.2 m) b. Coconut processing room c. Yard waste and food waste shredding room d. Yard waste and food waste composting room	8,68 × 7 m = 60,76 m² 6,72 × 7,85 = 52,75 m² 4,57 × 8,8 m = 37,5 m² 6 × 16,1 m = 96,6 m²
	Total	247,61 m²
3	Inorganic Waste Processing Room: a. PET storage room (T, 1.2 m) b. LDPE storage room (T, 1.2 m) c. HDPE storage room (T, 1.2 m) d. Plastic shredding room e. Plastic melting room f. Plastic pellet molding room g. Plastic drying room h. Plastic washing room i. HDPE plastic processing room j. Glass storage room (T, 1.2 m) k. Glass shredding machine room l. Glass melting furnace room. m. Glass molding room n. Box/cardboard storage room (T, 1.5 m) o. Can and metal storage room (T, 1 m) p. Box/cardboard and can and metal packaging room	 3,17 × 1,875 m = 5,94 m² 3,17 × 1,75 m = 5,54 m² 3,17 × 1,75 m = 5,54 m² 5,625 × 2 m = 11,25 m² 7,425 × 1,75 m = 12,9 m² 7,5 × 5 m = 37,5 m² 1,875 × 5,17 m = 9,69 m² 2,45 × 5,17 m = 12,6 m² 2,35 × 6,61 m = 15,53 m² 2,72 × 1,5 m = 4,08 m² 4,72 × 2,85 m = 13,45 m² 4,72 × 2,2 m = 10,38 m² 4,72 × 1,5 m = 7,08 m² 5 × 2,375 m = 11,87 m² 1,875 × 5 m = 9,375 m² 5,6 × 5 m = 28 m²
	Total	200,72 m²
4	Hazardous Waste Room: a. Hazardous waste storage room b. Hazardous waste transportation room	 1,36 × 4,72 m = 6,42 m² 2 × 4,72 m = 9,44 m²
	Total	15,92 m²
5	Residue Chamber: a. Residue storage chamber b. Residue combustion chamber (Incinerator)	 3,08 × 5 m = 15,4 m² 1,8 × 1,38 m = 2,45 m²
	Total	17,85 m²
6	TPST Additional Rooms: a. Administration Room (Office) b. Toilet c. Prayer Room d. Prayer Room Toilet	 4,2 × 6 m = 25,2 m² 2 × 1,5 m = 3 m² 6 × 6 m = 36 m² 6 × 3,5 m = 21 m²

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No.	Space	Land Requirements
	e. Warehouse f. TPST Operational Vehicle Parking Area g. Worker Vehicle Parking Area h. Security Post	3,55 × 5 m = 25 m^2 4,2 × 6 m = 25,2 m^2 2,16 × 8,05 m = 17,38 m^2 4 × 6 m = 24 m^2
	Total	176,78 m^2
Total Area Requirement		**816,96 m^2**

c. Cost Budget Plan (RAB) for TPST Construction

The Budget Plan (RAB) for the construction of the TPST in Lhoknga Subdistrict, Aceh Besar Regency, was calculated in 5 stages of work. The budget details for each stage of work are as follows in Table 9.

Table 5. Summary of the Overall Budget Plan for the Lhoknga Subdistrict TPST

No.	Job Description	Total Cost (IDR)	
I	Preparation	Rp	24.060.987
II	TPST Construction Work	Rp	1.679.821.955
III	Procurement of Waste Processing Equipment	Rp	2.383.800.579
IV	Electrical Installation Work	Rp	7.373.450
V	Other Work	Rp	27.303.600
	Total Budget	Rp	4.122.360.570

Conclusion

This study contributes to the development of a data-driven Integrated Waste Processing Facility (TPST) planning framework as a strategic solution for waste management in Lhoknga Sub-district, Aceh Besar Regency. The planning results indicate that existing waste management faces structural challenges related to limited resources, infrastructure, and community participation, highlighting the need for an integrated facility at the sub-district level. The proposed TPST is designed to manage 83.78 m^3/day of waste projected until 2043 through organic, inorganic, and residue treatment systems in compliance with national regulations, with an estimated construction cost of IDR 4.12 billion. This planning provides practical implications for local policy and spatial planning, particularly for sustainable waste management in coastal tourism areas.

This study is limited to TPST planning based on existing conditions, population and waste generation projections over a 20-year period, including layout design and construction cost estimation. Operational and maintenance costs were not included. Future efforts should include the development of digital-based waste management information systems for real-time TPST monitoring, further studies on operational and maintenance costs, and financial feasibility analyses such as NPV, IRR, and BCR to support policy and investment decisions.

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