Funded by the European Union

DESK STUDY ON THE POTENTIAL AND TECHNICAL REQUIREMENTS FOR UTILISATION OF REFUSE-DERIVED FUEL TECHNOLOGIES & RDF OFF-TAKERS IN INDONESIA: VOLUME 2: CLUSTERING RDF IMPLEMENTATION AND OFF-TAKER POTENTIAL (based on SustainiMap RDF Insight Tool)

September 2024

Project: Support for Infrastructure Investments in Indonesia (S4I)
Assistance Project
Consulting Services for Project Implementation

Assistance for the Establishment of Indonesia's Development Bank Project – Implementation Consultant
Employer: Perseroan Terbatas Sarana Multi Infrastruktur ("PT SMI")
Project Id: ACA/2019/408-641
Procurement No: 506536

DORNIER Group Synergy Consulting

The Project is funded by the European Union

COVER PAGE

Client / Partner and Financier (name, contact person):	PT SMI
Project Title:	Support for Infrastructure Investments in Indonesia (S4I): Consulting Services for Project Implementation
Project No./ BMZ No.:	Project Number ACA/2019/408-641; Procurement Number: 506536
Consultant	Waste Management Expert Team
Reporting title, report number:	Desk Study on the Potential and Technical Requirements for Utilisation of Refuse-Derived Fuel Technologies & RDF Off-Takers in Indonesia: Volume 2: Clustering RDF Implementation and Off-Taker Potential
Main contractual dates (date of Contract Agreement, commencement date, completion date):	Contract Agreement: 15 March 2022 Commencement Date: 29 March 2022 Completion Date: 29 December 2025
Prepared:	JV Dornier – Suntrace – Synergy Consulting
Approved:	PT SMI: Tata Sumirat, Team Leader Puti Faraniza, Project Manager

This publication has been prepared with the support of the European Union.

The Project is funded by the European Union

The Dornier SustainiMap RDF Insight tool combines the concepts of sustainability and mapping, reflecting the tool's integration of results from Multi-Criteria Analysis and Geographic Information System (GIS) Analysis. The tool provides insightful analysis and mapping for sustainable RDF facility development, suitable for a range of stakeholders including development banks and environmental agencies, reflecting socio-economic development goals and market potential.

Table of Contents

1. Context....6
2. Contextualizing Refuse-Derived Fuel Management in Indonesia....8
2.1 Criteria for Decision Making on establishment of an RDF Facility....10
2.2 Integrating the Three: Landfills, RDF Facilities, and Traditional versus Potential Off-taking Industries....12
3. The Critical Role of Decision-Making Tools....13
4. Data Collection and Analysis....14
4.1 Outreach to Industry Associations....14
4.1.1 Indonesian Cement Industry....14
4.1.2 Indonesian Fertilizer Industry....15
4.1.3 Metal Foundry Association....15
4.1.4 The Plastic Industry Association....16
4.1.5 The Smelter Association....16
4.1.6 Pulp and Paper Industry....16
4.1.7 Textile Industry....17
4.2 Off-Taker Survey: Introduction and Background....17
4.2.1 Survey Methodology and Key Findings....17
5. The Features of the SustainiMap RDF Insight Tool....21
5.1 Creation and Refinement of the SustainiMap RDF Insight Tool....21
5.2 Combining GIS and Multicriteria in SustainiMap RDF Insight....22
5.2.1 How Criteria Weights Are Determined....24
5.2.2 Note on Potential Off Takers....25
5.3 Utilisation for SustainiMap RDF Insight....26
5.3.1 Use of Secondary Data and Limitations....26
5.3.2 Utilisation of The Survey Results....27
5.4 "SustainiMap RDF Insight" as an Initial Screening Tool for RDF Facility Planning....28
6. MCA findings....29
6.1 Ranking Results....30
6.2 Cluster Details Presentation....35
7. Findings of SustainiMap RDF Insight....37
7.1 Scope of Analysis....37

The Project is funded by the European Union

7.2 Demand and Supply Integration 38
7.3 Presenting The Findings 39
7.4 Provinces GIS Mapping 41
7.4.1 Jawa Island 41
7.4.2 Sumatera Island 43
7.4.3 Kalimantan Island 45
7.4.4 Sulawesi Island 46
7.4.5 Nusa Tenggara Archipelago 47
7.4.6 Papua Island 48
Annex 1 – Structured Questionnaires 49
Annex 2 – Off-taker Survey Results 55
Annex 3 - The Excel MCA Model in Detail 62

The Project is funded by the European Union

LIST OF ABBREVIATIONS

CV	Calorific Value
EF	Existing RDF Facilities in Vicinity
EIA	Environmental Impact Assessment
FGD	Focus Group Discussions
GIS	Geographic Information System
INAPLAS	Asosiasi Industri Olefin, Aromatik dan Plastik Indonesia (Indonesian Olefin, Aromatic and Plastics Industry Association)
MCA	Multi-Criteria Analysis
MCDA	Multi-Criteria Decision Analysis
MCDM	Multi-Criteria Decision-Making
MoEF	Ministry of Environment and Forestry
MoU	Memorandum of Understanding
MSME	Micro, Small, and Medium Enterprises
MSW	Municipal Solid Waste
MW	Megawatt
NPK	Nitrogen, Phosphorus, and Potassium
P	Population in the Nearest City
PLN	Perusahaan Listrik Negara
PLTU	Pembangkit Listrik Tenaga Uap (Power Plant)
POT	Potential Off-takers in Vicinity
PS	Potential Raw Material Suppliers for an RDF Facility
PT	Perseroan Terbatas
PT SMI	Perseroan Terbatas Sarana Multi Infrastruktur
R	Risks on Plausibility/Completeness of Data
RDF	Refuse-Derived Fuels
SIG	Semen Indonesia Group
SIPSN	Sistem Informasi Pengelolaan Sampah Nasional (National Waste Management Information System)
TO	Traditional Off takers in Vicinity
TPA	Tempat Pembuangan Akhir (Landfill)
TPST	Tempat Pembuangan Sampah Terpadu (Integrated Landfill)
TSR	Thermal Substiitution Rate
UPT	Unit Pengelola Teknis (Technical Management Unit)
V	Volume/Size of a Landfill

The Project is funded by the European Union

1. Context

In the rapidly evolving landscape of waste management and renewable energy, the implementation of refuse-derived fuel (RDF) projects in Indonesia presents a unique set of challenges and opportunities. The key to navigating this complex terrain lies in the development of a screening tool, which is indispensable in making informed investment decisions regarding the location and development of potential RDF facilities. Such a tool serves a crucial role in mitigating investment risks by providing a comprehensive analysis of various critical factors. In its early stage it provides the basis to offer a holistic screening of potential projects, encompassing waste availability for RDF and potential demand proximity to landfills.

Such a screening tool helps facilitate strategic decision-making and planning, enabling involved entities to decide which locations to choose to go a step further and develop pre-feasibility and feasibility studies. By also assessing industry synergies of existing and or potential RDF off takers, the suggested screening tool aids in identifying partnerships with municipalities in charge and strategic alignments with off-taking industries, ensuring that the development of RDF facilities is not only economically viable but also contributes to the broader sustainability and renewable energy objectives of Indonesia.

The tool compiles insights gathered throughout this study, leveraging a diverse data collection strategy. This approach includes an analysis of secondary data, enriched by firsthand information from stakeholder interviews and surveys. The tool consists of two major components:

- The study utilizes databanks in Excel and GIS, detailing information on landfills and off-takers. These databases are tailored specifically for the study's objectives, aiming to identify strategic clusters for the development of RDF facilities. The selection is guided by the potential for off-take agreements and the overarching environmental goal of minimizing landfill usage in the future.
- Multi-Criteria-Analysis model, that scores evaluated clusters of potential RDF supply and demand within a given province.

This tool is engineered to provide an intricate and layered analysis, essential for making informed decisions in the complex domain of RDF facility establishment. The multi-criteria decision-making aspect incorporates a comprehensive set of criteria currently focussing on potential development impact and economic feasibility of an RDF facility development in a selected region.

Complementing this, the GIS component adds a spatial dimension visualising the analysis. It enables the precise mapping of potential sites in relation to critical factors such as proximity to waste sources (landfills), infrastructure, and off-taking industries. This spatial analysis helps align geographical implications, logistical challenges, and opportunities, providing a clear visual representation of the most suitable clusters for RDF facilities at a screening phase.

These integrated features elevate the screening tool beyond a mere decision-support system to a strategic planning tool, designed to navigate the complex realm of RDF project development in Indonesia. It harmonizes environmental sustainability with economic viability, paving the way for in-depth exploration during the pre-feasibility and feasibility phases.

The Project is funded by the European Union

The current configuration of the decision-making tool for evaluating potential RDF facilities in Indonesia has been primarily designed from the perspective of a development bank. This orientation means that the tool's algorithm assigns specific weights to various criteria based on factors that development banks typically prioritize, such as potential project feasibility, socio-economic impact, environmental consideration.

However, recognizing the diverse needs and priorities of different stakeholders, the tool has been designed with a high degree of flexibility. Set of criteria and their weights can adapted to suit the requirements of decision makers. For instance, if an organisation is more oriented towards environmental and health interventions, the tool can be adjusted accordingly. Users have the capability to add new criteria relevant to their goals, such as technology considerations, air quality impact, or the effects on local ecosystems. Moreover, the weighting of existing criteria can be altered to reflect changing priorities.

This adaptability transforms the tool into a dynamic solution, capable of accommodating a broad spectrum of objectives and viewpoint. By allowing users to customise criteria and their respective weights, the tool becomes a comprehensive platform that aligns with the specific goals of different entities, whether they are development banks, environmental agencies, or public health organisations. This feature ensures that the tool remains relevant and effective across various scenarios and decision-making processes, particularly in the diverse and evolving field of RDF facility development at the screening phase.

The data of analysis was collected at the previous stages of the study with the support of the Ministry of Environment and Forestry and PT SMI.

The Project is funded by the European Union

2. Contextualizing Refuse-Derived Fuel Management in Indonesia

Indonesia, with its vast population and rapid urbanisation, faces significant challenges in waste management. The country generates millions of tons of solid waste annually, much of which ends up in landfills. This scenario presents not only environmental concerns but also a missed opportunity to utilise waste as a resource.

Indonesia's reliance on landfills for waste management not only contributes to environmental challenges like greenhouse gas emissions and leachate generation but also leads to broader impacts. These include habitat destruction, groundwater contamination, air pollution from toxic gases, and an increase in disease vectors such as rodents and insect. Refuse-derived fuel emerges as a transformative solution in this context. This process not only aids in effective waste management but also contributes to sustainable energy production, aligning with Indonesia's growing focus on renewable energy sources and waste-to-energy initiatives.

The implementation of RDF technology can mitigate these issues by reducing the volume of waste that reaches landfills. RDF, being a product of materials such as plastics, biodegradable waste, and other combustibles, provides a dual benefit. It not only reduces landfill dependency but also creates a source of alternative energy. This is particularly pertinent in Indonesia, where energy demand is continuously rising. By tapping into RDF, Indonesia can address two critical issues simultaneously: managing its growing waste problem and meeting its increasing energy needs in a more sustainable manner.

The adoption of RDF is closely aligned with Indonesia's national goals for sustainability and environmental protection. The country has committed to reducing its greenhouse gas emissions and increasing the share of renewable energy in its energy mix. By transforming waste into a resource, RDF supports the circular economy concept, which is integral to sustainable development. Furthermore, the development of RDF facilities can lead to technological advancements, capacity building, and the creation of new jobs, contributing to the country's economic growth while adhering to its environmental commitments.

The Economic and Environmental Potential of RDF Facilities in Indonesia:

1. Economic Advantages of Proximity to Landfills (80km as a logistically justified radius): Establishing RDF facilities near landfills in Indonesia offers substantial economic benefits. The close proximity to waste sources reduces transportation costs significantly, as the primary raw material – municipal solid waste – is readily available. This logistical advantage can lead to substantial cost savings, enhancing the overall feasibility and profitability of RDF projects. Additionally, these facilities stimulate local economies by creating new jobs in both the construction and operational phases. The development of a local RDF industry can also foster ancillary industries, such as supporting equipment manufacturing and maintenance services, further bolstering economic growth in the medium and long-runs.
2. Environmental Benefits and Efficiency Enhancement: Environmentally, RDF facilities near landfills can drastically reduce the environmental impact of waste disposal. By diverting waste from landfills to RDF production, these facilities can significantly lower greenhouse gas emissions, particularly methane, which is a potent contributor to climate change. Moreover, the conversion of waste into RDF is an effective way to manage non-recyclable waste, thus reducing landfill volume and extending their operational life. The energy produced from Refuse-Derived Fuel (RDF) represents a cleaner alternative to traditional

The Project is funded by the European Union

fossil fuels for several key reasons, which contribute significantly to Indonesia's transition towards more sustainable energy sources:

- **Lower Greenhouse Gas Emissions**: RDF, derived from municipal solid waste, typically results in lower net greenhouse gas emissions when combusted compared to fossil fuels. This reduction is partly because the carbon dioxide released during the combustion of biogenic (organic) components of waste is considered part of the natural carbon cycle, as opposed to the carbon from fossil fuels, which introduces carbon stored for millions of years back into the atmosphere.
- **Waste Reduction**: Utilizing waste to produce RDF tackles the issue of waste accumulation in landfills, which is a significant problem in Indonesia. By diverting waste from landfills, RDF production reduces methane emissions—a potent greenhouse gas—produced by the anaerobic decomposition of organic waste in landfills.
- **Energy Recovery from Non-Recyclable Materials**: RDF includes the fraction of waste that is non-recyclable. By converting this waste into energy, RDF technology ensures that even materials that cannot be recycled are used efficiently, reducing the overall environmental impact of waste disposal and contributing to a more circular economy.

The strategic location of these facilities may also enhance operational efficiency, ensuring a steady and reliable supply of waste feedstock, which is crucial for continuous energy production.

3. Contribution to Indonesia's Circular Economy Goals: The establishment of RDF facilities aligns well with Indonesia's broader goals of fostering a circular economy. By turning waste into a valuable resource, RDF technology embodies the principles of a circular economy, where waste is minimised, and resources are used efficiently. This approach not only addresses the waste management challenge but also contributes to the country's renewable energy mix. Indonesia's commitment to increasing the share of renewable energy in its portfolio can be significantly supported by RDF, as it provides a sustainable and locally sourced energy alternative. This not only aids in achieving national energy goals but also contributes to global efforts in reducing carbon emissions.

Important goal of implementing interventions like RDF facilities, as part of a broader waste management strategy, is the reduction of landfill usage, one of a central perspective for Ministry of Environment and Forestry. This objective is critical for several reasons:

Environmental Impact Reduction: Landfills are a significant source of environmental pollution, including greenhouse gas emissions, particularly methane, which is a potent contributor to climate change. They also pose risks of groundwater contamination and negatively impacts local ecosystems. By diverting waste from landfills to RDF facilities, these environmental impacts can be significantly reduced.

Sustainable Waste Management: The conversion of waste into RDF is an example of a sustainable waste management practice. It allows for repurposing of waste materials that would otherwise contribute to the growing problem of landfill overuse. This approach aligns with the principles of a circular economy, where waste is minimised, and resources are utilised more efficiently.

The Project is funded by the European Union

Conservation of Land Resources: Landfills require large areas of land, which could otherwise be used for industry (in some cases even agriculture), conservation, or urban development in the long run. By reducing reliance on landfills, valuable land resources are redirected to more beneficial uses.

Public Health and Safety: Landfills can have adverse effects on public health and safety, including contamination, increased traffic from waste transport vehicles, and potential for pest infestations in nearby communities.

Economic Efficiency: Over time, the costs associated with landfill operations can be significant, including land acquisition, maintenance, and eventual closure and post-closure care. RDF facilities, by diverting waste from landfills, reduce these long-term financial burdens on municipalities and governments.

Energy Recovery and Resource Utilisation: RDF facilities contribute to energy recovery by converting waste into a usable fuel source. This not only provides an alternative to fossil fuels but also ensures that the inherent energy in waste materials is effectively utilised rather than being lost in landfills.

2.1 Criteria for Decision Making on establishment of an RDF Facility

Deciding whether or not to establish a facility for refuse-derived fuels involves considering several critical criteria that span across environmental, economic, technical, regulatory, and social aspects:

Availability of Feedstock:	The consistent availability of sufficient waste materials to be converted into RDF is a primary consideration. This includes assessing the quantity, quality, and composition of the waste. In the current study this was addressed through utilisation of data on landfill annual supply provide by the Ministry of Environment and Forestry. Large size of landfills and demand are considered as proxies for assumed economic viability to be précised at the pre-feasibility and feasibility stages after the screening stage.
Market Demand for RDF	This reflects demand for RDF as a fuel source. This involves understanding the market size, potential off taker (like cement industries, other industries), and the competitive landscape, including the presence of alternative fuels. In the current study the demand was reflected as extrapolation from industry insights and stakeholder survey reported values (see next chapters).

The Project is funded by the European Union

Environmental Impact and Compliance	Any RDF facility must comply with environmental regulations. This includes conducting Environmental Impact Assessments (EIA), ensuring air and water pollution controls, and considering the facility's carbon footprint and its alignment with sustainability goals. At the screening stage a proximity to large cities and the idea to reduce a landfill size as a consequence of RDF production are considered as proxy for environmental impact.
Technology and Operational Efficiency:	Responses from the stakeholder survey indicated perceived technological appropriateness and efficiency. In subsequent phases, the technology must be validated as effective and appropriate for the available waste types, while also meeting the requirements of off-takers. Operational efficiency, including the ease of maintenance and scalability of the technology, is also important.
Transportation and Logistics	The proximity of the waste source to the facility and the end-user of RDF is important. Logistics costs, including transportation of waste and the finished product, can significantly impact the project's overall feasibility. 80 km radius is selected as initial filter, precise locations need to be investigated at the next phases.
Further considerations not directly included into screening phase, but assumed as readiness of the sector to be investigated at later stages	**Regulatory and Policy Framework:** Understanding and adhering to existing regulations regarding waste management and energy production is essential. This includes permits, zoning laws, and waste disposal regulations to be checked at the implementation. **Community Acceptance and Social Impact:** Gaining the support of the local community is crucial. This involves addressing concerns about pollution, traffic, noise, and contamination, and demonstrating the project's benefits, such as job creation and environmental improvements. **Land Availability and Suitability:** Availability of suitable land at a reasonable cost is necessary. The site should be appropriate in terms of size, accessibility, and should not be prone to environmental hazards like flooding. **Energy Recovery Efficiency:** The energy recovery efficiency from the RDF process must be sufficiently high to ensure the project's viability. This involves assessing the

The Project is funded by the European Union

	calorific value of RDF and its suitability as a fuel replacement in target industries. **Long-term Sustainability:** The project should align with long-term sustainability goals, including waste reduction, recycling, and renewable energy targets

Each of these criteria must be thoroughly evaluated to ensure that the establishment of an RDF facility is viable, sustainable, and beneficial from both an environmental and economic standpoint.

2.2 Integrating the Three: Landfills, RDF Facilities, and Traditional versus Potential Off-taking Industries

Identifying Off-taking Industries for RDF: The success of RDF facilities in Indonesia heavily relies on identifying and establishing strong connections with off-taking industries. These industries, which could range from cement manufacturing to fertilizer production, play a crucial role in determining the demand for RDF. The first step involved a comprehensive analysis to identify those industries that rely on high-energy fuels and are seeking sustainable, cost-effective alternatives. Cement plants, for instance, can use RDF as a partial replacement for coal, offering both environmental benefits and cost savings. By understanding the specific energy needs and sustainability goals of these industries, RDF facilities will have to tailor their production to meet market demands effectively.

Benefits of Proximity Between RDF Facilities and Off-taking Industries: Establishing RDF facilities near both landfills and potential off-taking industries presents numerous benefits. Proximity reduces transportation costs and carbon footprint, making RDF a more attractive and environmentally friendly option for industries. This logistical advantage serves as a significant selling point for RDF facilities during contract negotiations with various industries. Additionally, close proximity allows for better coordination and reliability in supply, which is crucial for industries that require a consistent and uninterrupted flow of fuel. For industries looking to reduce their environmental impact, sourcing RDF from nearby facilities aligns with their sustainability objectives, as it demonstrates a commitment to reducing waste and promoting renewable energy sources within the local ecosystem.

The Project is funded by the European Union

3. The Critical Role of Decision-Making Tools

In the context of RDF projects, screening tools play a critical role in guiding investment decisions by evaluating various risk factors and project feasibility. The results of study findings were summarised in a screening exercise matching revealed results of the RDF Supply and RDF Demand sides – through the SustainiMap RDF Insight tool designed for the purposes of this study.

The tool relied on data collection from primary and secondary sources, encompassing an excel model (see Annex 3), a GIS databank (submitted as source files separately), as well as map Atlas visualising the results of the analysis.

The SustainiMap RDF Insight tool has been designed to evaluate various dimensions including socio-environmental and economic impacts, alongside the technical feasibility and potential of a location for developing into an RDF production cluster, by analyzing supply and demand within a specified region. By providing a comprehensive analysis of these factors, SustainiMap RDF Insight enables an informed decision-making to select RDF clusters for further exploration, driven by potential for successful implementation and sustainable operation considerations.

SustainiMap RDF Insight incorporates a range of criteria to evaluate the viability of a project comprehensively. This includes analysing local waste management practices, availability and composition of waste, proximity to landfills, potential socio-economic impacts. The tool also assesses the market demand for RDF, including potential off-takers and the competitive landscape. This thorough analysis helps in understanding the holistic picture of the project's potential, guiding investors toward decisions that align with project sustainability principles.

Screening tools not only aid in the initial decision-making process but also assist in strategic planning and project development. By highlighting key areas of concern and potential, SustainiMap RDF Insight tool enables investors and developers to focus their resources effectively.

SustainiMap RDF Insight allows also to evaluate potential synergies with off-taking industries. This involves analysing factors such as the geographical distribution of industries, their demand, sustainability policies, and openness to using alternative fuels like RDF. Financial aspects, such as estimated investment costs, operational expenses, and projected revenues, however, are not accessed at the level of screening, and need to be investigated at the next level of project maturity. The proxy for financial viability is the landfill size and demand segment in a cluster.

By providing insights into these areas, the screening tool helps RDF project developers and investors identify the most viable and profitable partnerships with off-taking industries. It also aids in crafting targeted strategies to approach and collaborate with these industries, ensuring a mutually beneficial relationship that supports the growth and sustainability of the RDF sector in Indonesia.

Clustering is evaluated at the provincial level, incorporating the most promising landfills and demand sites located within a proximity of 80 km, all within the boundaries of a single province.

The Project is funded by the European Union

The following chapters describe the data collection methods and analysis utilised in the study, as well as the configuration of the multi-criteria analysis tool.

4. Data Collection and Analysis

4.1 Outreach to Industry Associations

In October 2023, PT SMI and the Ministry of Environment and Forestry have facilitated the organisation of structures outreach to Industrial Association of Indonesia, which were deemed to be potential off takers. A structured questionaire has been submitted to industries before this outreach event to enquire on their awareness of RDF technologies and readiness of adaptations to the particular industries (see Annex 1). The following findings were revealed during the stakeholder interview and used for extrapolation of off-taker demand in RDF.

4.1.1 Indonesian Cement Industry

The Indonesian cement industry is predominantly led by Semen Indonesia Group (SIG) and Indocement, with smaller actors in the market. The Indonesian Cement Industry is a significant player in the country's industrial landscape, with 16 major companies operating 48 cement kilns. These companies are primarily located in Java, with a few spreads across Sumatera, Sulawesi, Kalimantan, and Papua. About 75% of the industry expressed their readiness for co-firing, and the thermal substitution rate (TSR) is 7.8%. The industry is a major consumer of coal, estimated at 8 million tonnes per month and reaching 13 million tonnes per month at full capacity, with a TSR target of 10%.

The Ministry of Environment and Forestry guidelines, established in 2009, outline the regulations concerning hazardous materials and municipal waste, including technical specifications. The industry has been actively exploring alternative fuels, such as biomass and RDF.

The path towards RDF adoption commenced with the initiative to construct the first RDF plant in 2014, which was completed in Cilacap by 2017. For instance, Indocement, one of the major players, has pioneered bio-drying pilot plants in Palimanan, Narogong, and Citeurep. The first RDF plant in Cilacap, supplies RDF to Solusi Bangun Indonesia. The plant processes 160 tonnes of waste per day, producing 80 tonnes of RDF through bio-drying. Technical specifications for RDF production adhere to guidelines set by the industry and the MoEF.

Semen Indonesia Group (SIG) contributes to 50% of the production capacity of all cement industries in Indonesia. While major players like SIG, Indocement, and Semen Jawa are ready for RDF adoption, smaller companies face challenges due to the lack of feeding and handling systems. The industry is keen on becoming RDF off-takers, with a focus on operational efficiency.

The MoEF has established emission regulations for hazardous fuel and RDF, with limits set for CO emissions. Cement companies are required to install Continuous Emission Monitoring Systems integrated with the MoEF system for monitoring. Before 2021, permits allowing the use of alternative fuel derived from waste had a validity period of 5 years. However, following the enactment of Government Regulation 22 of 2021, technical permits (Pertek) and operation suitability certificates (SLO) remain valid indefinitely unless there are alterations in conditions necessitating changes to environmental documentation. Integration of RDF utilization must be

The Project is funded by the European Union

specified in the environmental documentation, and if absent, adjustments to the environmental documentation are obligatory.

Despite the industry's interest in RDF, challenges such as heat loss, high moisture content, and lower calorie value have led to lower production capacities. To address this, improved systems for emission control and bypass systems need to be installed, which poses financial challenges for smaller companies.

The industry is actively involved in collaborations, as seen in MoUs with regional governments and waste management companies, indicating a commitment to RDF adoption. Municipalities are showing interest, and the future National Roadmap for the cement industry aims to guide the industry's sustainable practices. The industry, operating at 65% of its capacity, seeks government support, including tax reductions, to facilitate the transition to RDF and ensure a sustainable future.

The industry demand in RDF has been extrapolated for the purposes of the current study at the level of 51,000 t/annum on average per enterprise, based on stakeholder interviews re-presenting an industry co-firing target of 10%. During pre-feasibility stage of a project development, it is recommended to verify specific demand of off-takers located in a cluster in which an RDF facility is planned.

All association members are included into the GIS database.

4.1.2 Indonesian Fertilizer Industry

The Indonesian Fertilizer Industry comprises five major members, producing NPK with feedstock from natural gas and ammonia for urea. The industry is exploring decarbonisation, including co-firing with coal and biomass, with a current coal consumption of 1.5 million tons/year. Biomass co-firing studies are ongoing focussing on the associated power plants. The association is cautious about RDF due to varying heating values and concerns about heat consistency, supply continuity, and economic aspects, however, is interested in exploring RDF-co-firing potential in case technological and environmental concerns can be appropriately addressed.

For the purposes of the current screening study, the demand potential was extrapolated based on industry responses during stakeholder outreach events, at the level of 40,000 t/annum as enterprises' average. During pre-feasibility stage of a project development, it is recommended to verify specific demand of off-takers located in a cluster in which an RDF facility is planned.

All association members are included into the GIS database.

4.1.3 Metal Foundry Association

The Metal Foundry Association has 45 members, with various sizes and production capacities for aluminium and nickel. Electricity consumption is significant, mainly for aluminium refining in the automotive industry. There is a lack of information about RDF, and the industry primarily relies on electricity. Industry has no objection, that electricity consumed may be produced with RDF co-firing. For the scope of this study, this implies that regulations aimed at reducing the use of Municipal Solid Waste (MSW) within the energy sector shall apply yet rendering them insignificant for the objectives of the current research.

The Project is funded by the European Union

The extrapolated demand is assumed at zero level for the purposes of the current study in the medium run.

All association members are included into the GIS database.

4.1.4 The Plastic Industry Association

The Plastic Industry Association includes 85 companies concentrated in West Java. While still needing coal for boilers, there is potential for RDF in some processes, however primary industrial focus is plastic recycling, not RDF production. Concerns include high silica content in Jakarta's RDF and the need for proper RDF residue handling. Pyrolysis and chemical recycling are considered, but challenges exist, including license adjustments.

INAPLAS is actively engaged in a pilot project in Jimbaran to address the challenges associated with plastic waste. The focus is on producing RDF as an alternative to managing multilayered plastic. One of the primary issues faced in this endeavour is the scarcity of plastic, as traditionally, plastics are recycled for their higher economic value.

To ensure the successful implementation of RDF, there is a need for clear standards and guidelines. INAPLAS is actively providing valuable inputs to the government, urging the establishment of an Indonesian National Standard for RDF. Moreover, the proposal includes the creation of RDF centers or clusters that cover multiple regions, indicating an integrated and collaborative approach to waste management.

The diverse demands of various association members, coupled with the industry's prioritization of recycling, advocate for projecting zero demand in the mid-term as part of this study's focus. The industry may become co-supplier of raw materials for RDF factories. In each specific project case, it is recommended to consult the position of INAPLAS towards a defined project and involve their members in stakeholder consultation and demand determination studies.

All major association members are included into the GIS database.

4.1.5 The Smelter Association

The Smelter Association has 18 members relying on coal as primary source of energy and some members have their own power plants. Challenges include waiting for government policies related to electric vehicles and complex modifications for RDF use, especially in liquid form.

However, industry mentioned interest in exploring RDF technologies in their production processes. For the purposes of this study, the average industry demand at enterprise level was assumed by extrapolation from the announced plans at the level of 20,000 t/annum. It is recommended to specify these estimations in each particular case at the stage of pre-feasibility and feasibility levels.

All association members are included into the GIS database.

4.1.6 Pulp and Paper Industry

In the pulp and paper industry, there are 112 members, varying in size from large to MSMEs. The average industry consumption includes coal, electricity, and biomass. Some factories have size constraints, leading to an idea of establishing RDF processing facilities from paper waste in East Java. Factories pay for waste treatment services, and there is a notion to transform

The Project is funded by the European Union

small mills into RDF providers. The industry imports three million tons/year of paper, with an emission reduction roadmap of the Waste Reduction Directorate of the Ministry of Environment and Forestry.

The industry interviews revealed that association members cannot target more than 2% of co-firing, and the plans are scattered to constitute a consolidated demand for offtake. However, the industry may be considered in the future as a supplier of raw material for RDF's. The extrapolated demand is assumed at zero level for the purposes of the current study in the medium run, however, with growth of awareness and readiness for RDF offtake across the country, the role of pulp and paper industry may be revisited.

One major pulp & paper company, PT Tjiwi Kimia is considered as one off-taker in the analysis due to its experience in utilizing RDF and has installed boiler for RDF. One additional major company, PT Indah Kiat Pulp & Paper has also utilised boiler for RDF. However, due to its limited internal waste supply, the company is considered only as additional potential supplier of RDF.

Furthermore, it is advisable to engage with individual companies within the most promising clusters during later stages of RDF project development. This engagement should aim to assess their current aspirations and plans concerning the establishment of RDF factories.

All members of paper and pulp industry association are included into GIS database.

4.1.7 Textile Industry

Representatives of textile industry were not participating at the stakeholder outreach in October 2023. Similar to pulp and paper industry the textile sector is considered for the purposes of this study as a potential supplier of raw materials for RDF production.

4.2 Off-Taker Survey: Introduction and Background

Following the stakeholder consultations conducted in October 2023, an off-taker enterprise voluntary survey was initiated by PT SMI in November – December 2023. The results of the survey are available in the Annex 2 to this report.

The purpose of the survey conducted was to assess the current and potential adoption of Refuse-Derived Fuel (RDF) in various industries across Indonesia. The survey targeted entities in sectors such as cement, paper, and fertilizer production, aiming to gather further insights into their current energy consumption, RDF usage plans, and potential collaboration with local governments.

4.2.1 Survey Methodology and Key Findings

Entities representing various industries were approached, and their responses were collected through a structured questionnaire. The questions focused on current energy sources, RDF adoption plans, existing trials, and potential collaboration with local governments.

The following key findings are in line with the response received during industry outreach through association are derived from the survey:

Cement Industry:	Several cement production units, such as PT Semen Indonesia and PT Indocement Tunggal Perkasa Tbk, have conducted trials and plan to increase RDF usage gradually.

The Project is funded by the European Union

	Cooperation with local governments, such as Bali, Tuban, Sidoarjo, Gresik, and Surabaya, is already underway. In addition, two cement companies have implemented RDF. PT Solusi Bangun Indonesia has utilised ca. 50 tpd in Cilacap within three years. Meanwhile, PT Indocement have implemented RDF in Palimanan and Citeureup with limited amount of supply. It is important to note that both companies have agreement with DKI Jakarta provincial government to utilize 150 tpd RDF for PT SBI and 550 tpd RDF for PT Indocement.
Paper and Pulp Industry:	Companies like PT. Surabaya Mekabox and PT. Pabrik Kertas Tjiwi Kimia, Tbk have reported plans to use RDF based on the survey, with the latter awaiting operationalisation. Challenges in the paper industry include the need for government study results and the necessity to conduct studies before implementing RDF usage. At current stage of analysis, only PT Tjiwi Kimia is considered as potential off-taker. Other the companies of this industry are considered as additional supplier of RDF.
Fertilizer Production:	Petrokimia Gresik and PT Pupuk Sriwidjaja Palembang are exploring RDF adoption but highlight the need for further studies. PT Conch South Kalimantan Cement is in the planning phase, aiming to conduct comparative studies with other cement industries.

The responses of the industry are summarised in the table below:

Table 1: Survey responses of various industry stakeholders

Pabrik Pupuk Iskandar Muda-1 (PT Pupuk Iskandar Muda)	• No current use of RDF. • No plans or trials reported.
Pabrik Pupuk Iskandar Muda-2 (PT Pupuk Iskandar Muda)	• Similar to the first facility, no current use of RDF. • No plans or trials reported.
Fasilitas Produksi Semen (PT Cemindo Gemilang Tbk)	• Current fossil fuel usage: 2500 – 3000 tonnes/day. • Plans to use RDF with trials conducted and full implementation in 2024. • Potential RDF use: Not yet known.
Grinding Plant Bayah (PT Cemindo Gemilang)	• Current fossil fuel usage: 300 tonnes/day. • Uses boilers. • Trials with RDF conducted, plans to use RDF in 2024. • Potential RDF use: 5 tonnes/day.
Grinding Plant Bengkulu (PT Cemindo Gemilang)	• Similar to the Bayah facility, conducted trials with plans to use RDF in 2024.
Industri Pengecoran Besi Dan Baja (PT. Metinca Prima Industrial Works)	• Current fossil fuel usage: 16 MMBTU. • No plans for RDF use reported.
Fasilitas Produksi Tissue (PT. Graha Bumi Hijau)	• Current fossil fuel usage: 0.03 tonnes/day. • No plans or trials reported.
Fasilitas Produksi Tissue (PT Graha Bumi Hijau)	• Current fossil fuel usage: 28 tonnes/day. • No plans or trials reported.
Indocement Unit Pabrik Citeureup (PT Indocement Tunggal Pratama)	• Current fossil fuel usage: 800-850 tonnes/day. • Plans to use RDF, with trials conducted.

The Project is funded by the European Union

	• Potential RDF use: Gradual increase until 2030 to reach 3800 tonnes/day.
Pabrik Pengecoran Stainless Steel Dan High Alloy (PT Trieka Aimex)	• No current RDF uses. • Equivalent to electricity production of 1.5 MW/day.
Grinding Plant Ciwandan (PT Cemindo Gemilang)	• Current fossil fuel usage: 300 tonnes/day. • Conducted trials with plans to use RDF in 2024.
Grinding Plant Cibitung (PT Cemindo Gemilang)	• Similar to the Ciwandan facility, conducted trials with plans to use RDF in 2024.
Pabrik Kujang 1a (PT Pupuk Kujang)	• No current RDF use. • No plans or trials reported. • Current energy source: Gas, Electricity, with a boiler.
Pabrik Kujang 1b (PT Pupuk Kujang)	• Similar to Kujang 1A, no current RDF use, plans, or trials reported.
Pabrik Semen (PT Solusi Bangun Indonesia Tbk – Pabrik Cilacap)	• Current fossil fuel usage: 1505.59 tonnes/day. • Already implemented in commercial scale within 3 years to utilize 50 tpd RDF. PT SBI also acts as RDF facility 's operator, in cooperation scheme with Cilacap regency Government. • Potential RDF use: 120 – 168 tonnes/day.
Textile (PT Sari Warna Asli I)	• Current fossil fuel usage: 70 tonnes/day. • Plans to use RDF before 2025.
Industri Garment (PT Bengawan Solo Garment Indonesia)	• Current fossil fuel usage : 2 tonnes/day.
Fasilitas Produksi Textile (PT. Iskandar Indah Printing Textile)	• No current RDF use. • No plans or trials reported.
Indocement Unit Pabrik Palimanan (Cirebon) (Pt Indocement Tunggal Perkasa Tbk)	• Current fossil fuel usage: 400-500 tonnes/day. • Plans to use RDF, with trials conducted. • Potential RDF use: Gradual increase until 2030 to reach 800 tonnes/day.
Pabrik Pengecoran Stainless Steel Dan High Alloy (PT Trieka Aimex)	• No current RDF use. • Equivalent to electricity production of 1.5 MW/day.
Grinding Plant Ciwandan (PT Cemindo Gemilang)	• Current fossil fuel usage: 300 tonnes/day. • Conducted trials with plans to use RDF in 2024.
Grinding Plant Cibitung (PT Cemindo Gemilang)	• Similar to the Ciwandan facility, conducted trials with plans to use RDF in 2024.
Pabrik Kujang 1a (PT Pupuk Kujang)	• No current RDF use. • No plans or trials reported. • Current energy source: Gas, Electricity, with a boiler.
Pabrik Kujang 1b (PT Pupuk Kujang)	• Similar to Kujang 1A, no current RDF use, plans, or trials reported.
Textile (PT Sari Warna Asli I)	• Current fossil fuel usage: 70 tonnes/day. • Plans to use RDF before 2025.
Industri Garment (PT Bengawan Solo Garment Indonesia)	• Current fossil fuel usage : 2 tonnes/day.
Fasilitas Produksi Textile (PT Iskandar Indah Printing Textile)	• No current RDF use. • No plans or trials reported.
Indocement Unit Pabrik Grobogan Jawa Tengah (PT Indocement Tunggal Perkasa Tbk)	• Current fossil fuel usage: < 5 tonnes/day. • Plans to use RDF, with trials conducted. – Potential RDF use: Gradually until 2030 to reach 300 tonnes/day.
Industri Kertas Industri (PT. Mekabox International)	• No current RDF use or plans reported.
Fasilitas Produksi Semen Tuban (PT Semen Indonesia (Persero) Tbk.)	• Current fossil fuel usage: 6,200 tonnes/day. • Plans to use RDF, with trials conducted. – Potential RDF use: 375 tonnes/day. – Exploring cooperation with several local governments.
Pabrik Kertas Pt. Setia Kawan Makmur Sejahtera (PT. Setia Kawan Makmur Sejahtera)	• Current fossil fuel usage: 8 tonnes/day. • No plans or trials reported.
Paper Machine, Power Plant, Wwt, Swt (PT Adiprima Suraprinta)	• No current RDF use. • Current energy source: 0 tonnes/day, Using PLN.

The Project is funded by the European Union

Pabrik Kertas & Karton Box (PT. Surabaya Mekabox)	• Current fossil fuel usage: +- 300 tonnes/day. • Plans to use RDF in 2024, with potential RDF use of +- 15 tonnes/day.
Fasilitas RDF Dan Boiler (PT. Pabrik Kertas Tjiwi Kimia, Tbk)	• Current fossil fuel usage: Ca. 3000 tonnes/day. • Plans to use RDF with a potential use of 250 tonnes/day. – Not yet operational.
Fasilitas Produksi (PT Indonesia Royal Paper)	• Current fossil fuel usage: 75 tonnes/day. • No plans or trials reported. • Awaiting government study results for RDF use.
Pabrik Pupuk Petrokimia (PT Petrokimia Gresik)	• Current fossil fuel usage: 190 tonnes/day. • No plans or trials reported. • A study is needed for RDF use.
Grinding Plant Gresik (PT Cemindo Gemilang)	• Current fossil fuel usage: 300 tonnes/day. • Conducted trials with plans to use RDF in 2024.
Grinding Plant Pontianak (PT Cemindo Gemilang)	• Similar to the Gresik facility, conducted trials with plans to use RDF in 2024.
Fasilitas Produksi Semen (PT. Conch South Kalimantan Cement)	• Current fossil fuel usage: Kiln (700 tonnes/day) and PLTU (375 tonnes/day). • Plans to conduct comparative studies for RDF use. • Potential RDF use: 3 tonnes/day (Planning).
Indocement Unit Pabrik Tarjun, Kalsel (PT Indocement Tunggal Perkasa Tbk)	• Current fossil fuel usage: 150 – 200 tonnes/day. • Plans to use RDF, with trials conducted. • Gradual increase until 2023 to reach 300 tonnes/day.
Grinding Plant Batam (PT Cemindo Gemilang)	• Similar to other facilities, conducted trials with plans to use RDF in 2024.
Semen (PT Semen Kupang (Persero))	• Current fossil fuel usage: 300 tonnes/day coal. • No plans or trials reported.
Grinding Plant Muara Jawa (PT Cemindo Gemilang)	• Similar to other facilities, conducted trials with plans to use RDF in 2024.
Fasilitas Produksi Semen (PT.Sdic Papua Cement Indonesia)	• Current fossil fuel usage: 932 tonnes/day. • Plans to use RDF, with a potential use of 100 tonnes/day.
Pabrik Semen Tonasa (PT Semen Tonasa)	• Current fossil fuel usage: 3500 tonnes per day. • Plans for RDF use with the local government building a waste management facility. • RDF consumption potential: 100 tonnes/day.
Semen Bosowa Maros (PT Indocement Tunggal Perkasa Tbk)	• Current fossil fuel usage: < 5 tonnes/day. • Plans to use RDF, with trials conducted. • Gradual increase until 2030 to reach 300 tonnes/day.
Pabrik Semen (PT Conch North Sulawesi Cement)	• Current fossil fuel usage: 800 tonnes/day. • Plans to use RDF, with a potential use of 5 tonnes/day.
Indarung (PT Semen Padang)	• Current fossil fuel usage: Ca. 4500 tonnes/day. • Plans to use RDF, with a potential use of 300 tonnes/day.
Fasilitas Kiln Semen (PT Semen Padang)	• Current fossil fuel usage

The survey uncovered an encouraging trend towards the adoption of Refuse-Derived Fuel (RDF) across multiple industries in Indonesia. Nonetheless, hurdles including the necessity for additional research and the operationalization of RDF practices persist. Sustained cooperation among industries, local governments, and regulatory authorities, bolstered by initiatives in research and awareness-raising, is essential for promoting sustainable practices and advancing Indonesia's environmental objectives. Within the context of this analysis, values extrapolated from industry outreach efforts were employed as proxies for specific data reported by survey participants.

The Project is funded by the European Union

5. The Features of the SustainiMap RDF Insight Tool

5.1 Creation and Refinement of the SustainiMap RDF Insight Tool

The development process of "SustainiMap RDF Insight," a multicriteria decision-making tool for assessing potential for establishment RDF facilities in Indonesia is outlined in the following components:

Preparation of Status Quo Analysis of RDF Technology implementation and Recommendations: A comprehensive research and industry outlook was implemented at the first stage of the desk study revealing opportunities and constraints on RDF facility development in Indonesia and providing insights for the subsequent phase for project scoping at the second stage of the analysis.

Initial Data Gathering through Focus Group Discussions (FGDs): The development process commenced with FGDs in May 2023, which were instrumental in gathering foundational data and insights. These discussions provided a platform for diverse stakeholders to voice their perspectives and experiences, laying the groundwork for the tool's design.

Data Collection with support of PT SMI and Indonesian Ministry of Environment and Forestry: Critical data regarding the locations of major landfills and average composition of waste generated at major locations were provided by and the Indonesian MoEF. This information was crucial in identifying potential sites for RDF facilities and understanding the nature and volume of waste available for conversion into RDF, together with locations of industrial sites of potential off-taking industries.

Interviews with Industrial Associations: In-depth interviews were conducted with relevant industrial associations, which were deemed as potential RDF off-takers or additional suppliers of raw materials for RDF facilities (as for instance paper and pulp industry or textile sector). These interviews helped in understanding the demand side of the RDF market, including the requirements and preferences of industries that could utilize RDF as a fuel source. This step was essential in ensuring that the tool's analysis would be market-relevant and practical for the purpose of scoping.

Data Analysis and Fact-Checking: The collected data were analysed and fact-checked. This rigorous analysis ensured the accuracy and reliability of the information that would form the basis of the tool's decision-making framework, especially in verification of GIS coordinates provided by the MoEF for relevant entries of the model.

Establishment of a Working Group at Dornier (Delphi Group): Dornier established a specialised working group to lead the development of the tool. This group comprised of specialists in spatial planning, waste management, energy sector, circular economy, logistics and brought together diverse expertise and perspectives, crucial for the creation of a comprehensive tool based on a combination of multicriteria analysis and GIS research and analytics.

Development of an Open Model for Screening/Scoping: The working group developed an open model for screening, focusing on integrating multi-criteria analysis with GIS functions. This approach ensured that the tool would not only screen projects based on a range of factors

but also incorporate spatial analysis for site selection and future feasibility studies and help visualise the results.

Internal Review and Technical Validation by Dornier's Technical Departments: The draft screening model underwent an internal cross-check and validation process with Dornier's technical departments. This step was crucial for ensuring the model's technical soundness and operational feasibility for screening purposes.

Finalisation of the Open Model: The result of this thorough and collaborative process was the creation of "SustainiMap RDF Insight." This tool represents a combination of multi-criteria decision analysis and a Geographic Information System, tailored to meet the specific needs and challenges of RDF facility development in Indonesia.

Each stage of the process contributed significantly to the development of "SustainiMap RDF Insight," ensuring that the tool is not only grounded in robust data and expert knowledge but also aligned with the practical realities and needs of the Indonesian context.

5.2 Combining GIS and Multicriteria in SustainiMap RDF Insight

Dornier's decision to combine Geographic Information System and multi-criteria analysis in the development of "SustainiMap RDF Insight" was driven by the need for a comprehensive approach to evaluating potential RDF facility locations in Indonesia and matching assumed demand and supply for RDF across various regional clusters. This integration offered key advantages:

Enhanced Spatial Analysis: GIS allowed for the visualisation and analysis of geographical data, such as proximity to landfills and proximity to potential off-takers. This spatial context is essential for understanding the logistical and environmental implications of site selection. Coordinates of landfills and off-takers help analyse transport connections at the next stages and adequate and precise site locations.

Multi-dimensional Decision-making based on multi-criteria analysis (MCA): This brings in the ability to evaluate multiple, often conflicting criteria simultaneously. This is important in RDF facility planning at the screening stage, where decisions need to balance economic, environmental, technical, and social factors. MCA allows for the assessment of these diverse criteria in a structured and quantifiable manner, ensuring a well-rounded decision-making process using paid-comparison analysis (see model technical notes in excel).

Comprehensive Risk Assessment: Combining GIS with MCA enables a more thorough risk assessment. GIS can provide data on environmental risks at future stages of analysis, while MCA can evaluate non-spatial risks (from perspective of a development bank, as offered in the tool).

Facilitates Stakeholder Engagement: The visual and analytical capabilities of GIS, coupled with the structured decision-making framework of MCA, help facilitate better stakeholder engagement. Stakeholders can more easily understand and contribute to the decision-making process when they can visualize data and see how different criteria are weighted and evaluated.

Flexibility and Customisation: The integration allows for flexibility and customisation in the decision-making process. Different stakeholders may prioritize different criteria, and the

The Project is funded by the European Union

combined GIS-MCA approach can accommodate these varying priorities by adjusting weights and parameters, leading to more tailored and acceptable outcomes. Also adjusting MCA at further stages of project development may offer additional perspective in decision making, when, for instance deciding about a specific location of an RDF facility within a cluster.

The Delphi method is a structured communication technique originally developed as a systematic, interactive forecasting method which relies on a panel of experts. In the context of MCA for RDF facility Development, the Delphi method was used to gather, refine, and consolidate expert knowledge and opinions, particularly when precise information was partially available or unavailable.

Expert-Based Consensus Building: The Delphi method employed in the "SustainiMap RDF Insight" played a crucial role in reaching a consensus among experts regarding the key criteria essential for making decisions on the location of RDF facilities. This method involved multiple rounds of questionnaires distributed to a panel of experts, with the goal of selecting indicators for decision-making related to RDF facilities. The focus was on factors such as off-taker potential and potential production capacities, considering the perspective of a development bank. Following each round, the responses were collected, aggregated, and then shared with the entire group, facilitating collaboration and consensus-building among the experts involved.

The following criteria were voted to be included for analysis and to drive decision making:

- Volume / Size of a Landfill
- Calorific value/Production Potential
- Population in the nearest city
- Off-takers in vicinity (max.80km)
- Envisaged Demand of Off-takers (medium run)
- Potential raw material suppliers for an RDF facility (e.g. paper & textile)
- Assumed Supply Demand Match
- Risks on plausibility/completeness of the obtained data

Refinement of Criteria and Weightings: The iterative nature of the Delphi method allows for the continuous refinement of criteria and their weightings. As experts provided feedback, criteria were added, removed, or re-weighted based on a group expert judgment, ensuring that the tool stays relevant and effective in assessing RDF facility locations.

The Delphi method is particularly suitable for "SustainiMap RDF Insight" due to the complex, interdisciplinary nature of RDF facility location planning. It allows for the integration of diverse perspectives, from environmental scientists to waste management experts and urban planners, ensuring a well-rounded decision-making tool.

This method also supports the tool's adaptability, allowing it to evolve with changing circumstances and new information, which is crucial in the dynamic field of waste management.

The use of the Delphi method in "SustainiMap RDF Insight" aligns with the tool's objective to provide a comprehensive, expert-driven, and adaptive approach to multi-criteria decision-making for RDF facility location planning. This method enhances the tool's ability to handle complex and uncertain scenarios, making it a robust solution for RDF facility planning at the initial screening stage with high degree of reasoning reliability.

The Project is funded by the European Union

This Geographic Information System based RDF investment decision-making tool is integrating various key elements to assist in making informed and strategic decision-making. It involves analysing geographical data to identify optimal locations for RDF facilities both driven by off-taker demand and supply (in view of reducing large landfills).

The initial selection and weighting of individual criteria in the "SustainiMap RDF Insight" screening tool, designed from the perspective of a development bank, are guided by the specific priorities and risk assessment frameworks typically employed by such financial institutions.

The "SustainiMap RDF Insight" - MCA considers a range of environmental, economic, and operational factors, aligning with a development bank's goals of promoting sustainable development, environmental responsibility, and economic viability, in view of utilising potential for RDF facilities installation and attraction of new potential off-takers and raw material suppliers to increase the importance of an RDF potential site. The inclusion of risk assessment also reflects a commitment to informed decision-making. Specific weights assigned to each criterion should be based on the bank's priorities and the unique context of further projects.

The tool is designed to be open and adaptable, allowing for the integration of criteria specific to health and environmental considerations. If relevant data is available, weights can be adjusted to prioritize factors like air and water quality impact, public health benefits, and ecological footprint at the next stages of a project appraisal.

Users have the option to add new criteria or modify the weighting of existing ones. This flexibility is crucial for tailoring the tool to different perspectives or specific project goals, or application of similar methodologies at the next stage of project development.

5.2.1 How Criteria Weights Are Determined

SustainiMap RDF Insight follows a model that determines criteria weights based on paired comparison methodology. This model helps in quantifying the relative importance of various criteria by comparing them in pairs. The paired comparison methodology is particularly useful when decision-makers face a set of criteria that need to be weighed against each other to make informed and balanced decisions.

In paired comparison, each criterion is compared directly against every other criterion. During each comparison, decision-makers are asked to judge which of the two criteria is more important and to what extent. This is often done using a scale (for example, a numerical scale where 1 indicates equally important and higher numbers indicate increasing levels of importance, and lower number decreasing importance).

Development of a Comparison Matrix: The results of these pairwise comparisons are arranged in a matrix form. This matrix is used to calculate the relative weights of each criterion. Each cell in the matrix represents the outcome of a comparison between two criteria. For example, if criterion A is twice as important as criterion B, the cell where A and B meet might have a value of 2.

Normalisation and Weight Calculation: The matrix values are then normalised to determine the weights. The weight for each criterion is calculated by averaging the values in its corresponding row in the normalised matrix.

The Project is funded by the European Union

Advantages of Paired Comparison: This method helps in simplifying complex decision-making scenarios by breaking them down into more manageable comparisons. It facilitates a more structured and quantitative unbiased approach to understanding the relative importance of different factors. The method helps reveal inconsistencies in judgments, which can then be addressed to improve the decision-making process.

Application in MCA: In MCA, these weights are crucial as they influence the overall scoring and ranking of various options based on multiple criteria. The paired comparison method ensures that the weighting process is comprehensive and reflects the nuanced preferences and priorities of the decision-makers.

In summary, a model that uses paired comparison methodology for determining criteria weights is an effective tool in multi-criteria decision analysis. It provides a systematic and quantifiable approach to assess the relative importance of various criteria, enhancing the robustness and transparency of the decision-making process.

Current criteria:	Weights
Volume / Size of a Landfill	13%
Calorific value/Production Potential	17%
Population in the nearest city	12%
Offtakers in vicinity (max.80km)	17%
Envisaged Demand of Offtakers (medium run)	19%
Potential raw material suppliers for an RDF facility (paper & textile)	8%
Assumed Supply-Demand Match	12%
Risks on plausibility/completeness of the obtained data	3%

Figure 1: Example of how criteria weights are currently being weighted in SustainiMap RDF Insight

5.2.2 Note on Potential Off Takers

In the context of "SustainiMap RDF Insight" potential off-takers are assumed to demonstrate a certain level of demand, derived from information obtained during the stakeholder interviews. It is important to highlight that the demand for RDF utilization could significantly grow through focused efforts on raising awareness and creating an enabling environment, as recommended in the initial phase of the study. Such enabling environment entails market incentives and specialised promotion programmes reflecting industry needs and allowing to utilise RDF technologies at grater scale.

If potential off-takers show interest in using RDF, PT SMI assuming a role of a national development bank can play a pivotal part in facilitating this transition. PT SMI can enter into dialogues with these industries to understand their specific investment needs and operational challenges in incorporating RDF. Such dialogues can reveal insights into the technical, financial, and regulatory support required for these industries to switch to RDF in cooperation with the Ministry of Environment and Forestry. This can include financing for equipment upgrades, assistance in regulatory compliance, or technical training.

Strengthening RDF Potential: By engaging with potential off-takers, development banks can help broaden the RDF market, making certain future RDF locations more viable. Understanding the needs and constraints of these industries allows for a more targeted approach in developing RDF facilities, ensuring that they are strategically located and designed

to meet the demands of both traditional and potential off-takers. A proactive approach by engaging with potential off-takers can lead to a more robust and diversified RDF market, increasing potential for RDF. This not only strengthens the business case for existing and future RDF facilities but also contributes to broader environmental and sustainability goals by expanding waste-to-energy initiatives.

5.3 Utilisation for SustainiMap RDF Insight

5.3.1 Use of Secondary Data and Limitations

The tool integrates data from earlier studies conducted on RDF facilities' locations. This includes analysis of geographical, environmental, and socio-economic factors that influence the suitability of sites for RDF projects. Such historical data provides a baseline understanding of the landscape in which these facilities operate, including insights into optimal locations based on past research.

"SustainiMap RDF Insight" is a sophisticated tool designed for evaluating potential RDF facility locations, but like any analytical tool, it has its limitations. Understanding these limitations is crucial for effective utilisation and further development of the tool:

Distance Limitation Between RDF Facilities and Landfills: The tool currently operates under the assumption that the maximum feasible distance between RDF off-takers and landfills is 80 kilometres, and within one province. This limitation affects the selection of potential sites, as it excludes locations that are slightly more distant from landfills, potentially overlooking viable options that could be feasible if bordering provinces are combined.

Variability and Limitations in Landfill Data: The quality and recency of data regarding landfills are crucial for accurate analysis. In the case of "SustainiMap RDF Insight," the landfill data utilised come from various years, such as 2020 and 2021, and 2022. No historical trends are adopted into the analysis, which may omit changes on the ground. Changes in waste composition, landfill management practices, or local regulations can significantly affect the viability of an RDF project. At the next stages of project appraisal, it is recommended to use historical trends and adapt policy scenarios in the analysis of feasibility.

Lack of Detailed Information on Landfill Volume: The tool does not currently include detailed data development of volumes at landfills. This limitation restricts the ability to accurately assess the long-term availability of waste as a feedstock for RDF production. The volume development trends of waste in landfills is a critical factor in determining the sustainability and operational lifespan of an RDF facility.

Distance between population centers and landfills: Another limitation of the "SustainiMap RDF Insight" tool concerns the assessment of the distance between population centers and landfills, currently population at the nearest cities (city) is used as a proxy of an envisaged magnitude of public health impact. However, in pre-feasibility and feasibility studies impact areas are to be determined more precisely. Therefore, the distance from residential areas is a critical factor in site selection to minimise health risks and enhance public safety.

Regulatory Compliance and Zoning Laws: Different regions have varying regulations regarding the permissible distance between waste processing facilities and residential areas. The tool currently is not designed to provide detailed insights into these regulatory nuances, which are crucial for compliance and avoiding legal challenges.

The Project is funded by the European Union

Logistical and Operational Challenges: While closer proximity to population centers can offer logistical advantages (e.g., shorter transport distances for waste), it also brings challenges like traffic congestion and higher potential for accidents, which needs to be addressed at the further stages of analyses.

To ensure the effectiveness and accuracy of the tool, there is a need for continuous updating and integration of new data at the next stages of a project.

5.3.2 Utilisation of The Survey Results

The results of the survey were utilised in the following layers:

- GIS Database Integration
- Off-taker Clustering within 80 km Radius
- Demand-Supply Matching

GIS Database Integration: All industry players have been included in the GIS database and MCA. For those participants who shared their potential demand data for RDF, this information was strategically incorporated into the off-taker cluster evaluation matrix. This matrix serves as a crucial tool for assessing the feasibility and demand patterns of RDF in various clusters ranking individual landfills or clusters in view of their suitability for development of RDF facilities reflecting MCA.

In cases where participants did not provide potential demand data, their GIS coordinates were also included in the database and extrapolated values for potential RDF usage were assumed, ensuring a comprehensive dataset for cluster evaluation. The demand assumptions of some similar companies utilised the highest demand provided by the survey.

Off-taker Clustering within 80 km Radius: All identified off-takers are geographically located within the GIS, forming the basis for a systematic clustering strategy. A clustering radius of 80 km as mentioned before has been established to define proximity relationships among off-takers. This radius aligns with strategic considerations for efficient RDF distribution and supply chain logistics.

The clustering process involves grouping off-takers within the defined radius, ensuring a balance between supply and demand. The geographic proximity facilitates streamlined RDF transportation and logistical efficiency. Moreover, this clustering approach takes into account landfills within the same radius, offering a holistic view of the RDF ecosystem within a specific province.

Demand-Supply Matching:

The demand for RDF, as identified through participant communications and GIS extrapolations, is systematically matched with the available supply. This critical step involves aligning the demand patterns of off-taker clusters with the potential RDF production capacities within the specified province. This has been done with the support of MCA. Also, specific overview tables and maps are available in the model.

The matching process considers factors such as production capabilities, logistical feasibility, and environmental impact. By ensuring a harmonious balance between demand and supply, this approach aims to optimise RDF utilisation and minimise inefficiencies in the distribution network.

The utilisation of survey results ensures a data-driven approach to RDF integration in Indonesia. The incorporation of GIS, off-taker clustering, and demand-supply matching enhances the precision and effectiveness of RDF utilisation strategies, setting the stage for a sustainable and efficient RDF ecosystem in the country.

5.4 "SustainiMap RDF Insight" as an Initial Screening Tool for RDF Facility Planning

"SustainiMap RDF Insight" serves as an advanced screening tool, designed to assist in the preliminary evaluation and decision-making process for potential RDF facility locations. However, it is important to understand that while this tool provides initial insights and guidance at the screening phase. For final decisions on the size and location of an RDF facility, a comprehensive approach involving a pre-feasibility study followed by a full feasibility study is essential.

Role of SustainiMap RDF Insight:

The tool is primarily used for initial screening, helping to identify potentially suitable locations based on various criteria like proximity to landfills, environmental impact, and market demand for RDF. It helps narrow down options and focus resources on the most promising sites, but it provides a high-level view rather than detailed, site-specific analysis.

Fact finding - the next step:

Incorporating a fact-finding mission as a next step in the decision-making process for RDF facility location selection, particularly after potential priority sites have been identified through the "SustainiMap RDF Insight" screening tool, is a crucial element. This step ensures a grounded and comprehensive understanding of the site-specific realities, which can significantly influence the outcome of the subsequent pre-feasibility and feasibility studies. The fact-finding mission typically involves the following elements:

On-Site Visits and Direct Observations: Teams visit the shortlisted locations to gather first-hand information. This includes observing the physical characteristics of the sites, understanding the local infrastructure, and assessing logistical aspects like accessibility and proximity to waste sources and off-takers. Direct observations help in identifying any potential issues that might not be evident through secondary data or GIS analysis, such as local topography, or unrecorded land use practices.

Engagement with Local Stakeholders: Fact-finding missions provide opportunities to engage with local stakeholders, including community leaders, local government officials, potential off-takers, and other relevant parties. These interactions are vital for understanding the local socio-economic dynamics, community attitudes towards RDF projects, and potential support or opposition. Stakeholder engagement also helps in identifying any local regulatory or bureaucratic challenges.

Environmental and Social Impact Considerations: The mission includes a preliminary judgement on potential environmental and social impacts. This involves observing the local ecology, understanding the demographics of nearby communities, and gauging potential impacts on local livelihoods and environment. This early assessment can guide more detailed environmental and social impact studies during the feasibility phase.

The Project is funded by the European Union

Data Verification and Supplementing Existing Data: A key aspect of the fact-finding mission is to verify the data used in the screening process. This includes confirming the accuracy of landfill data, waste composition, and other key parameters.

Report Preparation and Recommendations: Following the mission, a detailed report is prepared, summarizing the findings and providing recommendations for the next steps. This report serves as a critical input for the pre-feasibility study, offering insights and observations that can significantly influence the project's direction.

By integrating a fact-finding mission into the RDF facility site selection process, decision-makers can ensure a more grounded and comprehensive evaluation of potential sites. This step bridges the gap between theoretical analysis and practical realities, providing a strong foundation for the detailed studies that follow.

Pre-Feasibility Study:

After initial screening, and fact finding a pre-feasibility study is conducted on the shortlisted sites, following stakeholder consultations and fact-finding investigations. This study delves deeper into the practical aspects of establishing an RDF facility, including more detailed environmental assessments, logistical considerations, and preliminary financial analysis. The pre-feasibility study aims to determine whether moving forward with a project is worth considering before investing significant time and resources into a full feasibility study.

Feasibility Study:

Following a positive outcome from the pre-feasibility study, a comprehensive feasibility study is the next step. The feasibility study's goal is to provide all necessary information to make an informed decision about whether to proceed with the RDF project, considering major technical, economic, environmental, and social aspects.

Importance of Sequential Analysis:

This sequential approach, starting with a screening tool and moving through pre-feasibility to feasibility studies, ensures that decisions are made with the best available information, minimizing risks. It allows for a phased investment of time and resources, with each phase designed to provide more detailed and specific information, thereby enhancing the decision-making process.

While "SustainiMap RDF Insight" is a valuable tool for initial screening and narrowing down potential sites for RDF facilities, it should be seen as the first step in a more comprehensive process. Final decisions should be based on detailed pre-feasibility and feasibility studies that thoroughly evaluate all relevant aspects of the project. This approach ensures that any investment in RDF facilities is well-considered, feasible, and sustainable.

6. MCA findings

A matrix of 77 landfill groups containing both 27 individual landfills and 50 clusters thereof have been identified in spatial analysis. For each landfill the following information is evaluated.

- Volume / Size of a Landfill
- Calorific value/Production Potential
- Population in the nearest city
- Off-takers in vicinity (max.80km) within one province

The Project is funded by the European Union

- Envisaged Demand of Off-takers (medium run)
- Potential raw material suppliers for an RDF facility (paper & textile)
- Assumed Supply-Demand Match Potential (at the screening stage)
- Risks on plausibility/completeness of the obtained data

6.1 Ranking Results

Each of the data domains was ranked at the scale from 0 to 10, and all criteria were weighted based determined value of each domain. Cumulative scope and ranked were assigned to each landfill group (cluster or individual landfill) considered in the analysis. Then, ranked list of landfill groups, consisting of individual landfills and clusters was created as below (Table 2).

The Project is funded by the European Union

Table 2: Ranked landfill groups of 16 analysed provinces

Province	Landfill or Cluster	Landfill Ton/Year	Est.Cal. Value MJ	Total Ton Production Annual of pellet equivalents	Total Offtakers	Estimated Demand Ton/Year	Number of textile factories and paper	MCA SCORES									Ranked Landfills from 1 to X
								Population in the nearest city	Size of a Landfill	Score MJ/Production Potential	Score Population	Number of Offtaker Scores	Demand Score	Additional supplier score	Assumed Supply-Demand Match Potential	Total score of a landfill, MCA formula	
Jawa Barat	Cluster: Jawa Barat-1 : 10 landfill(s)	4,874,449	49,676,933,399	2,739,966	11	1,497,930	35	19,572,922	9.87	9.87	6.90	5.50	8.61	2.97	9.62	7.91	1
Jawa Barat	TPST Bantargebang	2,292,221	23,360,694,867	1,288,475	19	1,739,791	46	9,571,031	4.64	4.64	3.37	9.50	10.00	3.90	9.06	6.77	2
Jawa Barat	Cluster: Jawa Barat-2 : 11 landfill(s)	4,940,514	50,350,221,149	2,777,102	4	70,930	90	21,168,242	10.00	10.00	7.46	2.00	0.41	7.63	9.98	6.30	3
Jawa Barat	TPA Sarimukti	671,084	6,520,922,256	352,118	20	1,739,791	118	2,510,103	1.36	1.27	0.88	10.00	10.00	10.00	6.57	5.87	4
Jawa Barat	Cluster: Jawa Barat-4 : 9 landfill(s)	4,711,659	48,017,892,865	2,648,460	5	60,000	38	18,144,111	9.54	9.54	6.39	2.50	0.34	3.22	9.98	5.77	5
Jawa Barat	Cluster: Jawa Barat-6 : 8 landfill(s)	4,645,594	47,344,605,115	2,611,325	2	-	33	16,548,791	9.40	9.40	5.83	1.00	-	2.80	10.00	5.32	6
Jawa Barat	Cluster: Jawa Barat-5 : 10 landfill(s)	4,757,284	48,482,870,593	2,674,107	6	40,000	82	18,442,792	9.63	9.63	6.50	3.00	0.23	6.95	0	5.00	7
Jawa Barat	TPA Sumur Batu	365,000	3,566,050,000	213,854	19	1,739,791	46	3,075,690	0.74	0.77	1.08	9.50	10.00	3.90	4.35	4.93	8
Jawa Barat	UPT TPA Cipayung	362,810	3,473,361,535	198,406	19	1,739,791	41	2,484,186	0.73	0.71	0.88	9.50	10.00	3.47	3.90	4.81	9
Jawa Barat	Cluster: Jawa Barat-3 : 10 landfill(s)	4,336,259	44,192,082,107	2,437,445	4	20,000	110	20,087,982	8.78	8.78	7.08	2.00	0.11	9.32	0	4.80	10
Jawa Barat	Cluster: Jawa Barat-7 : 10 landfill(s)	4,768,234	48,594,465,248	2,680,262	2	50,930	44	19,859,287	9.65	9.65	7.00	1.00	0.29	3.73	0	4.50	11
Jawa Barat	TPA Burangkeng	224,883	2,291,847,246	126,408	19	1,739,791	47	3,805,200	0.46	0.46	1.34	9.50	10.00	3.98	0.43	4.27	12
Jawa Timur	Cluster: Jawa Timur-12 : 21 landfill(s)	1,243,413	12,671,989,867	698,932	4	36,500	25	27,503,629	2.52	2.52	9.69	2.00	0.21	2.12	9.96	3.86	13
Jawa Timur	Cluster: Jawa Timur-5 : 20 landfill(s)	1,211,595	12,347,718,221	681,047	4	60,000	26	24,288,878	2.45	2.45	8.56	2.00	0.34	2.20	9.94	3.73	14
Jawa Timur	Cluster: Jawa Timur-13 : 27 landfill(s)	1,305,525	13,304,988,278	733,846	2	-	23	28,372,672	2.64	2.64	10.00	1.00	-	1.95	10.00	3.72	15
Jawa Barat	Cluster: Jawa Barat-8 : 9 landfill(s)	1,160,820	11,830,253,603	652,506	2	-	104	15,114,442	2.35	2.35	5.33	1.00	-	8.81	10.00	3.58	16
Jawa Timur	Cluster: Jawa Timur-9 : 19 landfill(s)	1,217,333	12,406,193,820	684,272	2	20,000	25	25,098,092	2.46	2.46	8.85	1.00	0.11	2.12	9.98	3.56	17
Jawa Timur	TPA Benowo	218,023	2,229,286,607	123,351	18	376,500	21	2,870,000	0.44	0.44	1.01	9.00	2.16	1.78	7.88	3.54	18
Jawa Tengah	Cluster: Jawa Tengah-3 : 21 landfill(s)	1,225,917	12,493,683,622	689,098	2	109,500	30	21,055,965	2.48	2.48	7.42	1.00	0.63	2.54	9.89	3.51	19
Jawa Timur	Cluster: Jawa Timur-7 : 18 landfill(s)	1,189,933	12,126,958,006	668,871	2	20,000	23	23,734,074	2.41	2.41	8.37	1.00	0.11	1.95	9.98	3.47	20

The Project is funded by the European Union

Province	Landfill or Cluster	Landfill Ton/Year	Est.Cal. Value MJ	Total Ton Production Annual of pellet equivalents	Total Offtakers	Estimated Demand Ton/Year	Number of textile factories and paper	MCA SCORES									Ranked Landfills from 1 to X
								Population in the nearest city	Size of a Landfill	Score MJ/Production Potential	Score Population	Number of Offtaker Scores	Demand Score	Additional supplier score	Assumed Supply-Demand Match Potential	Total score of a landfill, MCA formula	
Jawa Timur	TPA Jabon	203,670	1,608,993,000	106,937	18	376,500	23	2,082,801	0.41	0.39	0.73	9.00	2.16	1.95	7.55	3.47	21
Jawa Timur	Cluster: Jawa Timur-10 : 18 landfill(s)	1,128,832	11,504,259,833	634,525	2	20,000	25	23,718,725	2.28	2.28	8.36	1.00	0.11	2.12	9.98	3.44	22
Jawa Timur	Cluster: Jawa Timur-11 : 17 landfill(s)	1,058,387	10,786,334,221	594,928	4	-	22	21,064,277	2.14	2.14	7.42	2.00	-	1.86	10.00	3.42	23
Jawa Timur	TPA Paras Poncokusumo,; TPA Randuagung; TPA TALANGAGUNG	145,007	1,406,859,854	84,355	18	376,500	18	2,654,448	0.29	0.30	0.94	9.00	2.16	1.53	6.90	3.35	24
Jawa Barat	TPA Cimenteng; TPA Kadaleman	204,400	2,301,850,600	117,552	10	1,619,791	23	2,470,219	0.41	0.42	0.87	5.00	9.31	1.95	0.42	3.32	25
Jawa Timur	Cluster: Jawa Timur-2 : 13 landfill(s)	770,641	7,853,831,234	433,184	5	160,000	21	17,435,471	1.56	1.56	6.15	2.50	0.92	1.78	9.74	3.31	26
Banten	Cluster: Banten-3 : 6 landfill(s)	1,358,582	13,845,705,145	763,670	7	40,000	8	9,009,245	2.75	2.75	3.18	3.50	0.23	0.68	9.96	3.29	27
Jawa Barat	Cluster: Jawa Barat-9 : 12 landfill(s)	718,403	7,321,457,265	403,820	2	292,000	18	17,720,090	1.45	1.45	6.25	1.00	1.68	1.53	9.50	3.13	28
Jawa Timur	Cluster: Jawa Timur-3 : 15 landfill(s)	856,973	8,733,662,142	481,711	2	-	21	19,283,811	1.73	1.73	6.80	1.00	-	1.78	10.00	3.04	29
Jawa Timur	TPA SUPITURANG	191,194	2,160,495,590	127,221	13	216,500	25	846,126	0.39	0.46	0.30	6.50	1.24	2.12	8.82	2.99	30
Jawa Tengah	Cluster: Jawa Tengah-1 : 13 landfill(s)	681,739	6,947,798,105	383,211	2	50,930	1	19,545,349	1.38	1.38	6.89	1.00	0.29	0.08	9.91	2.86	31
Banten	Cluster: Banten-4 : 6 landfill(s)	1,358,582	13,845,705,145	763,670	2	-	8	9,009,245	2.75	2.75	3.18	1.00	-	0.68	10.00	2.83	32
Banten	Cluster: Banten-1 : 5 landfill(s)	1,191,922	12,147,223,392	669,989	3	-	8	7,654,895	2.41	2.41	2.70	1.50	-	0.68	10.00	2.75	33
Banten	TPA JATIWARINGIN	498,590	5,622,848,725	290,464	7	40,000	23	3,909,000	1.01	1.05	1.38	3.50	0.23	1.95	9.90	2.72	34
Jawa Tengah	Cluster: Jawa Tengah-5 : 14 landfill(s)	680,695	6,937,163,389	382,624	2	-	18	12,794,429	1.38	1.38	4.51	1.00	-	1.53	10.00	2.64	35
Banten	TPA Rawa Kucing	443,785	3,479,498,174	221,387	7	40,000	28	1,930,556	0.90	0.80	0.68	3.50	0.23	2.37	9.87	2.61	36
Sumatera Utara	Cluster: Sumatera Utara-3 : 11 landfill(s)	714,768	7,284,413,241	401,777	3	-	1	11,326,779	1.45	1.45	3.99	1.50	-	0.08	10.00	2.57	37
Jawa Tengah	Cluster: Jawa Tengah-2 : 9 landfill(s)	421,621	4,296,867,082	236,997	2	61,320	-	14,886,681	0.85	0.85	5.25	1.00	0.35	-	9.82	2.50	38
Banten	TPST Cipeucang	166,660	1,613,852,982	87,164	5	40,000	36	1,747,906	0.34	0.31	0.62	2.50	0.23	3.05	9.68	2.30	39
Jawa Barat	TPA Kertawinangun; TPA Pecuk	198,268	2,983,933,400	134,406	3	312,000	32	1,851,383	0.40	0.48	0.65	1.50	1.79	2.71	8.39	2.29	40

The Project is funded by the European Union

Province	Landfill or Cluster	Landfill Ton/Year	Est.Cal. Value MJ	Total Ton Production Annual of pellet equivalents	Total Offtakers	Estimated Demand Ton/Year	Number of textile factories and paper	MCA SCORES									Ranked Landfills from 1 to X
								Population in the nearest city	Size of a Landfill	Score MJ/Production Potential	Score Population	Number of Offtaker Scores	Demand Score	Additional supplier score	Assumed Supply-Demand Match Potential	Total score of a landfill, MCA formula	
Banten	TPA Cilowong	150,267	1,491,395,112	85,105	7	40,000	9	1,622,630	0.30	0.31	0.57	3.50	0.23	0.76	9.67	2.29	41
Jawa Timur	Cluster: Jawa Timur-8 : 20 landfill(s)	1,134,705	11,564,115,333	637,827	2	20,000	25	23,496,368	2.30	2.30	8.28	1.00	0.11	2.12	-	2.28	42
Jawa Timur	Cluster: Jawa Timur-4 : 6 landfill(s)	190,311	1,939,515,099	106,975	2	50,930	-	11,505,816	0.39	0.39	4.06	1.00	0.29	-	9.67	2.19	43
Sulawesi Selatan	Cluster: Sulawesi Selatan-1 : 10 landfill(s)	614,465	6,262,194,993	345,396	2	36,500	-	4,977,315	1.24	1.24	1.75	1.00	0.21	-	9.93	2.18	44
Sumatera Utara	TPA Terjun	457,773	4,142,843,659	227,666	4	-	-	2,494,512	0.93	0.82	0.88	2.00	-	-	10.00	2.18	45
Sulawesi Selatan	Cluster: Sulawesi Selatan-2 : 10 landfill(s)	550,605	5,611,374,967	309,499	2	109,500	-	4,372,256	1.11	1.11	1.54	1.00	0.63	-	9.75	2.18	46
Jawa Timur	Cluster: Jawa Timur-1 : 8 landfill(s)	149,637	1,524,992,932	84,112	3	185,930	1	8,859,520	0.30	0.30	3.12	1.50	1.07	0.08	8.46	2.14	47
Jawa Tengah	Cluster: Jawa Tengah-4 : 7 landfill(s)	307,694	3,135,797,058	172,957	2	50,930	7	7,017,848	0.62	0.62	2.47	1.00	0.29	0.59	9.80	2.13	48
Jawa Timur	Cluster: Jawa Timur-6 : 16 landfill(s)	1,048,167	10,682,179,210	589,183	2	40,000	25	19,368,192	2.12	2.12	6.83	1.00	0.23	2.12	-	2.07	49
Jawa Tengah	TPA Jatibarang	313,891	3,093,234,031	176,768	1	109,500	28	1,659,975	0.64	0.64	0.59	0.50	0.63	2.37	9.57	2.07	50
Sumatera Selatan	Cluster: Sumatera Selatan-2 : 5 landfill(s)	429,875	4,380,977,350	241,636	2	5,475	1	3,952,421	0.87	0.87	1.39	1.00	0.03	0.08	9.98	2.01	51
Sumatera Utara	TPA Tandukan Raga; TPA Namorube Julu	167,900	1,938,405,500	96,431	4	-	1	1,953,986	0.34	0.35	0.69	2.00	-	0.08	10.0000	2.01	52
Sumatera Barat	Cluster: Sumatera Barat-1 : 10 landfill(s)	333,682	3,400,648,168	187,565	2	109,500	-	2,665,609	0.68	0.68	0.94	1.00	0.63	-	9.59	1.95	53
Riau	Cluster: Riau-1 : 4 landfill(s)	294,389	3,000,209,145	165,479	2	-	3	2,464,805	0.60	0.60	0.87	1.00	-	0.25	10.00	1.87	54
Jawa Barat	TPA Pasir Bajing	81,483	778,573,218	43,625	2	292,000	46	2,585,607	0.16	0.16	0.91	1.00	1.68	3.90	5.35	1.87	55
Jawa Tengah	TPA Penujah	131,765	1,838,121,750	83,363	2	112,250	9	1,596,996	0.27	0.30	0.56	1.00	0.65	0.76	9.06	1.87	56
Sumatera Selatan	TPA Sukawinatan	332,185	3,509,537,800	199,704	1	5,475	1	1,686,073	0.67	0.72	0.59	0.50	0.03	0.08	9.98	1.85	57
Sulawesi Selatan	TPA Antang Tamangapa	328,500	3,347,839,641	184,652	2	146,000	-	1,432,189	0.66	0.66	0.50	1.00	0.84	-	9.45	1.84	58
Jawa Tengah	TPA Berahan Kulon; TPA Candisari	110,588	1,235,430,491	63,506	2	109,500	14	1,203,956	0.22	0.23	0.42	1.00	0.63	1.19	8.80	1.83	59
Aceh	Cluster: Aceh-1 : 6 landfill(s)	139,911	1,425,873,439	78,645	2	50,930	-	1,805,445	0.28	0.28	0.64	1.00	0.29	-	9.55	1.73	60

The Project is funded by the European Union

Province	Landfill or Cluster	Landfill Ton/Year	Est.Cal. Value MJ	Total Ton Production Annual of pellet equivalents	Total Offtakers	Estimated Demand Ton/Year	Number of textile factories and paper	MCA SCORES									Ranked Landfills from 1 to X
								Population in the nearest city	Size of a Landfill	Score MJ/Production Potential	Score Population	Number of Offtaker Scores	Demand Score	Additional supplier score	Assumed Supply-Demand Match Potential	Total score of a landfill, MCA formula	
Banten	Cluster: Banten-2 : 2 landfill(s)	40,880	416,620,044	22,979	2	1,825	1	2,773,586	0.08	0.08	0.98	1.00	0.01	0.08	9.94	1.71	61
Jawa Tengah	TPA Kunci; TPA Malabar; TPA Tritih Lor Cilacap	77,288	754,173,377	44,740	2	112,250	-	1,988,622	0.16	0.16	0.70	1.00	0.65	-	8.26	1.69	62
Kalimantan Selatan	Cluster: Kalimantan Selatan-1 : 3 landfill(s)	68,917	702,350,667	38,739	2	2,920	-	642,381	0.14	0.14	0.23	1.00	0.02	-	9.95	1.63	63
Jawa Tengah	TPA Kalijurang; TPA Kaliwlingi	48,578	551,358,598	31,964	2	112,250	6	1,809,096	0.10	0.12	0.64	1.00	0.65	0.51	7.56	1.63	64
Aceh	Cluster: Aceh-2 : 2 landfill(s)	47,355	482,609,683	26,619	2	-	-	764,135	0.10	0.10	0.27	1.00	-	-	10.00	1.63	65
Nusa Tenggara Timur	Cluster: Nusa Tenggara Timur-1 : 2 landfill(s)	63,821	650,422,056	35,874	2	3,650	-	586,522	0.13	0.13	0.21	1.00	0.02	-	9.93	1.62	66
Sulawesi Utara	Cluster: Sulawesi Utara-1 : 4 landfill(s)	42,035	428,393,331	23,628	2	1,825	-	624,703	0.09	0.09	0.22	1.00	0.01	-	9.95	1.61	67
Kalimantan Timur	Cluster: Kalimantan Timur-2 : 2 landfill(s)	52,109	531,052,974	29,291	2	40,000	-	574,697	0.11	0.11	0.20	1.00	0.23	-	9.05	1.55	68
Papua Barat	Cluster: Papua Barat-1 : 2 landfill(s)	43,409	442,396,575	24,401	2	21,900	-	228,612	0.09	0.09	0.08	1.00	0.13	-	9.38	1.55	69
Sumatera Utara	Cluster: Sumatera Utara-2 : 14 landfill(s)	779,358	7,942,665,471	438,083	2	-	1	12,371,473	1.58	1.58	4.36	1.00	-	0.08	-	1.42	70
Jawa Tengah	TPA Ngembak	27,740	300,979,000	16,015	3	160,430	30	1,501,145	0.06	0.06	0.53	1.50	0.92	2.54	3.04	1.36	71
Kalimantan Timur	Cluster: Kalimantan Timur-1 : 1 landfill(s)	24,820	252,947,884	13,952	2	50,930	-	434,459	0.05	0.05	0.15	1.00	0.29	-	7.46	1.36	72
Sumatera Utara	Cluster: Sumatera Utara-1 : 12 landfill(s)	774,977	7,898,013,647	435,620	2	-	1	10,936,273	1.57	1.57	3.85	1.00	-	0.08	-	1.35	73
Jawa Timur	TPA Bandungrejo; TPA Banjarsari	22,493	381,252,113	16,851	6	242,430	6	1,301,635	0.05	0.06	0.46	3.00	1.39	0.51	-	1.19	74
Kalimantan Selatan	Cluster: Kalimantan Selatan-2 : 2 landfill(s)	24,959	254,361,416	14,029	2	109,500	-	648,268	0.05	0.05	0.23	1.00	0.63	-	4.57	1.09	75
Sumatera Selatan	Cluster: Sumatera Selatan-1 : 4 landfill(s)	97,805	996,763,456	54,977	2	50,930	1	1,673,438	0.20	0.20	0.59	1.00	0.29	0.08	-	0.60	76
DI Yogyakarta	Cluster: DI Yogyakarta-1 : 3 landfill(s)	127,053	1,294,832,779	71,417	2	-	-	1,572,183	0.26	0.26	0.55	1.00	-	-	-	0.55	77

The Project is funded by the European Union

6.2 Cluster Details Presentation

Detailed information on estimated demand and supply at the screening stage within each cluster can be obtained from the Dashboard (orange tab in the model: DashBoard_Cluster at "SustainiMap RDF Insight" model, and contains the following data:

- Cluster Number in the Dashboard,
- Cluster Sequence Numbering per Province,
- Province,
- City of Landfill and its population,
- Cluster name,
- Overview of demand and supply per chosen cluster. The demand-side provides the information of off-taker facilities in each cluster. The supply-side provides the information of landfills in each cluster.
- Off-taker name, sequence numbering, industry, city of off takers Address, estimated Demand T/Y.
- Landfill Landfills name, sequence numbering, landfill volume Tons/Y, calorific value in MJ, Landfill Production Potential in Pallets Equivalent Tons/Y
- Textile and Pulp factories number in a cluster.
- “SUM”-row information of every cluster data analysed provides the total number of corresponding information of each column.

The dashboard allows to choose a cluster of interest and information used in "SustainiMap RDF Insight" model will be presented as an overview. Here is the example on how the information per cluster is presented:

The Project is funded by the European Union

Bali-1	Overview per chosen Cluster						DEMAND						SUPPLY					
	Cluster Number	Cluster Sequence Numbering per Province	Province	City of Landfill	Population	Name of Cluster	Offtaker sequence numbering	Offtakers	Industry	City of Offtakers	Address	Demand T/Y	Landfill sequence numbering	Landfills	Tons/Y	Total MJ	Production Pallets Tons/Y	Textile and Pulp factories in Cluster
	33	1	Bali	Kab. Jembrana	317064	Bali-1	1	PT Semen Tonasa	Cement	Kab. Buleleng	Celukan Bawang, Gerokgak, Buleleng Regency, Bali 81155, Indonesia	50930,2	1	TPST Peh	12446,5	126845924,2	6997,0018	0
	33	1	Bali	Kab. Buleleng	791813	Bali-1	1	PT Semen Tonasa	Cement	Kab. Buleleng	Celukan Bawang, Gerokgak, Buleleng Regency, Bali 81155, Indonesia	50930,2	2	TPA Bengkala	56611,5	576944364,9	31825,073	0
	33	1	Bali	Kab. Bangli	258721	Bali-1	1	PT Semen Tonasa	Cement	Kab. Buleleng	Celukan Bawang, Gerokgak, Buleleng Regency, Bali 81155, Indonesia	50930,2	3	TPA BANGLI	21291,18	216984646,6	11969,182	0
	33	1	Bali	Kab. Gianyar	515344	Bali-1	1	PT Semen Tonasa	Cement	Kab. Buleleng	Celukan Bawang, Gerokgak, Buleleng Regency, Bali 81155, Indonesia	50930,2	4	TPA Temesi	169725	1729717148	95413,661	0
	33	**1**	**Bali**	**Kota Denpasar**	**788589**	**Bali-1**	**1**	**PT Semen Tonasa**	**Cement**	**Kab. Buleleng**	**Celukan Bawang, Gerokgak, Buleleng Regency, Bali 81155, Indonesia**	**50930,2**	**5**	**TPA SARBAGITA SUWUNG**	**257755,94**	**2626866221**	**144901,68**	**0**
	33	1	Bali	Kab. Klungkung	206925	Bali-1	1	PT Semen Tonasa	Cement	Kab. Buleleng	Celukan Bawang, Gerokgak, Buleleng Regency, Bali 81155, Indonesia	50930,2	6	TPA Sente	8190,6	83472801,73	4604,4786	0
	33	SUM	Bali	0	2878456	Bali-1	0	1	1	0	0	50930,2	0	6	526020,72	5360831107	295711,08	0

Figure 2: Cluster overview in Excel Spreadsheet

Furthermore, an overview of all 51 clusters analysed is presented in the table adjacent to the cluster overview described above. This table allows users to easily filter and extract important information from the cluster analysis. The data provided in this table mirror the information in the cluster overview but are consolidated to display the entire cluster in one table.

In addition to Dashboard Cluster Overview, a summary of each cluster is to be found in SUM_DemSupply Tab. It contains the information of all SUM-rows of all clusters listed in the Dashboard Cluster.

The Project is funded by the European Union

7. Findings of SustainiMap RDF Insight

7.1 Scope of Analysis

A provincial-level analysis was conducted to examine clusters of off-takers and landfills utilizing Geographic Information System technology. Initially, 452 landfills spanning 38 provinces were identified from the Ministry of Environment and Forestry database (SIPSN). From this pool, 180 landfills across 16 provinces were selected for Multi-Criteria Analysis (MCA) consideration, taking into account off-takers' availability throughout all Indonesian provinces. These selected landfills underwent detailed analysis regarding waste generation, composition, and annual waste supply within the timeframe of 2018-2022, based on available data. Among the 514 Indonesian cities/regencies with identified landfills, 146 were included in the study. The estimation of calorific value was derived based on waste composition.

In terms of suppliers, large landfills with a capacity of over 90,000 tons per year were preselected for individual evaluation with a focus on potential off-taking within approximately 80 kilometers, aiming to initiate large-scale implementation of landfill reduction policies. 180 landfills within the proximity of 80 kilometers to potential off-takers were grouped into 50 clusters. Additionally, a supplementary supplier database was established, encompassing 207 factories operating across Indonesia, particularly in the textile and paper industries.

Regarding off-takers, a total of 75 off-taking entities across 16 provinces were identified, including cement, fertilizer, pulp & paper producers, as well as metal casting and smelting industries. It is worth noting that coal-fired power plants, while included in the databases, were not considered potential off-takers due to industry regulations pertaining to RDF standards.

	Indonesia Landfill Potential			Study Coverage
	38 provinces (452 Landfills)	16 analysed provinces (whole landfills observation)	22 provinces without potential off-takers (Supply Potential)	16 analysed provinces 50 cluster data (181 landfills observation)
Waste entering landfill (t/a)*	24,095,314	20,315,732	3,779,582	14,341,458
Percentage from 38 provinces	*100%*	*84%*	*16%*	*60%*
Number of City/Regency**	337	228	109	147
Percentage from 38 provinces	*100%*	*68%*	*32%*	*43%*

Figure 3: Indonesia landfill potential and study coverage potential

The table above provides a comprehensive comparison of Indonesia's landfill potential, delineated by the annual waste entering landfill data in tonnes. Specifically, it outlines the potential across three distinct categories: the entirety of 38 provinces, the 16 analysed provinces without consideration of the buffer zone of 80 kilometers regarding off-taker availability, and the remaining 22 provinces where potential off-takers have not been identified. This data is sourced from the Ministry of Environment and Forestry (MoEF) via SIPSN, offering insights into the varying landfill potentials across different regions of Indonesia.

The study analysis, employing a demand-based approach to assess off-taker availability, encompasses approximately 60% of waste generation (i.e., waste entering landfill data) across all 38 Indonesian provinces. This coverage corresponds to approximately 43% of the population residing in the respective cities and regencies under study.

The Project is funded by the European Union

In addition, other 22 provinces are identified to have certain potential based on the supply data of landfill waste generation. The ranking of these 22 provinces, based solely on expected annual waste generation in tonnes, positions Bali as the most promising province from the supply side. However, it is crucial to conduct further inspection and observations of the data in terms of data reliability due to unprocessed data from the MoEF. Currently, off-takers are not identified in these provinces, but could potentially be revealed in subsequent stages of analysis. These provinces may be considered for further investigation in case other logistics arrangements and patterns are explored, such as short-sea or long-distance export shipping, cross-provincial off-take integration, or potential openings in other industries that could utilize RDF. Additionally, new standards enabling municipal waste-based RDF for off-take in new industries may also be explored in these provinces. The list of these provinces ranking can be seen below. It is important to note that DKI Jakarta is not included in this list due to the fact that the waste from DKI Jakarta is transferred to the Bantar Gebang landfill located in Jawa Barat.

No.	Province	Expected Waste generation (t/a)	Share of 38 provinces in total waste generation
1	Bali	1,014,874	4%
2	Kepulauan Riau	421,226	2%
3	Nusa Tenggara Barat	374,914	2%
4	Kalimantan Barat	269,357	1%
5	Lampung	256,214	1%
6	Kalimantan Tengah	236,114	1%
7	Papua	228,318	1%
8	Jambi	220,879	1%
9	Sulawesi Tengah	215,625	1%
10	Sulawesi Tenggara	132,254	1%
11	Kepulauan Bangka Belitung	122,137	1%
12	Papua Tengah	71,171	<1%
13	Gorontalo	55,823	<1%
14	Maluku	36,150	<1%
15	Maluku Utara	27,952	<1%
16	Sulawesi Barat	27,262	<1%
17	Papua Selatan	24,725	<1%
18	Kalimantan Utara	16,007	<1%
19	Bengkulu	15,904	<1%
20	Papua Barat Daya	12,359	<1%
21	Papua Pegunungan	317	<1%

Figure 4: Potential of provinces without identified off takers

7.2 Demand and Supply Integration

The success of Refuse-Derived Fuel (RDF) facilities in Indonesia hinges significantly on the identification and establishment of robust connections with off-taking industries. These industries, which encompass a broad spectrum from cement manufacturing to fertilizer production, wield substantial influence in shaping the demand for RDF. Their involvement is pivotal as they serve as primary consumers of RDF, utilizing it as a viable alternative fuel source. Therefore, fostering strong partnerships and collaborations with these industries is paramount in ensuring the viability and sustainability of RDF initiatives across the country. By aligning the production and supply of RDF with the specific needs and requirements of these off-taking industries, Indonesia can maximize the utilization of its waste resources while simultaneously addressing environmental concerns and promoting sustainable development.

The Project is funded by the European Union

The identified supply and demand analysed in SustainiMap RDF Insight covers various number of entities and landfills across 16 provinces which distribution is found in table below:

Entity type	Number of entities	Number of provinces where entity type is located	Number of cities where entity type is located
Demand			
Cement Industry	24	13	22
Fertilizer Industry	10	5	7
Pulp & Paper Industry (PT Tjiwi Kimia Sidoarjo)	1	1	1
Others (Smelter and Metal industry)	40	7	22
Supply			
Landfills	180	16	153
Additional Supply (Pulp and paper, textile, plastic) *	194	7	32
*Additional supply mainly identified in Java Island. Analysis only includes the number of entities within the cluster. Potential supply in t/a is not provided.			

Figure 5: Supply and Demand overview

7.3 Presenting The Findings

The outcome of "SustainiMap RDF Insight" is presented through an interactive web map that utilizes GIS data from the analysis. This web map incorporates several layers, including landfills, off-takers such as fertilizer and cement companies, as well as other relevant entities and identified clusters. Each layer provides specific information corresponding to its category. Users can interact with the map to explore and access detailed information about RDF facilities, off-takers, and clusters, facilitating informed decision-making and analysis in the field of waste management and RDF utilization. The web map overview can be seen in the picture below:

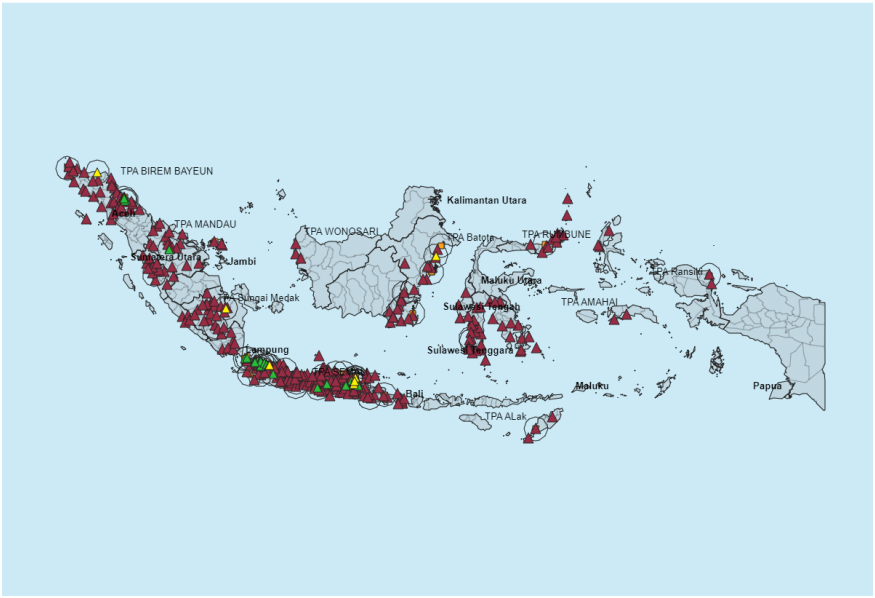


Figure 6: Overview of offline GIS Web map

The web map is generated using the results derived from the analysis and is created independently of the Excel file. Therefore, any changes made to the data in the Excel file, such as adding new landfills, off-taker entities, or clusters, may require separate adjustments to the web map. This ensures that the information displayed on the web map remains accurate with the latest data from the analysis.

The Project is funded by the European Union

The primary findings of the MCA-Analysis reveal the potential for RDF facilities in 16 provinces across Indonesia. These provinces were selected based on the presence of potential off-takers within each province. Below is the list of potential provinces along with their respective supply and demand data:

Province	Rank (1-16)	No. Of Clusters	No.of Cities/ Regencies	No.of Landfills	Waste Production (t/a)	Supply: Pellets equivalent (t/a)	Number of additional supply industries	Number of additional supply factories	No.of Offtaker Industry Type	Offtaker Industry type	No.of Factory	Aggregate Demand (t/a)*
Jawa Barat	1	9	21	25	5,689,212	3,198,283	5	120	7	Cement; Fertilizer; Pulp & Paper; Steel; other	21	2,031,791
Jawa Timur	2	13	27	37	1,718,569	966,121	3	27**	6	Cement; Fertilizer; Pulp & Paper; Steel; other	21	613,360
Banten	3	4	6	7	1,366,612	768,263	2	9**	4	Cement; Steel; other	8	41,825
Jawa Tengah	4	5	30	38	2,043,306	1,148,678	3	32	2	Cement;Steel	5	272,680
Sulawesi Selatan	5	2	10	11	623,532	350,529	0	0	1	Cement	2	146,000
Sumatera Barat	6	1	10	10	333,682	187,585	0	0	1	Cement	1	109,500
Sumatera Utara	7	3	7	13	779,358	438,129	1	1	1	Steel	4	-
Riau	8	1	3	4	294,389	165,496	1	3	1	Steel	1	-
Aceh	9	2	7	8	187,266	105,275	0	0	2	Cement, Fertilizer	2	50,930
Nusa Tenggara Timur	10	1	2	2	63,821	35,878	0	0	1	Cement	1	3,650
Sulawesi Utara	11	1	4	4	42,035	23,631	0	0	1	Cement	1	1,825
Papua Barat	12	1	2	2	43,409	24,403	0	0	1	Cement	1	21,900
Sumatera Selatan	13	2	7	9	527,680	296,644	1	2	2	Cement;Fertilizer	2	56,405
Kalimantan Timur	14	2	2	2	52,109	29,294	0	0	2	Cement;Fertilizer	2	90,930
Kalimantan Selatan	15	2	5	5	93,875	52,774	0	0	1	Cement	2	112,420
DI Yogyakarta	16	1	3	3	127,053	71,425	0	0	1	Steel	1	-
TOTAL		50	146	180	13,985,908	7,862,405		194			75	3,553,217

** To be verified at FS level*
*** PT Indah Kiat Pulp & Paper (Serang) and PT Tjiwi Kimia (Sidoarjo) are considered as additional supplier to RDF Facility based on its experiences in RDF supplier. PT Tjiwi Kimia is considered as Offtaker.*

Figure 7: 16 Potential analysed provinces with respective information on supply and demand

Province	Total Clusters and TPA	Average Score	Cumulative Province Rank
Jawa Barat	17	4.73	1
Jawa Timur	18	3,04	2
Banten	8	2.56	3
Jawa Tengah	11	2.19	4
Sulawesi Selatan	3	2.07	5
Sumatera Barat	1	1.95	6
Sumatera Utara	5	1.91	7
Riau	1	1.87	8
Aceh	2	1.68	9
Nusa Tenggara Timur	1	1.62	10
Sulawesi Utara	1	1.61	11
Papua Barat	1	1.55	12
Sumatera Selatan	3	1.48	13
Kalimantan Timur	2	1.46	14
Kalimantan Selatan	2	1.36	15
DI Yogyakarta	1	0.55	16

Figure 8: Cumulative ranking of 16 analysed provinces

The MCA also conducted an analysis to rank the 16 provinces based on the weighting score applied in the MCA. The ranking, as displayed in the table above, identifies Jawa Barat, Jawa Timur, Banten, Jawa Tengah, and Sulawesi Selatan as the most potential provinces for RDF facilities. This ranking is determined by considering the respective demand and supply data of each province.

The Project is funded by the European Union

7.4 Provinces GIS Mapping

7.4.1 Jawa Island

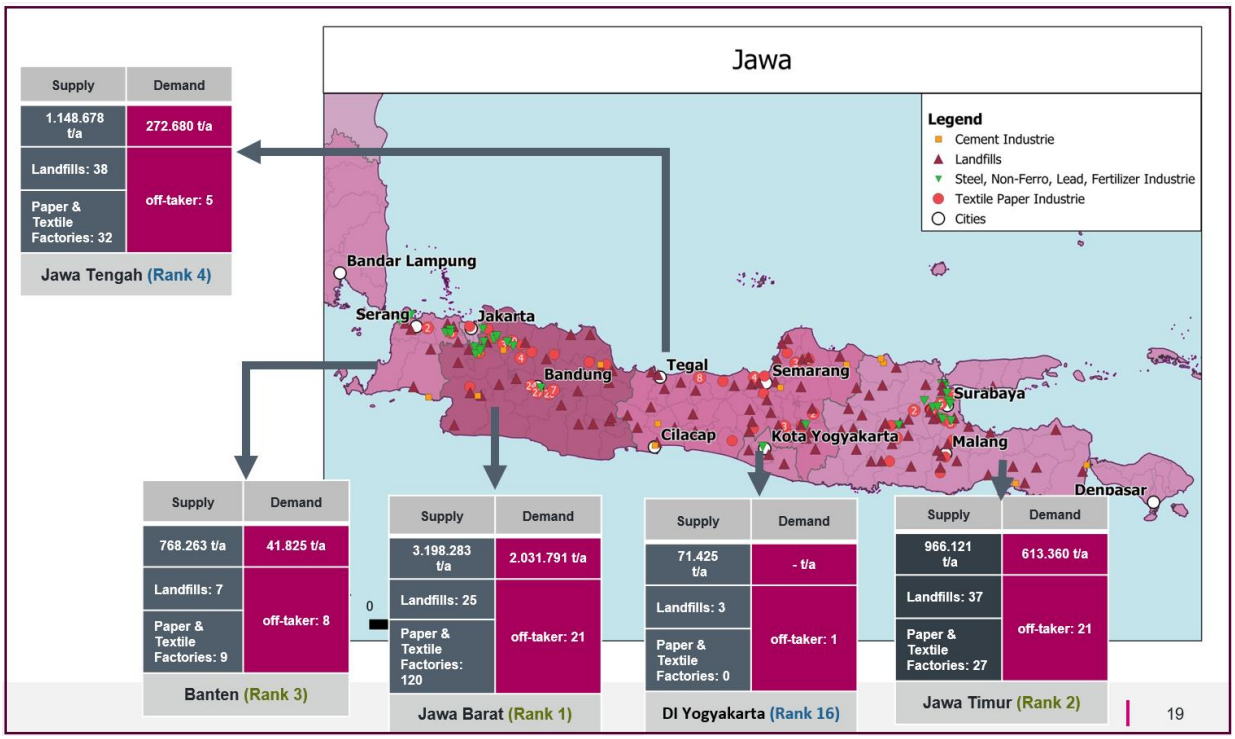


Figure 9: Jawa Island GIS Mapping

- **Jawa Barat (Rank 1)**
  17 landfill groups have been identified with off-take and supply sides within an 80-kilometer vicinity, comprising both eight individual landfills and nine clusters in various landfills combinations. Notably, the top five clusters within Jawa Barat Province are also ranked among the top 10 clusters nationwide. These top clusters include various potential landfills, such as *TPA Sarimukti, TPA Pasir Sembung, TPA Cikundul, PA Cimenteng, TPA Galuga, UPT TPA Cipayung, TPST Bantar Gebang, TPA Sumur Batu, TPA Jalupang, TPA Burangkeng, and TPA Panembong*.

  In Jawa Barat Province, 21 off-takers have been identified, representing various industries including cement, fertilizer, and smelting. Among the top-ranked clusters (1-5) in Jawa Barat Province, companies such as Indocement Tunggal Prakarsa Citeureup & Cirebon, Solusi Bangun Indonesia, Semen Jawa, Aluzindo Panduan Mulia, Jui Shin Indonesia, and Nakakin Indonesia are included as potential off-takers. Additionally, ranked 6 includes Pupuk Kujang as a potential off-taker, indicating a broad coverage of off-takers across different industries within Jawa Barat Province. The total annual supply identified for Jawa Barat Province exceeds 3.1 million tonnes of pellets, whereas total annual demand exceeds 2 million tonnes of pellets.

  To support these initiatives, regional governments are encouraged to facilitate roadshow activities and ascertain the specific interests of off-taking industries in RDF off-take revealed during these engagements. Furthermore, collaboration via cement associations can be instrumental in establishing communication with major players and advancing specific plans. Upon confirmation of project viability, efforts should be made to engage potential suppliers in the textile and paper industries, thus broadening the scope of collaboration and ensuring the successful implementation of RDF initiatives.

The Project is funded by the European Union

- **Jawa Timur (Rank 2)**
  18 landfill groups have been identified with off-take and supply sides within an 80-kilometer vicinity, encompassing both five individual landfills and 13 clusters. Notably, the top five clusters within Jawa Timur Province are ranked between the 13th and 20th out of 77 landfill groups analysed nationwide. These top clusters include a variety of landfills, such as *TPA Randuagung, TPA Belahan Tengah, TPA Karangdiyeng, TPA Banjardowo, TPA Pandantoyo, TPA Gunung Panggung, TPA Tambakrigadung, TPA Ngipik, TPA Gunung Maddah, TPA Blandongan, TPA Randegan, TPA Benowo, TPA Jabon, TPAS Sekoto, TPA Paras Poncokusumo, TPA Talangagung Kepanjen, TPA Lempeni, TPA Supiturang, TPA Bestari, TPA Tlekung, TPA Kedungdowo, TPA Klotok Kota Kediri, TPA Selupuro, TPA Mrican, TPA Srabah, TPA Segawe, TPA Bendil, TPA Milangsari, TPA Karangjati, TPA Bandungrejo, TPA Banjarsari, TPA Ngegong, and TPA Winongo*.
  Jawa Timur Province has potential annual supply of over one million tonnes pellets with potential annual demand of ca. 613,000 tonnes pellets from 21 off takers. The top off takers included in the top clusters are Semen Indonesia - Tuban, SBI Tuban, Semen Imasco Asiatic, Dupan Anugerah Lestari, Peroni Karya Sentra, Indonesia Smelting Technology, Indra Eramulti Logam Industri, PT Tjiwi Kimia Pulp & Paper.
  PT Tjiwi Kimia Pulp & Paper, located in Sidoarjo, is the only potential off-taker in pulp & paper industry identified in the analysis, with potential off taking capacity of 36,500 t/a. It represents 50% of its boiler capacity (2023).
  To support these endeavors, it is recommended for regional governments to lend support to roadshow activities and diligently assess the specific interests of off-taking industries in RDF off-take, as revealed during these engagements. Collaboration via cement associations can facilitate communication with major players and aid in the follow-up of specific plans. Upon confirmation of project viability, it is recommended to reach out to potential additional suppliers to further bolster the implementation of RDF initiatives and ensure their success.

- **Banten (Rank 3)**
  Eight landfill groups have been identified with off-take and supply sides within an 80-kilometer vicinity, comprising both 4 individual landfills and 4 clusters with various landfill combinations. Notably, among the clusters within Banten province, two are ranked the 27th and 32nd among clusters analysed across Indonesia. Top clusters of Banten Province encompass a variety of top landfills, such as *TPA Bagendung, TPA Jatiwaringin, TPA Rawa Kucing, TPA Dengung, TPA Cilowong, and TPST Cipeucang*.
  Banten province has potential supply of ca. 760,000 tonnes pellets per year with the expected annual demand of 41,000 tonnes pellets from 8 potential off takers. The off takers from the top clusters in this province include Cemindo Gemilang Lebak, Stainless Steel Primavalve Majubersama, and Non Ferindo Utama.
  PT Indah Kiat Pulp & Paper, one major pulp & paper industry player has utilised boiler for own RDF production with the installed capacity of 438,000 t/a. The company supplies the boiler 100% with its own waste production.

- **Jawa Tengah (Rank 4)**
  Eleven landfill groups have been identified with off-take and supply sides within an 80-kilometer vicinity, encompassing both six individual landfills and five clusters. Notably, the top three clusters within Jawa Tengah Province are ranked 19th, 31th, and 35th nationally. The top potential landfills in Jawa Tengah Province included in the top three

The Project is funded by the European Union

clusters mentioned are *TPA Kaliwlingi, TPA Kaliwlingi, TPA Muarareja, TPA Pegongsoran, TPA Penujah, TPA Kalijurang, TPA Kalipancur, TPA Malabar, TPA Kunci, TPA Ble, TPA Tritih Lor Cilacap, TPA Kaligending, TPA Semali, TPA Bojonglarang, TPA Krasak, TPA Bandengan Jepara, TPA Berahan Kulon UPT TPA Tanjungrejo, TPA Sukoharjo, TPA Ngembak, TPA Candisari, TPA Jatibarang, TPA Darupono Baru, TPA Cebak, TPA Sanggrahan, TPA Blondo, TPA Ngronggo, TPA Banyu Urip, TPA Tanggan, TPA Pasuruhan, TPA Winong, TPA Kabupaten Klaten, TPA Putri Cempo, TPA Mojorejo, and TPA Sukosari Jumantono.*
Jawa Tengah province exhibits a potential supply exceeding 1.1 million tonnes of pellets per year, with an expected annual demand of over 270,000 tonnes from five potential off takers. Among the top clusters in this province, off takers include Sinar Tambang Arthalestari (Semen Bima), Solusi Bangun Indonesia, and Semen Grobogan.

- **DI Yogyakarta (Rank 16)**
  DI Yogyakarta Province is found to have the potential supply of more than 71,425 tonnes of pellets per year. The supply derives from *TPA Banyuroto, TPA Wukirsari, and TPST Regional Piyungan* landfills. Additionally, the province has one identified off-taker from the steel industry (Karya Hidup Sentosa, CV.).
  It is recommended that the province shifts its focus towards other municipal solid waste (MSW) management initiatives rather than exclusively prioritizing RDF off-taking projects. This recommendation remains valid unless the steel industry within the province expresses interest in RDF off-taking projects or if other feasible business opportunities arise. Increasing awareness and promoting RDF utilization may also aid in garnering interest from industries not previously considered in the study.

7.4.2 Sumatera Island

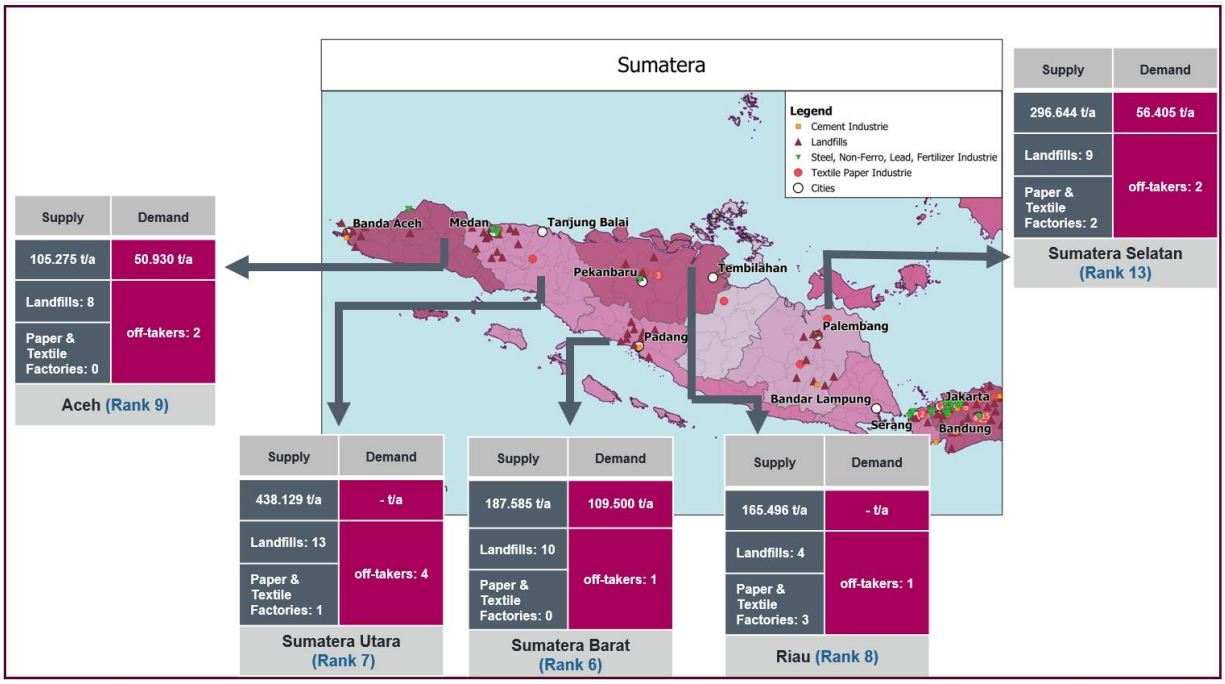


Figure 10: Sumatera Island GIS Mapping

The Project is funded by the European Union

- **Sumatera Barat (Rank 6)**
  One cluster comprises ten landfills, ranked 53 out of 77 ranked landfill groups analysed nationwide. This cluster includes various potential landfills, such as *TPA Gunung Bungkuak, TPA Regional Solok, TPA Muaro Batuak, TPA Bukik Sangkiang, TPA Ladang Laweh, UPTD TPA Aie Dingin, TPA Sampah Kayu Gadang, TPA Sei Andok, TPAS Tungkal Selatan, and TPA Regional (representing Kota Payakumbuh, Kab. Agam, Kab. Lima Puluh Kota, and Kota Bukittinggi)*. These landfills represent a total potential supply of more than 180,000 tonnes pellets per year.
  Currently, the off take mainly involves the cement industry, with Semen Padang Indarung being the primary player. It is crucial to explore the interest of the cement industry further in this cluster to potentially expand off-take opportunities and enhance the utilization of RDF from these landfills, observing the potential demand of this facility comprises ca. 109,000 tonnes pellets per year.

- **Sumatera Utara (Rank 7)**
  Five landfill groups, ranked between 37 and 73 out of 77, consist of various combinations of 13 landfills. These landfill groups consist of two individual landfills and three clusters. These clusters include *TPA Terjun, TPA Tandukan Raga, TPA Namorube Julu, TPA Padang Cermin, TPA Bahorok, TPA Tangkahan Durian, TPA Kwala Bingai, TPA Baja, TPA Nangbelawan, TPA Belidaan, TPA Tanjung Pinggir Pematangsiantar, TPA Tongging, and TPA Keriahen*.
  The potential supply derives from above landfills achieves approximately 438,000 tonnes pellets per year. Meanwhile, the potential demand should further be identified, unless the steel industry located in the province reveals interest in RDF off-taking projects or other business cases arise.
  Currently, the main off-taker from these clusters is in the steel industry, with companies like Asia Raya Foundry, Cipta Baja Raya, Growth Asia, and Sentana Multi Makmur.

- **Riau (Rank 8)**
  One cluster consists of four landfills, ranked 54 out of 77 ranked landfill groups analysed. This cluster includes *TPA Pinggir, TPA Tualang, TPA Buantan Besar/Siak, and TPA-2 Muara Fajar*. Around 165,000 tonnes of pellets per year is expected as potential supply in the region. Currently, there is one off-taker in the steel industry, Riau Baja Indo, whose interest in RDF off-take needs to be explored further. Engaging with Riau Baja Indo to assess their interest and potential utilization of RDF from these landfills could open up opportunities for off-take partnerships and enhance the sustainability of waste management practices in the region.

- **Aceh (Rank 9)**
  Two clusters, each with a different number of landfills, have been identified. These two clusters are estimated to have a potential annual supply of approximately 105,000 tonnes and a potential annual demand of approximately 50,000 tonnes of pellets per year, respectively. The demand primarily originates from two identified off-takers.
  The first cluster comprises of six landfills, ranked 60 out of 77 ranked landfill groups analysed. These landfills include *TPA Kota Banda Aceh, TPA Lhok Batee, TPA Babah IE, TPA Bukit Meusara Kota Jantho, TPA Cot Padang Lila, and TPA Regional Blang Bintang*. The second cluster consists of two landfills, ranked 65 out of 77 ranked landfill groups, namely *TPA Uber-Uber and TPA Teupin Keubeu*.
  Exploring the interest of the cement industry, particularly companies like Solusi Bangun Andalas, and Pupuk Iskandar Muda, a fertilizer producer, is crucial. Despite their

The Project is funded by the European Union

participation in the survey revealing no plans with RDF, continuing dialogue with these industries is essential. By engaging in ongoing discussions, potential opportunities for collaboration and RDF off-take may arise, contributing to sustainable waste management practices in the region.

- **Sumatera Selatan (Rank 13)**
  Within an 80-kilometer vicinity, three landfill groups have been identified with off-take and supply sides, consisting of one individual landfill and two clusters. The total potential supply of Sumatera Selatan Province is approximately 290,000 tonnes of pellets per year, with potential demand estimated at around 56,000 tonnes of pellets per year from two off-takers.
  The analysis identifies two clusters, one ranked 51 with 5 landfills and the other ranked 76 with 4 landfills out of a total of 77 ranked landfill groups. The first cluster includes *TPA Panengahan, TPA Kalimiring, TPA Bumi Ayu, TPA Bakung, and TPA Karangrejo*. The second cluster includes *TPA Simpang Kandis, TPA Bukit Kancil, TPA Martapura, TPA Belitang*. One inidivual big landfill includes TPA Sukawinatan. Currently, the main off-taker from these clusters is in the cement industry, particularly Semen Baturaja. In addition, there is also one identified fertilizer industry, namely Pupuk Sriwidjaya Palembang.
  Exploring the interest of the cement industry further is crucial to potentially expand off-take opportunities and enhance the utilization of RDF from these landfills. Engaging with Semen Padang and other cement industry players to assess their interest and potential utilization of RDF can lead to partnerships that contribute to sustainable waste management practices and resource utilization.

7.4.3 Kalimantan Island

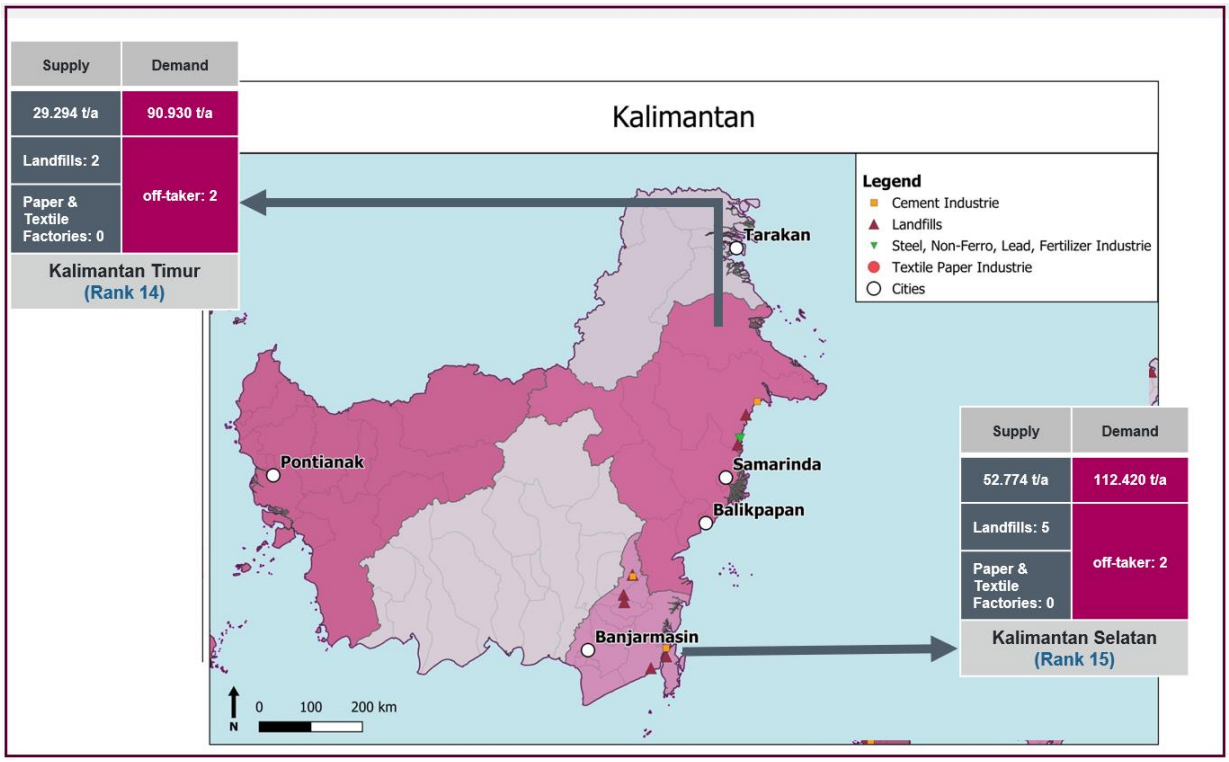


Figure 11: Kalimantan Island GIS Mapping

The Project is funded by the European Union

- **Kalimantan Timur (Rank 14)**
  Two landfill groups, ranked between 68 and 72 out of 77 nationally, consist of two clusters. Kalimantan Timur Province has supply potential of approx. 29,000 tonnes pellets per year. From demand side, Kalimantan Timur has a less demand potential than Kalimantan Selatan with approx. 90,000 tonnes pellets per year.
  The top ranked cluster in the province includes *TPA Bukit Pinang, TPA Sambutan, TPA Manggar, TPA Buluminung, and TPA Bekotok*. The identified off takers in the whole province include PT Kobexindo Cement from cement industry and Pupuk Kalimantan Timur from the fertilizer industry.
- **Kalimantan Selatan (Rank 15)**
  Two landfill groups, ranked 63 and 75 out of 77 nationally, comprise of two clusters. Kalimantan Selatan Province has a potential supply of approx. 52,000 tonnes pellets per year and approx. 112,000 tonnes pellets potential demand.
  The potential supply derives from five landfills, namely *TPA Bongkang, TPA Batu Merah, TPA Telang, TPA Betung, and TPA Sungup*. Meanwhile, the potential off takers are mainly from cement industry, namely PT Conch Cement Indonesia Tabalong and PT Indocement Tunggal Prakarsa - Tarjun Plant.

7.4.4 Sulawesi Island

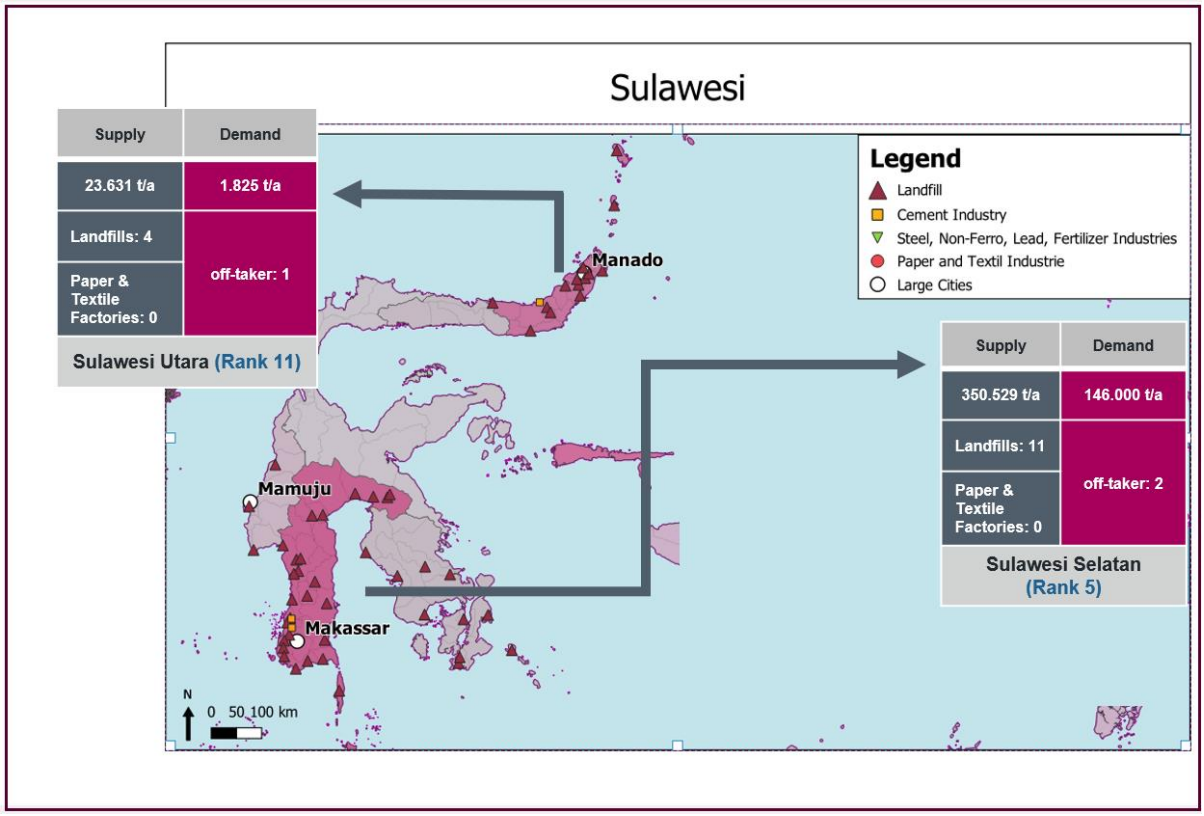


Figure 12: Sulawesi Island GIS Mapping

- **Sulawesi Selatan (Rank 5)**
  Three landfill groups, ranked between 44 and 58 out of 77 nationally, consist of two clusters. In Sulawesi Island, Sulawesi Selatan Province has more promising supply and demand potential of approx. 350,000 tonnes pellets per year and 146,000 tonnes pellets per year respectively compared to Sulawesi Utara Province.

The Project is funded by the European Union

The potential supply of Sulawesi Selatan Province includes 11 landfills, namely *TPA Lempa, TPA Padangloang, TPA Taraweang, TPA Bontoa, TPA Bonto Ramba, TPA Antang Tamangapa, TPA Tondong, TPA Batu Terang, TPA Pabentengang, TPA Balang, and TPA Pasippo*. From demand side, the potential demand comes from cement industry, includes PT Semen Tonasa and PT Semen Bosowa Maros.

- **Sulawesi Utara (Rank 11)**
  Sulawesi Utara is identified to have one cluster comprising four landfills, namely *TPA Mobongo, TPA Inuai, TPA Bonawang, and TPA Pinolantungan*, with a potential annual supply of 23,000 tonnes of pellets. On the demand side, the province is found to have one potential off-taker from the cement industry, namely PT Conch Cement Indonesia. The total potential demand in the province is approximately 1,800 tonnes of pellets per year.

7.4.5 Nusa Tenggara Archipelago

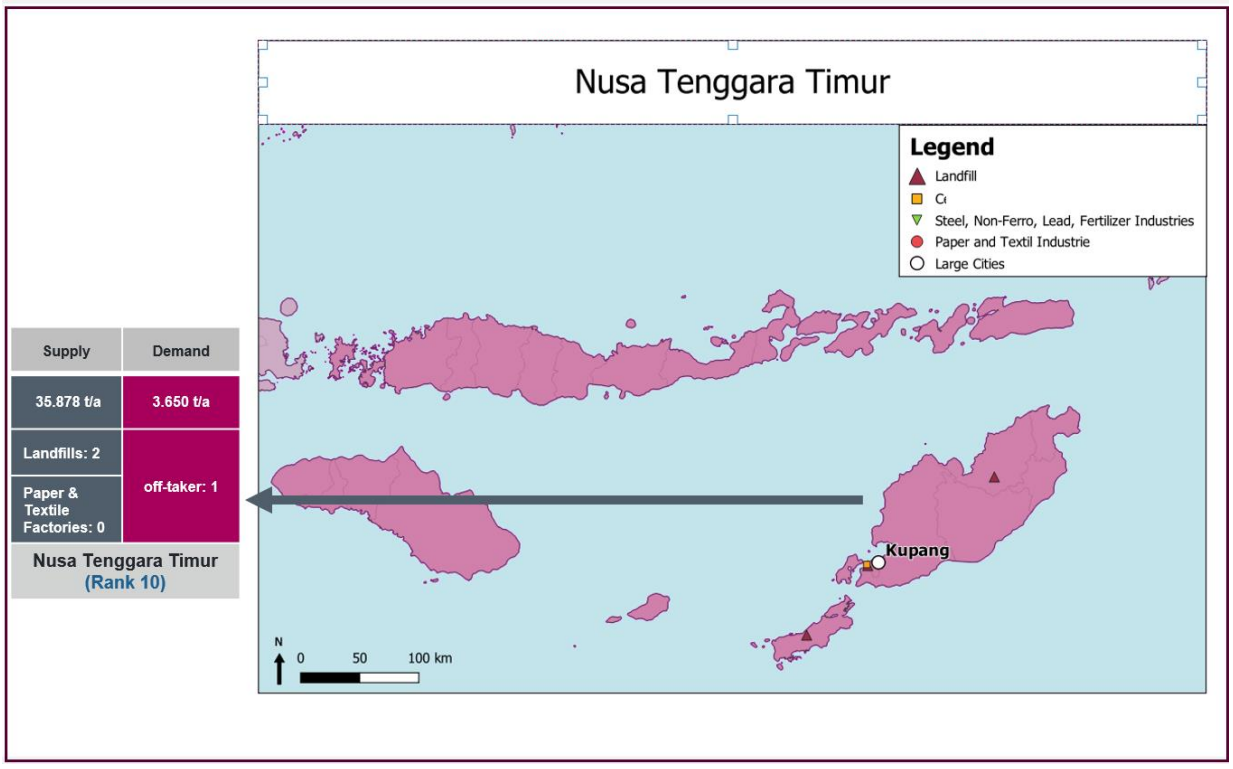


Figure 13: Nusa Tenggara Archipelago GIS Mapping

- **Nusa Tenggara Timur (Rank 10)**
  Nusa Tenggara Timur is identified to have one cluster comprising two landfills, namely *TPA Alak and TPA Oelunggu*, with a potential annual supply of 35,800 tonnes of pellets. The cluster in Nusa Tenggara Province is ranked 66 out of 77 national ranked landfill groups. On the demand side, the province is found to have one potential off-taker from the cement industry, namely Semen Kupang. The total potential demand in the province is approximately 3,600 tonnes of pellets per year.

The Project is funded by the European Union

7.4.6 Papua Island

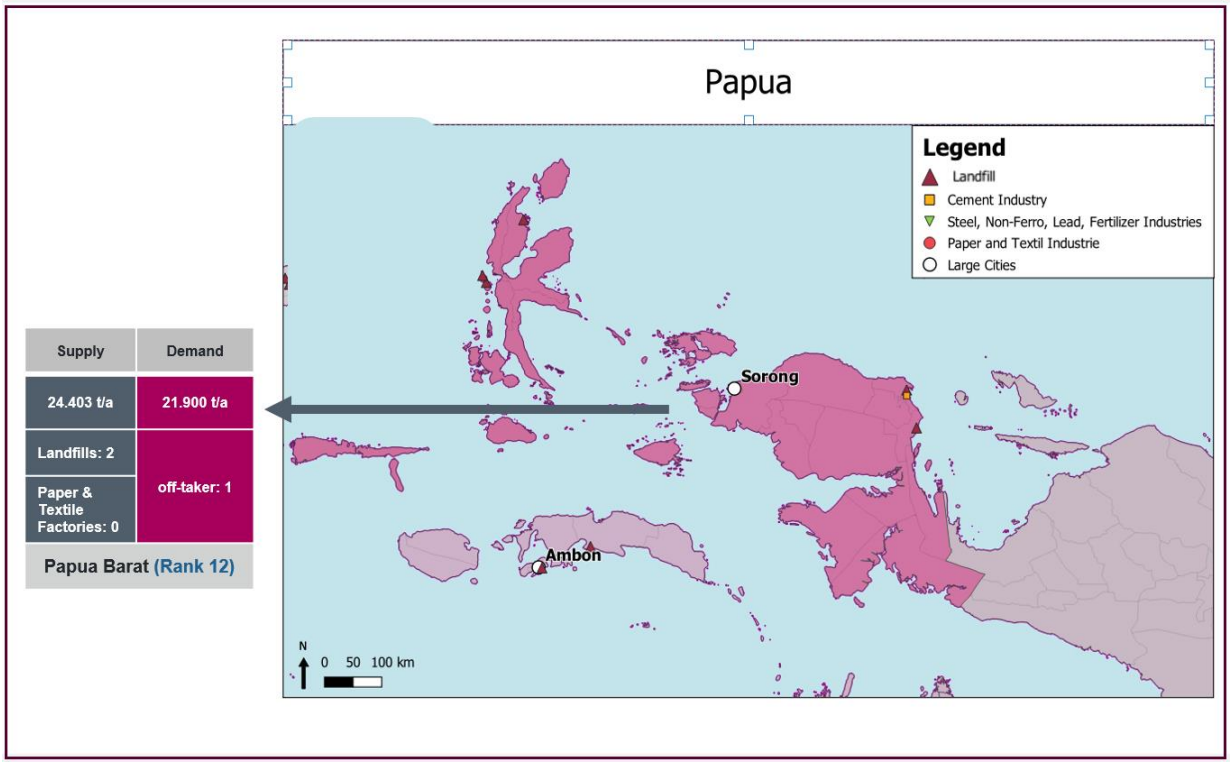


Figure 14: Papua Island GIS Mapping

- **Papua Barat (Rank 12)**

  Papua Barat is identified to have one cluster comprising two landfills, namely *TPA Sowi Gunung and TPA Ransiki*, with a potential annual supply of 24,400 tonnes of pellets. The cluster ranked 69 out of 77 ranked landfill groups nationally. On the demand side, the province is found to have one potential off-taker from the cement industry, namely SDIC Papua Cement Indonesia. The total potential demand in the province is approximately 21,900 tonnes of pellets per year.

The Project is funded by the European Union

Annex 1 – Structured Questionnaires

Questionnaire for the Indonesian Ministry of Environment and Forestry to gauge the interest from major Indonesian industrial associations regarding the adoption of refuse-derived fuels (RDF):

Indonesian Ministry of Environment and Forestry

Questionnaire on the Adoption of Refuse-Derived Fuels (RDF) by Industries

Dear [Association Name],

We are reaching out to understand your members' potential interest in using refuse-derived fuels (RDF). Your feedback will be valuable in shaping our policies and actions towards a sustainable energy future for Indonesia. Please take a few minutes to fill out this questionnaire:

1. **Awareness:** Are you aware of the concept and benefits of refuse-derived fuels (RDF)?
    - Yes
    - No
2. **Current Energy Sources:** What are the primary sources of energy currently used by your member companies?
    - Coal
    - Natural Gas
    - Biomass
    - Petroleum
    - Others: _____
3. **RDF Interest:** How interested would your member companies be in replacing or supplementing their current energy sources with RDF?
    - Very Interested
    - Somewhat Interested
    - Neutral
    - Somewhat Uninterested
    - Not Interested
4. **Barriers:** What do you perceive as the biggest barrier to the adoption of RDF by your member companies?
    - Lack of awareness about RDF
    - Technological challenges
    - Economic factors
    - Regulatory concerns
    - Others: _____
5. **Cost Willingness:** Would your member companies be open to bearing slightly increased costs initially if RDF proves to be more sustainable in the long run?

The Project is funded by the European Union

- Yes
- Maybe
- No

6. **Volume Needs:** Roughly, how much fuel (in tonnage) do your member companies consume on a monthly basis?
7. **Technical Assistance:** Would your member companies require technical assistance or training to shift to RDF?
    - Yes
    - No
8. **RDF Suppliers:** Would your member companies prefer domestic or international suppliers for RDF?
    - Domestic
    - International
    - No preference
9. **Environmental Concerns:** How important is it for your member companies to reduce their carbon footprint and contribute to a more sustainable environment?
    - Very Important
    - Somewhat Important
    - Neutral
    - Somewhat Unimportant
    - Not Important
10. **Policy Incentives:** What kind of incentives or policy support from the government would encourage your member companies to adopt RDF?
    - Tax breaks or subsidies
    - Technical training
    - Regulatory ease
    - Public recognition or certification
    - Others: _____
11. **Future Meetings:** Would your member companies be open to attending seminars or workshops organised by the Ministry of Environment and Forestry to better understand the potential of RDF?
    - Yes
    - Maybe
    - No
12. **Detailed Interview:** Would representatives from your member companies be willing to participate in a more detailed interview to further discuss the adoption of RDF?

The Project is funded by the European Union

- Yes
- Maybe
- No

Thank you for taking the time to complete this questionnaire. Your input is invaluable in guiding our initiatives for a cleaner and sustainable Indonesia.

Yours sincerely ,

Name, position

Indonesian Ministry of Environment and Forestry

Auxiliary Questions

Refuse Derived Fuels (RDF) Interest and Requirements Questionnaire

Dear Member,

Refuse Derived Fuels, commonly known as RDF, are fuels produced from various types of waste, such as municipal solid waste (MSW), industrial waste, or commercial waste. The primary aim of producing RDF is to divert waste away from landfills and convert it into valuable energy resources. Through a combination of manual and mechanical sorting processes, recyclables and inert substances are removed from the waste, leaving behind a homogenised mix which can then be used as a fuel. Using RDF not only helps in managing waste but also presents a sustainable and eco-friendly alternative to traditional fossil fuels. It plays a crucial role in reducing greenhouse gas emissions, conserving natural resources, and providing a potential economic advantage to industries that adopt it as a replacement or supplement to conventional fuels.

This questionnaire is designed to understand your company's inclination towards Refuse Derived Fuels (RDF). We're also keen to explore any technical, logistical, financial, and environmental needs your company might have in relation to RDF usage. Your cooperation is deeply valued.

General Information:

1. **Company Name:** _____
2. **Region of location:** _____
3. **Contact Name and Position:** _____
4. **Email:** _____
5. **Phone Number:** _____
6. **Primary Industry/Segment:** _____
7. **Company's Annual Revenue:** _____
8. **Number of Employees:** _____

Interest in Refuse Derived Fuels:

8. **Are you familiar with the concept of RDF?**
    - Yes
    - No
9. **Are you currently using RDF in your operations?**
    - Yes

The Project is funded by the European Union

- No

10. Are you interested in using RDF in your production processes?

- Yes
- No

11. If yes to question 9, please specify which types of RDF you are using and in what quantities (monthly/annually).

12. If yes to question 9, What percentage of your fuel source is currently constituted by RDF?

12. If yes to question 10 please specify which types of RDF you intend / estimate to use and in which quantities (monthly/annually).

13. If yes to question 10, What percentage of your fuel source could be constituted by RDF?

14. What are the main reasons for your interest in RDF? (Select all that apply)

- Cost savings
- Environmental concerns/benefits
- Energy efficiency
- Regulatory compliance
- Positive public image
- Others (Please specify) _____

15. Are you aware of any initiatives in your region to start producing RDF?

- Yes, if yes please provide information on initiatives known to you_____
- No

16. **Are you aware of any incentives offered by the government or other institutions for the use of RDF?**

- Yes
- No
- If yes, please specify which ones and if your company has availed any of them.

14. **Would financial incentives or subsidies increase your interest or feasibility in adopting RDF?**

- Significantly
- Moderately
- Slightly
- Not at all

Technical Requirements:

15. **List the specific technical specifications of RDF that your operations require.** (e.g., calorific value, moisture content, ash content, etc.)

16. **Do you have any equipment or infrastructure constraints when considering the use of RDF?**

The Project is funded by the European Union

- Yes
- No
- If yes, please describe in detail.

17. **Would you require any modifications to your existing equipment to accommodate the use of RDF?**

- Yes
- No
- If yes, please specify the type and scale of modifications.

18. **Are there specific RDF forms or processing techniques that are preferable for your operations?** (e.g., pellets, fluff, etc.) Please provide a preference ranking if possible.

Support in Technical Adjustments of Existing Operations:

19. **Would you require external technical support or consultancy to adapt your existing operations to accommodate RDF?**

- Yes
- No

20. **If your responsible industry association could provide technical support, workshops, or consultancy services on RDF adaptation, would this be of interest to your company?**

- Highly interested
- Moderately interested
- Slightly interested
- Not interested

Environmental and Health Considerations:

21. **Are you aware of the environmental risks and benefits associated with the use of RDF compared to traditional fuels?**

- Yes
- No

22. **Do you have concerns regarding the environmental impacts of RDF production or utilisation?**

- Yes
- No
- If yes, please describe your concerns.

23. **Are you aware of any health considerations or risks associated with the use of RDF?**

- Yes
- No
- If yes, please specify.

24. **Do you have a dedicated team or department to oversee environmental and health standards in relation to fuel sources, including RDF?**

- Yes
- No

Logistical Requirements:

The Project is funded by the European Union

25. **What is the preferred mode of RDF delivery to your facility?**

- Truck
- Rail
- Ship maritime
- Ship inland waterway
- Pipeline (if applicable)
- Others (Please specify) _____

26. **How frequently would you require RDF deliveries?**

- Daily
- Weekly
- Monthly
- Quarterly
- Others (Please specify) _____

27. **Do you have storage facilities for RDF at your operation site?**

- Yes
- No

28. **If yes to question 27, what is the capacity of your storage facilities?**

- …..

29. **Are there specific packaging requirements you have for RDF?** (e.g., bulk, bags, sealed containers, etc.)

- …..

30. **Have you engaged with your stakeholders (employees, local communities, customers) regarding the potential shift to RDF?**

- Yes
- No

31. **If you were to consider adopting RDF, would you be interested in tools or resources to facilitate stakeholder engagement and awareness about RDF?**

- Yes
- No

Additional Considerations:

32. **Are there any regulatory or licensing issues you foresee with the use of RDF in your operations?**

- Yes
- No
- If yes, please describe in detail.

33. **Are there any other concerns, questions, or comments you'd like to add regarding the use of RDF in your operations?**

Thank you for your time and participation. Your insights will help shape a sustainable future for our industry in Indonesia.

The Project is funded by the European Union

Annex 2 – Off-taker Survey Results

Name of Production Facility or Factory (example: ABCD Production Facility)	Company Name	Related Company Associations	Location of Production Facility or Factory (Province)	District/city where the production facility or factory is located	Do production facilities or factories currently utilise RDF as an alternative fuel?	Existing Energy Source	Does the production facility or factory use boilers?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)?	Does the factory have a plan or roadmap to use RDF as an alternative energy source?	Targeted utilisation of alternative fuel (RDF) in the production process	Has the plant ever trialled the use of RDF as an alternative fuel?	Does the mill have a calculation of the potential use of RDF?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)	Does the mill have a plan or roadmap to use RDF as an alternative energy source?	What is the potential use of RDF as an alternative fuel? (tonnes/day)	Does it currently have an MoU with the local government?	If yes, please state the name of the local government that is a partner in the MoU	Does it currently have a Cooperation Agreement with the local government?	If yes, please state the name of the government that is a partner in the cooperation agreement	State the name of the waste facility that is the current RDF input source (e.g. TPST/ITF/TPA Kota ABCD).	How much RDF is received (tonnes/day)?	What is the potential use of RDF as an alternative fuel? (tonnes/day)2	Mention any other relevant information related to RDF utilisation (if any)
Pabrik Pupuk Iskandar Muda-1	PT Pupuk Iskandar Muda	Asosiasi Produsen Pupuk Indonesia (APPI)	Aceh	Lhokseumawe	No								0	No	0	No		No		None yet	0	0	-
Pabrik Pupuk Iskandar Muda-2	PT Pupuk Iskandar Muda	Asosiasi Produsen Pupuk Indonesia (APPI)	Aceh	Lhokseumawe	No								0	No	0	No		No		None yet	0	0	-
Fasilitas Produksi Semen	PT Cemindo Gemilang Tbk	Asosiasi Semen Indonesia (ASI)	Banten	Lebak	No								2500 - 3000	Yes	45	No		No		None	None yet	Not yet known	None
Grinding Plant Bayah	PT Cemindo Gemilang	Asosiasi Produsen Pupuk Indonesia (APPI)	Banten	Bayah, Banten	No								300	Yes	5	No		No		None yet	0	5	Trials have been conducted, with plans to use RDF in 2024.
Grinding Plant Bengkulu	PT Cemindo Gemilang	Asosiasi Produsen Pupuk Indonesia (APPI)	Bengkulu	Bengkulu	No								300	Yes	5	No		No		None yet	0	5	Trials have been conducted, with plans to use RDF in 2024.
INDUSTRI PENGECORAN BESI DAN BAJA	PT. METINCA PRIMA INDUSTRIAL WORKS	Asosiasi Industri Pengecoran Logam Indonesia (APLINDO)	DKI Jakarta	JAKARTA TIMUR	No								16 MMBTU	No	0	No		No		0	0	0	0
Fasilitas produksi tissue	PT. Graha Bumi Hijau	Asosiasi Pulp dan Kertas Indonesia (APKI)	Jawa Barat	Kabupaten Bekasi	No								0,03	No	0,2	No		No		Landfill TPA Kabupaten Bekasi	-	0,2	-
Fasilitas Produksi Tissue	PT Graha Bumi Hijau	Asosiasi Pulp dan Kertas Indonesia (APKI)	Jawa Barat	Karawang	No								28	No	0.3	No		No		Landfill TPA Kabupaten Karawang	-	0.6	-
Indocement Unit	PT Indocement	Asosiasi Semen	Jawa Barat	Kabupaten Bogor	Yes	Coal;	No	800-850 ton/day	Yes	Prior to 2023	Yes	Yes										Gradually until 2030	-

The Project is funded by the European Union

Name of Production Facility or Factory (example: ABCD Production Facility)	Company Name	Related Company Associations	Location of Production Facility or Factory (Province)	District/city where the production facility or factory is located	Do production facilities or factories currently utilise RDF as an alternative fuel?	Existing Energy Source	Does the production facility or factory use boilers?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)?	Does the factory have a plan or roadmap to use RDF as an alternative energy source?	Targeted utilisation of alternative fuel (RDF) in the production process	Has the plant ever trialled the use of RDF as an alternative fuel?	Does the mill have a calculation of the potential use of RDF?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)	Does the mill have a plan or roadmap to use RDF as an alternative energy source?	What is the potential use of RDF as an alternative fuel? (tonnes/day)	Does it currently have an MoU with the local government?	If yes, please state the name of the local government that is a partner in the MoU	Does it currently have a Cooperation Agreement with the local government?	If yes, please state the name of the government that is a partner in the cooperation agreement	State the name of the waste facility that is the current RDF input source (e.g. TPST/ITF/TPA Kota ABCD).	How much RDF is received (tonnes/day)?	What is the potential use of RDF as an alternative fuel? (tonnes/day)2	Mention any other relevant information related to RDF utilisation (if any)
Pabrik Citeureup	Tunggal Pratama	Indonesia (ASI)																				to reach 3800 tonnes/day	
Indocement Unit Pabrik Citeureup	PT Indocement Tunggal Perkasa Tbk	Asosiasi Semen Indonesia (ASI)	Jawa Barat	Kabupaten Bogor	Yes	Coal;	No	800-850 ton/day	Yes	Prior to 2023	Yes	Yes										Gradually until 2030 to reach 3800 tonnes/day	-
Indocement Unit Pabrik Palimanan (Cirebon)	PT Indocement Tunggal Perkasa Tbk	Asosiasi Semen Indonesia (ASI)	Jawa Barat	Kabupaten Cirebon	Yes	Coal;	No	400-500 ton/day	Yes	Prior to 2023	Yes	Yes										gradually until 2030 to reach 800 tonnes/day	-
Pabrik Pengecoran Stainless Steel dan High Alloy	PT Trieka Aimex	Asosiasi Industri Pengecoran Logam Indonesia (APLINDO)	Jawa Barat	Citereup	No								0	No	Equivalent to electricity production of 1.5 MW/day	No		No		-	0	Equivalent to electricity production of 1.5 MW/day	-
Grinding Plant Ciwandan	PT Cemindo Gemilang	Asosiasi Produsen Pupuk Indonesia (APPI)	Jawa Barat	Ciwandan, Cilegon	No								300	No	5	No		No		None yet	0	5	Trials have been conducted, with plans to use RDF in 2024.
Grinding Plant Cibitung	PT Cemindo Gemilang	Asosiasi Produsen Pupuk Indonesia (APPI)	Jawa Barat	Cibitung, Bekasi	No								300	Yes	5	No		No		None yet	0	5	Trials have been conducted, with plans to use RDF in 2024.
Pabrik Kujang 1A	PT Pupuk Kujang	Asosiasi Produsen Pupuk Indonesia (APPI)	Jawa Barat	Cikampek	No								0	No	0	No		No		None	0	0	Current energy source from Gas, Electricity. Has a boiler.
Pabrik Kujang 1B	PT Pupuk Kujang	Asosiasi Produsen Pupuk Indonesia (APPI)	Jawa Barat	Cikampek	No								0	No	0	No		No		None	0	0	Current energy source from Gas, Electricity. Has a boiler.

The Project is funded by the European Union

Name of Production Facility or Factory (example: ABCD Production Facility)	Company Name	Related Company Associations	Location of Production Facility or Factory (Province)	District/city where the production facility or factory is located	Do production facilities or factories currently utilise RDF as an alternative fuel?	Existing Energy Source	Does the production facility or factory use boilers?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)?	Does the factory have a plan or roadmap to use RDF as an alternative energy source?	Targeted utilisation of alternative fuel (RDF) in the production process	Has the plant ever trialled the use of RDF as an alternative fuel?	Does the mill have a calculation of the potential use of RDF?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)	Does the mill have a plan or roadmap to use RDF as an alternative energy source?	What is the potential use of RDF as an alternative fuel? (tonnes/day)	Does it currently have an MoU with the local government?	If yes, please state the name of the local government that is a partner in the MoU	Does it currently have a Cooperation Agreement with the local government?	If yes, please state the name of the government that is a partner in the cooperation agreement	State the name of the waste facility that is the current RDF input source (e.g. TPST/ITF/TPA Kota ABCD).	How much RDF is received (tonnes/day)?	What is the potential use of RDF as an alternative fuel? (tonnes/day)2	Mention any other relevant information related to RDF utilisation (if any)
Pabrik Semen	PT. Solusi Bangun Indonesia Tbk - Pabrik Cilacap	Asosiasi Semen Indonesia (ASI)	Jawa Tengah	Cilacap	Yes	Coal;	No	1505.59 ton Raw Coal / hari	Yes	Prior to 2023	Yes	Yes										120 - 168 ton / day (Design Existing Capacity RDF Feeding Point to ILC : 5-7 tph) ; Actual Consumption : 90 - 120 ton / hari (Stock RDF Limit/ sering habis) ; Planning : Design Capacity RDF Feeding Point to SLC : 12 tph (Need Investment)	RDF with low moisture content produces NCV between 15 - 16 GJ/ton RDF. RDF can substitute the use of Coal in the combustion process. RDF has a heterogeneous size so that it has the potential to cause CO in the combustion process if the volume that enters at one time is too much. With heterogeneous size, the stability of RDF consumption is quite fluctuating. RDF contains a lot of chlorine, potentially build up.

The Project is funded by the European Union

Name of Production Facility or Factory (example: ABCD Production Facility)	Company Name	Related Company Associations	Location of Production Facility or Factory (Province)	District/city where the production facility or factory is located	Do production facilities or factories currently utilise RDF as an alternative fuel?	Existing Energy Source	Does the production facility or factory use boilers?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)?	Does the factory have a plan or roadmap to use RDF as an alternative energy source?	Targeted utilisation of alternative fuel (RDF) in the production process	Has the plant ever trialled the use of RDF as an alternative fuel?	Does the mill have a calculation of the potential use of RDF?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)	Does the mill have a plan or roadmap to use RDF as an alternative energy source?	What is the potential use of RDF as an alternative fuel? (tonnes/day)	Does it currently have an MoU with the local government?	If yes, please state the name of the local government that is a partner in the MoU	Does it currently have a Cooperation Agreement with the local government?	If yes, please state the name of the government that is a partner in the cooperation agreement	State the name of the waste facility that is the current RDF input source (e.g. TPST/ITF/TPA Kota ABCD).	How much RDF is received (tonnes/day)?	What is the potential use of RDF as an alternative fuel? (tonnes/day)2	Mention any other relevant information related to RDF utilisation (if any)
TEXTILE	PT SARI WARNA ASLI I	Asosiasi Pertekstilan Indonesia (API)	Jawa Tengah	KARANGANYAR	Yes	Coal;	Yes	70 TON / day	No	Prior to 2025	No	No											ECO-FRIENDLY, ENERGY EFFICIENT
Industri garment	PT BENGAWAN SOLO GARMENT INDONESIA	Asosiasi Pertekstilan Indonesia (API)	Jawa Tengah	Boyolali	No								2	No	2	No		No		-	-	-	-
Fasilitas Produksi Textile	PT. Iskandar Indah Printing Textile	Asosiasi Pertekstilan Indonesia (API)	Jawa Tengah	Surakarta	No								0	No	0	No		No		None	0	0	None
Indocement unit Pabrik Grobogan Jawa Tengah	PT Indocement Tunggal Perkasa Tbk	Asosiasi Semen Indonesia (ASI)	Jawa Tengah	Kabupaten Grobogan	Yes	Coal;	No	< 5 ton/day	Yes	2023	Yes	Yes										gradually until 2030 to reach 300 tonnes/day	-
INDUSTRI KERTAS INDUSTRI	PT. MEKABOX INTERNATIONAL	Asosiasi Pulp dan Kertas Indonesia (APKI)	Jawa Timur	MOJOKERTO	No								None	No	None	No		No		None	None	None	None
Fasilitas Produksi Semen	1. PT Semen Indonesia (Persero) Tbk.	Asosiasi Semen Indonesia (ASI)	Jawa Timur	Tuban	Yes	Coal;Others;Electricity (PLN);	No	6.200 ton/day	Yes	2023	Yes	Yes										375 ton/day	Already exploring cooperation with Bali, Tuban, Sidoarjo, Gresik and Surabaya
Pabrik Kertas PT. Setia Kawan Makmur Sejahtera	PT. Setia Kawan Makmur Sejahtera	Asosiasi Pulp dan Kertas Indonesia (APKI)	Jawa Timur	Tulungagung	No								8	No	0	No		No		0	0	0	0
Paper Machine, Power Plant, WWT, SWT	PT ADIPRIMA SURAPRINTA	Asosiasi Pulp dan Kertas Indonesia (APKI)	Jawa Timur	GRESIK	No								0 ton/day, Using PLN	No	0 ton/day	No		No		TPST	0	0	-
Pabrik Kertas & Karton Box	PT. Surabaya Mekabox	Asosiasi Pulp dan Kertas Indonesia (APKI)	Jawa Timur	Gresik	Yes	Coal;	Yes	+- 300 ton / day	Yes	2024	Yes	Yes										+- 15 ton / day	None

The Project is funded by the European Union

Name of Production Facility or Factory (example: ABCD Production Facility)	Company Name	Related Company Associations	Location of Production Facility or Factory (Province)	District/city where the production facility or factory is located	Do production facilities or factories currently utilise RDF as an alternative fuel?	Existing Energy Source	Does the production facility or factory use boilers?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)?	Does the factory have a plan or roadmap to use RDF as an alternative energy source?	Targeted utilisation of alternative fuel (RDF) in the production process	Has the plant ever trialled the use of RDF as an alternative fuel?	Does the mill have a calculation of the potential use of RDF?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)	Does the mill have a plan or roadmap to use RDF as an alternative energy source?	What is the potential use of RDF as an alternative fuel? (tonnes/day)	Does it currently have an MoU with the local government?	If yes, please state the name of the local government that is a partner in the MoU	Does it currently have a Cooperation Agreement with the local government?	If yes, please state the name of the government that is a partner in the cooperation agreement	State the name of the waste facility that is the current RDF input source (e.g. TPST/ITF/TPA Kota ABCD).	How much RDF is received (tonnes/day)?	What is the potential use of RDF as an alternative fuel? (tonnes/day)2	Mention any other relevant information related to RDF utilisation (if any)
Fasilitas RDF dan boiler	PT. Pabrik Kertas Tjiwi Kimia, Tbk	Asosiasi Pulp dan Kertas Indonesia (APKI)	Jawa Timur	Sidoarjo	No								Ca. 3000	Yes	250	No		No		None yet	None yet	250	Not yet operational
Fasilitas Produksi	PT Indonesia Royal Paper	Asosiasi Produsen Pupuk Indonesia (APPI)	Jawa Timur	Jombang	No								75	No	None yet	No		No		None yet	0	None yet	need the results of a study from the Government that is massively socialised about the use of RDF
Pabrik Pupuk Petrokimia	PT Petrokimia Gresik	Asosiasi Produsen Pupuk Indonesia (APPI)	Jawa Timur	Gresik	No								190	No	it is necessary to conduct a study	No		No		None yet	0	it is necessary to conduct a study	No studies have been conducted on the use of RDF as a substitute for fossil energy sources
Grinding Plant Gresik	PT Cemindo Gemilang	Asosiasi Produsen Pupuk Indonesia (APPI)	Jawa Timur	Gresik	No								300	Yes	5	No		No		None yet	0	5	Trials have been conducted, with plans to use RDF in 2024.
Grinding Plant Pontianak	PT Cemindo Gemilang	Asosiasi Produsen Pupuk Indonesia (APPI)	Kalimantan Barat	Pontianak	No								300	Yes	5	No		No		None yet	0	5	Trials have been conducted, with plans to use RDF in 2024.
Fasilitas Produksi Semen	PT. Conch South Kalimantan Cement	Asosiasi Semen Indonesia (ASI)	Kalimantan Selatan	Kabupaten Tabalong	No								Kiln (700 ton/day) dan PLTU (375 ton/day)	Yes	Kiln (8 ton/day)	No		No		Landfill TPA Kabupaten Tabalong, Desa Bongkang	3 Ton/day	8 Ton/day	Still planning, and will conduct comparative studies to several cement industries.

The Project is funded by the European Union

Name of Production Facility or Factory (example: ABCD Production Facility)	Company Name	Related Company Associations	Location of Production Facility or Factory (Province)	District/city where the production facility or factory is located	Do production facilities or factories currently utilise RDF as an alternative fuel?	Existing Energy Source	Does the production facility or factory use boilers?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)?	Does the factory have a plan or roadmap to use RDF as an alternative energy source?	Targeted utilisation of alternative fuel (RDF) in the production process	Has the plant ever trialled the use of RDF as an alternative fuel?	Does the mill have a calculation of the potential use of RDF?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)	Does the mill have a plan or roadmap to use RDF as an alternative energy source?	What is the potential use of RDF as an alternative fuel? (tonnes/day)	Does it currently have an MoU with the local government?	If yes, please state the name of the local government that is a partner in the MoU	Does it currently have a Cooperation Agreement with the local government?	If yes, please state the name of the government that is a partner in the cooperation agreement	State the name of the waste facility that is the current RDF input source (e.g. TPST/ITF/TPA Kota ABCD).	How much RDF is received (tonnes/day)?	What is the potential use of RDF as an alternative fuel? (tonnes/day)2	Mention any other relevant information related to RDF utilisation (if any)
Indocement Unit Pabrik Tarjun, Kalsel	PT Indocement Tunggal Perkasa Tbk	Asosiasi Semen Indonesia (ASI)	Kalimantan Selatan	Kabupaten Kota Baru	Yes	Coal;	No	150 - 200 ton/day	Yes	Prior to 2023	Yes	Yes											Gradually until 2023 to reach 300 tonnes/day	-
Grinding Plant Batam	PT Cemindo Gemilang	Asosiasi Produsen Pupuk Indonesia (APPI)	Kepulauan Riau	Batam	No								300	Yes	5	No		No		None yet	0	5	Trials have been conducted, with plans to use RDF in 2024.
Semen	PT Semen Kupang (Persero)	Asosiasi Semen Indonesia (ASI)	Nusa Tenggara Timur	Kota Kupang	No								300 ton coal/day	No	10 ton/day	No		No		None	None	10	None
Grinding Plant Muara Jawa	PT Cemindo Gemilang	Asosiasi Produsen Pupuk Indonesia (APPI)	Nusa Tenggara Timur	Muara Jawa, Kutai Kartanegara	No								300	Yes	5	No		No		None yet	0	5	Trials have been conducted, with plans to use RDF in 2024.
Fasilitas Produksi Semen	PT.SDIC Papua Cement Indonesia	Asosiasi Semen Indonesia (ASI)	Papua Barat	Manokwari	No								932	No	100	No		No		Landfill - TPA Kota Manokwari	100	60	-
Pabrik Semen Tonasa	PT Semen Tonasa	Asosiasi Semen Indonesia (ASI)	Sulawesi Selatan	Kabupaten Pangkajene & Kepulauan	Yes	Coal;Electricity (PLN);	No	3500 ton per hari	Yes	2023	Yes	Yes										100 ton/day	The Pangkajene & Kepulauan Regency Government is building an RDF-based waste management facility with a capacity of 20 tonnes per day with PT Semen Tonasa as the off-taker (both parties have

The Project is funded by the European Union

Name of Production Facility or Factory (example: ABCD Production Facility)	Company Name	Related Company Associations	Location of Production Facility or Factory (Province)	District/city where the production facility or factory is located	Do production facilities or factories currently utilise RDF as an alternative fuel?	Existing Energy Source	Does the production facility or factory use boilers?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)?	Does the factory have a plan or roadmap to use RDF as an alternative energy source?	Targeted utilisation of alternative fuel (RDF) in the production process	Has the plant ever trialled the use of RDF as an alternative fuel?	Does the mill have a calculation of the potential use of RDF?	What is the current quantity of fossil fuel use as the main energy source (tonnes/day)	Does the mill have a plan or roadmap to use RDF as an alternative energy source?	What is the potential use of RDF as an alternative fuel? (tonnes/day)	Does it currently have an MoU with the local government?	If yes, please state the name of the local government that is a partner in the MoU	Does it currently have a Cooperation Agreement with the local government?	If yes, please state the name of the government that is a partner in the cooperation agreement	State the name of the waste facility that is the current RDF input source (e.g. TPST/ITF/TPA Kota ABCD).	How much RDF is received (tonnes/day)?	What is the potential use of RDF as an alternative fuel? (tonnes/day)2	Mention any other relevant information related to RDF utilisation (if any)
																							signed an MoU).
Semen Bosowa Maros	PT Indocement Tunggal Perkasa Tbk	Asosiasi Semen Indonesia (ASI)	Sulawesi Selatan	Kabupaten Maros	Yes	Coal;	No	< 5 ton/hari	Yes	Prior to 2023	Yes	Yes										Gradually until 2030 to reach 300 tonnes/day	-
Pabrik Semen	PT Conch North Sulawesi Cement	Asosiasi Semen Indonesia (ASI)	Sulawesi Utara	Bolaang Mongondow	No								800	No	5	No		No		-	-	5	-
Indarung	PT Semen Padang	Asosiasi Semen Indonesia (ASI)	Sumatera Barat	Padang	No								Ca. 4500	Yes	104	Yes	Padang	No		None	None yet	300	None
Fasilitas Kiln Semen	PT Semen Padang	Asosiasi Semen Indonesia (ASI)	Sumatera Barat	Padang	No								4060	Yes	150	Yes	Government of Kota Padang	No		Landfill-TPA	104	150	Still under PUPR-Ministry of Work review
Pabrik UREA Pusri	PT Pupuk Sriwidjaja Palembang	Asosiasi Produsen Pupuk Indonesia (APPI)	Sumatera Selatan	Palembang	No								1500	Yes	15	No		No		None yet	0	15	Plan to use RDF in 2024
Grinding Plant Medan	PT Cemindo Gemilang	Asosiasi Produsen Pupuk Indonesia (APPI)	Sumatera Utara	Medan	No								300	Yes	5	No		No		None yet	0	5	Plan to use RDF in 2024. Trials have been conducted using RDF.

The Project is funded by the European Union

Annex 3 - The Excel MCA Model in Detail

Spreadsheet DataCalc

Starting with the spreadsheet titled "DataCalc", which contains raw data provided by the Ministry of Environment and Forestry of Indonesia (hidden spreadsheet to avoid data losses).

The following reference has been used to assess calorific value:

Categories of waste		Mj/ kg			Mj/t raw mater	Mj/T pallets
Organic Material (food waste, yard waste		5			5000	10000
Woods		15			10000	15000
Paper and cardboard		10			15000	20000
Plastic		20			25000	30000
Textiles		15			20000	25000

The spreadsheet titled "Filter" details a process where calculations were performed on all data from a database. This spreadsheet is designated as a backup data source for a first-layer filter focused on large waste generation area. After applying this initial filter, selected landfills were then processed and moved to the next stage, MCA for further evaluation.

At the same time in GIS clusters were created to detect potential demands, and landfills in vicinity of 80 km were identifies and evaluated similar as individual landfills in vicinities of large waste generation areas. Both clusters and individual landfills were moved to MCA.

The titled MCA details the use of multi-criteria analysis (MCA) to refine a list of top-ranked landfills, prioritizing those with the highest volume and calorific value while excluding duplicates and selecting only the sites with the most recent data. This spreadsheet lays the groundwork for MCA to prepare for further screening and in-depth investigations once the current study concludes.

Purpose of this spreadsheet is a basis for MCA (multicriteria analysis) to prepare the screening list for further investigations, after current study is completed.

Results represent a screened list for further investigations at fact finding missions.

Additional parameters are added - scoring of the landfill on the scale of 0 to 10, in relation to the maximum - e.g. production potential, demand estimation, and applies to all parameters

The Project is funded by the European Union

Some suppliers and off-takers which may be located in radius of 80 km to several times are not excluded (counted each time they are located in a vicinity of a landfill) - this will be regulated by MCA.

Clusters of landfills are also evaluated the spreadsheet MCA details components used in a multi-criteria analysis for landfill site evaluation from 2019 to 2022. It includes a variety of data points:

- Regional and district locations of landfills and clusters.
- Percentage composition of different types of waste found in current landfills7clusters, including food waste, wood, paper, plastic, metal, fabric, rubber, leather, glass, and other unspecified waste types.
- The annual waste generation in tonnes and the total calorific value (MJ/Ton) for each landfill.
- The data's plausibility is checked and indicated as either calculated (1) or extrapolated (0).
- The population of the nearest city to each landfill is listed as a proxy for social impact, which will require adjustment at the pre-feasibility stage.
- The reliability of the landfill data is scored for risk assessment purposes, alongside various normalisation scores ranging from 1 to 10 for aspects like tonnage, calorific value, population, and distance to off-takers.
- GIS-extracted data provides the coordinates of landfills, distances to traditional and potential off-takers (such as coal, cement, fertilizer, textile, and paper factories) within a 125 km radius, and verifies if coordinates are correct.
- Scores are assigned to clusters of traditional and potential off-takers based on the number of entities and their distance from the landfills, serving as a proxy to express cluster potential.
- Additional suppliers are also scored, and existing RDF facilities in the vicinity are accounted for.
- Assumed risks based on the plausibility and completeness of data are scored, and a total score for each landfill is calculated using an MCA formula.
- Finally, landfills are ranked according to the results derived from the applied formula.

Scale of 0 to 10 for all parameters

- Different criteria in a multicriteria analysis model have varying units or measurement scales. For example, one criterion might be measured in MJ, another in km, and a third in units of time. Without bringing them to a common scale, it becomes challenging to compare and analyse their relative importance or contribution to the overall decision.
- Weights are assigned to criterion based on its relative importance. If the criteria are not on the same scale, assigning meaningful and fair weights becomes problematic. Bringing all criteria to a common scale allows for a more straightforward and accurate weighting process.

The Project is funded by the European Union

- Ensuring consistency across criteria is crucial for a fair and reliable analysis. Having different scales for various criteria can introduce biases and inconsistencies in the decision-making process. A common scale helps eliminate these issues, ensuring that each criterion is treated consistently.
- Performing mathematical operations and aggregating scores is simplified when all parameters are on the same scale. It allows for straightforward mathematical operations such as addition or averaging, making the analysis more manageable and interpretable.
- Using a common scale enhances the interpretability of the results. Stakeholders involved in the decision-making process can more easily understand when all criteria are presented in a comparable format.
- Bringing criteria to a common scale often involves normalization. Normalizing criteria involves transforming them into a standard unit or dimensionless quantity. This process helps in removing the influence of the original measurement units, making the analysis more robust and less sensitive to the choice of units.

Spreadsheet on Weight (3 tabs) presents a model for determining criteria weights using a paired comparison methodology within the Delphi process, focusing on eight criteria important for waste management and RDF facility planning. The weights assigned to each criterion are as follows:

Current criteria:	Weights
Volume / Size of a Landfill	13%
Calorific value/Production Potential	17%
Population in the nearest city	12%
Offtakers in vicinity (max.80km)	17%
Envisaged Demand of Offtakers (medium run)	19%
Potential raw material suppliers for an RDF facility (paper & textile)	8%
Assumed Supply-Demand Match	12%
Risks on plausibility/completeness of the obtained data	3%

These weights reflect a development bank's perspective, emphasizing social responsibility and the specific targets of the study (demand and off-taker perspective). The current weights are provided as recommendations, and it is noted that changing these weights could lead to different results, depending on the decision-maker's goals. This underscores the customizable nature of the model, allowing it to be tailored to various objectives and priorities.

The model encapsulated in Weights utilizes a formula to rank landfills (LFR) based on various criteria in MCA, each with a specific weight that reflects a development bank’s focus on sustainable development, environmental responsibility, and economic viability.

The criteria considered are:

The Project is funded by the European Union

*LRF=Wv*V+Wcv* CV+Wp*P+Wto*TO+Wo*O+Wd*D+Wsd*SD+Wr*R*

LRF= landfill rank
V= Volume / Size of a Landfill
CV= Calorific value/Production Potential
P= Population in the nearest city
TO= Offtakers in vicinity (max.80km)
D= Envisaged Demand of Offtakers (medium run)
PS= Potential raw material suppliers for an RDF facility (paper & textile)
SD= Assumed Supply-Demand Match
R= Risks on plausibility/completeness of the obtained data

NB: Other criteria may be added, or omitted
The formula considers a range of environmental, economic, and operational factors, aligning witha development bank's goals of promoting sustainable development, environmental responsibility, and economic viability, in view of utilising potential for RDF facilities installation and attraction of new potential offtakers and raw material suppliers to increase the importance of an RDF potential site. The inclusion of risk assessment also reflects a commitment to informed decision-making. Specific weights assigned to each criterion should be based on the bank's priorities and the unique context of further projects.

The Project is funded by the European Union

LRF (Landfill Rank):
Demontrates interest in environmental sustainability and responsible waste management. The consideration of landfill rank reflects a commitment to assessing and addressing environmental impacts associated with waste disposal.

V (Volume/Size of a Landfill):
The volume or size of a landfill is a crucial factor as it directly relates to the scale of waste management operations. Larger landfills usually require more substantial investments, but they could also have a greater impact on waste management efficiency.

CV (Calorific Value):

Calorific value it indicates the energy potential of the waste for RDF, production potential

P (Population in the Nearest City):

The population in the nearest city which could influence the amount of waste generated, ans a proxy to estimate level of adverse impact onsociety.

TO (Offtakers):

Recognizing established markets or consumers of Refuse-Derived Fuel (RDF) within a specified radius is crucial for supporting an RDF facility. This acknowledges the importance of understanding and catering to the existing demand for RDF products.

D (Demand):

Envisagesd demand, or market potential for RDF products

PS (Potential Raw Material Suppliers for an RDF Facility):
New potential suppliers increase the attractiveness of a site.

SD (Demand Supply Matching at Screening Stage):

Demand-driven judgment at the screening phase assumes, that even is supply estimated using the current methodology and official data may not be sufficient for an RDF factory, a factor of demand is a prevailing one, and cluster with demand exceeding supply are provided a better score. However, at the feasibility stage additional investigation on available raw material supply needs to be implementing, including checking for informal sector landfills, waste collection practices and additional sources of raw materials for a factory.

R (Risks on Plausibility/Completeness of Data):
Including a criterion for assessing the risks associated with data quality indicates a commitment to robust decision-making to prioritize projects with thorough and reliable data, minimizing uncertainties.

Defining the scores for weighting in a Delphi process

The process of defining scores for weighting by pairwise comparison is detailed in a two-step methodology typically conducted in a workshop setting to ensure statistically reliable judgments.

Completion of the pairwise comparison matrix (Step 1):

Criteria are evaluated two at a time based on their relative importance, with index values ranging from 1 to 9. A score of 1 indicates equal importance, while a score of 9 suggests one parameter is extremely more important than the other. For inverse importance, fractional values from 1/1 to 1/9 are used, where 1/9 denotes a parameter being extremely less important than another.

The values are input into a cross-matrix, with the diagonal containing only values of 1, representing a parameter compared to itself. The matrix is filled out such that if parameter A's importance relative to B is n, then B's importance relative to A is entered as 1/n, ensuring consistency.

The Project is funded by the European Union

Calculating the criteria weights (Step 2):

A normalised comparison matrix is created by dividing each matrix value by the sum of its column. The weights of individual parameters are derived by calculating the mean of each row in this normalised matrix. These weights are already normalised to sum to 1.

This approach allows for the determination of normalised weights for parameters within the entire system, first for macro-level parameters and then for micro-level criteria. The normalised weights reflect the significance of each parameter in the context of the whole system.

The process for defining scores through pairwise comparison involves two key steps, typically conducted in a workshop setting to ensure statistically reliable judgments.

Step 1 – Pairwise Comparison Matrix:

- Two criteria are compared at a time to determine their relative importance, with index values ranging from 1 to 9 based on their perceived importance.
- A score of 1 indicates equal importance, while a score of 9 suggests extreme importance of one parameter over another. Lesser importance is indicated by fractional values between 1/1 to 1/9.
- Values are filled into a cross-matrix row by row, with the matrix's diagonal containing values of 1 since it compares a parameter to itself.
- After filling in the upper half of the matrix, the lower half is automatically completed with reciprocal values for consistency.

Step 2 – Calculating Criteria Weights:

- A normalised comparison matrix is created by dividing each value by the sum of its column.
- The weights of the individual parameters are then calculated by averaging each row of this normalised matrix, with the sum of weights normalised to 1.

This procedure establishes the normalised weights of parameters within the entire system and is conducted for both macro-level and micro-level criteria.

A normalised comparison matrix is created by dividing each value by the sum of its column.

The average of each row in this matrix provides the normalised weight of each parameter, ensuring the sum of weights equals 1.

This method allows for the determination of a parameter's weight within the whole system, applicable to both macro and micro-level criteria. The normalised weights help ensure that all parameters are considered fairly and proportionally in the overall assessment.

The Project is funded by the European Union

In the context of decision-making models and tools, has three spreadsheets „Weights Delphi," "Weights Pay," "Result Weights" to serve as a tool for weights determination a multi-criteria analysis (MCA) framework.

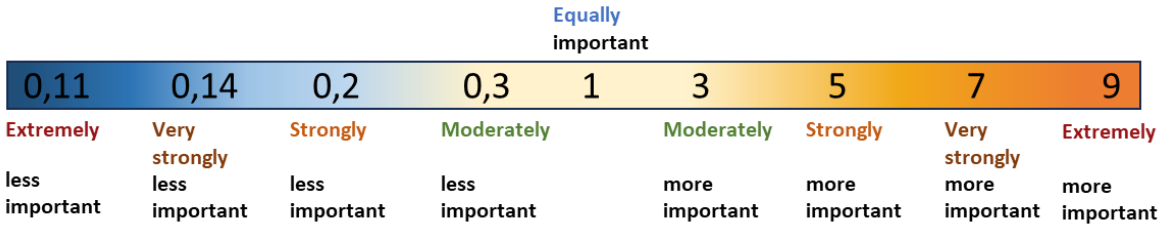
1. **Weights Delphi: represents cumulative criterial weighting by task of study experts.**
2. **Weights Pax: can be utilised to correct the wights by additional participants (currently values are the same as in Delphi Weights**
3. **Weights Result** Result weights are the final set of weights used in the MCDA process. They are derived after considering all inputs, discussions, and adjustments from the previous methods (like Delphi and pairwise comparisons).

- These weights are applied to the criteria to calculate a final score or rank for each decision option within the model.

The overall goal is to integrate expert opinion, reduce bias, and ensure that the final weights reflect a comprehensive and balanced view of all criteria considered in the decision-making process.

The Project is funded by the European Union

		A	B	C	D	E	F	G	H
		Volume / Size of a Landfill	Calorific value/Production Potential	Population in the nearest city	Offtakers in vicinity (max.80km)	Envisaged Demand of Offtakers (medium run)	Potential raw material suppliers for an RDF facility (paper & textile)	Assumed Supply-Demand Match	Risks on plausibility/completeness of the obtained data
A	Volume / Size of a Landfill	1	0,333333333	2	1	1	2	1	4
B	Calorific value/Production Potential	3,00	1,00	2	1	1	2	1	4
C	Population in the nearest city	0,50	0,50	1,00	2	0,5	2	1	4
D	Offtakers in vicinity (max.80km)	1,00	1,00	0,50	1,00	3	3	1	6
E	Envisaged Demand of Offtakers (medium run)	1,00	1,00	2,00	0,33	1,00	9	1	7
F	Potential raw material suppliers for an RDF facility (paper & textile)	0,50	0,50	0,50	0,33	0,11	1,00	1	5
G	Assumed Supply-Demand Match	1,00	1,00	1,00	1,00	1,00	1,00	1,00	2
H	Risks on plausibility/completeness of the obtained data	0,25	0,25	0,25	0,17	0,14	0,20	0,50	1,00



The Project is funded by the European Union

Spreadsheet Offtakers represent data for GIS integration on various industries below:

Off-takers and Suppliers	data from GIS the following information on off-takers - *Cement* - *Fertilizer* - *Steel* - *Investment Casting* *Non-Ferro Casting -* - *Aluminium* - *Lead Recycle Industries* - *Alloy Aluminium*

Information on additional Suppliers (paper and textile industry) is provided in the respective spreadsheet.

A comprehensive spreadsheet on Landfill List with proven coordinated and other information is provided too.

In addition, information is provided on the Minutes of meetings with associations MoM_OT_IA Tab and in industry Survey Tab, which served as the basis for extrapolation of the demand.

The following extrapolation has been made in the model:

Extrapolation				
	Indonesian Cement Industry	50930	t/year / enterprise	extrapolated from total industry demand communicated
	Indonesian Pulp and Paper Industry Associations (APKI)	0		not considered in the analysis
	Indonesian Fertilizer Producer Association	40000	t/year / enterprise	extrapolated from total industry demand communicated
	Indonesian Metal Casting Industry Association	0		based on interviews prefer electricity and not RDF, but restrictions on energy sector will onl
	Indonesian Olefin, Aromatic and Plastic Industry Association (INAPLAS)	0		
	Indonesian Processing and Refining Industry Association (AP3I)/Smelter	20000	t/year / enterprise	extrapolated from estimation under restrictive assumptions of less than 1% co-firing
	Textile industry association	0		

The Project is funded by the European Union

The excel data also consists of various spreadsheets with respective functions as follows:

- DemandSupply_Intern : Important source of cluster information. The main role of this spreadsheet is a meeting point for all sources data and providing cluster analysis and categorization. this spreadsheet should not be edited or changed in case no new source information data are found.
- DashBoard_Cluster: This is a "user" interface for the information available at *DemandSupply_Intern* spreadsheet. Here all overviews and summaries of the clusters can be viewed.
- SUM_DemSupply: This spreadsheet is a feeder for MCA cluster ranking and contains summary information for each cluster.
- ProvLevelSupply: Overview of utilised landfills per province.
- Sum_ProvLevel: Overview of information based on provinces.
- Report: MCA result table adapted for insertion into the report.
- MCA: Multi Criteria Analysis Spreadsheet.
- Result Weight: Overview of weights determination for the multi-criteria analysis (MCA) framework
- Manual: The manual on using the excel data.

Furthermore, it is important to note that the Excel file also contains hidden spreadsheets that may have direct or indirect connections to the aforementioned spreadsheets. Therefore, it is advised to refrain from deleting these spreadsheets.