



Fuel processing innovation (Badriah) based on Refuse Derived Fuel (RDF) at Pangkep Environmental Office

Nur Annisa Ali^{1*}, Muh. Akmal Ibrahim², Muhammad Yunus³

^{1,2,3}Public Administrasion, Hasanuddin University, Indonesia. E-mail: nurannisaali3@gmail.com

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ABSTRACT

Innovation in environmental management is an important effort to enhance the efficiency and effectiveness of governance, particularly in addressing increasingly complex waste management issues. The Environmental Agency of Pangkep Regency has implemented a waste-to-fuel processing innovation (Badriah) based on Refuse Derived Fuel (RDF) through the Badriah Plant, aimed at reducing waste accumulation in landfills (TPA) while simultaneously producing environmentally friendly alternative fuel. This study employs a descriptive qualitative approach to analyze the implementation of the RDF innovation and evaluate aspects such as relative advantage, compatibility, complexity, trialability, and observability. The results show that the RDF innovation has significant advantages in reducing dependence on fossil fuels, although it still faces challenges regarding community acceptance and technology optimization. This innovation reflects the local government's commitment to sustainable waste management and supports renewable energy production while also generating economic value. However, to ensure the sustainability of this innovation in the future, improvements in environmental impact mitigation and community involvement are necessary.

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Corresponding Author:

Nur Annisa Ali,
Social Sciences and Political Science /Public Administrasion,
Hasanuddin University,
Jln,Biola 7 Blok 10 Perumnas Antang, South Sulawesi, 90234, Indonesia
Email: nuraanisaali3@gmail.com

1. Introduction

Innovation is a creative idea implemented to address pressures from a problem or as an action of adopting and applying new methods to achieve desired outcomes. Innovation also involves carrying out tasks using more effective methods. In the context of governance, innovation is a key element in realizing efficient management. The implementation of innovation is a crucial stage where new ideas, products, or processes begin to be applied and integrated into existing systems. This stage ensures that innovation does not remain a concept, but is adopted, applied, and functions according to the planned objectives. This process involves adjusting strategies, allocating resources, changing organizational structures, and adapting the behaviors of individuals and groups so that innovation can be optimally applied and have a positive impact on organizational performance (Tidd, 2018).

According to Goffin (2016), innovation is the introduction of new or improved products or services, or processes to meet existing or potential customer needs in a different and more effective way. Pisano (2015) emphasizes that innovation is not just about product development, but also about the creation of value that occurs through the application of new knowledge and creative ideas. Furthermore, Freeman and Soete (2017) explain that innovation encompasses changes that can lead to significant technical and economic advancements, thus contributing to growth and competitiveness in an increasingly complex and dynamic market.

The government believes that innovation is an important breakthrough that not only serves as a primary driver in enhancing the effectiveness and efficiency of governance (good governance) but also becomes key in improving the quality of public services (good public service) (Manar & Alfirmid, 2023). Innovation, as a rational choice, has become an integral part and demand for public organizations, both at the central and regional government levels, in line with various changes and dynamics of societal demands. Innovation is expected to serve as a strategy to enhance the leverage of organizational performance, both in producing products and services (Sururi, 2017).

Based on Government Regulation (PP) Number 38 of 2017 regarding Regional Innovation, regional innovation aims to improve the performance of local governments, highlighting the importance of innovation in achieving development goals. Additionally, the Regulation of the Minister of Administrative Reform and Bureaucratic Reform (Permenpan RB) Number 91 of 2021 concerning the Development of Public Service Innovation plays a role in maintaining the quality and sustainability of innovation in the public sector. This policy encourages regional government organizations to continue innovating to enhance the quality of their services and performance. According to the Regulation of the Minister of Administrative Reform and Bureaucratic Reform of the Republic of Indonesia Number 5 of 2019 regarding the Public Service Innovation Competition, public service innovation is a breakthrough in the type of service that includes creative ideas or concepts, whether original or adapted or modified, that provide benefits to the community, both directly and indirectly. Many public service innovations are developed by Public Service Organizing Units. These innovations represent the spirit and creative thinking of service providers to improve service quality, making it better than before (Wibowo & Pratomo, 2021).

Waste and its management have become an increasingly urgent issue in Indonesian cities. The handling and management of waste problems in urban areas are becoming more complex and complicated as the population and urban activities increase (Nurhayati, 2020). Innovation serves as a solution to overcome various obstacles and issues faced by public organizations in carrying out their duties (N. P. M. Van der Voet, 2016). Innovation policies are regulated by government regulations that are continuously updated to ensure their implementation is more effective and produces positive impacts on government performance. The importance of innovation for regional organizations lies in its ability to address shortcomings in work and fill existing gaps (Huitema, 2020). Innovation in work is a tangible manifestation of organizational innovation that encourages the emergence of new ideas to solve tasks. Three stages of innovative behavior that support organizational performance include: the ability to generate new ideas, promoting those ideas to relevant parties, and realizing those ideas in the form of concrete actions. Therefore, innovation is not just a concept, but also a practical reality that can change the way regional organizations works and the results they achieve (B. J. H. van der Voet, 2017).

Waste is defined as items or materials that no longer hold utility. This perspective often leads to the negative assumption that waste must be removed from the environment by any means necessary. Therefore, a paradigm shift regarding waste is needed so that the community can become more aware of the importance of managing their own waste, thereby minimizing the environmental impact caused by waste. In the future, waste management should focus more on changing community perspectives and behaviors, as well as prioritizing community

involvement in the management process (bottom-up), because top-down approaches have proven to be ineffective (Shafique Alavi, 2020).

One relevant example of innovation is Refuse Derived Fuel (RDF), an alternative fuel derived from the management of urban waste. RDF is produced by separating non-burnable waste and recycling materials such as glass and metal, while organic waste, paper, and plastic are processed into shredded raw materials to produce RDF fluff or pellets. Waste with a high carbon content, once separated from recyclable materials, is most suitable for RDF production. The RDF system has two main functions: production and combustion (Kumar, 2016). Utilizing waste as fuel or RDF is one option for addressing urban waste issues (Chaerul, 2020).

Innovation in the renewable energy sector, particularly in the form of Refuse Derived Fuel (RDF), is defined as the application of new and advanced technologies aimed at transforming waste materials into energy sources, which not only helps reduce the consumption of fossil fuels but also plays a crucial role in mitigating the adverse environmental impacts associated with waste disposal and energy production (Michael Ayorinde Dada et al., 2024).

The Environmental Agency of Pangkep Regency is a regional government agency responsible for environmental management in Pangkep Regency, South Sulawesi. The main tasks of this agency include the protection, maintenance, and management of the environment to ensure its sustainability. This agency also plays a crucial role in ensuring that regional development occurs in line with sustainability principles and environmental preservation. The Environmental Agency of Pangkep Regency implements various programs related to waste management, pollution control, air and water quality monitoring, and environmental rehabilitation. One important innovation that has been implemented is the Badriah Plant, which is a facility for processing waste into Refuse Derived Fuel (RDF). This innovation aims to reduce waste accumulation and transform it into an environmentally friendly alternative fuel.

The Refuse Derived Fuel (RDF) innovation in Pangkep, South Sulawesi, is realized through the construction of the Badriah Plant, which is the first Refuse Derived Fuel (RDF) waste management technology in Eastern Indonesia and the fifth nationally. This represents a significant step in reducing waste at landfills and generating renewable energy, aligning with the goals of sustainable regional development. The Badriah Plant is a result of collaboration between the South Sulawesi Provincial Government and the Pangkep Regency Government. The development was carried out with an allocation of IDR 23 billion, of which IDR 15 billion came from financial assistance from the South Sulawesi Provincial Government in 2023 and IDR 8 billion from the Pangkep Regency Government.

Innovation requires adequate and proportional budget support to ensure its sustainability and success, especially for innovations that require substantial funding in their activities, from the planning stage to implementation (James, 2018). Without sufficient budget allocation, the execution of innovations can be hindered, preventing the intended goals from being realized optimally. Therefore, budget support becomes a key factor and an important indicator that directly impacts the success of an innovation, both in the short and long term (Mahpudin, 2022).

The main objective of developing the Badriah Plant is to reduce the accumulation of RDF waste in Pangkep, which is expected to process around 50 to 60 tons of waste per day, producing fuel from waste at a rate of 35 to 40 percent. It also aims to reduce air pollution and improve waste management efficiency in the area. By utilizing RDF, it is hoped to increase the Thermal Substitution Rate (TSR) at PT Semen Tonasa to reach 25% in the coming years, as RDF is used as an alternative fuel to replace coal, reducing dependence on conventional fossil fuels and supporting more environmentally friendly production.

The Refuse Derived Fuel (RDF) innovation in Pangkep Regency has a significant impact on waste reduction and air pollution. Specifically, RDF helps to reduce the accumulation of waste in landfills (TPA) by utilizing non-recyclable waste as alternative fuel. By processing organic

waste, plastics, and paper into RDF, the volume of waste that needs to be managed in landfills decreases drastically. This reduces pressure on landfill capacity, extends its operational lifespan, and mitigates potential soil and water pollution caused by waste accumulation. From the perspective of air pollution, the use of RDF as a substitute fuel for coal, as implemented at PT Semen Tonasa, helps to lower carbon dioxide emissions and other pollutants. RDF produces lower emissions compared to conventional fossil fuels, contributing to improved air quality and a reduced carbon footprint in the region. This innovation also supports the local government's efforts to achieve sustainable development targets through renewable energy and pollution emission reduction.

In the implementation of RDF (Refuse Derived Fuel)-based waste management innovation through the Badriah Plant, several challenges still need attention. One of the main issues is complaints from the surrounding community regarding unpleasant odors arising during the waste processing, despite efforts to control the odor through the spraying of bio-factors. This indicates a gap in the effectiveness of environmental impact mitigation. Additionally, the suboptimal prioritization of job opportunities for local residents around the plant has contributed to dissatisfaction, which has the potential to disrupt social relations and the sustainability of the innovation. These two factors present obstacles to the overall success of the innovation.

Similar challenges have also been found in the implementation of waste management innovations elsewhere. Based on previous research conducted by Setianingsih (2022), it was explained that the implementation of the Reduce, Separate, and Utilize (KANG PISMAN) program by the Tegallega Waste Processing Site has not been fully effective due to several unmet factors, including a lack of commitment from leaders to engage the community in waste sorting activities, a shortage of staff, and the non-functioning biodigester machine at the Tegallega Waste Processing Site.

Likewise, research by Ahmad (2021) indicated that the innovation of the waste bank program has a positive impact on reducing the burden on cleaning staff through more effective waste management. The innovation process is reflected in the recruitment of waste bank managers, consisting of individuals who are environmentally conscious, ensuring a strong commitment to program implementation. The quality of the innovation heavily relies on the active role and cooperation of the community in maintaining the environment. However, the effectiveness of this program is influenced by several factors, such as limited facilities and infrastructure due to insufficient government funding, as well as the importance of human resources capable of changing community mindsets to participate in environmental cleanliness efforts.

According to the research conducted by Febiola (2020), the success of the Refuse Derived Fuel (RDF) innovation at the Jeruklegi landfill in Cilacap Regency is highlighted as being significantly supported by effective leadership, a strong organizational culture, and adequate financial and human resources. This innovation has developed through collaboration with the private sector, provincial government, and donor countries, demonstrating the critical importance of cross-sector collaboration in supporting the success of RDF-based waste management innovations. This multifaceted approach not only enhances the effectiveness of the innovation itself but also fosters a more sustainable and comprehensive strategy for addressing waste management challenges.

Many studies indicate various failures and challenges in the implementation of innovation, which often result in a lack of effectiveness in improving governance (Pratama, 2020). These studies highlight that although innovations are designed to enhance government systems and the efficiency of public services, factors such as a lack of leadership commitment, resource limitations, and low community participation often hinder their implementation. Additionally, other factors, such as bureaucratic capacity, budget availability, political support, leadership roles, and the quality of human resources and skills, also influence the success and failure of

innovations (Trivellato, 2021). These challenges collectively contribute to the failure of innovations to achieve the goal of creating a more effective and responsive government.

The novelty of this research lies in the evaluation of RDF (Refuse Derived Fuel)-based waste management innovation in Pangkep Regency, which has not been extensively studied. Unlike previous studies that focused on technical or social challenges, this research combines an analysis of sustainability aspects, community participation, and the role of local government. This study also highlights issues of odor and social dissatisfaction around the Badriah Plant, as well as the potential of RDF as a solution for waste management and a source of renewable energy. The results are expected to provide new contributions to the literature on technological innovations in waste management and energy, as well as recommendations for more effective implementation in other regions.

Innovation is often closely related to the ever-changing and dynamic environmental conditions. According to Kurniawan (2015), innovation becomes crucial in the midst of the ongoing dynamics and developments in the surrounding environment. A dynamic environment demands that organizations continuously adapt and develop new ways to respond to changes. Therefore, innovation is a response to the need to remain relevant and competitive in a constantly evolving landscape. Organizations that are able to innovate effectively will be better prepared to face new challenges and opportunities that arise with the passage of time.

Innovation, according to (Rogers, 2003), is an idea, practice, or object that is perceived as new by individuals or groups, and then spreads through a diffusion process. This process consists of several stages: knowledge, persuasion, decision, implementation, and confirmation, during which innovations can be accepted or rejected by members of society or organizations. Rogers also identifies five key attributes that influence the rate of adoption of innovations: relative advantage, compatibility, complexity, trialability, and observability.

Relative advantage refers to the extent to which an innovation is perceived as superior to previous methods. Compatibility reflects the degree to which an innovation aligns with the values and needs of users. Complexity indicates the level of difficulty in understanding and applying the innovation, while trialability refers to the ability to test the innovation before full adoption. Finally, observability refers to the extent to which the results of the innovation are visible and recognized by others. These attributes are key factors in determining the success or failure of an innovation in society.

This research utilizes Rogers' diffusion of innovation theory to evaluate the effectiveness of implementing RDF technology in waste management in Pangkep Regency, as well as to identify the challenges and opportunities faced in this innovation's implementation.

This study will elaborate on the waste-to-fuel innovation (Badriah) through Refuse Derived Fuel (RDF) technology implemented by the Environmental Agency of Pangkep Regency. The research focuses on how RDF technology innovation can manage waste more effectively and support environmental sustainability, as well as evaluate its impact on reducing the negative effects of waste management. Therefore, this article will address the following research question: How can the implementation of RDF in Pangkep Regency effectively address waste management challenges and support environmental sustainability?

2. Method

In this study, the author employs a qualitative approach characterized by its descriptive nature, with the primary aim of providing a thorough and in-depth explanation of various phenomena through comprehensive data collection methods. Descriptive research is conducted with the intention of exploring and gaining a deeper understanding of the values associated with independent variables, whether focusing on a single variable or multiple variables, all without making direct comparisons between these variables or attempting to relate them to other

external factors. This approach allows for a nuanced exploration of the subject matter, capturing the complexities and intricacies inherent in the variables being studied.

The timeline for this research will be conducted from August 12 to September 23, 2024. The object of this research is the Department of Environment of Pangkep Regency. The focus of this study is the Implementation of the Waste Fuel Processing Innovation (Badriah) Based on Refuse Derived Fuel (RDF) at the Department of Environment of Pangkep Regency. The data sources include primary data, which is obtained directly from the research object, and secondary data, which serves as supporting data for the primary data and is obtained from literature such as documents, reports, and other references related to this research. The data sources used consist of two types: primary data, which is obtained directly from the research object, and secondary data, which serves as supportive data for the primary data and is obtained from literature such as documents, reports, and other references related to this research.

The data collection techniques in this study employ methods appropriate for qualitative research models. In line with this, qualitative data collection techniques can be carried out through observation, interviews, and documentation (Sugiyono, 2016). In qualitative research, the data analysis model used by the researcher is the interactive model proposed by Miles, Huberman, and Saldana (2014: 12-14). The components in data analysis (Miles, 2014) include: a) Data Condensation; b) Data Display; and c) Conclusion Drawing.

3. Analysis and Results

3.1. Relative Advantage

Relative advantage refers to the extent to which an innovation is considered better than existing solutions or products. The relative advantage of RDF (Refuse Derived Fuel) innovation is one of the key factors in evaluating the adoption of this technology, particularly in the context of waste management and renewable energy production. Relative advantage pertains to the degree of benefits that RDF offers compared to traditional waste management methods, such as incineration or landfill disposal.

RDF in Pangkep Regency plays a crucial role in reducing the volume of waste in landfills by processing around 50 to 60 tons of waste per day, thereby decreasing the need for new landfill sites. The remaining waste consists only of metals, glass, and textiles, which cannot be processed. Additionally, RDF enhances waste management efficiency through its ability to process nearly all types of waste and also produces solid fuel (BADRIAH) with economic value, achieving 35-40%. This RDF-based waste processing innovation not only contributes to waste reduction and environmental impact mitigation but also provides economic added value to the community. Furthermore, the collaboration with PT. Semen Tonasa positions RDF as a substitute for coal fuel, offering a cleaner and more environmentally friendly alternative. With the potential for carbon emission reduction from fossil fuel use, the advantages of RDF are increasingly evident in reducing landfill waste and providing a sustainable solution. The success of this innovation is reinforced by plans for further collaboration with PT. Semen Bosowa, which is currently in the planning stages.

Overall, the implementation of Refuse Derived Fuel through the Badriah Plant contributes to reducing negative environmental impacts, such as air pollution and waste accumulation, while providing a more sustainable energy source. This innovation supports sustainable development goals by integrating waste management and renewable energy production into one efficient solution.

A comparison with traditional methods emphasizes that Refuse Derived Fuel offers a more environmentally friendly and efficient solution, reducing pollution and dependence on fossil fuels. Although this technology requires significant initial investment, the long-term benefits in terms of waste reduction and carbon emissions make it a better and more sustainable choice.

The relative advantage of RDF indicates a high potential for adoption, aligning with the needs and goals of more environmentally friendly and sustainable development.

3.2. Compatibility

The Refuse Derived Fuel (RDF) innovation, which has been successfully implemented in waste management practices in Pangkep Regency, demonstrates a remarkably high level of compatibility with both local needs and environmental goals. As a cutting-edge waste-to-fuel processing technology, RDF is specifically designed to address the increasing demand for more efficient waste management solutions, while simultaneously supporting the broader environmental sustainability objectives that are increasingly desired by the local community.

The Environmental Agency has also made adjustments to ensure the compatibility of Refuse Derived Fuel with local conditions, particularly because its plant is located near residential areas in Padang Lampe Village, Ma'rang District, Pangkep Regency. The agency has made efforts to minimize negative impacts on local residents by implementing measures such as using bio-factors to reduce odors from the waste at the plant and prioritizing employment for local residents, which has helped enhance the effectiveness and sustainability of this innovation. These adjustments reflect the Environmental Agency's commitment to maintaining community support and ensuring smooth plant operations, despite existing challenges.

To ensure that this innovation remains relevant and meets community needs, the agency continuously evaluates and receives feedback from the public. Additionally, they collaborate with various stakeholders, including PT Semen Tonasa, to ensure that RDF not only meets eco-friendly energy needs but also provides economic benefits to the surrounding community. Through this approach, the Environmental Agency ensures that RDF remains aligned with local needs and sustainable development goals.

3.3. Complexity

Compatibility refers to the extent to which an innovation aligns with or can be integrated into the existing values, experiences, and needs of users. The Refuse Derived Fuel (RDF) innovation implemented in waste management in Pangkep Regency demonstrates a high level of compatibility. RDF, as a waste-to-fuel processing technology, is designed to meet the need for more efficient waste management and to support the environmental sustainability goals desired by the community.

One of the main challenges related to complexity is the community's complaints regarding the odors produced by the waste processing. To address this issue, the Environmental Agency has taken measures such as using bio-factors to reduce odors, aiming to enhance the acceptance of this innovation by the community. This step demonstrates an effort to facilitate public understanding and increase acceptance of Refuse Derived Fuel.

The Environmental Agency also faces uncertain situations, such as complaints from the community and demands from local residents for employment at the plant. In response to these challenges, the Environmental Agency strives to maintain good communication with all stakeholders, as well as to monitor and evaluate emerging complaints. By responding promptly and adjusting strategies as needed, the Environmental Agency aims to reduce operational complexity and improve the adoption of RDF innovation within the community.

Overall, while the Refuse Derived Fuel (RDF) innovation encompasses several complex elements that can significantly impact its adoption particularly the considerable time required for the comprehensive processing of waste into usable fuel the proactive measures implemented by the Environmental Agency to address community complaints and adapt their strategies effectively demonstrate a committed effort to minimize the various challenges associated with the implementation and utilization of this advanced technology.

3.4. Triability

Trialability refers to the extent to which an innovation can be tested or experimented with before it is fully adopted. The innovation of Refuse Derived Fuel (RDF) demonstrates a good level of trialability, as this technology has been tested in other regions before being implemented in Pangkep Regency. The experience from the implementation of RDF in Java provides a strong foundation for its execution in Pangkep. The previous trial process allows for a better understanding of the potential benefits and challenges that may be faced in applying this technology.

In Pangkep, RDF has been implemented through the establishment of the Badriah Plant, which is the first waste-to-fuel processing facility in Eastern Indonesia. The presence of the Badriah Plant reflects a concrete step in testing and applying RDF at the local level. The Environmental Agency has made various adjustments to ensure that this innovation can be accepted and well integrated into the local context. For example, the use of bioactivators to reduce odors and the prioritization of job opportunities for local residents are part of efforts to ensure that RDF can be effectively tested and applied in the region.

Furthermore, the implementation of RDF in Pangkep allows for direct monitoring of its performance and impacts in local conditions. This trial process provides useful feedback for further adjustments, ensuring that this innovation meets the needs and expectations of the local community. With this experience and adjustments, the DLH is able to identify and address issues more quickly, thereby enhancing the success and acceptance of the RDF innovation in Pangkep.

3.5. Observability

Observability refers to the extent to which the results or benefits of an innovation can be observed and evaluated by others. The level of observability of the Refuse Derived Fuel (RDF) innovation is quite high, as the outcomes of this innovation can be clearly observed by various parties. RDF, as a technology for processing waste into fuel, offers benefits that are visible and measurable, both in environmental and economic terms.

One of the most observable aspects is the reduction in the amount of waste at the landfill (TPA). With the implementation of RDF, waste that previously accumulated at the TPA is now processed into fuel used in production processes. This process clearly reduces the volume of waste that needs to be managed traditionally and decreases the burden on the TPA. Additionally, the use of RDF as an alternative fuel at PT Semen Tonasa also provides tangible and visible impacts. The decrease in coal usage and its replacement with RDF demonstrates a commitment to renewable energy utilization. This can also be observed through the reduction of carbon emissions and lower environmental impacts, resulting from decreased dependence on fossil fuels.

The Environmental Agency (DLH) also facilitates the visibility of this innovation through reports and documentation that are accessible to the community and relevant stakeholders. This allows the public to directly see the benefits of RDF in the context of waste management and cleaner energy production.

Overall, the observability of RDF is reinforced by measurable and observable outcomes, including waste reduction, improved energy efficiency, and positive environmental impacts. In this way, the RDF innovation not only provides direct benefits but also offers evidence that can be seen and assessed by others.

4. Conclusion

The Environmental Agency of Pangkep Regency deserves appreciation for the success of the Refuse Derived Fuel (RDF) innovation through the Plant Badriah, which has successfully transformed waste into an environmentally friendly alternative fuel. This RDF technology was

tested in other areas before being implemented in Pangkep, providing a strong foundation for its local application. This innovation reflects the local government's commitment to achieving sustainable waste management and supporting renewable energy production. Additionally, RDF has generated economic value and is currently in the process of developing a cooperation plan with a second party, PT Semen Bosowa, after previously collaborating with PT Semen Tonasa. With adjustments made to maintain community support and mitigate negative environmental impacts, RDF has been able to provide significant benefits, both in reducing waste volume at landfills (TPA) and decreasing dependence on fossil fuels. Through structured implementation and ongoing evaluation, the Environmental Agency of Pangkep Regency demonstrates seriousness and dedication in supporting environmentally friendly and sustainable development.

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