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AN INVESTIGATION OF EFFECTIVE COMMUNITY DRIVEN MATERIAL RECOVERY FACILITY (MRF) IN URBAN WASTE MANAGEMENT – A CASE STUDY OF MRF IN WATTALA

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Abstract: Sri Lanka as a developing country, continues to use the take-make-dispose paradigm of the conventional linear economy. Scarcity of resources and municipal solid waste management problem that linear economies may pinpoint as the underlying cause. By using a Community-driven Material Recovery Facility (CdMRF) as a tool, the Sustainable Circular Economy, a novel developing idea pertinent to the Sri Lankan context, can be a better alternative in this research study's effort to address such difficulties. Waste can be converted into a resource should be a significant fact in this study. Wattala CdMRF is the selected case study. The mixed method used for this study and methodology used are onsite observations, 11 Key Informant Interviews (KII), 35 questionnaire surveys were conducted for the households, commercial enterprises and material collectors by using random sampling method. The key findings of this study demonstrate converting informal material collector occupation into a formalized profession, saving mechanism through resource banking establishment, formalized National Waste Management Committee and Journey of Transformation (JoT) through innovations. The sustainability of the CdMRF is largely dependent on social indicators, with community as the core element of running to achieve Sustainable Circular Economy while enhancing environmental positive externalities.

Keywords: Circular Economy, Community driven Material Recovery Facility, Municipal Solid Waste Management, Sustainability

1. Introduction

Sri Lanka's rapid urbanization and population growth have created an alarming demand-supply curve, resulting in price fluctuations, environmental damage, and increased global competitiveness. Limited resources are strained by a growing population, causing an inability to meet peoples' needs and wants. The long-term impact of the Covid-19 pandemic and the existing economic inflation crisis on Sri Lanka's economy is a significant challenge(Ajwani-Ramchandani & Bhattacharya, 2022). It is essential to address not only economic issues but also social and environmental concerns. The modern linear economic model is inadequate to deal with these issues, and more sophisticated ways to mitigate the negative effects of production plants are necessary (*Circular Cities Cities of Tomorrow*, 2020).

Municipal solid waste management is also a major challenge for Sri Lanka, especially in urban context with rapid population growth. Economic expansion generates significant amounts of waste, including non-perishable waste, which poses a severe threat to the environment and public health. The 2017 Meethotamulla waste dumping tragedy gained global attention, highlighting the lack of community awareness and alternatives to landfilling for waste management (Fernando, 2019). According to Waste Management Authority and Central Environment Authority data, Sri Lanka generates 7,000 metric tons of solid waste per day, with 60% occurring in the Western Province (Central Environmental Authority, 2022) . On average One person generates 1-0.4 kg of waste on average per day (ibid), with only half being collected by local authorities due to insufficient waste disposal services.

Much of the waste is illegally disposed of in urban areas by informal and formal collectors, households, and businesses. The majority of solid waste ends up   in open landfills, which is a significant issue for developing-country landscapes (Fernando, 2019). As an island nation, Sri Lanka is at a critical juncture, as it continues to rely predominantly on open dumping.

Since 2005, the concept of Circular Economy (CE) has been gaining popularity as a solution to two major concerns. The impending demand-supply gap and the realization of the scarcity of resources. The CE model aims to promote sustainable development by reducing waste and circular way of resource consumption (Budihardjo et al.,2022). In an urban context, the CE model involves creating a closed-loop ecosystem where resources are utilized in the most

efficient way possible. This means changing the current linear model of "resources-products waste" to a closed-loop model of "resources-products-waste-new resources" through the use of closed-loop supply systems such as reuse, remanufacturing, refurbishment, repurpose, redesign, recovery, and recycling (Azizuddin et al., 2021). Material Recovery Facilities (MRFs) can be a vital part of this process to support recovery and recycling in the CE system.

Individuals and society play a crucial role in waste management, Circular Economy (CE), recovery, and recycling (Dwipayanti, 2011). Human behavior and social awareness are key factors that can influence the success or failure of related planning procedures. To address waste management challenges, community involvement and a comprehensive understanding of the topic are necessary at all levels of government. This research study focuses on converting 'waste into wealth' through community-driven mechanisms, which can contribute to achieving sustainable CE development through Material Recovery Facility (MRF) recovery and recycling processes.

The Circular Economy (CE) is a popular alternative, and the Community driven Material Recovery Facility (MRF) model can be used as a tool to achieve it. The Wattala MRF, an NGO-initiated program, can serve as a case study for the MRF model. The MRF model can promote resource recovery while reducing waste volume, and community involvement plays a key role in influencing the national waste volume (Forum, 2018).

Increasing community awareness of waste resource capability and new systems to collect recyclable waste from households, commercial and other establishments can be expected through this model. The research problem highlights the interconnections between waste, Material Recovery Facility (MRF) recycling centers, community involvement, and the Circular Economy (CE) system, which have not been explored in Sri Lanka. The research study aims to investigate the suitability of MRF models and how they can be improved and adapted to different cities, scales, and collaborations.

2. Literature Review

2.1 SUSTAINABLE DEVELOPMENT THROUGH CIRCULAR ECONOMY PRACTICES
'Sustainability' is a term and field of study that is typically related with development and carries a variety of meanings, including "living within means," "balancing between spaces," "responsible consumption," and "the capacity to remain indefinitely," among others (Azizuddin et al., 2021). Circular cities objective is to achieve sustainable development, which entails fostering environmental quality, economic prosperity, and social fairness for the benefit of present and future generations (*Circular Cities Cities of Tomorrow*, 2020).

The cheap and widespread availability of input commodities made the linear model conceivable, but it is no longer sustainable, necessitating the "closing of the loop" to produce a sustainable growth model. The theoretical underpinnings of a circular economy are not explicitly attributed to any individual work or person, but rather have evolved over time from a number of theoretical ideas. The idea gained popularity in the 1970's when it could be used to describe contemporary industrial processes and economic systems. The CE concepts, has underpinned three principles characterizing the circular economy as value preservation, resource optimization, system effectiveness (Forum, 2018) .

The CE may be conceptually developed according to two different guidelines: there are the more systemic projects which must be developed "top down" and "bottom up". It is essential to promote reuse, sharing or Product-as-a-Service models. CE represents five pillars of the economy as sustainable outputs, increased product life, sharing, product as a service and end of life(*Circular Cities Cities of Tomorrow*, 2020) . The concept CE is based on the regenerative cycle, which facilitates the reuse of used products, parts, and material in an efficient way, thereby increasing the profitability and reducing the environmental distraction (Khan & Haleem, 2021). Managing the waste properly, the country should focus on investing in to effectively convert its waste management practice into a CE one. To deal with the challenges of implementing CE practices, a multi-faceted and inclusive collaborative approach coming from stakeholders is necessary (Ahmed et al., 2022).

2.1.1. Circular Economy principals
According to the World Economic Forum (2018), it has basic three principals introduced for CE as follows;

- Value preservation - maximizing the value of raw resources throughout the manufacturing process. Extending the usefulness of a product can be accomplished by reusing or repurposing its parts, as well as by repairing or refurbishing them.
- Resource optimization - using fewer, primary resources in a more efficient manner while also making greater use of renewable energy sources and recycling and reusing materials.
- System effectiveness - mitigating the systematic loss of human-beneficial substances during the production/consumption cycle and managing externalities. It depends on partnerships and their linkages.

2.2 WASTE RESOURCE OPTIMIZATION
According to the previously discussed CE principals,2nd principal describes about resource optimization. The value of converting waste into wealth has grown significantly (Ajwani-Ramchandani & Bhattacharya, 2022). Simply waste can

be identified as a dispose material. Against to that waste can be optimized as a value addition resource. In the waste management system 3R principal, which is reduce, reuse, recycling considered as a core. The idea of reducing waste, reusing resources and products, and recycling them is called the "3Rs." Reducing means that you choose to use things carefully so that you make less waste. Reusing means using things or parts of things more than once as long as they are still useful. Recycling is the process of using waste as a resource (Fernando, 2019).

Stringent regulatory restrictions and a high level of public awareness frequently assist successful recycling in developed and urbanized countries. Limited recycling techniques and solid waste management policies make waste management more difficult in developing countries. As a result of their ability to gather and recycle used products with economic value, informal sectors have played an essential role in controlling solid waste in developing nations (Budihardjo et al., 2022). For the purposes of reverse logistics Extended Producer Responsibility (EPR), a CdMRF is a recycling facility that can be included in the industry.

2.3 VALUE ADDITION TO WASTE

Adding value to waste categories that were not initially profitable is a miraculous aspect of the MRF model and recycling industry. The MRF incorporates value addition procedures such as sorting, washing, collecting into marketable amounts, drying, compacting, bailing and cleaning. Plastic claims that categorizing

Polymers is how we may maximize their value. Further segregation methods can highly influence to the value addition process. The quality and market worth of recovered wastes are enhanced by value addition (Mwanza et al., 2019). Sustainable value creation processes in the converting and industrial sectors can be improved by a better grasp of how value is added. The production of sustainable value is a significant focal point for attaining circular economies.

2.4 COMMUNITY DRIVEN MATERIAL RECOVERY FACILITY MODEL (MRF)

The term " Community driven Material Recovery Facility model (CdMRF)" refers to a method that actively involves residents in waste disposal and recycling efforts. Ultimately, the goals of CdMRF is to lessen the amount of waste that ends up in landfills, increase the amount of recyclables recovered, and decrease waste production at the source (Budihardjo et al., 2022).The community is fundamental to integrated solid waste management since it is a community driven approach to waste management. The community is considered a unified entity, and providing them with information about the waste management system can improve relationships and promote collaboration for mutual benefit. A formal waste management system may not be effective if it disregards informal scavenging systems, which have proven to be resourceful. Therefore, the informal sector should be included in the construction of a new waste management system. Efforts should be made to improve the working conditions and efficiency of informal workers, and expand material recycling coverage. To achieve this, authorities should recognize the social, economic, and environmental benefits of informal recycling (Dwipayanti, 2011). The community, as the facility's end users, should be aware to and actively engage in all phases of construction. In order to ensure the long-term viability of the CdMRF, it is essential that solid waste management, which must be "environmentally effective, economically affordable, and socially acceptable," be properly adapted to local conditions in terms of approaches and methods used. This will allow for the least possible negative impact on the environment to be achieved at the lowest possible cost and the greatest possible social acceptability (Dwipayanti, 2011) .

This study addresses the research gap regarding the relationship between waste, MRF recycling centers, community involvement, and the CE system. The concept of community-driven material recovery facilities has been explored in developing countries such as the Philippines, Indonesia, and Bangladesh, but not in Sri Lanka.

The study's scope and limitation focus more on MRF than on the Circular Economy concept. Accordingly specific three research questions framed as; what is the role of Community driven Material Recovery Facility in Circular Economy? Can MRF as a service business model be effectively applicable in Sri Lankan context? What are the challenges and opportunities to implement the MRF model in Sri Lankan context?

3. Methodology

3.1 CASE STUDY SELECTION

Figure 1: Wattala MRF center (source: By the Author)

The Wattala Material Recovery Facility center has been selected as the case study which is a pilot project named PHINLA, which is part of a global program funded by the German BMz in 2019 located in Wattala (figure 1). This program aims to create livelihood opportunities through waste management and to support local authorities in implementing better policies and regulations for solid waste management. The MRF is an effective solution to promote resource recovery while reducing waste volume. Selection of this case study mainly based on three factors. One is its location because Wattala area is close proximity to Colombo and highly urbanized area. Secondly Community involvement beacuse mainly this MRF model is running as a public private partnership model and through vulnerable community empowerment. Thirdly Wattala MRF is dealing with each and every type of non-perishable waste categories in recycling process.

3.2 DATA COLLECTION PROCEDURE

A combination of qualitative and quantitative data collection methods was employed to investigate a newly introduced Material Recovery Facility (MRF) pilot project. Qualitative data was gathered through onsite observations and Key Informant Interviews (KII), while quantitative data was obtained through a structured questionnaire survey conducted in two distinct categories as one for households and commercial enterprises, and the other for material collectors. Given the novel nature of the MRF pilot project, the insights of experts played a pivotal role in deepening the research's understanding.

The primary data source in this study was semi-structured KII, facilitated through the use of a carefully designed questionnaire. This section outlines the methodology employed, encompassing the procedures for sampling interviewees, the actual execution of the interviews, ethical considerations, interview protocols, transcription of interviews, and subsequent data analysis.

To select participants for the KII, a purposive sampling method was predominantly employed. This approach aimed to include individuals such as MRF model developers, stakeholders associated with the MRF model, policy makers in waste management and environmental sectors, and experts in fields related to the Circular Economy. Additionally, a prerequisite for potential interviewees was a minimum of two years of relevant experience in their respective domains. Ultimately, the research involved 11 selected participants, each contributing valuable expertise to the study's exploration of the newly introduced MRF pilot project.

Comprehensive on-site observations were systematically carried out at the Material Recovery Facility (MRF) premises over the course of a single weekday. These observations were conducted with a keen focus on gaining insights into the daily waste collection routines, the intricacies of the waste segregation process, and the operational procedures employed for handling machinery dedicated to each segregated waste category. The utilization of observational evidence extended to capturing photographs and video clips that effectively documented the machinery's intricate processes and operational nuances. Additionally, this observational method served a vital role in the data triangulation process, facilitating a cross-verification of expert insights and material collector perspectives through the structured utilization of an observation guide.

The questionnaire survey was conducted to gain insights into the perceptions of households, commercial entities, and material collectors while also assessing their current living standards. Two distinct surveys were conducted: one targeting households and commercial enterprises and the other focusing on material collectors. Separate survey sheets were prepared for each category. Each survey predominantly consisted of multiple-choice questions, as open-ended questions had yielded hesitant responses in a pilot survey.

For the material collector survey, a sample of 15 actively engaged collectors was selected out of a total of 30 at the Wattala MRF, with contact details obtained from the MRF field coordinator. The household and commercial survey, on the other hand, employed random sampling to ensure an unbiased sample framework. The sample size for this survey was 20, with a 75% allocation to households and 25% to commercial units. This equated to 15 households and 5 commercial establishments. In total, the research encompassed 35 participants, mainly household heads, aged between 35 - 65. The study also considered Wattala's sub-administrative divisions—Hendala, Welisara, and Pamunugama—when selecting the sample, and a map with GPS locations was used to guide the sample selection process.

In here data analysis was done through the analytical framework created based on thematic categorization technique as identified two major themes categories as 'optimum use of waste' and 'sustainability of MRF model' through addressing research objectives and research questions as further mentioned in the research findings.

4. Research Findings

4.1. OPTIMUM USE OF WASTE

Under optimum use of waste theme there are sub two themes as 'waste segregation' and 'waste recycling'.

4.1.1 Waste segregation

The greatest method for utilizing waste as a resource is waste segregation. Mixed waste cannot be utilized as a resource. When waste has been collected, it must be sorted before it can be considered a usable resource.

Consequently, general knowledge of this subject is essential. Social attitudes play a significant role in determining waste sorting desires.

Local Authorities (LA) are responsible for the collection and disposal of waste (Nishanthi & Kaleel, 2021). Many residents are of the belief that waste services should be the primary duty of local and governments and that economic factors do not always promote participation in waste management operations. In terms of policy guidelines, mandated policies have a significant effect on the willingness of inhabitants to separate their waste (Gudmann Knutsson et al., 2021).

(Development Officer, Wattala PS) - *"We do not collect waste if people do not segregate them properly. But few of them are still not doing it properly."*

(HH respondent, Age 42) – *"LA does not come to collect thus lane waste because they expect money from us. Therefore we did not segregate waste previously but now we segregate waste because twice a week waste collector in our village come to collect them and he gives money too."*

Local Authorities do not collect unsegregated waste, and people are forced to segregate waste. According to the HH & commercial questionnaire survey sample data shows 100% of people do primary segregation within their own premises and most of them are willing to segregate their waste as for their convenience to manage and impact of LA policies. Some residents complained about LA does not come to collect their waste because they expect money for the collection. So they do not have many options apart from burning, or illegally dumping it. Yet, the involvement of material collectors is the optimal answer because they collect waste while also paying for it. MRF material collectors provide genuine work of segregation rather than Local Authority labors. But Local Authority labors are considered it as a salaried job. Sometimes conflict arise between them due to that. Waste segregation is a primary method and further segregation is the secondary method which can be done through MRF as a supportive mechanism to the LA.

4.1.2 Waste Recycling
The solid waste generation according to the waste volume data by weight in Wattala, Plastic is the majorly collected waste category in the highest percentage of (33.35%). Glass (28.96), Paper (23.17%) and other (9.91%) waste are collected in somewhat same percentages by weight according to the graphically represented data. Metal is the lowest (4.61%) collected waste category collected in the in Wattala. All of these waste categories can be recycled in MRF. Material collectors have major responsible in waste collection, further segregation and recycling processes. Achieving a circular economy is aided greatly by recycling. Materials that would have otherwise been thrown away are recovered, cleaned up, and put back into production. Since the focus of a circular economy is on reusing and recycling resources, the value added to recovered MSW is of particular importance in a circular economy. In modern environment, recycling has gone from being a nicety to a necessity due to the importance of turning waste into useful products (Mwanza et al., 2019). Accordingly objective one is totally covered under this theme and the RQ 1 is partially covered.

4.2 SUSTAINABILITY OF MRF MODEL
Under Sustainability of MRF model theme there are sub three themes as economic, environmental and social performance as they are the key indicators of sustainability measures (Schroeder et al., 2019).

4.2.1 Economic performance
It is important for people to understand how to optimally use limited resources, and the MRF economic model can help achieve this by utilizing resources in the present while also providing opportunities for future generations to do the same. Value creation in recycling operations is achieved through value addition activities, which require a strengthened supply chain and a diverse economy. The MRF model stimulates a diversified economy through market competition and acts as an intermediary processing center to reduce the gap between material collectors and industry. Several industries have already cooperated with MRFs, such as Eco-Spindles, Anton PVC Company, and Glass Company. A CdMRF can be integrated into the industry to fulfill extended producer responsibility or extended stakeholder responsibility and reverse logistics. By reusing waste for market income and enhancing the lives of vulnerable groups, the Circular Economy aims to achieve economic sustainability and value preservation, especially in the face of resource constraints and economic crises. Therefore, MRFs supplying high-quality secondary raw materials to the industry can promote local and national economic sustainability, achieving the first principal of the Circular Economy.

4.2.2 Social performance
This project's success is primarily due to community awareness. Most individuals properly dispose of waste because waste collectors recognized its economic and environmental benefits. Hence, waste collectors prioritize public wellbeing. The level of education does not affect to be an expertise person in this waste management field. But awareness and trainings are necessary inputs. We can see the difference of waste collectors' knowledge enhancement regarding waste segregation as well. According to the survey data 66% of material collectors have secondary education. Therefore education levels had no significant effects on waste management intentions and actions (Gudmann Knutsson et al., 2021).

According to the waste collectors' questionnaire survey low-income people are motivated to do waste collection as a self-employment. Women's side has more contribution because even the people who are housewives have chosen to do this as self-employment. 73% of them consider it as a primary source of income generation. And 93% mentioned that their prior intention is to select waste collecting as profession is social well-being. Due to that waste dispose to the environment is very low.

Waste collectors are having lack of recognition due to social exclusiveness. Therefore, improve the position of informal waste collectors as formal occupation and encourage them about this job field. The importance of formalizing informal waste collectors as a profession through registration and identity cards has been identified. Previously, these collectors were not respected or trusted by the community. By increasing awareness and appealing to residents' personal conscience, loyalty to waste separation systems can be increased. This project helped to recognize the value of people and the environment.

(Material collector, Age 46) – *"Before I worked in a Middle-East country. Few years later I came back to Sri Lanka and looked for job. That time I selected material collection profession as my primary income job because of this PHINLA project awareness. Now I expand my waste collection sectors and areas. My average monthly income is about Rs. 250000."*

From analyzing waste collectors' average income of a waste collectors is Rs. 24,887. It reflects that waste collection is a good income earning method and also it caused for the poverty reduction as well.

Community awareness is essential for behavioral change in waste disposal. It is necessary to educate people about waste categories, their environmental hazards, and how to turn waste into a resource. A resource banking system in the preschool education system can help improve waste management. In addition, the waste management process needs to be reversed from "generator should pay" to "generator is paid" to encourage waste separation and promote a profitable MRF system. Policy directed towards promoting "material repayment" can positively influence waste separation behavior.

The viability of MRF depends on its operational viability, which can be achieved through a Public-Private Partnership (PPP) model. Collaboration between the business sector, local government, and NGOs is necessary for MRF's success. The PPP model ensures better benefit distribution, and 10% of profits from the MRF process goes to Wattala PS, while most of the profits go to the material collectors' association. A private company, comprising four individuals appointed as corporate directors, operates the MRF project under the PPP model, in collaboration with the LA.

The MRF in Sri Lanka has introduced capacity building programs among material collectors, promoting entrepreneurship and innovation in waste management. They have developed MSMEs (Medium and Small-scale Micro Enterprises) and introduced eco-bricks made from residual waste, providing specific recognition to collectors as "Recycle Industrial Assistants" awarded by the National Vocational Training Authority. The good part of that is those MSMEs voluntarily share their knowledge with other parts of the country as well as a journey of transformation (JoT).

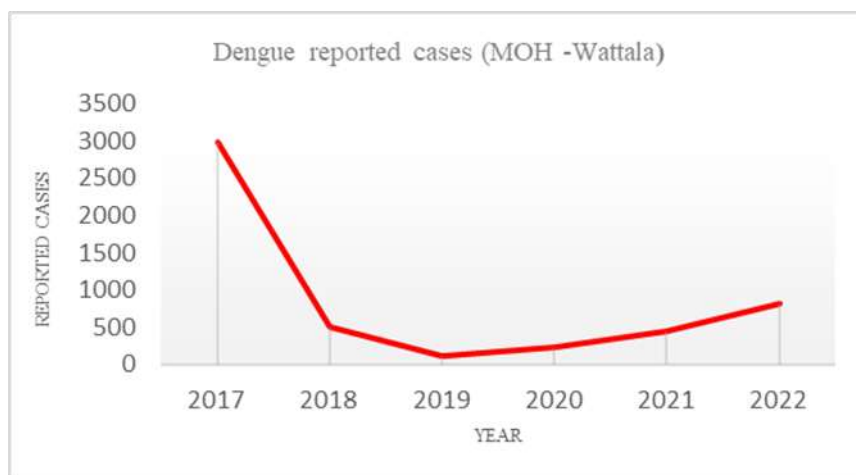*4.2.3 Environmental performance*

Figure 2 : Wattala dengue decreasing curve 2017-2022 *Source: Wattala MOH*

Environmental awareness has been identified as an important factor in willingness to participate in waste management behavior (Gudmann Knutsson et al., 2021) residents' knowledge, attitude and practices concerning dengue virus management. Many participants indicated a need for more knowledge about solid waste management

as one aspect of disease control, implying that health considerations may be one motivating factor for effective waste management behavior.

The implementation of the waste management project in Wattala has led to a significant decrease in the incidence of dengue fever in the area. This is due to the recycling of plastic bottles and polyethene, which have a high likelihood of retaining water. The project also includes the collection of non-biodegradable waste such as tires during the rainy season and promoting a monthly environmental fair where individuals can bring their separated waste to a designated public location. The Wattala MOH has reported a decreasing trend in dengue cases from 2017-2022 (figure 2).

5. Discussion & Conclusion

The study primarily focused on two main themes: "Optimum Use of Waste" and "Sustainability of MRF Model," each with sub-themes.

Under the "Optimum Use of Waste" theme, waste segregation and waste recycling were discussed. The research highlighted the significance of waste segregation in turning waste into a usable resource, emphasizing the role of social attitudes in waste sorting. It also examined the impact of local authorities' policies on waste separation behavior. The research found that people were willing to segregate waste, primarily due to the convenience of managing waste and the influence of local authority policies. Additionally, the involvement of material collectors was seen as an optimal solution, as they collected waste and paid for it, contributing to effective waste segregation.

The "Waste Recycling" sub-theme addressed the increasing consumption of non-biodegradable materials like polythene and plastic in Sri Lanka. The paper emphasized the importance of recycling these materials to mitigate environmental damage. The research showed that various waste categories, including plastic, glass, paper, and others, could be effectively recycled in the Material Recovery Facility (MRF). Material collectors played a crucial role in waste collection, further segregation, and recycling processes.

The "Sustainability of MRF Model" theme delved into economic, social, and environmental performance indicators as key measures of sustainability. The economic performance section discussed how the MRF model could stimulate economic growth, particularly through value addition processes and supply chain strengthening.
It also highlighted the role of the MRF in providing high quality secondary raw materials to industries, promoting local and national economic sustainability.

In terms of social performance, the research emphasized community awareness and the positive impact of the MRF on employment opportunities, particularly for low-income individuals. It also discussed the livelihood development achieved through waste management and behavioral changes in waste management practices.

Regarding environmental performance, the study addressed health and environmental problems related to waste management and highlighted the role of the MRF in reducing dengue fever incidents. It also discussed the positive impact of the MRF on mitigating environmental issues caused by improper waste disposal.

The MRF model can be adapted to various local authorities in Sri Lanka, but its success depends on effective localization within a specific community. The key to success lies in the community's acceptance and embrace of the MRF, which can be achieved through community awareness and active involvement. Factors influencing the MRF's applicability include economies of scale, waste volume, operational costs, and population density. Implementing the MRF as a public-private partnership (PPP) can bring benefits to local authorities, industries, stakeholders, and the community.

While previous MRF projects in Sri Lanka had a low success rate, the Wattala MRF distinguishes itself with its efficient supply chain, involvement of low-income communities, and value addition processes. To ensure long-term viability without relying on government funding, adopting a service business model is crucial, focusing on continuous service enhancements. In terms of sustainability, the MRF model's economic, social, and environmental performances should be evaluated. Notably, the social performance is emphasized due to its reliance on community behavior.
In conclusion, the research findings align closely with the discussion and conclusions of the paper, providing a comprehensive understanding of how the Material Recovery Facility (MRF) model can contribute to waste management, economic growth, social development, and environmental sustainability in the context of Circular Economy principles.

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