

Ecological and Economic Impacts of 3R in Surakarta's Urban-Agricultural Interface

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Abstract. In the urban-agricultural nexus of Surakarta, Indonesia, effective waste management plays a pivotal role in safeguarding ecological and resource integrity. This research delves into the interplay between the 3R (Reduce, Reuse, Recycle) approach and its implications for both the environment and local agrarian economies. Using a descriptive framework, 120 urban households were interviewed in-depth, adopting a revenue approach to assess the economic valuation of agrarian waste. Results indicated a strong inclination amongst Surakarta inhabitants to integrate 3R principles, motivated by both economic gains and ecological stewardship. Agrarian waste presented an economic value of IDR 52,514.28, with 3R methodologies offering avenues to bolster household agrarian incomes, reduce environmental degradation, and optimize resource use. This was observed through decreased waste-associated costs, repurposing opportunities, and resource recovery. Yet, the full ecological and economic potential of 3R is hampered by challenges like limited community and government backing, awareness shortfalls, and infrastructural deficiencies. Addressing these challenges could enhance sustainable resource management and ecological balance within Surakarta's urban-agricultural context.

1 Introduction

The waste problem has always been a concern around the world. The increase in the volume of waste worldwide is caused by various factors. The past few years, the volume of waste has been increasing in Indonesia due to Indonesia's vast population and rapid growth. Additionally, the consumption patterns of its individuals have played a role in the development of hazardous or difficult-to-decompose wastes such packaging waste. As culture grows, handling and control will become more and more difficult due to the complexity of the waste's nature and composition.

Big cities tend to produce more waste. The high migration of rural communities to urban areas has increased regional density. One of the cities that became the destination of migration was the city of Surakarta. As a result, managing waste in urban areas is more challenging than managing waste in rural areas on the outskirts of Surakarta. Over the past few decades, the volume of household waste has multiplied in residential areas with high densities of population. High rural-to-urban migration rates, urban residents' changing

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lifestyles, economic development, rising social standing among urban community groupings, and other factors all have a significant role in the volume of household waste produced [1]. To overcome this situation, good sustainable waste management is needed.

Instead of a linear process, sustainable waste management uses a cyclical process to manage waste without jeopardizing the prospects of future generations. The 3R concept of Reduce, Reuse, and Recycle is a widely accepted approach to waste management. These principles aim to minimize the amount of waste generated, maximize the use of materials, and promote the recovery of resources from waste [1]. The program encourages individuals and communities to reduce the amount of waste they generate, reuse items as much as possible, and recycle materials that cannot be reused. This approach has gained popularity due to its potential to address environmental and social problems while simultaneously providing economic benefits[2].

The field of 3R (reduce, reuse and recycle) offers a great economic opportunity. This is due to a number of factors, including: The cost benefits associated with reducing waste in production processes and by supporting reused products rather than new ones. Reducing costs while improving efficiency are always appealing for any business or institution [2]; Growing demand from consumers looking for green, recycled or upcycled products that come with positive environmental stories behind them[1]; Additionally there has been increased awareness among communities regarding global warming which negates carbon emissions [3]; Increased participation policies driven through local authorities urging residences engage repair protect natural ecosystems gives much needed assistance push forward cycle followed others before them advancing technology already attained– further proof concise planning together leads inevitable successes[4].

Local communities in Surakarta can collect and manage their own garbage with the help of waste banks in order to decrease waste and get economic advantages of implementing 3R. Implementing 3R through waste bank benefits the community by providing extra income in addition to aiding in environmental cleanup. The income of the city's poor can improve innovations of 3R implemented at the local level through waste banks [5,6]. This improvement can occur if there is good waste management through 3R assisted by a waste bank. It is hoped that the 3R can become a driving force to increase household income.

Studies on 3R had been conducted [7], but mostly studied the impact of 3R on environmental hygiene, innovative waste management models, and the effectiveness of waste management [8][9]. Several studies have also examined the role of 3R in improving the community's economy[10][11][12]13]. However, it has not been studied how significant the role of 3R in the household economy is. Therefore, this study aimed to analyze how 3R was developed to improve the household economy in Surakarta City. This study focused on the 3R model in relation to the economic conditions of urban communities.

2 Methods

This study uses a descriptive methodology. The research location taken was Surakarta, Central Java due to the trend of increasing waste entering the TPA in Surakarta [14]. Extensive interviews using a questionnaire about the implementation of the 3R (Reduce, Reuse, and Recycle) were distributed to 120 respondents using purposive sampling. The revenue approach is used to analyze the data and is supported by a description that supports the results of the analysis.

$$TR = P \times Q \quad (1)$$

Where TR is total revenue (Rp), P is price (Rp) and Q is quantity of waste (kg)

3 Result and Discussion

Surakarta is a city with a high population density. This goes with the amount of waste that generated by the community. Based on data from the Surakarta City Environment Service, the average amount of waste entering the TPA per day in 2020 reached 294.73 tons and increased to 299.45 tons in 2021 [7]. The amount of waste is from the private and the public in general. The waste originated from the household waste. The composition of household waste is grouped based on the type of waste that is sold at the Garbage Bank in each sub-district in Surakarta. Classification of types of waste is used to determine the economic value of waste. The classification of types of inorganic waste used is cardboard, newspapers, paper, glass bottles, plastic, cans, PET bottles, duplex, iron, aluminum, etc. In addition to looking at the composition of other inorganic waste, there are other organic wastes and Hazardous and Toxic Materials (B3). Other inorganic waste is waste that cannot be sold in waste banks such as plastic bags, plastic packaging, straws, sacks, toothbrushes, and various other inorganic waste. Organic waste is food leftovers, leaves, animal carcasses, and other organic waste. The results of sampling the composition of the waste are explained in Figure 1.

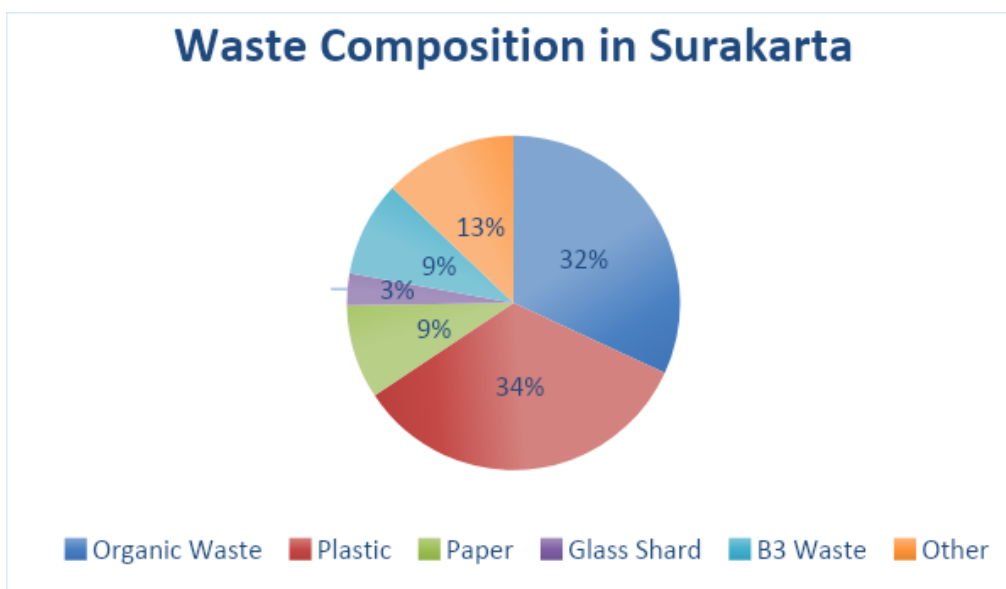


Fig.1. Waste Composition in Surakarta Household, 2021
Source: Primary Data, 2023



Fig.2.Type of Inorganic Waste



Fig.3. Weighing of Waste in the Waste Bank

The waste produced by society has economic value. Either salable or not. An analysis of the economic value of waste in Surakarta was generated based on the price of waste and the waste that sold to waste banks. The types of waste that are sold as listed in Table 1 are the types of waste that can be sold at collectors in Surakarta. Table 1 shows that the average economic value generated by households when managing waste properly is IDR 52,514.28 per month. The largest type of waste is glass bottles with a generation of 6 kg and an economic value of IDR 6000 per month. The lowest economic value is found in the type of duplex waste. Meanwhile, the organic waste that is processed into compost is consumed personally by the respondents without knowing how much (kg) is produced.

Table 1. Average waste generated every month, prices, and waste economic analysis

Type of waste	Weight of waste (Kg/Bulan)	Price (Rp)	
Paper	2.3205	Rp800	Rp1,856.40
Newspaper	1.3333	Rp800	Rp1,066.64
Cupboard	5.742	Rp1000	Rp5,742.00
Plastic	2.4609	Rp800	Rp1,968.72
Glass Bottle	6	Rp1000	Rp6,000.00
PET Bottle	3.1439	Rp800	Rp2,515.12
Cans	2.0625	Rp8000	Rp16,500.00
Duplex	2.61	Rp200	Rp522.00
Iron	3.2778	Rp1500	Rp4,916.70
Alumunium	1.6667	Rp1000	Rp1,666.70
Others	4.88	Rp2000	Rp9,760.00
Sum			Rp52,514.28

Source: Primary Data, 2023

The results of the economic analysis state that the average amount that respondents get each month when implementing 3R through the waste bank is IDR 52,514.28. These results indicate the existence of additional income without the need for large capital and manpower. Although this value is not proportional to the number of household expenditures of the respondents. This modest increase in income has made many respondents reluctant to carry out 3R activities other than for environmental reasons and global warming [4,10,11,15]. Even so, the results of this economic analysis are still greater than the value of the fee to pay the waste manager, which is IDR 5,125.

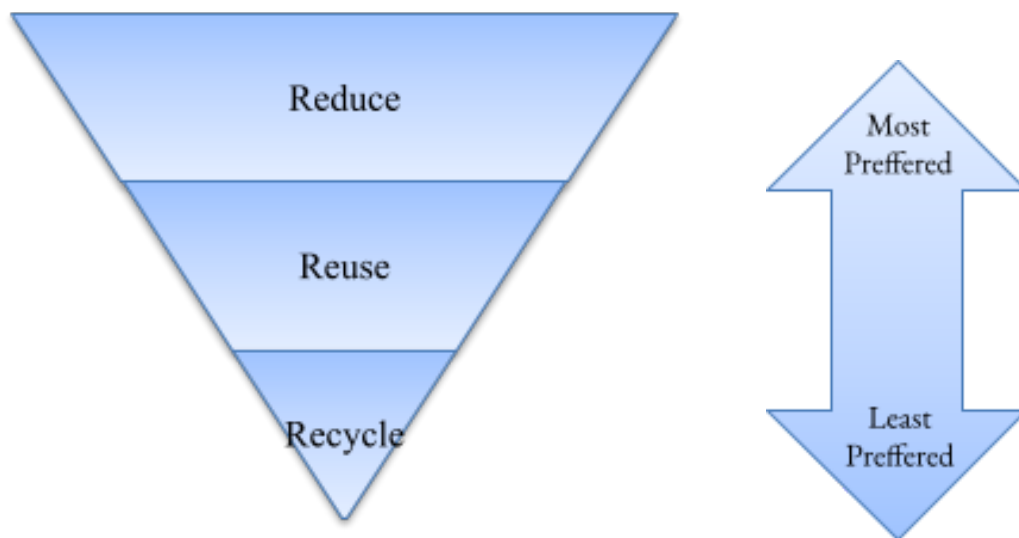


Fig.4. The Hierarchy of Waste Management, [16]

Table 2. Willingness to Do 3R

Reduce	64,1%	35,9%
Reuse	60,0%	40,0%
recycle	36.7%	63,3%

Source: Primary Data, 2023

Figure 4 shows the ordering of the waste management hierarchy which is carrying out waste management. This sequence also describes the willingness to carry out waste management. This is due to the ease of managing waste starting from reducing, reusing, and

finally, recycling. Following the hierarchy in Figure 4, the results of the willingness to do 3R in Surakarta society are illustrated in Table 2. Like the 3R hierarchical theory, the number of Surakarta people who are willing to do 3R is highest at the reduce level of 64.1%, followed by reuse of 60% and finally recycle of 36.7%.

Reduce is the first principle of waste management in the 3R approach. It involves the prevention and minimization of waste generation by reducing the amount of waste produced at the source. Many people in Surakarta are willing to reduce goods to reduce waste by 64.1%. Implemented reduce, households could save money by minimizing the amount of waste they generate and reusing items instead of buying new ones. The people of Surakarta are trying to reduce their use of plastic such as shopping plastic bags, plastic straws, and plastic cups and replace them with more environmentally friendly items. Separation of waste at the source can also achieve the same goal of waste reduction, intensified by public awareness and education. Waste reduction is an essential component of sustainable solid waste management and helps to conserve natural resources and reduce environmental pollution[1,7,17,18].

Reducing the amount of waste generated through the implementation of 3R policies can lead to several economic benefits in urban areas. Firstly, it reduces the costs incurred by local governments and authorities in waste disposal. The people of Surakarta on average pay a monthly garbage fee of Rp. 30,000-Rp. 50,000 per month. If the community can reduce waste, the value of waste fees will also decrease. The lower the volume of waste, the less money needs to be spent on waste management. This reduction in costs can free up resources for other municipal services, such as infrastructure development or social programs. Furthermore, the reuse and recycling of waste can create economic opportunities for local community. For instance, recycling community's program can buy and sell recyclable materials. This can stimulate economic development and create jobs in the recycling industry[7,8,12,19,20].

Reuse is the second principle of waste management in the 3R approach. It involves the secondary and subsequent use of waste materials either in part or whole. Reuse of waste is exemplified by trade in second-hand goods such as clothes, electronics, automobiles, furniture, and other merchandise. Many people in Surakarta already want to reuse goods to reduce waste by 60%. They are trying to be more aware and reuse items that can still be used, such as eco bags, clothes, eco friendly places to eat, etc. Reuse is achieved through sorting done at the source rather than the disposal site and through detailed processes of checking, cleaning, refurbishing, repairing whole items or spare parts. Examples of reuse include the reuse of plastic bottles for packaging locally made drinks and the use of solid waste by farmers to improve soil fertility. Reuse is an essential component of sustainable waste management and helps to conserve natural resources and reduce environmental pollution [7,15,18].

In addition to reducing waste that generate, the reuse component of 3R can have a significant impact on local economies. As previously mentioned, reusing materials can create economic opportunities for local businesses. In particular, it can support the growth of small and medium-sized enterprises that specialize in repairing, refurbishing, or repurposing items. These businesses can generate income by selling these items, thereby boosting the local economy. Moreover, the reuse of items can also reduce expenses. This is because many used items can be acquired at a lower cost than new ones. However, it is important to note that while the economic benefits of 3R policies are significant, proper education and government support are necessary for these 3R policies to be successfully implemented and for these benefits to materialize. Despite the growing awareness of 3R policies in developing economies, progress remains slow.[3,16,21]

Recycling is another important component of 3R policies and has the potential to support local economies. By recycling waste materials, Surakarta can reduce their

environmental impact by conserving natural resources and reducing the amount of energy required to produce new products. Not many people in Surakarta are willing to recycle goods to reduce waste, which is 36.7%. People in Surakarta who carry out 3R through waste banks can take part in recycling activities such as making floor mats, wall hangings, flower crafts etc. Where it can be sold which produces a price range of IDR 10,000 – IDR 200,000. Recycling aims to recover valuable resources from waste and reduce the amount of waste that ends up in landfills or incinerators. Recycling is an essential component of waste management and helps to conserve natural resources and reduce environmental pollution[7]

These findings suggest that the community, government, and waste bank management must constantly strengthen and develop the 3R together. There may also be a lack of public awareness and education regarding the importance of 3R policies and their potential benefits. In order to solve these issues and develop solutions that support sustainable waste management practices, policymakers and stakeholders must collaborate. The required infrastructure for waste management, such as trash cans and recycling bins, must be provided, and 3R policies must be encouraged at both the individual and corporate levels. Governments should also pass laws and regulations that promote 3R attempts and offer suitable incentives for recycling to individuals, businesses, and the unorganized sector.

4 Conclusion

The 3R has been proven to play a role in waste management. The result shows that waste still has an economic value of IDR 52,514.28 in Surakarta. 3R has a role in increasing the income of households such as reducing that can reduce the costs incurred in waste disposal. Reuse that can create economic opportunities by repairing, refurbishing, or repurposing items. And recycling can recover valuable resources from waste and reduce the amount of waste that ends up in landfills or incinerators. However, 3R still has many shortcomings that must be improved, such as lack of support from community, government, and waste bank management; lack of awareness and education, infrastructure and regulation. If the weaknesses of waste management can be addressed, the role of the 3R to increase the income of urban households can be improved.

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