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## **Eco-Design of A Digital-Based Waste Bank in Sukoharjo: Pentahelix Synergy Approach**

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### **Abstract**

Alternative solutions in overcoming the waste problem are carried out by developing a waste bank which is a social engineering activity that teaches people to sort waste and raises public awareness in waste management. The eco-design innovation of waste processing with a digital-based waste bank program with a synergistic pentahelix approach has become an innovation at the grassroots level, especially in Sukoharjo. This study uses a qualitative method, which is equipped with data analysis with descriptive statistics. The effectiveness of waste management is defined by the high amount of managed waste, the amount of waste being recycled, and the large economic benefits resulting from waste management. This is due to the low percentage of managed waste and the low percentage of recycled waste, which of course also has low economic benefits. Waste banks in the Sukoharjo area need to be further involved in this waste management, so that the effectiveness of its management increases and the economic benefits taken can be maximized. The existence of a waste bank has proven to be effective in reducing waste problems in Sukoharjo. it is necessary to use digital technology which is still rarely used by waste banks in Sukoharjo. Therefore, an eco-design of waste management through a digital-based Waste Bank in Sukoharjo needs to be implemented. Eco-design of waste management through the Waste Bank in this study is to use Pentahelix synergy, namely collaboration between elements of government, academia, the business sector, community, and the media.

**Keywords:** Eco-design; waste bank management; Pentahelix synergy

## INTRODUCTION

The waste problem is a universal phenomenon. The more advanced and modern the culture of society, the more waste is produced. The high rate of piles of garbage is directly proportional to the increase in public consumption which triggers social conflicts and environmental crises. Garbage in various cities is a crucial problem experienced by big cities in Indonesia (Suryani, 2014). In his research (Setyaningrum, 2015) stated that the overall amount of waste production in Indonesia reached 151,921 tons per day. This means that each Indonesian resident produces an average of 0.85 kg of solid waste per day. The government of the Republic of Indonesia responds normatively to the waste management crisis conditions that have an impact on the occurrence of environmental crises, through comprehensive waste management efforts from upstream to downstream in accordance with UU Number 18 of 2008 Pasal 12.

In Law No.18 of 2018 concerning Waste Management, it is explained that everyone has the right to participate in the decision-making process, implementation, and supervision in the field of waste management. In this case, waste reduction activities can be carried out by being reused, recycled, and/or easily decomposed by natural processes. Waste management is still focused on the downstream level, so that waste accumulates in the Final Disposal Site (TPA). The broad impact of poor waste management is the emergence of methane gas into the atmosphere and causing the greenhouse effect and worsening global warming (Herlambang, 2010). Bad impacts can also occur for the community by causing soil damage, water pollution, air quality to health (Fidelis O Ajibade et al, 2021). Data from <http://sipsn.menlhk.go.id/sipsn/public/data/achievement>, shows that the achievement of national waste management performance in general, district/city piles from 2019 -2020 has increased, in line with the increase in waste reduction and improved waste management.

The Industrial Revolution 4.0 is a turning point for a new breakthrough in the world of Information Technology by developing collaboration in waste management. An increase in waste handling in the 4.0 revolution era needs to be balanced by developing various digital technologies. The use of various innovations and digital technology is a solution to the waste problem in Indonesia. Some of them at the national level are BankSampah.id which is a web and mobile-based application that aims to support the operational activities of Waste Banks throughout Indonesia, at the regional or city level including the Mountrast application in West Jakarta as a solution to the problem



of plastic waste as a mental resolution of trust activities. management that can absorb new workers during the Covid 19 pandemic, e-Recycle which is a mobile application-based waste processing program, transporting garbage and others.

Transport Garbage as a digital waste management platform for the people of Medan city by providing services such as picking up trash, giving out composter bins for free, investing in gold, saving trash, and giving trash that other competitors don't have. Garbage Transport has its own business model concept that can be a profitable consideration for investors to close (invest) in Garbage Transport (Andriana, Lubis, Juned, & Hasdiana, 2019). The use of digital media in waste management is still in the form of discourse at the stage of being socialized and implemented and its effectiveness has not been tested.

Garbage is an environmental and urban community problem that until now has no solution. The limited number of waste disposal sites (TPA) in Sukoharjo Regency makes this waste problem increasingly complex. Data from the Sukoharjo Environment Agency (DLH) noted that the people of Sukoharjo dispose of up to 130 tons of garbage per day, even up to 160 tons for holidays. DLH's target in June 2019 is to reduce waste by up to 50 tons per day. The Sukoharjo Regency Government has tried to reduce the amount of waste with various programs. Some of the waste programs of the Sukoharjo Regency Government include: Socialization to the public about waste management, maximizing waste management to the village level, utilizing waste into methane gas, reforestation in the TPA environment, to the establishment of a Waste Bank. Waste bank is one of the alternatives in waste management strategies (Asteria, 2016). Garbage, apart from being a problem in itself on environmental impacts, also adds to the budget for the government budget. The waste bank is one of the programs that can change the pattern of people's views on waste management (Sekarningrum, 2017).

The development of the regional solid waste network system in Sukoharjo Regency based on the Sukoharjo Regency Regulation No. 14 of 2011 concerning the Sukoharjo Regency's RTRW in 2011-2031 includes: 1. expansion of the waste network including: Baki District, Tawang Sari District, Nguter District and Polokarto District. 2. development of the Mojorejo Final Processing Site (TPA); and 3. improvement of waste transportation facilities. While the realization of other regional infrastructure network systems in the form of a solid waste system includes 1. Expansion of the solid waste network to all sub-district capitals that have not been served 2. Addition of waste transport facilities 3. Development of the Mojorejo TPA.

Several strategic issues related to waste management in Sukoharjo Regency, among others: 1. Waste management at the Mojorejo Final Processing Site (TPA) has not been maximized 2. The Mojorejo Final Processing Site (TPA), Bendosari Sub-district is estimated to be able to survive collecting waste in Sukoharjo for the next five years. This condition is influenced by the volume of waste which has increased every year 3. There are still many people in Sukoharjo Regency who litter, empty land, rivers 4. There are still few people in Sukoharjo Regency who do 3R on waste generation. In fact, by carrying out the 3R process on existing waste, it can provide environmental and economic benefits for the community. The Head of the Sukoharjo Environment Agency (DLH) Agustinus Setiyono (2020) stated that the Sukoharjo Regency Government (Pemkab) encouraged residents to activate waste banks as an effort to empower the economy during the Covid-19 pandemic and intensively disseminate information to the community to establish waste banks up to the RT level. /RW. The community is invited to help facilitate the establishment of a waste bank in their environment, so that the waste bank becomes a solution for handling waste problems.

Several strategic issues related to waste management in Sukoharjo Regency, among others: 1. Waste management at the Mojorejo Final Processing Site (TPA) is not maximized 2. Places The development of integrated waste management can be developed by integrating all elements of the solid waste life cycle based on the 3R process (Reduce, Reuse and Recycle); integration of technical, environmental, social, financial, institutional, and political aspects to ensure system sustainability; and active participation of all public, private and community stakeholders in the conception and planning of processes and solutions. The pentahelix collaboration in environmental control has been carried out in Indonesia (Amrial, A., Muhamad, E., & Adrian, 2017). Previously, the triple helix collaboration in waste management had been implemented (Rosenlund, J., Rosell, E., & Hogland, 2017) which resulted in the concept of collaboration still having problems, with the resulting solutions needing to be given a barrier and provided a common arena for dialogue. However, although there are still many obstacles Anttonen et al. (2018) encourage the government to apply the triple helix to be applied to waste innovation policies so that there are systemic changes. This study adopted the findings of Rosenlund et al. (2017); Anttonen et al. (2018); and Amrial et al. (2017), who carry the concept of collaborative development elements to overcome environmental problems, especially waste management, and in this study use the pentahelix synergy approach.



Based on the above background, this study seeks to measure the effectiveness of waste management through a waste bank in Sukoharjo and ecodesign of waste management through a digital-based waste bank with a synergy pentahelix approach in Sukoharjo to be developed into a policy brief so that it can be implemented at the community level.

## LITARURE REVIEW

### Waste Management with Waste Bank

One of the government's efforts to overcome the waste problem is the waste bank program. According to the Minister of Environment Regulation No. 13 of 2012, a waste bank is a place for sorting and collecting waste that can be recycled and/or reused that has economic value. The waste bank is a collective dry waste management system that encourages the community to participate actively in it. This system will accommodate, sort, and distribute waste with economic value so that with a waste bank, public welfare can increase (Wulandari, D., Utomo, S. H., & Narmaditya, 2017).

Community-based waste management with 3R emphasizes more on how to reduce and utilize waste more wisely and environmentally friendly. Through the concept of a waste bank, the community will be educated and trained to respect waste, so that they are willing to collect, sort, and save waste. This collecting, sorting and canistering behavior can be shaped and built, although it takes a long time to get used to it. The way waste banks work in general is almost the same as other banks, there are customers, bookkeeping, and management (Danang P., Aditya B., 2017).

The concept of a waste bank is not much different from the concept of 3R (Reduce, Reuse, Recycle). If in the 3R concept it is emphasized how to reduce the amount of waste generated by using or recycling it, in the concept of a waste bank, the most emphasized is how to make waste that is considered useless and has no benefits can provide its own benefits in the form of money, so that people are motivated to sort out the waste they produce. This sorting process reduces the amount of waste heap generated from households as the largest producer of waste in urban areas. The concept of the Garbage Bank makes people aware that waste has a selling value that can generate money, so they care about managing it, starting from sorting, composting, to making waste as an item that can be reused and has economic value (Aryenti, 2012).

## Digital-based Waste Management

The study of waste management at the global level leads to a sustainable circular economy. One of the studies on the application of the circular economy concept in various countries in the world is the research of Professor Sadhan Kumar Ghosh, Department of Mechanical Engineering, Jadavpur University, Kolkata-700032, India, President of the International Society of Waste Management, Water and Water (ISWMAW). His research shows how the implementation and efforts to realize the circular economy concept in various countries, especially in the Asian region such as China, India, and Japan. In Japan, for example, from the results of his research, the key to the successful realization of a circular economy in the country is a business culture that emphasizes collaboration and a comprehensive approach to both measurement and action. The study also concludes that the transition to a circular economy requires a holistic and consistent approach across the policy spectrum. The use of digital technology in the waste management system can be applied in various lines such as transportation, waste data information systems, recycling system efficiency, and others. Research on the use of digital technology includes research in Islamabad and Rawalpindi Pakistan. This study examines the problem of application-based vehicle routing (VRP) that accommodates various rules of thumb such as zone restrictions, vehicle capacity, time, road infrastructure, and types of commodities. The results showed that the use of the application was able to increase the efficiency and effectiveness of the problem of transportation of waste collection and disposal (Hina, Szmerekovsky, Lee, Amin, & Arooja, 2020).

Another research is the use of information technology on waste on a national scale in South Africa with the South African Waste Information System (SAWIS). With this information system, it turns out to be able to change waste management for the better. This system also has a positive influence on companies that use waste data information to pay attention to company operations and as a form of corporate responsibility for reporting environmental concerns (Linda Godfrey, 2010). Utilization of information technology is also raised in research on recycling household waste. An intelligent incentive-based recycling system designed using the Internet of Things and data analytics technology. The basic incentive-based recycling system in Shanghai China, with data on 19 specific recyclable items from August 21, 2018 to March 20, 2019, was able to increase recyclable waste by 229.3%. Under the new information sharing platform, stakeholders can collaborate seamlessly on recycling and household waste reduction (Jieyu Zhou, Peng Jiang, Jin Yang, 2021).



Research related to digital-based waste management has also been carried out in Indonesia. The research is mainly in the use of digital applications or online applications in waste management. Among these studies is the SMASH online platform research which has a reach in the Bekasi area. This study identifies a waste bank management system based on an online platform. Through this identification, it is known the difference in management between online and conventional-based systems so that they can support improving the performance of online waste banks in the future which can be implemented by the central and local governments, communities/environmental activists, the private sector and also the general public (Dadi Rusdiana, 2019). The use of digital applications is also utilized by the Sekarmelati waste bank in Kudus Regency. The implementation of information technology used is a mobile-based raw media management information system by utilizing GPS (Global Positioning System) technology called Bang Sam. This application is needed to ensure the smooth production of processed waste can continue through the management of waste raw materials (Arsya Yoga Pratama, Yusiana Rahma, 2019).

Research using digital applications is also carried out comprehensively in the Yogyakarta Region based on waste management problems in the Piyungan TPST and the area around the area. Some of the results from these studies are the GoWaste Application which is intended for several operators in the development of creative villages who are assigned to use applications to use the buying and selling features and to market products entrusted by the entire community (Julius Alfredo Marpaung, Shafia Rahmi Suada, 2020). Smart Zone application, which carries the concept of community development. Smart Zone aims to create and develop a zero waste lifestyle among the community through superior services, namely challenges, shops, events, trash banks, and open donations which are expected to have a persuasive, preventive, and repressive impact (Novi Wijayaningsih, Mia Nur Arifah, 2020)

The WiKlin application is an application that offers a product overview including a business model canvas, system design and tree user interface diagrams. To implement the Wiklin platform, there is a feasibility study such as investment costs, financing sources, sales projections, profit and loss reports, scenarios for each cashflow and investment feasibility analysis. It was stated that this investment was feasible to implement (Nabila Dearmi Jefri, Rifky Krismantoro, 2020). The RePro (Recycling Project) application is an application that supports the plastic waste recycling business that combines creative innovation with the latest technology so

that it becomes a creative economy. RePro APP is used to promote products from RePro including, RePro Ecobrick Sofa, RePro Bench Park, RePro Stool, RePro Tile, RePro Paving Block, RePro 3D Printer Filament and RePro Tote Bag. Each RePro product is the result of recycled plastic waste that has gone through a series of production processes (Nely Anggraini, Sri Apriani, 2020).

The many applications that have been running, such as Smash, Gringgo, Angkuts, SIMALU and OBABAS, as well as other applications that may be being worked on or are still in the idea stage, are a form of concern for environmentalists, especially providing alternatives in an effective waste management system. Therefore, this study is designed to compare the waste management systems of the various applications developed with the pentahelix synergic approach, looking at the roles of the four pentahelix sectors, namely academics, government, business, community, and media (AGBCM) (Imas, 2016). The Pentahelix collaboration, which is a collaborative activity between lines/fields of Academic, Business, Community, Government, and Media, or known as ABCGM is known to accelerate the development of considerable potential, in this case a digital-based waste management system.

### **Pentahelix Synergy in Waste Management**

Research related to the role of waste management itself has been carried out quite a lot, including research on waste management in Kupang Kidul Ambarawa which examines the role of the community and the private sector in waste management. The results of observations regarding waste management in the Kupang Kidul area have involved the community and the private sector in their roles. However, the role of the private sector is still very minimal so that the community in the Kupang Kidul area still experiences several obstacles in waste management, especially the role as a provider of funds. In addition, there are still few private parties who think that waste in the area needs to be managed. Private parties who have been involved are still individuals (Manurung, 2013).

Another research is that waste management research should not only focus on the end of pipe method but also increase efforts in the clean production mechanism. Using the case of waste management in Yogyakarta, the results of this study suggest several steps to synergize approaches and highlight the importance of stakeholder participation in optimizing waste management for environmental sustainability (Muthmainnah, 2007). The importance of the role of various parties in waste





management is also shown in a study in the Bandung area which describes describing waste management through community social capital. The results show that in the network aspect, with the similarity of backgrounds (bonding), the cooperation between various parties (Bridging), and social relations (Linking) between various parties in the implementation of waste management, the waste management system can be socialized and implemented. The waste management system will be effective if it is based on community social capital. Social capital is the social strength of the community in achieving the common goal of a Waste-Free Zone (Rio Syahli, 2017).

Pentahelix research in the form of FGDs has also been conducted in a case study in Garut Regency. In this study, the FGD was attended by 28 participants consisting of 3 academic representatives, 7 company representatives, 6 community representatives, 10 government representatives, and 2 media representatives. The results showed that there were 7 strategic issues, namely technology, processing, education, economy, institutions, policies, and coordination that needed to be discussed further through further FGDs. All elements are expected to continue to communicate and collaborate and be able to complete the discussion of the 7 issues to be proposed as solutions to the Garut Regency Government, so that they can be used as material for policy formulation to overcome waste problems (Dini Turipanam Alamanda, Hadum Hadiansyah, 2020).

Based on the literature review above, the research carried out is still partial, a more comprehensive research related to digital-based waste management in Indonesia with a synergistic pentahelix approach has so far not been found. Therefore, this study seeks to find the effectiveness of waste bank management in Sukoharjo, and finally to find an eco-design for digital-based waste management with a synergistic pentahelix approach.

## **RESEARCH METHOD**

This study uses a qualitative method, which is equipped with data analysis with descriptive statistics. The first problem formulation will be answered by analyzing qualitative data based on descriptive statistical indicators, the purpose of which is to describe the waste management system in waste management businesses that have digital applications in Sukoharjo Regency. The second research problem will be solved by analyzing qualitative data, to apply the Pentahelix Synergy Approach in digital-based waste management in Sukoharjo Regency. Furthermore, an effective

digital-based waste management design was made with the Pentahelix Synergy Approach. The result is a digital-based waste management eco design modeling with the implementation of the elements in Pentahelix Synergy, that consist of government, business, academics, community, and media.

To see waste management in waste management businesses that have digital applications in Sukoharjo Regency, historical data is needed in the form of waste management performance achievements. This historical data is part of secondary data which is interpreted as a source of research data obtained indirectly or through intermediary media (Miles, Huberman, & Saldana, 2014). Secondary data in this case there are several data collected from the official pages of waste management units and on the National Waste Management Information System (SIPSN) page of the Ministry of Environment and Forestry (<http://sipsn.menlhk.go.id/sipsn/>). The page displays the achievements of national waste management performance, the indicators of which are waste generation, waste reduction, managed waste, unmanaged waste, and national waste management.

## **RESULT AND ANALYSIS**

### **Effectiveness of Waste Management in Sukoharjo**

Garbage is one of the problems in the national scope, along with the speed of population growth in Indonesia. This needs to be addressed by developing a comprehensive waste management strategy from upstream to downstream. This is important to do to maintain the cleanliness and safety of the environment which will have an impact on public health in general. In waste management, there are economic benefits that can be obtained through processing organic waste and recycling inorganic waste.

Waste problems are also found in Sukoharjo Regency, Central Java. Based on historical data for 2020, so far, the Sukoharjo Regency Government has made efforts to handle waste. This is supported by the existence of waste management facilities, such as the addition of a fleet of dump trucks, garbage collection equipment, construction of 3R TPS, regional TPA management, training for 3R TPS management officers, addition of daily freelance staff for road sweepers and garbage pickers, organizing socialization activities. waste, as well as the development of Waste Banks at RT, RW and village levels Until 2020, there are 45 waste banks spread across all sub-districts in Sukoharjo Regency.



Table 1 presents data on the amount of waste generated and the amount of waste handled in Sukoharjo Regency in the last two years. The amount of waste handled is still far from the total existing waste generation. In 2019, the waste handled reached 50.19% of the total waste generation. Meanwhile, in 2020 there was a decline, where waste handling was only 46.45% of the total waste generation in that year. If viewed from the indicator of the amount of waste handled, then this waste management can be said to be ineffective. The average waste handling in the last two years has only reached 48.33% (still below 50%). The effectiveness of waste management will be achieved if the percentage of waste handling approaches 100%. This is certainly a challenge as well as an opportunity for the Waste Bank in the Sukoharjo Regency to take a role in handling this waste. So, in the future waste management can reach 100%. That indicate waste bank is a new alternative for waste management. Waste that is considered to have no value is then saved and invested in a waste bank. The working mechanism for saving waste is almost the same as the mechanism for saving money in banks in general, where each waste saver gets an account number and a waste savings book.

**Table 1**  
**Waste Generation and Waste Handling in Sukoharjo Regency**

Year	Annual Waste Generation (tons)	Annual Waste Handling (tons)
2020	134.604,99	62.540,92
2019	133.536,71	67.028,60

*Source: <http://sipsn.menlhk.go.id/sipsn/> (July 2021)*

Table 2 displays data on the amount of waste generated and the amount of recycled waste and waste raw materials. In waste recycling activities there are economic benefits that can be taken from the products resulting from the recycling of the waste. The amount of waste that is recycled is very small compared to the total amount of waste generated. In 2019, the percentage of recycled waste reached 6.98% of all waste generation. Furthermore, in 2020 there was a slight increase in the amount of recycled waste, reaching 7.74% of the total waste generation. The performance of this achievement is still relatively low, so it is necessary to increase efforts to maximize the economic benefits of waste management. Waste

banks can play a role here, in terms of recycling waste management, so that they are more optimal in handling waste management and take economic benefits. That indicate waste bank system, the presence of waste that has been selected from the house, waste collection facilities in the form of glangsing or plastic, waste bank administrators, an agreed waste collection schedule, a recording system, cooperation with collectors and agreement on waste collection schedule by collectors. The mechanism of the waste bank is waste sorting, depositing waste, weighing waste, recording, and transporting waste. The waste bank is one way of managing waste that applies the concept of community-based waste management with the 3 R (reduce – reuse – recycle).

**Table 2**  
**Waste Generation and Waste Recycling in Sukoharjo Regency**

<b>Year</b>	<b>Annual Waste Generation (tons)</b>	<b>Annual Waste Recycling (tons)</b>	<b>Annual Waste Raw Material (tons)</b>
2020	134.604,99	10.412,28	0
2019	133.536,71	9.327,17	12,78

*Source: <http://sipsn.menlhk.go.id/sipsn/> (July 2021)*

The effectiveness of waste management is defined by the high amount of managed waste, the amount of waste being recycled, and the large economic benefits resulting from waste management. Based on the historical data of SIPSN, it can be said that waste management in Sukoharjo Regency has not been effective. This is due to the low percentage of managed waste and the low percentage of recycled waste, which of course also has low economic benefits. Waste banks in the Sukoharjo area need to be further involved in this waste management, so that the effectiveness of its management increases and the economic benefits taken can be maximized. The pentahelix model is a reference in developing synergies between related agencies in supporting as optimally as possible in order to achieve goals.



## Pentahelix Synergy Approach in Eco-design of Waste Management through a Digital-Based Waste Bank in Sukoharjo

Figure 1. Pentahelix Synergy Approach for Digital-Based Waste Bank



Source: Analysis Result (2021)

The use of the Pentahelix synergy approach in this study involves elements of academics, government, business, community, and media (AGBCM) which are translated as government, education, business, community components, and the media. This study will look at and further analyze the role of each element in the Eco-design of waste management through a digital-based Waste Bank in Sukoharjo. Based on findings in the field, there is still a lack of awareness of Waste Banks in utilizing digital applications ranging from waste collection to financial records. Therefore, in this study the results of qualitative analysis to produce an eco-design of waste management through a Digital-based Waste Bank by optimizing the role of elements of education, government, business sector, community, and media. The following is an eco-design of waste management through a Digital-based Waste Bank in Sukoharjo.

Based on the Figure 1, it shows that the optimization of the role of each element is not only done in one direction but can be done with cooperation between elements. Furthermore, the optimization of the role of each element can be described as follows:

## 1. Government

So far, the local government of Sukoharjo has done many things to support the existence and development of Waste Banks in the Sukoharjo area. In addition to collecting data on the number of waste banks, the Sukoharjo Regional Government also encourages the formation of waste banks up to the RT/RW level. This certainly needs to be appreciated as a form of socialization by the Sukoharjo government in the development of the Waste Bank in the Sukoharjo area. However, various training and technical guidance from local governments have not been felt so far. Guidance and assistance regarding waste bank management both conventionally and digitally are still very minimal, not intensively carried out. Therefore, there is a need for support from local governments, in waste management by waste banks which are utilizing digital technology. The government's role in eco-design of waste management through a digital-based Waste Bank in Sukoharjo can be done by:

- a) The government can act as a regulator and supervisor in the management of digital-based waste banks, including licensing, implementation, monitoring, control, promotion, programs, development, and socialization of the use of digital technology in waste bank governance.
- b) Cooperate with the education sector or the digital business sector for waste management, to provide training and technical guidance to waste bank managers
- c) Utilization of government social media and collaboration with local media in conducting socialization, education, and literacy on the use of digital applications for waste bank management in the community.
- d) Generating public innovation policies in the use of digital technology, namely encouraging innovation networks and public partnerships – both by academics, business/private actors, and communities.
- e) The government can also play a role in coordinating and stimulating stakeholders who contribute to the development of digital-based waste banks by providing educational directions, providing rewards and incentives for the successful development of creativity and conservatism of digital-based waste banks.



## 2. Academics

Second, the role of education in the eco-design of waste management through digital-based waste banks. In the Sukoharjo Regency, educational activities related to education about waste are quite good. Education about the importance of disposing of waste in its place has been carried out from an early age, from early childhood education to higher education. In terms of waste management through a digital-based Waste Bank, of course, it is highly expected that the university level can play an active role through research programs and community service. It has already been implemented several times. However, it may not be optimized yet. Optimizing the role of the world of education in the eco-design of waste management through this digital-based Waste Bank can be done by:

- a) Development of research and community service by universities around the Sukoharjo area regarding the application and use of digital technology in waste management by the Waste Bank in the Sukoharjo Regency.
- b) Collaborating with local governments, business actors, communities such as in carrying out socialization and assistance to communities who are managing waste banks and waste bank customers in the use of digital technology.
- c) The world of education can also play a role in the distribution of information, by publishing the results of research, community service, and joint activities related to digital-based waste banks, both through print and digital media, on a local and national scale.
- d) Education on basic education is no less interesting to do because in general, waste bank customers and managers are housewives, of course, knowledge about the use of digital technology in handling waste is a very meaningful additional education for children.

## 3. Business

It is undeniable that the development of digital applications involves the business or business sector in the form of start-ups or development by existing business institutions. The business sector becomes a facilitator, a provider of digital technology that will be used by the user community both as managers

and customers of digital-based waste banks. In Sukoharjo itself, there are not many waste banks that use waste management applications. Among those who have taken advantage of this digital technology is Sapu Jagad Waste Bank, Gentan, Bendosari Sukoharjo, and Karung Emas Waste Bank, Tanjung, Nguter Sukoharjo which have actively utilized the “Smash” application. As for other applications, such as “Rapel” that reaches the Sukoharjo area, so far there is none. Waste Banks that have shown positive results in the use of digital technology in waste bank management can be a raw model for other waste banks to follow in their footsteps of success. With the increasing number of waste banks that utilize digital technology, it is hoped that they will also be able to move the business sector in Sukoharjo. The business sector in eco-design of waste management through a digital-based waste bank in Sukoharjo can be done by:

- a) Business actors can work together with local governments or academics to provide coaching and mentoring to the community in terms of using digital applications in waste management by waste banks.
- b) The CSR program is a strategic target for the development of collaboration between the business sector and the community who is managing waste banks. This program is very strategic to run, considering that many industries and companies are developing in Sukoharjo.
- c) For the creative economy business community, they can also do marketing and business matching, collaborate with waste banks to market waste that has been collected or that has been recycled into economic value by utilizing digital media.

#### **4. Media**

The industrial era 4.0, stepping on 5.0 will not be separated from the role of digital media. The development of digital media has complemented the role of print media, which is expected to help, in this case helping to promote waste management through Digital-based Waste Banks.

- a) Maximizing the role of digital media both owned by the government, academics, business actors, and the waste bank itself to show the existence of the Waste Bank in the Sukoharjo area.





- b) Through this media, it should also be directed to be able to change the mindset of the community managing and customers of waste banks in the Sukoharjo area, especially regarding the use of digital technology in waste management through waste banks.
- c) Support for publications in the form of promotions and creating a digital-based waste bank brand image by local governments, academics, and local news media.
- d) Various promotional instruments must be optimized for information distribution and image improvement of digital-based waste banks.

## 5. Community

The community, or community members themselves, is a key target in waste management through this digital-based Waste Bank. The community as managers or the community as customers of waste banks must have awareness of the use of digital technology because they are the subject of users of digital technology. The waste bank in Sukoharjo is evenly distributed in every sub-district in Sukoharjo. Based on data from SIPSN, the number of Sukoharjo waste bank units in 2020 is 45 units spread in almost every sub-district. In general, waste management is carried out through community-based Waste Banks such as Karangtaruna, PKK, or mosque communities. The culture and social culture of the Sukoharjo people, which are "*lembah manah*" and "*tepo seliro*", have greatly helped the running of the waste bank so far. However, those related to digital technology must still be encouraged, especially by millennials because most waste bank managers are a community of housewives. And this is very reasonable considering the important role of mothers in cleanliness in the homes of each resident.

The role of the community and society in the eco-design of waste management through this digital-based waste bank can be done by:

- a) The community who is managing the waste bank can involve young people who of course hope to be more aware of the use of digital technology so that they can help their community in using digital applications for the effectiveness and efficiency of their waste bank management.
- b) Be open to assistance and training on the use of digital applications and waste bank management, either by the government, academia, or

the business sector. Or for those who are already aware enough, they can open up innovative collaboration opportunities with the government, academia, or the business sector.

- c) Selection of the right digital application according to the location and needs of the waste bank. Such as whether digital applications such as Smash which contains complete waste bank governance management features, Rapel which is possible for waste sorting and distribution, Obabas for financial records, or another else. Of course, according to the agreement of community members or all waste managers.
- d) Monitoring and evaluating the use of digital applications that have been operated for the management of the waste bank. Not afraid to seek information and try out features that may be new to the community.

## CONCLUSION

The existence of a waste bank has proven to be effective in reducing waste problems in Sukoharjo. However, to make waste bank operations more effective, it is necessary to use digital technology which is still rarely used by waste banks in Sukoharjo. Therefore, an eco-design of waste management through a digital-based Waste Bank in Sukoharjo needs to be implemented. Eco-design of waste management through the Waste Bank in this study is to use Pentahelix synergy, namely collaboration between elements of government, academia, the business sector, community, and the media. Each has a role that can support the other between elements. With the eco-design of waste management through a digital-based Waste Bank with a synergistic Pentahelix approach, it is expected to increase the effectiveness of waste management through waste banks in the Sukoharjo area. So that it can help reduce the waste problem in the Sukoharjo area.



## REFERENCES

- Amrial, A., Muhamad, E., & Adrian, A. M. (2017). Penta helix model : A sustainable development solution through the industrial sector. 14th Hokkaido Indonesian Student Association Scientific Meeting. *HISAS*, 14, 152–156.
- Andriana, S. D., Lubis, D. A.-M., Juned, A. P., & Hasdiana. (2019). Pengelolaan Sampah Di Era Revolusi Industri 4.0 Berbasis Startup Digital. *QUERY: Jurnal Sistem Informasi*, 3(2), 24–32.
- Anttonen, M., Lammi, M., Mykkänen, J., & Repo, P. (2018). Circular economy in the Triple Helix of innovation systems. *Sustainability (Switzerland)*, 10(8), 2-14. <https://doi.org/https://doi.org/10.3390/su10082646>
- Arsya Yoga Pratama, Yusiana Rahma, F. N. (2019). “Bang Sam” Sebagai Media Pengelolaan Bahan Baku Kerajinan Hasil Sampah Berbasis Mobile Pada Bank Sampah Sekar Melati Di Kabupaten Kudus. *Jurnal SIMETRIS*, 9(2).
- Aryenti. (2012). Peningkatan Peranserta Masyarakat Melalui Gerakan Menabung Pada Bank Sampah Di Kelurahan Babakan Surabaya, Kiaracandong Bandung. *Jurnal. Pusat Litbang Permukiman Bandung*.
- Asteria, D. dan H. H. (2016). Bank Sampah Sebagai Alternatif Strategi Pengelolaan Sampah Berbasis Masyarakat Di Tasikmalaya. *Jurnal Manusia Dan Lingkungan*, 23(1), 136-141.
- Dadi Rusdiana, A. N. S. H. (2019). Online System dalam Pengelolaan Bank Sampah Studi Kasus: Kabupaten Bekasi, Jurnal Perencanaan Wilayah Dan Kota Institut Teknologi Sains Bandung. *Planners InSight*, 2(2).
- Danang P., Aditya B., T. I. . (2017). Pelaksanaan Program Bank Sampah dalam Sistem Pengolahan Sampah di Desa Jogodalu Kecamatan Benjeng Kabupaten Gresik. *Jurnal Penamas Adi Buana*, 1(1).
- Dini Turipanam Alamanda, Hadum Hadiansyah, A. R. (2020). Rancangan Solusi Pengelolaan Sampah Dengan Konsep Focus Group Discussion (FGD) Penta Helix Di Kabupaten Garut. *JESS (Journal of Education on Social Science)*, 4(2), 226–240.

- Fidelis O Ajibade et al. (2021). The Threatening Effects of Open Dumping on Soil at Waste Disposal Sites of The Threatening Effects of Open Dumping on Soil at Waste Disposal Sites of Akure City , Nigeria. *International Journal Environment and Waste Management*, X(Januari).
- Herlambang, A. (2010). Produksi Gas Metana Dari Pengolahan Sampah Perkotaan Dengan Sistem Sel. *Jurnal Teknik Lingkungan*, 11(3), 389–399.
- Hina, S. M., Szmerekovsky, J., Lee, E. S., Amin, M., & Arooja, S. (2020). Effective municipal solid waste collection using geospatial information systems for transportation: A case study of two metropolitan cities in Pakistan. *Research in Transportation Economics*, 84.
- Imas, S. (2016). Pentahelix Model To Increase Tourist Visit To Bandung And Its Surrounding Areas Through Huan Resource Development. *Academy of Strategic Management Journal*, 15(3).
- Jieyu Zhou, Peng Jiang, Jin Yang, X. L. (2021). Designing a smart incentive-based recycling system for household recyclable waste. *Journal Waste Management*, 123, 142–153.
- Julius Alfredo Marpaung, Shafia Rahmi Suada, Y. V. (2020). Aplikasi “Plastake” untuk daur ulang yang efektif. *Jurnal Ilmiah Penalaran Dan Penelitian Mahasiswa*, 4(2).
- Linda Godfrey, D. S. (2010). Improving waste management through a process of learning: the South African waste information system. *Waste Management & Research: Journal for a Sustainable Circular Economy*, 29(5), 501–511.
- Manurung, R. A. (2013). Peran Masyarakat dan Swasta dalam Pengelolaan Sampah di Kota Kecil Jawa Tengah(Studi Kasus: Kawasan Kupang Kidul, Kota Ambarawa). *Jurnal Wilayah Dan Lingkungan*, 1(3), 227–244.
- Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative Data Analysis* (3rd ed.). United States of America: Sage Publication.
- Muthmainnah, L. (2007). Menggugah Partisipasi & Membangun Sinergi: Upaya Bergerak dari Stagnasi Ekologis Pengelolaan Sampah. *Jurnal Ilmu Sosial Dan Ilmu Politik*, 11(2), 153–286.
- Nabila Dearmi Jefri, Rifky Krismantoro, A. A. (2020). Wiklin Platform Solutif dan Inovatif Sebagai Upaya pengelolaan Sampah di Provinsi Daerah Istimewa Yogyakarta. *Jurnal Ilmiah Penalaran Dan Penelitian Mahasiswa*, 4(2).



- Nely Anggraini, Sri Apriani, S. N. (2020). REPRO (Recycling Project) Sebagai Solusi Alternatif Pengelolaan Sampah di Era Revolusi Industri 4.0 Menuju Indonesia Zero Waste. *Jurnal Ilmiah Penalaran Dan Penelitian Mahasiswa*, 4(2).
- Novi Wijayaningsih, Mia Nur Arifah, M. N. I. (2020). Amart Zone: Application Improving Zero Waste Lifestyle Based on Community Development. *Jurnal Ilmiah Penalaran Dan Penelitian Mahasiswa*, 4(2).
- Rio Syahli, B. S. (2017). Pengelolaan Sampah Berbasis Modal Sosial Masyarakat. *Sosioglobal : Jurnal Pemikiran Dan Penelitian Sosiologi*, 1(2), 143–151.
- Rosenlund, J., Rosell, E., & Hogland, W. (2017). Overcoming the triple helix boundaries in an environmental research collaboration. *Science and Public Policy. Science and Public Policy*, 44(2), 153–162. <https://doi.org/https://doi.org/10.1093/scipol/scw045>
- Sekarningrum, B. (2017). Pengembangan Bank Sampah Pada Masyarakat Di Bantaran Sungai Cikapundung. *Jurnal Pengabdian Kepada Masyarakat*, 1(5), 292-298.
- Setyaningrum, I. (2015). Karakteristik Peningkatan Pengelolaan Sampah Oleh Masyarakat Melalui Bank Sampah. *Jurnal Teknik PWK (Perencanaan Wilayah Kota)*, 4(2).
- Suryani, A. S. (2014). Peran Bank Sampah Dalam Efektivitas Pengelolaan Sampah (Studi Kasus Bank Sampah Malang). *Aspirasi*, 5(1), 71–84.
- Wulandari, D., Utomo, S. H., & Narmaditya, B. S. (2017). Waste bank: Waste management model in improving local economy. *International Journal of Energy Economics and Policy*, 7(3), 36–41.

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