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# The circular economy strategies based on household waste management: Promoting environmental quality with the system dynamics approach

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**ABSTRACT**

The circular economy is an innovative economic model that converts waste into valuable products, while offering substantial benefits for both regional and national economies. This study investigated how the household waste management practices affected environmental degradation and public health using the System Dynamics technique. The study drew on various sources, including mass media, expert opinions, time series data, and scientific publications, to assess the effect of waste on water, air, and public health quality. The findings indicated a link between population growth and the increased waste generation, particularly from the domestic sources. The unmanaged waste poses a threat to air and water quality, while highlighting the need for an improved waste management. A 3R approach (Reduce, Reuse, and Recycle) in the circular economy offers clear environmental and economic benefits, such as the reduced environmental impact, the increased income generation, and the enhanced investment and job creation. Additionally, the circular economy promotes the recycling and green entrepreneurship, while boosting investment and job creation. Collaboration between governments and business owners strengthens local distribution and marketing, enhancing local self-sufficiency. In summary, the adoption of a circular economic model offers substantial and wide-ranging benefits for economies at both the regional and national levels.

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## INTRODUCTION

Waste is a problem faced by almost every human being on the planet. In 2018, the garbage production reached a backlog of 2.01 billion tons, which was followed by up to 70% population growth and urbanization. As forecasted by the World Bank, the global waste output by 2050 will reach 3.4 billion tons (The World Bank, 2021). Waste is an essential and conceivably lucrative factor in the waste management and the recycling sector in the industrialized nations, but the waste management remains a hurdle in the developing countries (Sassanelli et al., 2020). The waste issue is caused by inadequate production and a lack of the recycling on the created matters (Wilson et al., 2015). Among the waste management techniques that could be employed are extensive regulations and policies. Circular economy is indeed one of the new economic concepts striving to decrease and eliminate waste while converting the waste materials into the useful, new goods. The construction of a sustainable economic system by addressing economic, social, and environmental factors is referred to as circular economy (Millar et al., 2019; Andrews, 2015). The government can establish laws related to the industrial waste management sector by utilizing the Life Cycle Analysis (LCA) approach for analyzing efficiency of the manufacturing activities at various recycling stages to be reused (Plastinina et al., 2019). In Japan, this economic notion is implemented by community rules and policies based on the 3R (Reduce-Reuse-Recycle) paradigm, with a reward and punishment system.

The circular economic concept has been applied in the developed countries and is now a political aspect in policy design, by providing the people an access to resources, facilities, and education to change their behavior (Salmela, 2016). The waste production remains an issue in Beijing City of China, while the circular economic system has not been applied as well as possible because of low public awareness, pollution from the rising emission levels, and the declining public health due to waste-related pollutants (Yang et al., 2021). The population growth in the developing countries is associated with a higher level of toxicity generated by pollution as a result of improper waste management (Ndanguza et al., 2020). The increasing prevalence in the aggregate consumption brought about by population growth results in an annual increase in the waste production, while the ineffective waste disposal lowers the environment quality (Al-Khatib et al., 2015).

One of the nations in the development process is Indonesia. At the moment, Indonesia continues to lag behind in terms of waste management. From 2015 to 2017, 65.2 million tons of wastes were produced annually, with the estimated costs of up to 28.1 trillion rupiah. Improper waste management could have an adverse effect on state and regional economies (Badan Pusat Statistik, 2018). Every stakeholder involved in Indonesia is concerned about the waste management. As of the 2020 global SDG index, Indonesia was ranked 101st out of 166 countries (Bappenas, 2022). Proactive collaboration on the externalities of waste produced would be a concrete step for the pentahelix (government, university, business, media, and non-governmental organizations) to solve these issues (Maalla & Adipah, 2020). Through a people-based circular economic strategy, the Indonesian government must take a decisive action in concert with several stakeholders to change the community's perspective on waste as a resource with economic value (Kristianto et al., 2023).

Indonesia is an archipelago nation, while some of its border regions need to be given a special attention, most notably Bengkayang City of West Kalimantan Province, which separates Indonesia from Malaysia. With 17 city districts, Bengkayang City has the largest population within Bengkayang Regency. Bengkayang district's economic center is located in Bengkayang City. Therefore, the region's gross regional product (GRDP) increases, along with the population's output and consumption levels. In 2019, 34,723 people lived there, in which this number was an increase by 3.57 percent from 2015 (Bappeda, 2020). The current state of waste management in Bengkayang City is not optimal; waste in the Final Disposal Site landfill is left unattended, no government employees are assigned to manage the landfill, organic and inorganic wastes are still mixed, there is a lack of data on the waste production, access to the landfill is restricted, there is no waste processing industry, and the infrastructure and facilities are insufficient. The cultural sensitivity in waste management and long-term assistance in changing the public perspectives are important matters concerning the efficient use of waste resources in reducing the unfavorable effects resulted (Kristianto, 2020b).

Public health and environmental quality will be affected by the continuously growing waste output which fails to be adequately handled. Local governments need to take the proactive actions to lessen the negative externalities associated with waste by promoting the ideas of reducing, reusing, and recycling through assistance, education, and socialization (Khairunisa et al., 2020). The public health development index, regarding the effects of poor waste management, can be utilized as a tool to monitor and evaluate the development performance in terms of health (Ministry of Health of the Republic of Indonesia, 2018). Consequently, it is imperative to focus on enhancing the household waste management procedures. This can be accomplished by educating people about the importance of recycling and proper garbage disposal through education and awareness campaigns. The quantity of waste that ends up in landfills can be greatly decreased by urging families to segregate their waste and to recycle some items, such as paper, plastic, and glass (Guzzo et al., 2022). The circular economic system implementation might boost the state's GDP by supporting the industries that deal with recycling, waste management, and water supply (Grdic et al., 2020). Waste management for the government is an aspect of the charitable activity. National waste reduction is a shared responsibility between the government and wider population, while this matter affects public health (Nwogwugwu &; Ishola, 2019).

To address these issues, this study was conducted to investigate many aspects and interrelationships of the circular economy in the context of waste management. The emphasis was expanded to evaluate its effect on air, water quality, and public health, particularly in the Bengkayang Border area of West Kalimantan. The fundamental goal of this project was to develop a circular economic model that addressed and improved the quality of air, water, and public health in the given region. The research focused on understanding how waste management methods affected air, water quality, and public health in the Bengkayang Border region. By investigating the present waste management system and its consequences, the research aspired to offer a circular economic model that may successfully solve these issues. This approach sought to reduce waste creation, enhance resource efficiency, and, eventually, improve air and water quality, while improving public health.

The outcomes of this study will provide important insights into the possible benefits of a circular economic framework application in waste management, notably in terms of air, water, and public health. The study aims to help solve environmental and public health illnesses in the Bengkayang Border area by constructing a model specifically targeted to address these challenges.

## RESEARCH METHOD

The research was conducted in Bengkayang, a border region in West Kalimantan, over a period of ten years, from 2012 to 2022. The data were collected via the National Waste Management Information System, the Central Statistics Agency, and direct field observations. The data were utilized to examine a range of Temporary Disposal Sites and Final Disposal, as well as nature of the disposed waste. Several factors considered in the research were GDPR, population size, birth and mortality rates, water and air pollution, a risk of the contracting illnesses, and the uncontrolled household waste. However, it is important to acknowledge that this study is not without limitations.

The system dynamics concept was adopted for the research; this technique cannot be classified in terms of quantitative or qualitative features, but it focuses on the causal interactions and linkages among various sub-systems that construct a system and affect each other in a circle (Tasrif, 2015). This method seeks to describe the complex behavior and structure that occurs in the actual world during the learning, decision-making, and policy decision processes (Bakken, 1993; Sterman, 2009). The system dynamics approach uses instruments for issue resolution and prevention, including the Causal Loop Diagram (CLD) and Stock Flow Diagram (SFD) methodologies. The study used primary and secondary data sources, including conceptual, textual, and quantitative data bases. To analyze the degree of data accuracy compared to actual and projected values, the MAPE (Mean Absolute Percent Error) approach was used using the preset criteria (Bala et al., 2014) (Table 1).

Table 1. Criteria for Assessing the Mean Absolute Percent Error (MAPE)

| MAPE Value | Criteria |
|---|---|
| < 10% | Excellent |
| 10-20% | Good |
| 20-50% | Enough |
| >50% | Poor |

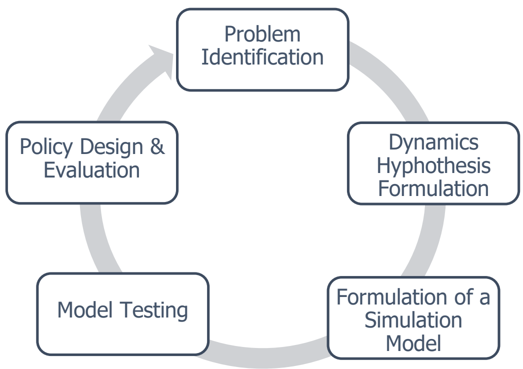


Figure 1. Stages of the method system dynamics (Stearman, 2020)

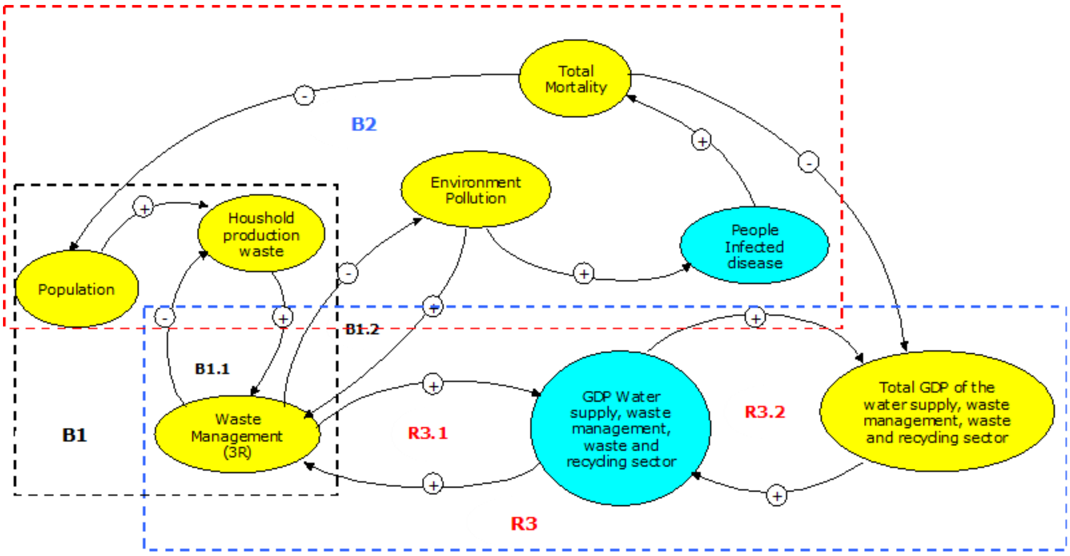


Figure 2. Causal loop diagram research framework

Models passing the validation test were considered to meet the requirements and simulated to establish the scenario for forecasting the model's future (Figure 1). Data in the model processed using the Powersim 10 application. The framework was organized into three subsystems, namely population subsystem, waste management subsystem, and public health subsystem (Figure 2).

In terms of the study structure, considering the research limitations, three subsystems to be examined:

1. The population subsystem in the circular economy model: This subsystem represents the relationship between population growth and prospect of the waste production increase in Bengkayang Regency, taking into consideration demographic factors. The weakness of the system dynamics model is that it only considers variables that directly affect population demographics, such as birth and death rates. The parameters of birth rate and the values of life expectancy, that have been collected and used in the model, effectively reflect the full range of the physical structure and the decision-making behavior.
2. The waste subsystem of the circular economic system: In this sub-model, the model constraints are applied to the elements that have a direct impact on the accumulation of waste generated by society, particularly from its source which is the household waste. Waste management is largely concerned with how waste is handled through a process that involves educational programs, facilities, infrastructure, recycling technologies, waste banks, the informal sector and applicable waste management regulations (Sukholthaman & Sharp, 2016).
3. Environmental and public health subsystem in the circular economy model: This submodel also discusses system constraints on variables that directly affect the accumulation of air and water pollutants. Air and water quality pollutant is described as the pollutant generated from household waste in terms of air and water pollution. The household waste can pollute air and water for not properly managed and disposed of. The unmanaged waste can lead to pollution, while endangering human health and natural environment. Airborne pollution is generated when incinerating organic and inorganic wastes, thus producing toxic gasses, including methane, sulfur dioxide and carbon monoxide.

The public health factor is related to environmental health and health behavior. Public health is about the way of people to understand the consequences of failing to care for the environment. Environmental health relates to the physical environment, both natural and man-made, including waste, water, air, housing and social factors (economic, educational, occupational, etc.). The physical environment is affected by the cleanliness of environment where people live. Poor environmental cleanliness is the cause of many diseases. For example, the availability of clean water can affect health because water is a basic human need and is used on a regular basis. The social environment is inextricably linked to the economic circumstances of the population. More impoverished individual or community means more difficulty to obtain health insurance, while more educated people understand health better.

## RESULT AND DISCUSSION

### Characteristics of Former Blue-Collar Employees

Bengkayang Regency is located near the Malaysian border, particularly in the Jagoi Babang District. Socioeconomic conditions in the community are rather straightforward (Table 2). However, waste management methods in the area have yet to completely adopt the 3R concept. Furthermore, the landfill remains an open dumping site with the suboptimal access and infrastructure. The landfill garbage is still erratic and contains both biological and inorganic debris. Furthermore, the site is utilized between oil palm fields and must be organized (Figure 3).

Waste management data have not been managed adequately; in West Kalimantan province, data on waste management in Bengkayang Regency have not been provided in the National Waste Management Information System. The current research made use of the subsequent data of household waste, births, population, pollution, infected population, and mortality, Regional GDP of the waste management, waste, and the recycling sector.

Table 2. Statistics of Bengkayang Regency, 2023

| Indicator variable | Unit | Value |
|---|---|---|
| Population sub model | | |
| Births | person/year | 67413 |
| Mortality | person/year | 32241 |
| Population | person/year | 293101 |
| Circular economy waste management sub-model | | |
| GDPR waste management | billions/year | 6310 |
| Waste generation | tons/year | 43257 |
| Managed household waste | tons/year | 12004 |
| Unmanaged household waste | tons/year | 20689 |
| Environmental pollution sub-model | | |
| Air pollution | mg/year | 51 |
| Water pollution | mg/year | 48 |
| Public health sub-model | | |
| Infected population | person/year | 63017 |

Source: Badan Pusat Statistik (2018) (processed)

Figure 3. Portrait of the location of the Bengkayang final processing site

Table 3. MAPE-Based Validation of Test Results

| MAPE value | | Population Sub-Model | | Sub-Model of waste management to GDP of the Waste Management sector | | Environmental Quality Sub-Model | | Public Health Sub-Model | |
|---|---|---|---|---|---|---|---|---|---|
| Value | Criterion | Value | Criterion | Value | Criterion | Value | Criterion | Value | Criterion |
| < 10% | Excellent | 3.75 % | Excellent | - | - | 3.4% | Excellent | 3.62% | Excellent |
| 10%-20% | Good | - | - | 11.47% | Good | - | - | - | - |
| 20%-50% | Enough | - | - | - | - | - | - | - | - |
| >50% | Bad | - | - | - | - | - | - | - | - |

**Model Validation Test**

The validity test determined the level of predictive accuracy by calculating MAPE (Mean Absolute Percentage Error), one of the assessment metrics typically used to measure predictive accuracy in time series analysis, along with the exponential smoothing approach. MAPE calculated the average percentage error between actual and model predicted values. The MAPE is a calculation of the prediction error presented as a percentage of the actual value. The prediction model becomes more accurate as the MAPE value reduces. Verification tests to measure the forecast accuracy using the exponential smoothing approach employed the data not used in establishing a model to test its performance. This method was frequently carried out by splitting the data into two parts, for model training and model validation. The model's capability to predict the previously unidentified test data was then evaluated using metrics, such as MAPE. For the test data with lower rates, the prediction model performed better MAPE value (Table 3).

**Population Subsystem**

The feedback loop of population growth was in the process of expansion, thus requiring the population size, with a tendency to increase year on year (Figure 4). Birth and death rates created a feedback loop, while the population size was determined by birth rate in a region. As the population grew, per-capita income rose, thus potentially increasing the amount of waste generated. Waste generation, as linked to environmental quality, was affected by the number and rate of births. The effect of waste production on environmental quality was reversed, meaning that the uncontrolled waste production will reduce environmental quality. Worse environmental quality led to a higher death rate and poor public health as a result of the pollution-related diseases. The population sub-model was designed to have only one level, which was the number of participants, with the growth being supported by the birth rate as a growth aspect and a decrease in the population due to the mortality rate.

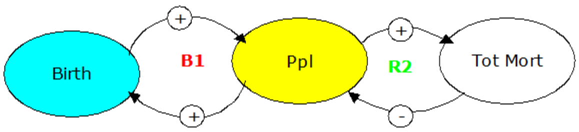


Figure 4. Population subsystem

**Household Waste Management Subsystem**

A steady increase in population led to the changes in structure of the amount of waste generated. Households, traditional markets, workplaces, businesses, public buildings and regions produced waste. The waste production was affected by the waste production rate per capita compared to the total population. The number of people increased, along with the amount of waste produced, with a significant and symmetrical interaction (Figure 5)

The waste management subsystem causally affected waste management (controlled and uncontrolled) at source. An increasing amount of wastes remained unmanaged because of being incinerated, dumped into waterways and rivers and deposited in landfills. This condition can be managed by controlling the source of waste before transporting it to Temporary Disposal Site. Issues that could be addressed included the way to select and sort waste in a polite way. Both biological and inorganic waste fall into this category (Khajevand & Tehrani, 2019). Waste selection and sorting starts at the household level (Ragaert et al., 2017). The waste reduction from this source can have a positive effect in reducing the amount of waste at Temporary Disposal Site. The result is a lower cost for the transportation. On the contrary, if waste at source cannot be managed, it will increase cost and potentially cause environmental damage, which has an impact on public health (Velis

& Mavropoulos, 2016). Stricter laws with a reward and punishment system, as well as the ongoing support and training, could help waste management at source. Government should provide infrastructure and facilities in support of the waste management program. More recycling can create opportunities for new businesses and sectors involved (Schulte et al., 2017). Expanding recycling has the potential to create new jobs and boost regional incomes (Aguilar-Hernandez et al., 2021).

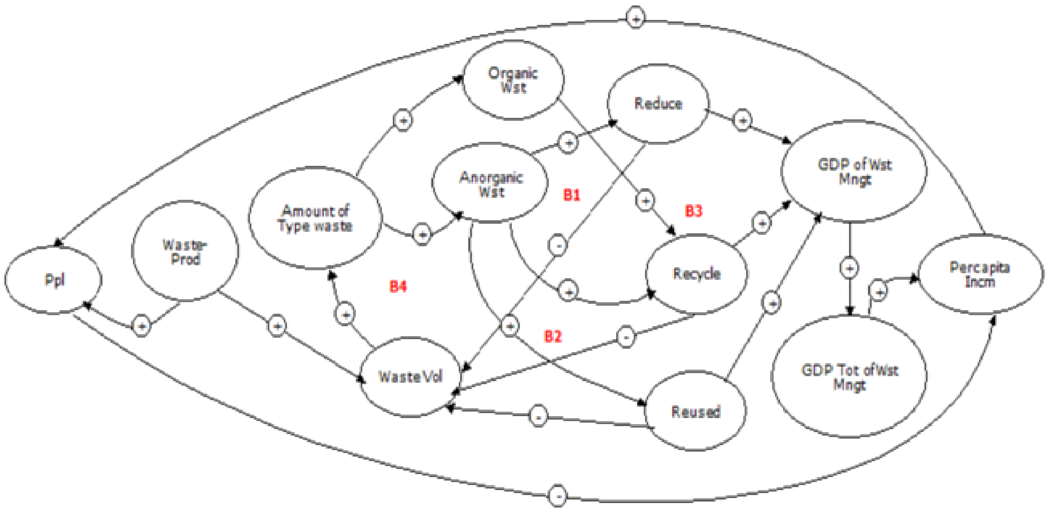


Figure 5. Waste management subsystem

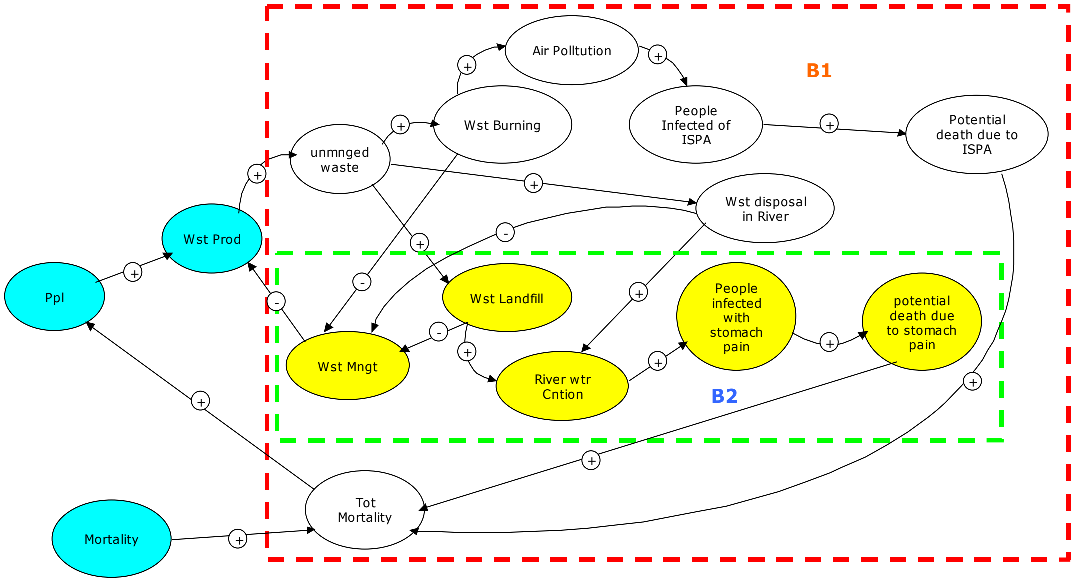


Figure 6. Environmental quality and public health subsystem

Table 4. Scenario Forecasting for Bengkayang Regency's Circular Economy, in 2023-2033

| Year | Household Waste Managed | Population | Water Pollution | Air Pollution | GDPR Sector | Infected Population |
|---|---|---|---|---|---|---|
| | ton | people | mg/l | mg/l | billion rp | people |
| 2023 | 12004.00 | 293101.00 | 48.00 | 51.00 | 6310.00 | 63017.00 |
| 2024 | 14404.80 | 351721.20 | 38.40 | 40.80 | 7572.00 | 50413.60 |
| 2025 | 17285.76 | 422065.44 | 30.72 | 32.64 | 9086.40 | 40330.88 |
| 2026 | 20742.91 | 506478.53 | 24.58 | 26.11 | 10903.68 | 32264.70 |
| 2027 | 24891.49 | 607774.23 | 19.66 | 20.89 | 13084.42 | 25811.76 |
| 2028 | 29869.79 | 729329.08 | 15.73 | 16.71 | 15701.30 | 20649.41 |
| 2029 | 35843.75 | 875194.90 | 12.58 | 13.37 | 18841.56 | 16519.53 |
| 2030 | 43012.50 | 1050233.88 | 10.07 | 10.70 | 22609.87 | 13215.62 |
| 2031 | 51615.00 | 1260280.65 | 8.05 | 8.56 | 27131.85 | 10572.50 |
| 2032 | 61938.00 | 1512336.78 | 6.44 | 6.85 | 32558.21 | 8458.00 |
| 2033 | 74325.60 | 1814804.14 | 5.15 | 5.48 | 39069.86 | 6766.40 |

Source: Badan Pusat Statistik (2018) (processed)

## Environmental Quality and Public Health Subsystem

Inadequate waste management can contribute to an increase in waste production. The environmental pollution was potentially caused by an enormous amount of waste generated in terms of air and water. Inadequate knowledge and local involvement in waste disposal reduced environmental quality (Sethy et al., 2019). By raising public awareness and strengthening legislation on the waste management, it is expected to minimize the waste generation from its sources and resolve the poor environment state (Figure 6).

Table 4 illustrates the prospective outcomes from implementing the circular economy in Bengkayang Regency. It suggests that an increase in population may lead to an expansion in the volume of household waste managed, which could yield advantages such as a reduction in water and air pollution, and possible disease contraction due to waste production

Ineffective waste management led to the reduced environmental value, resulting in the increased water and air pollution from the waste heating, disposal and dumping into stream and river. Air pollution caused by waste incineration potentially increased pollutants, by forming dust and airborne emissions, including CO (carbon monoxide), NO2 (nitrogen dioxide), CH4 (methane gas) and SO2 (sulfur dioxide). Ineffective waste management caused a decrease in environmental value, leading to the increased water and air pollution as a result of waste heating, disposing, and dumping into streams and rivers. Air pollution from waste incineration can increase pollutants in the form of dust and airborne emissions, including CO (carbon monoxide), NO2 (nitrogen dioxide), CH4 (methane gas) and SO2 (sulfur dioxide). Increasing levels of pollutants caused acid rain and greenhouse gas emissions, which can contribute to the global warming (Hosseinabad et al., 2017).

The local community's awareness related to consequences of environmental quality. This issue was related to the level of education attained (formal and informal) (Mamady, 2016); meaning that lower education level was equivalent to less knowledge about the negative health impacts of environmental degradation. Knowledge, attitudes and health awareness can be implemented with a spiritual approach and the ingrained education through collaboration with government as well as educational institutions to be actively involved with the local population and to provide knowledge about the impact of adverse environmental impacts on public health (Mugabi et al., 2018; Pradono & Sulistyowati, 2014).

## Main System with Policy Intervention of 3R

All community members need to practice discipline, consistency and sustainability, as a result of the synergy among understanding, attitudes and actual behavior. The community (pentahelix elements: general public, academia, government, private/ business and media) should cooperate and commit to managing waste in an integrated manner (see Figure 7 and Table 5). The population grew, along with the waste production. The state, as a policy maker, should not only legislate, but also act as a facilitating and supporting system for society, using the New Public Service (NPS) approach to provide more humane and inclusive public services (Klein et al., 2022).

Table 5. Mathematical Equations in Subsystems Model

| Subsystem | Mathematical Equations | Variable Description |
|---|---|---|
| Population subsystem | $PPl = ao + \beta_1 GrPPl_t - \beta_2 DecPPl_t$<br>$\beta_1 GrPPl_t = Brith \times PPl$<br>$\beta_2 DecPPl_t = Moratlity$ | PPl = Populatiom<br>GrPPl = Growth of Population<br>DecPPl = Decrease of Population |
| Waste management subsystem | $HWPr = bo_t + \beta_3 PPl_t + \beta_4 HWs_t - \beta_5 3R_t + \beta_6 GDPs_t$<br>$\beta_1 3R_t = ao + \beta_1 Red_t + \beta_2 Reu_t + + \beta_2 Rec_t$ | HWsPr = Household Waste Production<br>HWs = Household Waste<br>3R = Reduce, Reuse, Recycle<br>GDPs = Gross Domestic Brutto by Sector Waste Management |
| Environmental pollution and public health subsystem | $EnPol = co_t + \beta_7 APl_t + \beta_8 APc_t + \beta_9 WPl_t - \beta_{10} NMor_t + \beta_{11} DtISPA_t + \beta_{12} DtDiarr_t + \beta_{13} Oth_t$. | EnPol = Environmental Pollution<br>API = Air Pollution Load<br>APc =Air Pollution Control<br>WPl = Water Pollution Load<br>NMor = Natural Mortality<br>DtISPA = Death from ISPA<br>DtDiarr = death from Diarrhoe<br>Oth = Other Cases |

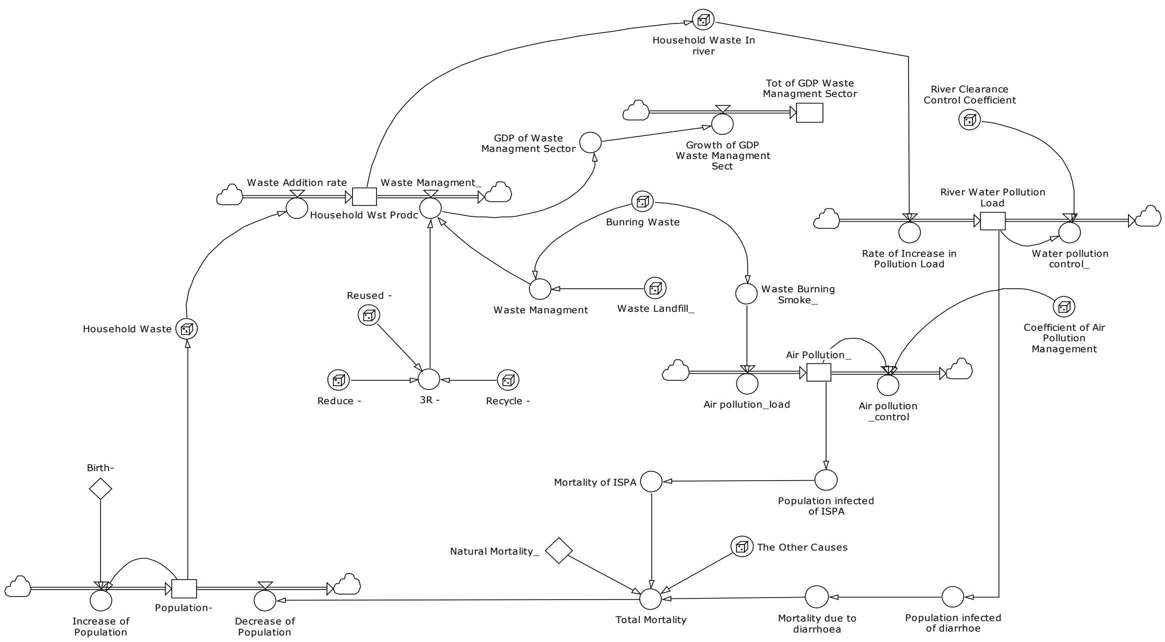


Figure 7. Circular economy main model

NPS is the revolutionary way of delivering public services, making them more effective and productive. Implementation of the NPS concept by involving the community in waste management can be achieved through the establishment of waste bank programs; recycling and composting programs; technological innovations, such as the smart sensors and artificial intelligence for monitoring waste generation and waste segregation/selection (Abbasi & Hanandeh, 2016), automatic waste collection system using the machine learning to identify waste by its type (Goyal et al., 2021), Android-based applications for reporting waste collection sites (Jie et al., 2021); partnerships between local governments and the private sector to improve infrastructure and innovative recycling schemes; landfill charges, recycling incentives and volume-based charging schemes for waste management; green curricula in all schools and training in waste management; and decentralization of waste management through the empowerment of local communities to manage their own waste, such as the development of community waste management systems and the empowerment of local groups to manage recycling and compost schemes (Yuliana et al., 2024).

### Research Implication

The waste management in Bengkayang City has not been optimal, in which the waste in the Final Disposal Site is left unattended, organic and inorganic wastes are still mixed, the data on waste generation is not available, an access to the Final Disposal Site is still very poor. The waste processing industry is not yet available, facilities and infrastructure are still minimal. The community participation is important in waste management and the continued support to change a paradigm regarding the use of waste to be productive in reducing its negative impacts (Kristianto, 2020a). If the amount of waste continues to increase and is not properly managed, it will have a negative impact on the environment quality and public health. Local authorities must take precautionary measures to prevent the negative external effects in the form of waste and to provide knowledge, assistance and socialization related to the concept of reduce, reuse and recycle (Bassi et al., 2021).

The implementation of a circular economy in Bengkayang City necessitates the involvement of a multitude of stakeholders (local government, general public, entrepreneurs, environmental activities and academics) to ensure an enhanced regional sustainable development process. A high amount of the unmanaged waste is due to a lack of awareness among the public regarding the correct methods of waste management. It is therefore necessary to implement a reward and punishment system for residents who demonstrate their capability to manage the household waste properly. In addition, the approaches based on customary law (local wisdom) and formal law may be required to address the behavior of those who continue to litter (Elamin et al., 2018). It is crucial to implement the comprehensive initiatives that encourage the community involvement and responsibility regarding the household waste. It requires continuous guidance and training on the direct activities, such as composting, utilizing fruit and vegetable waste as an eco-enzyme for use or trade, and creating biopores in each household to compost and absorb rainwater (Akcil, 2016).

It is imperative to be carried out, as inadequate waste management will undoubtedly have an adverse effect on the environment quality in terms of water, soil, and air. The societal benefit is that in a context of the newly introduced pricing structures, scarce resources, such as clean water and air, will be valued higher than cost of the increased payments for public services. Furthermore, this will apply to private goods where the costs for internalizing externalities exceed the costs themselves. While the long-term benefits seem promising, the immediate impact may result in a reduction of actual income (Dercon, 2014). The role of community engagement in curbing the disposal of waste to Temporary Disposal Site and achieving the objective of zero waste in Final Disposal Site is crucial and needs attention. This is particularly pertinent when considering the subject matters across the educational spectrum, encompassing from elementary school to higher education.

The necessity for the uninterrupted collaboration in providing support and training to the community with regard to proper waste management and the socialization about the environmental consequences from the inadequate waste management practices persists (Evans et al., 2017). The cooperation pertains to the utilization of household waste (organic and inorganic) in the creation of new products with useful and economic value. The SBM (Sustainable Business Model) concept, a business model focused on social and environmental aspects, can be developed within the MSMEs (micro, small and medium-sized enterprises) segment through the repurchase of production waste from their consumers (Hysa et al., 2020). Assistance and training are provided for small and medium-sized enterprises (SMEs) to allow them to produce the environmentally friendly products by minimizing the use of materials detrimental to the environment and human health and by implementing green production processes. In the household product segment, it demands product designs that can be continually optimized in terms of energy and cost efficiency, and incorporate new models (Ranta et al., 2021).

It is proposed that a waste bank is established in each of the city's rural settlements as a unit waste bank. Additionally, the Final Disposal Site will serve as the coordinating hub for these unit waste banks in Bengkayang City. This waste bank was established for the purpose of facilitating the sale and purchase of products derived from waste materials among the local community. These include organic liquid fertilizer, hand sanitizers, eco bricks, handicrafts and other useful items produced from waste materials within the community. The products can be exchanged by the community with producers by buying back the consumer's waste. From this extended product life-cycle system, both financial and customer loyalty can be preserved and made attractive, as producers obtain inexpensive resources from customers while customers earn supplementary income from the sale of the used products to consumers (Lacy & Rutqvist, 2015). The practice of open dumping is prohibited for the community to dispose of waste at the landfill, in order to maintain the quality of local landfill site (Popli et al., 2017).

It is evident that there is a necessity for the development of digital technology in conjunction with an environmentally friendly recycling processing technology, with the aim of facilitating a sustainable approach to waste management (Gupta, 2017). With the implementation of suitable technology, the recycling is merely one aspect of a larger regenerative process that can enhance the regional construction sector, while continuing to engage a diverse array of stakeholders. Digital technologies assume a crucial position in the transition to a circular economy by optimizing forward material flows and enabling reverse material flows. In this sense, circular economy models follow a trajectory analogous to that observed in product service systems, with the shared objective of managing waste within a societal context (Pagoropoulos et al., 2017).

High business opportunities should be accompanied by a streamlined bureaucratic process that can enhance the green investment climate. Efficient bureaucracy aims to facilitate the investment process for those interested in environmentally friendly businesses. However, it is important to note that the government maintains control over business activities, conducting Environmental Impact Analysis and certification for the eligible investors. The appropriate implementation of corporate social responsibility (CSR) policies benefits society and environment. Those responsible for formulating policy must play a significant role in implementing this approach (Babader et al., 2016). They should, for example, eliminate superfluous and problematic plastic items throughout the economy, encourage innovation, develop effective collection systems for recycling, ensure stable and recurrent funding is in place, and provide incentives for the increased use of recycled materials. It is imperative that such policy initiatives and leadership are provided in order to facilitate the transition scaling across all sectors. Policymakers can exploit opportunities to assist the green industry investors in establishing novel value creation mechanisms and demanding system reorganization. The issue of waste generation has been exacerbated by the rise in per capita income within the community, coupled with an influx of population in Bengkayang. Consequently, the quantity of waste generated on a per capita basis also increases, thus necessitating the improvements in infrastructure, facilities, and transport (MacArthur, 2021).

Research on the circular economy's effect on environmental degradation and public health from a socioeconomic standpoint demonstrates that the circular economic concept implementation can have a substantial positive impact. By reducing waste and enhancing resource efficiency, the circular economy helps to reduce the greenhouse gas emissions and other pollutants, while improving air and water quality. This directly benefits public health by lowering the prevalence of pollution-related disorders, including asthma and cardiovascular diseases. Furthermore, from a socioeconomic standpoint, the circular economy implementation may provide new employment possibilities in the recycling and refurbishing industries, while improving community economic well-being through more sustainable resource usage and the lowered prices. It also promotes innovation and development of the green technology, thus increasing economic and social resilience in facing the possible future environmental crises.

## CONCLUSION AND SUGGESTION

This research is able to identify a number of variables in order to construct a comprehensive model of domestic reuse in the Bengkayang area. The analysis, conducted using the System Dynamics method, has led to the formulation of various policy scenarios.

Population sub-model indicates a correlation between population growth in Bengkayang district and an accompanying increase in the quantity of waste generated by the local community, particularly in the form of residential waste. The relevance between population growth and waste generation is unidirectional, or reinforcing. The lack of awareness among the local population regarding environmental issues has the potential to result in the increased environmental pollution. A recommended policy strategy is the implementation of educational initiatives in the forms of assistance and training utilizing the participatory learning action method on a continuous basis. These should be conducted until the community is capable of managing its household waste independently. To achieve this, it is vital for key stakeholders, including academics, environmental activists, business owners and members of the media, to engage in the constructive dialogue and to collaborate on raising people's awareness on the household waste management.

The sub-model of waste management within the conceptual framework of the circular economy is concerned with the conversion of waste materials into new products with an enhanced value. If waste management is implemented consistently, the concept of a circular economy will function optimally and 3R activities will continue to increase within the community. The circular economy offers a comprehensive perspective that incorporates the fundamental 3R (reduce, reuse, recycle) principle as a means for mitigating the unmanaged waste. This is achieved through fundamental activities, such as waste selection and sorting, as well as the separation of organic and inorganic waste. One potential strategy for implementing the 3R is the establishment of a waste bank. This would involve the exchange of waste for monetary rewards. A composting program for organic waste management can be implemented by providing assistance to the community with regard to the production of organic fertilizer. MSME sector (micro, small and medium enterprises) in particular, works in collaboration with local governments and the recycling entrepreneurs outside the region with the objective of fostering community engagement through the sale of superior products. The circular economy concept has the potential to contribute to regional economic growth by facilitating the development of new business opportunities for the MSME sector based on recycling, and by increasing job creation through the implementation of an appropriate policy.

This sub-model of environmental pollution and public health elucidates the potential hazards posed by the improper management of household waste. The variables in this sub-model are interdependent and exhibit a balancing relationship. An increase in environmental pollution resulting from a lack of public awareness regarding household waste management will lead to a deterioration in health quality within the community. Adoption of the 3R waste management model has the potential to diminish contamination of water resources by reducing the amount of waste produced. The prevention of water contamination can reduce the risk of waterborne diseases and enhance overall public health by improving the quality of water supply. A strategy of waste management based on the concept of a circular economy may result in the reduced waste production and more efficient and safer waste management. Such a strategy may also prevent the accumulation of waste that could potentially lead to the transmission of disease.

A socio-economic analysis on the literature about the circular economy effects towards environmental degradation and public health shows that its adoption can result in significant beneficial consequences. The circular economy's emphasis on waste reduction and resource optimization can reduce environmental pollution, resulting in better air, water and soil quality. This, in turn, has the potential to reduce health hazards associated with exposure to pollution, such as respiratory diseases and other problems. From a socio-economic standpoint, a circular economy establishment can be translated into new job opportunities in resource recycling and recovery, as well as promote industrial innovation and sustainability. In addition, the improvement of environmental quality and public health means better productivity and quality of life, resulting in more equitable and sustainable economic growth.

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