ANALYSIS OF CIRCULAR ECONOMIC SYSTEM USING THE CAUSAL LOOP DIAGRAM MODEL IN WEST SUMATRA

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Abstract

Circular economy is an economic concept that implements sustainable development goals as well as a solution to the problem of waste produced by society, with the aim of creating new products from waste resources that are useful and have economic value. The aim of this research is to analyze the implementation of a circular economy using the Causal Loop Diagram model. The research method used is a qualitative and quantitative method with a causal loop diagram approach. The data analysis technique is to use quantitative and qualitative analysis through distributing questionnaires and interviews with informants. The results of this research are that a circular economy is influenced by population size which is able to increase waste generation which has an impact on various sectors such as environmental quality so that collaborative action is needed between stakeholders such as the general public, local government, entrepreneurs and environmental activists in implementing a circular economic system in the province West Sumatra in order to increase community participation to implement a circular economic system and indirectly support the achievement of development goals.

Keywords: Circular Economy; Causal Loop Diagrams; Sustainable Development

A. Introduction

West Sumatera is a located on the west coast of the central part of the island of Sumatera, consisting of lowlands on the west coast and volcanic plateaus formed by the Bukit Barisan. The like other areas in Indonesia, the climate of West Sumatera is generally tropical with fairly high air temperatures and is also one of the provinces crossed by the Equator. This Sumatera Barat has a population of 5,750,326 people spread across 12 regencies and 7 cities (Indonesia, 2018). Based on data obtained, (Badan Pusat Statistik Provinsi Sumatera Barat, 2021) it was found that farming and raising livestock are one of the most widely supported jobs by the people of West Sumatra. When viewed from the economic system implemented, West Sumatra uses a linear model economic system by maximizing results and profits but ignoring the long term by using the "take-use-dispose" and ultimately piling up garbage and damaging the environment. (Fadhillah, M. H., & Fahreza, 2023) stated that the circular economy is an effort to reduce waste and improve the environment.

Based on the performance report of the West Sumatra environmental service, waste generation in West Sumatra is as follows:

Table 1: Waste Generation above 50 Tons/Year

No	Regency/City	Information
1.	Pesisir selatan	56.558,72
2.	Solok Regency	58.083,03
3.	Sijunjung	36.471,20
4.	Tanah Datar	47.382,56
5.	Agam	80.163,78
6.	Lima puluh kota	56. 964,67
7.	Pasaman	44.884,05
8.	Dharmasraya	38.458,75
9.	Solok Selatan	27.542,75
10.	Pasaman barat	63.876,75
11.	Padang pariaman	79.593,54
12.	Mentawai Islands	13.902,75
13.	Padang	236.296,62
14.	Solok city	20.1999.06
15.	Sawahlunto	6.925,99
16.	Padang Panjang	17.986,62
17.	Bukittinggi	46.607,36
18.	Payakumbuh	34.041,59
19.	Pariaman	14.408,74
Amount		980.348,53

Source: West Sumatra Province Environmental Service Performance Report, 2023

Based on table 1 above, it can be seen that waste generation is a serious problem and needs to be handled. Waste that is not managed properly will hinder the achievement of a circular economy and this also identifies that the implementation of a circular economy to achieve sustainable development is still difficult to achieve. With the increasing number of community production and consumption, it will increase waste production in West Sumatra. (Torado, M.P., & Stephen, 2016) states that the Sustainable Development Goals (SDGs) are to increase income

and community welfare in order to Reduce poverty and inequality while always paying attention to the environment so that sustainable cities and settlements are created.

Based on table 1, above the circular economy is an important topic to discuss in order to achieve sustainable development goals. Additional waste continues to increase along with the growth of the human population. In general, this waste comes from the general public, UMKM food and beverage products; fisheries and agriculture. (Darmastuti, S, Cahyani, I.P., Afrimadona, A. & Syarif, 2021), (Nakamura & Kondo, 2018) the Circular Economy approach is integrated with the waste input-output processing process. Both natural and artificial waste piling up in various landsfills across so that a major problem. Improper waste management can pollution and environmental damage and can even pose a threat to human health. (Swarr et al., 2011), (Ghisellini, P., Cialani, C., Ulgiati, 2016), (Li, 2012). stated that through a circular economy it is able to create a balance between the environment and the economy and will directly have an impact on sustainable development.

Based on this, by conducting research related to the analysis of the circular economy based on the green economy to achieve environmentally friendly development goals. However, seen from the reality of the field, society tends to implement a linear economy for various reasons. Therefore, based on the reality and problems that occur, researchers are interested in conducting research related to the circular economy system the with title of the research presented is "Analysis of Circular Economic System Using the Causal Loop Diagram Model in West Sumatra".

B. Literature Review and Hypothesis Development

Understanding Circular Economy

A circular economy is often described as an economic system that combines the reduction, reuse and recycling of activities that require systemic change whose primary goal is to increase the economic and environmental value of future generations. According to (Julian Kirchherr, Denise Reike, 2017), (Chengkang Gao , Chengbo Gao , Kaihui Song, 2020), (Bassi et al., 2021) A circular economy is most frequently depicted as a combination of reduce, reuse and recycle activities. Furthermore (Belmonte-Uren˜a, L.J., Plaza-Úbeda, J.A., Vazquez-Brust, D., Yakovleva, 2021), (European Commission, 2018) argue that the use of renewable energy has a strong impact on economic growth. Therefore, with product innovation in business, this will have a positive impact on the economy and the environment. (Kasztelan, 2017) (Swarr et al., 2011),

(Rizos et al., 2017) argued that the productivity of resources and the recycling rate have a direct and significant impact on economic growth.

(Julian Kirchherr, Denise Reike, 2017) proposed to organize the economy as a circular system to ensure a sustainable development. This is in line with (Walters et al., 2016), (Lewandowski, 2016), (D'Amato et al., 2017) the environmental conservation benefits both the economy and the society. This new economic model has been developed to defeat the traditional model based on the principle"take, make and dispose. (Lewandowski, 2016) in particular of circular economy business and consumption models implying the selling of a service (instead of a product) or its leasing, refurbishment and remanufacturing. (D'Amato et al., 2017), (Nakamura & Kondo, 2018), (EEA, 2017), (Rizos et al., 2017) explains that circular economy also requires producers and consumers to becom more active participants in the recycling or reuse of products, forgetting about the passive"throwaway" culture of the linear economy. Based on the opinions and theories of these experts Circular Economy could help the transition to a degrowth path, that is less resource use with increasing wellbeing.

Circular Economy, Green Economy and Sustainable Development

One of the expected outcomes of a circular economy is essentially the existence of means to realiza new aspirations and hopes for economic management, and in particular to overcome the failures of liberal economies. According to (Sinha, 2022) that the existence of a circular economy is a step forward in the jouney of sustainable development, because it seeks to create an economic model that sepparates the use of resources from natural resources by reusing waste products of consumption and production as new input variables in the economy. The refore a circular economy can provide solutions, especially to overcome the environmental impact of production systems. With of a circular economy then not only to transform and increase productivity, but also to make the production system truly environmentally friendly and sustainable (Seppala, 2018), (Korhonen et al., 2018), (Thuy Ngoc & Tu Anh, 2016) Green economy is an economic concept that aims to improve the welfare and social equality of society, while reducing the risk of environmental damage. This is in line with the circular economy which strives for a circular economy is an economic system designed to dispose of waste, use everything effectively and efficiently by paying attention to environmental aspects.(Thuy Ngoc & Tu Anh, 2016), (Rizos et al., 2017). Based on this, by carrying out a circular economy analysis based on green economy, it can have a positive influence on sustainable development, especially in dealing with problems related to socio-economic and environmental issues (Thuy Ngoc & Tu Anh, 2016)

stated that there are three global issues that pose a threat to achieving sustainable development goals, including poverty, air pollution and biodiversity which are the three main pillars of sustainable development that have become a problem (Kasztelan, 2017), (Belmonte-Uren˜a, L.J., Plaza-Úbeda, J.A., Vazquez-Brust, D., Yakovleva, 2021).

Causal Loop Diagram

A causal loop diagram (CLD) is a visual tool that shows how variables in a system are related through cause and effect. CLDs are made up of arrows and words, and they are often accompanied by a narrative that describes the situation being depicted. CLDs are used in system dynamics to model the causal relationships between system components. They can help identify feedback loops, which are important because they can indicate non-obvious virtuous or vicious circles. Feedback loops can be reinforcing (vicious cycles) or balancing (goal-seeking). Complex interactions between loops can lead to unintended consequences.

Causal Loop Diagram (CLD) is a diagram that describes the cause and effect relationships of several interrelated elements in a system. There are two elements in CLD, namely variable elements (factors) which are conditions, actions, situations or decisions that influence each other in quantitative (measurable) and qualitative form and arrow elements (links) which are forming elements in a system (Bassi et al., 2021), (Lewandowski, 2016). The causal relationship between these variables shows two possibilities, namely: the possibility of the relationship moving in the same direction (+/ R = Reinforcing) or moving in the opposite direction (-/B = Balancing).

C. Research Method

This research uses a qualitative method of system dynamics with the tool used in the form of a Causal Loop Diagram. The research was conducted using the qualitative System Dynamics method with a Causal Loop Diagram approach. The source of data collected consists of mental data (observation experience) carried out by in-depth interviews and documentation. The data analysis technique was carried out using the triangulation method, namely interviews, observation and documentation. The object selection technique is carried out by researchers being directly involved and identifying information from four community groups, namely; farmers, fisheries, MSMEs and the general public or households. Documentation is carried out by taking several pieces of documentation. Next, the research team jointly carried out an analysis

of the circular economic system by creating a model based on a literature review and in accordance with conditions occurring in the field. The stages carried out are as follows:

1) Determine causal variables to construct a Causal Loop Diagram with the help of VENSIM software.
2) Determine the relationship (link/arrow) between variables and the polarity sign of the relationship which consists of a positive sign (+) or negative sign (-). [10] suggests that there are two polarities of relationship between variables, namely (a) positive polarity occurs when the cause variable increases then the effect variable also increases or when the cause variable decreases then the effect variable also decreases; and (b) negative polarity occurs if the cause variable increases then the effect variable will decrease or when the cause variable decreases then the effect variable increases.
3) Carry out loop polarity, consisting of two forms, namely:
   a) Positive loop polarity occurs when changes in the entire system reinforce the original change with the symbol R (Reinforcing).
   b) Negative loop polarity occurs when changes in the entire system reduce the original change with the symbol B (Balancing)

D. Discussion

Circular economy is a concept applied to reduce and reuse waste into useful and economically valuable products. This concept can also provide recycling-based business opportunities which can ultimately increase job opportunities, investment, economic growth, reduce poverty and increase regional income. The results of data analysis using the Causal Loop Diagram method in this research are as follows:

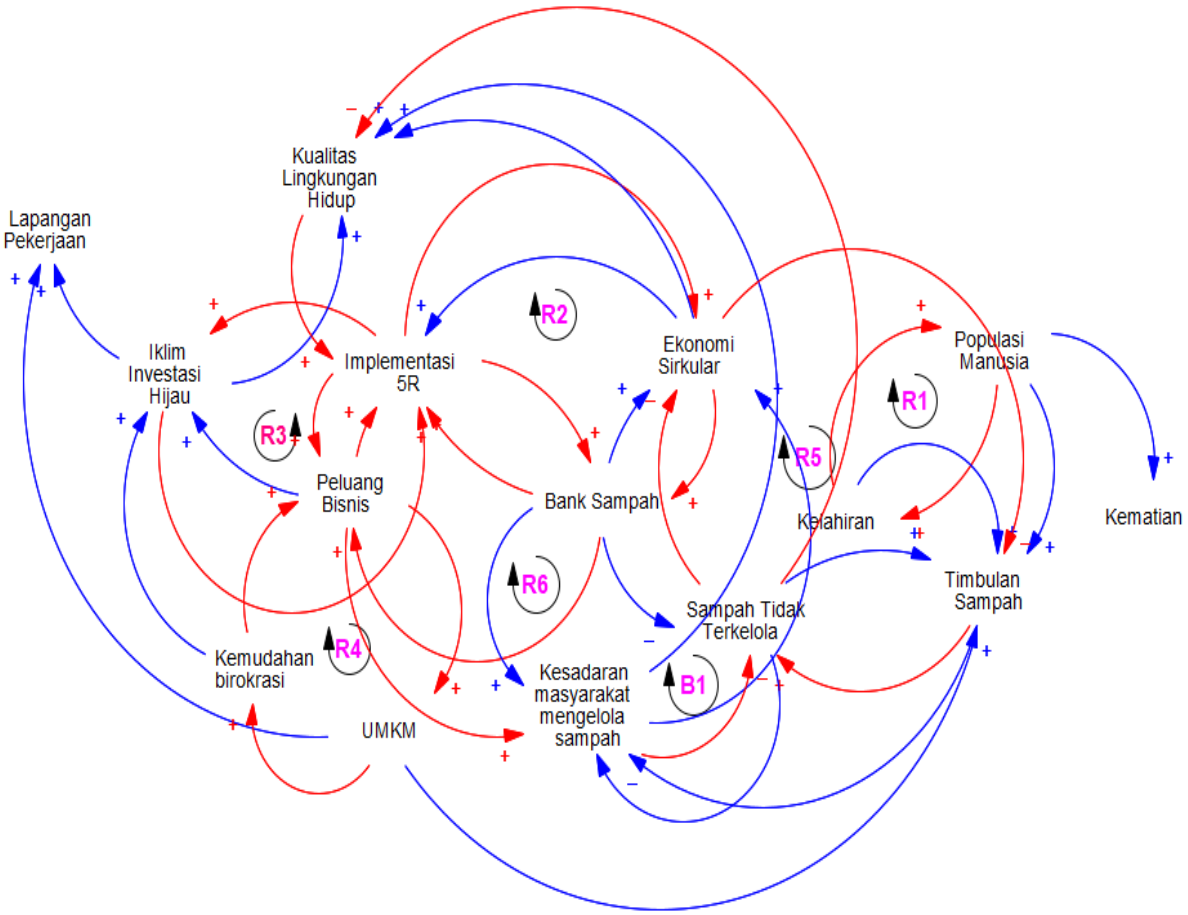

Figure 1: Analysis method using Causal Loop Diagram

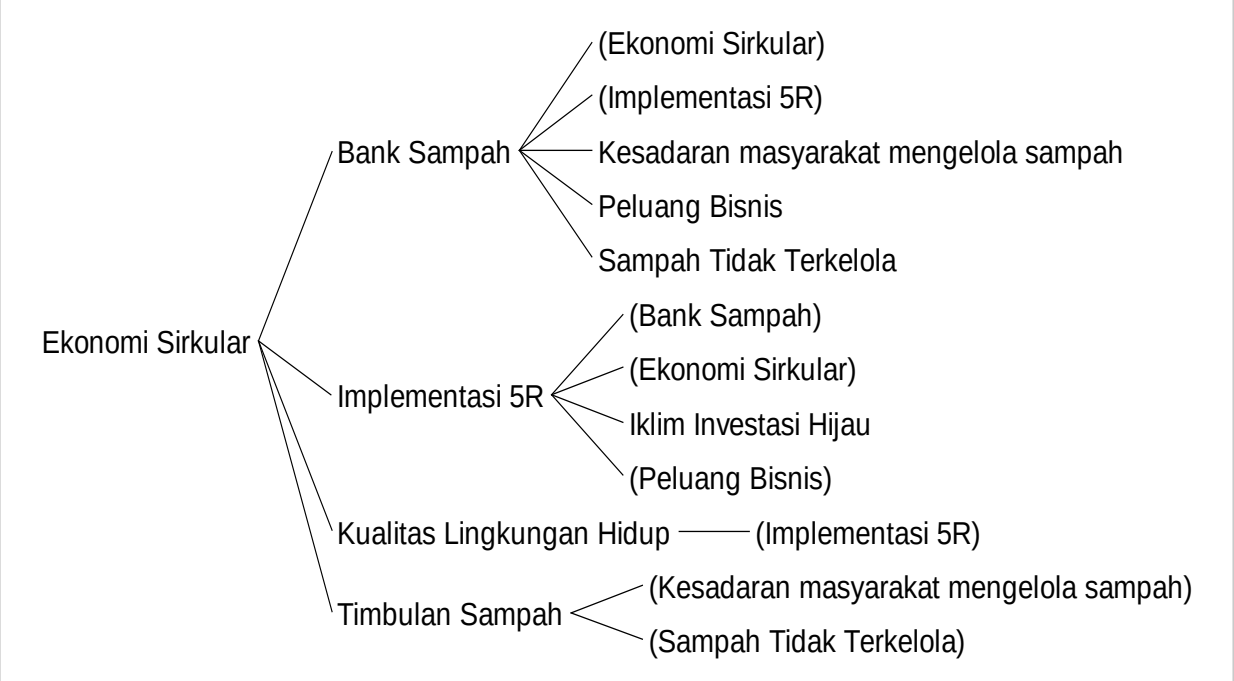

Figure 2: Causal Lopp Diagram graph

Based on the Causal Loop Diagram method that has been carried out, the results show that the circular economy influences various aspects and then influences other aspects and forms a circle, either in the form of positive loop polarity (Reinforcing) or in the form of negative loop polarity (Balancing). This can be seen in the Causal Loop Diagram itself, which is as follows:

1) In CLD R1 and R5 it is explained that population influences births and births influence population, when population increases, waste generation also increases. And when unmanaged waste increases, the achievement of a circular economic system will decrease and when the circular economy decreases, waste generation will increase. Therefore, using the Causal Loop Diagram method requires policy or bureaucracy from the government in waste management and public awareness in managing waste.
2) In CLD R2, it is explained that in realizing a clean province that supports a circular economy, the government has established a waste bank through the West Sumatra Provincial Environmental Service. Increasing waste banks managed by the government and waste management carried out by the community and business actors will have a positive impact on the implementation of 5R (Reduce, Reuse, Recycle, Refurbish and Renew) and will then have a positive impact on achieving a circular economy. Therefore, by using the Causal Loop Diagram method, government policies in waste management are able to maintain environmental quality and again influence the implementation of 5R (Reduce, Reuse, Recycle, Refurbish and Renew) and again support the concept of a circular economy.
3) In CLD R3, it is explained that the increasing implementation of 5R 5R (Reduce, Reuse, Recycle, Refurbish and Renew) will improve the green investment climate through product recycling and new innovations for unused waste and will further open up new business opportunities which will ultimately again increasing the implementation of 5R. And when 5R implementation increases, the waste bank will increase along with increased business opportunities and ultimately return to increasing 5R implementation as explained in CLD R6
4) In CLD R4, it is explained that business opportunities have increased, one of which is due to the implementation of 5R. and when these business opportunities increase, MSMEs also increase and with the ease of bureaucracy provided by the government, this will have an impact on the development of MSMEs and this will come back to influence business opportunities.
5) In CLD B1, it is explained that when public awareness of managing waste decreases, unmanaged waste will increase and ha; This causes a decrease in the quality of the environment. And this will affect the optimal implementation of 5R, business opportunities

and then return to public awareness in managing waste. Based on the CLD 4 pattern, it can be seen that public and business awareness in managing waste is very important in realizing a circular economy based on a green economy.

Based on the picture above, the circular economy concept needs to be improved by overcoming problems from waste sources. The government, through various policies, has made efforts to manage waste to create a clean environment. However, based on field facts, the results show that waste is not only related to the investment climate and bureaucracy, such as waste bank facilities provided by the government, but is more a matter of morals and community behavior as described in CLD B1, which forms a negative polarity circle where public awareness is still lacking. in managing waste will reduce the government's success in realizing a Circular Economy. One thing that can be done by the general public and business actors or the business world is to implement efficient consumption and production patterns of resources as well as innovative recycling of products or goods so that waste does not accumulate which can hinder the achievement of a circular economic system.

E. Conclusion

Based on the research results, it can be concluded that births will affect the human population and subsequently increase the generation of waste, environmental quality and the implementation of 5R (Reduce, Reuse, Recycle, Refurbish and Renew). Therefore, so that the circular economy in West Sumatra province can be implemented optimally, government policies or bureaucracy are needed in waste management and public awareness in managing waste. If waste is not managed well, this will cause a decline in the quality of the environment and have an impact on people's health so that they can achieve sustainable development goals.

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