

Factors Influencing Environmental Sustainability in the Dairy Agro-Industry in Indonesia

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Abstract. The phenomenon of Sustainable Development Goals (SDGs) initiated by the United Nations (UN) has become a global concern today. This is because in recent years, we have faced three crucial environmental crises, namely the climate crisis, the biodiversity and nature crisis, and the pollution and waste crisis. Why are these crises happening? These crises occur because of production and consumption patterns that are managed unsustainably, such as the overexploitation of the earth's resources. This has adverse impacts on the environment, climate change, damage to ecosystems, and increasing levels of pollution. To achieve environmental sustainability through improved consumption and production patterns, specialized strategies are needed that focus on raising awareness of material and energy use, recycling, waste management, nature conservation, and renewable energy. Sustainability issues in the environmental sector caused by unsustainable production and consumption patterns can also occur in the food and beverage industry. With the background mentioned above, this study aims to determine the factors that influence environmental sustainability in the dairy agro-industry in Indonesia. The analytical method used in this study is the MICMAC (Matrice d'impacts croisés-multiplication appliquée) method developed by the LIPSOR Prospective Strategic and Organizational Research Laboratory (foresight).

1 Introduction

Three important environmental issues the climate crisis, the biodiversity and nature crisis, and the pollution and waste crisis are currently of worldwide concern. This is due to the excessive use of the earth's resources, climate change, destruction of nature, and increasing levels of pollution and waste. To anticipate these problems, in 2015, the United Nations rolled out the Sustainable Development Goals (SDG) program. The Sustainable Development Goals (SDG) represent a global commitment to achieve better sustainable development. Every country, including Indonesia, has the responsibility to achieve the *Sustainable Development Goals* (SDG). By always considering sustainability aspects in every decision and action, we can build a better and more sustainable future for generations to come. The Sustainable Development Goals (SDGs) stem from the realization that natural resources are believed to be depleting. Therefore, we must use the environment more responsibly.

Goal 12 of the Sustainable Development Goals (SDG), Responsible Consumption and Production, is about ensuring sustainable consumption and production patterns, which are key to sustaining the livelihoods of current and future generations.

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Our planet is running out of resources due to a growing population. If the global population reaches 9.8 billion by 2050, the equivalent of almost three planets will be required to provide the natural resources needed to maintain current lifestyles. Therefore, we need to change our consumption habits and shift our energy supply to more sustainable sources. Sustainable consumption and production consider the entire life cycle of economic activities, from the extraction of resources and processing them into materials and products to the use of products and finally their disposal as waste or emissions. As such, sustainable consumption and production helps identify and develop solutions to improve the use of natural resources that can achieve multiple sustainability goals simultaneously, or the gains that occur when economic, social, and environmental aspects are addressed together.

Recent economic and social progress has had a degrading effect on the environment, jeopardizing the systems on which our future development and survival depend. This is a wake-up call for why we need to change our consumption patterns. Some ways to change consumption and production patterns include designing products to be durable, repairable, and recyclable. This also involves promoting practices such as reusing, repairing, and recycling products to minimize waste and resource depletion. We need to adopt a more sustainable lifestyle in which we can reduce consumption, choose products with a lower environmental impact, and reduce the carbon footprint of our daily activities [1].

The increase in human consumption and production has had a negative impact on environmental sustainability. Efforts to achieve sustainable consumption and production patterns need to align with the Sustainable Development Goals (SDGs), especially the 12th goal, which is to ensure sustainable consumption and production patterns [2]. Given the negative impact of consumption and production patterns on environmental sustainability, the purpose of this study is to examine the factors that influence sustainability in the environmental field of the dairy agro-industry in Indonesia. This research is necessary because the contribution of food waste and carbon footprint, which are indicators of consumption and production patterns in dairy commodities, is still high at around 8%. The following presents the contribution of each commodity to the carbon footprint and food waste [3].

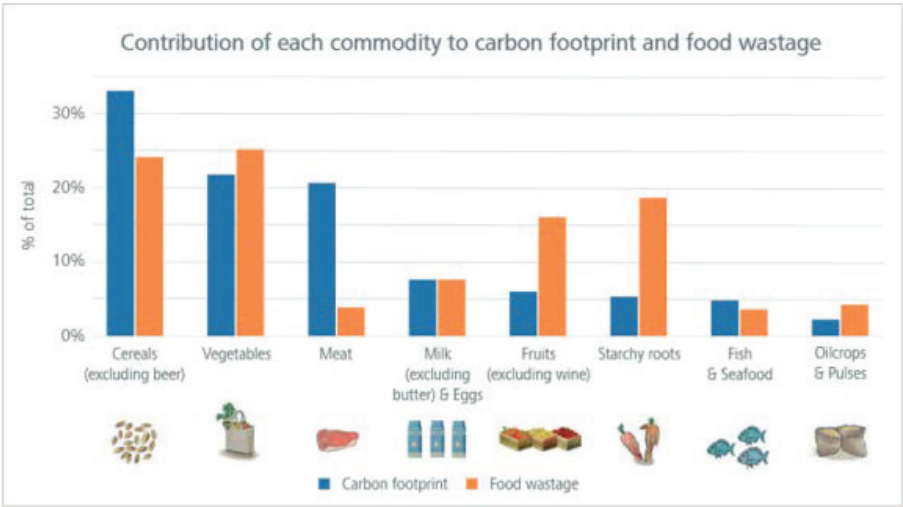


Fig. 1. Contribution of each commodity to carbon footprint and food waste

In the figure above, we can see the percentage of food wastage and the carbon footprint of some commodities. The carbon footprint is an efficient way to communicate issues related to climate change and the need to change consumption and production behavior. Reducing

the carbon footprint of the entire food supply chain makes the process environmentally friendly and therefore linked to environmental sustainability. Current food waste disposal systems, which focus on economic and environmental viability, need to try to use food waste as a resource input for agriculture. An effective and advanced waste management system needs to be created and adopted to handle massive waste production and to bridge the gap between production and waste disposal management[4].

2 Materials and Methods

To analyze the factors influencing environmental sustainability, the author used the MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée) analysis method. This method was developed by the LIPSOR Strategic and Organizational Research Laboratory Prospective (foresight). This method was used in this study to identify strategic variables and to analyze the influence and dependency between variables influencing environmental sustainability in the dairy agro-industry in Indonesia. This method has the advantage of being able to investigate several variables simultaneously, but it cannot provide an overall priority score for each variable [5].

The research methodology aimed to measure the influence and dependence of factors influencing environmental sustainability using the MICMAC method as follows ([6];[7]):

1. Listing the Elements: The first stage of the MICMAC assessment is to list the elements that characterize the model being developed, as well as the climate in which it operates.
2. Describing the Relationship between Elements: In a systemic approach, an element exists because of its relationship with other elements. The linkages between elements are captured, organized, and prepared for analysis to show the relationships between these variables in a double-entry table, known as a 'Dependency/Influence Matrix' (MDI), with each cell of the MDI matrix (i, j), where 'i' refers to the row position and 'j' refers to the column position.
3. Identifying Key Elements: Key elements important for model development were identified using direct classification in the MDI.

In the MICMAC method, variables are grouped into four quadrants based on dependence and influence categories, as shown in Fig 2.

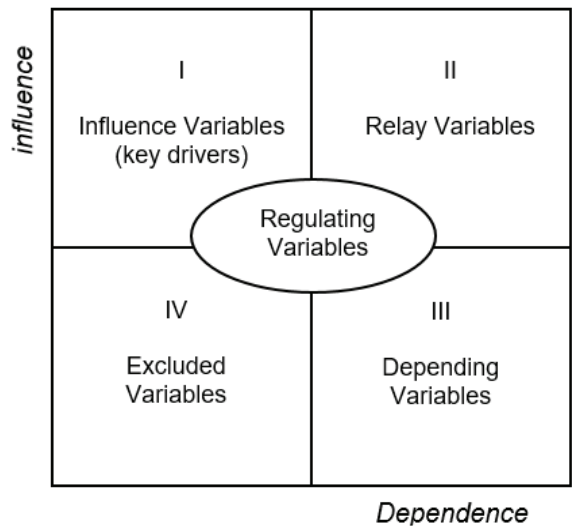


Fig 2. Influence and Dependency Quadrant

In **Fig 2**, the influence variable, or what is often called the "decisive variable," depicts a highly influential variable with little dependency. This variable is a crucial element in the system because it acts as a key factor. In quadrant II, there are relay variables, which are influential but highly dependent. These variables are often categorized as factors that illustrate the instability of a system. Any changes that occur in these variables have serious consequences on other variables. In quadrant III lies the dependent variable, or outcome variable. This variable is characterized by high dependency but little influence. This variable is quite sensitive to changes in influence variables and relay variables. Quadrant IV describes the excluded variable, or what is often known as the autonomous variable. This variable is characterized by small influence and small dependency. This variable is said to be excluded because it will not stop the work of a system or take advantage of the system itself [8].

3 Results and Discussion

Factors that influence environmental sustainability as follows:

Table 1. Environmental Sustainability Factors

No.	Factors	No.	Factors
1.	Energy efficiency	5.	Safety heath and environment
2.	Waste reduction	6.	Quality management
3.	Renewable energy	7.	Biodiversity
4.	Green transportation	8.	Water efficiency

Source: [9], [10]

The output of the MICMAC method is strongly influenced by the accuracy in identifying factors that influence environmental sustainability in the dairy agro-industry in Indonesia. The strategic factors or variables in the initial process are then input into the Direct Influence Matrix (MDI) to see the intensity of the direct influence and indirect influence of each variable on other variables.

The data in the MICMAC method is entered into the MDI with values ranging from 0-3 (the level of influence from low to high), denoted as 0: *No influence*; 1: *Weak*; 2: *Moderate influence*; 3: *Strong influence*. As shown in **Table 2**.

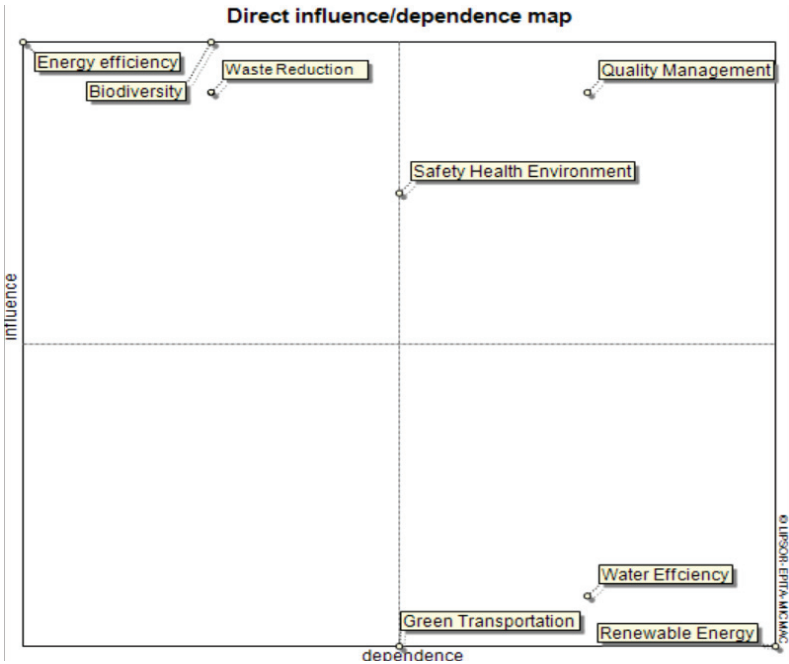
Filling in the MDI matrix in the MICMAC method determines the position of variables on the Influence and Dependence quadrant map, which is divided into four quadrants based on the categories of influence and dependence: influence variables, relay variables, dependent variables, and excluded variables, as shown in **Fig 2**. The position of variables in each quadrant explains the strength of relationships that have influence and dependence between variables influencing environmental sustainability in a dairy agro-industry in Indonesia. The position of the variables in each quadrant explains the strength of the relationship of influence and dependence between variables influencing environmental sustainability in a dairy agro-industry in Indonesia. Based on the results of the variable position mapping, the variables that influence environmental sustainability can be analyzed through their quadrant positions.

Table 2. Identify Values *Matrix Direct Influence* (MDI)

	1 : qty_mgt	2 : was_red	3 : rwb_ergy	4 : grn_trans	5 : she	6 : ergy_eff	7 : biosty	8 : wat_eff
1 : qty_mgt	0	3	3	3	3	2	3	2
2 : was_red	3	0	2	2	3	3	3	3
3 : rwb_ergy	1	1	0	2	1	1	1	1
4 : grn_trans	1	1	2	0	1	1	1	1
5 : she	3	3	2	2	0	2	2	3
6 : ergy_eff	3	3	3	2	3	0	3	3
7 : biosty	3	2	3	3	3	3	0	3
8 : wat_eff	2	1	2	1	1	1	1	0

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Description:
qty_mgt : Quality management
was_red : Waste reduction
rwb_ergy : Renewable energy
grn_trans : Green transportation
she : Safety health and environment
ergy_eff : Energy efficiency
biosty : Biodiversity
wat_eff : Water efficiency



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Fig 3. Influence and Dependence Quadrant of Factors Influencing Environmental Sustainability

The explanation of the output results of the MICMAC method in each quadrant in **Fig 3.** is as follows: Quadrant I (*influence variables*) contain the most influential variables in influencing environmental sustainability in a dairy agro-industry in Indonesia. The variables included in Quadrant I are waste reduction, energy efficiency, and biodiversity. By entering Quadrant I, waste reduction, energy efficiency, and biodiversity have the power to influence other factors and influence environmental sustainability. In Quadrant II (*relay variables*), there are sensitive variables that are very unstable in the system. If there is an intervention in these variables, it will influence the system as a whole [5]. The variables included in Quadrant II are safety health and environment, and quality management. In Quadrant III (*dependent variables*), the variables included are sensitive and dependent on changes in the variables in Quadrants I and II. These variables are influenced by variables in Quadrants I and II [11]. Variables in this quadrant are green transportation, renewable energy, and water efficiency. In Quadrant IV (*excluded variables*), the variables are characterized by having small influence and small dependence. These variables are said to be excluded because they will not stop the operation of a system or take advantage of the system itself [8]. There are no variables included in this quadrant.

All variables included in Quadrant I are determining variables and important elements in the system, advised as key factors in environmental sustainability [8]. The variables included in Quadrant I are waste reduction, energy efficiency, and biodiversity. In relation to environmental sustainability activities, waste reduction activities are currently being intensively carried out in the dairy agro-industry under study. The establishment of good wastewater treatment systems and facilities (WWTP) is a major contribution to the environment. With this great concern for the environment, the company has indirectly promoted environmental sustainability. The next variable in Quadrant I is energy efficiency. According to the researched dairy agro-industry, energy efficiency activities are a must if we care about environmental sustainability. The researched dairy agro-industry spent a large amount of funds to make these energy efficiency activities a success. The lighting of the office and factory environment supplied by the solar cell system is an example of an activity to succeed the energy efficiency program. Biodiversity is the third variable that falls into Quadrant I. In making wastewater treatment plants (WWTP), the dairy agro-industry studied strongly consider biodiversity factors. Environmental destruction is a factor that is highly guarded against by the dairy agro-industry studied. Therefore, in the construction of wastewater treatment plants (WWTP), the waste from this installation, when flowed into the river, has gone through strict standards to avoid damaging environmental sustainability. By paying attention to biodiversity, the dairy agro-industry studied strongly supports environmental sustainability. Quadrant II contains influential but highly dependent variables. The variables in this quadrant are sensitive and very unstable in the system. If there is an intervention in these variables, it will influence the system as a whole [5].

The variables included in Quadrant II are safety health and environment and quality management. The dairy agro-industry studied concern for environmental sustainability is reflected in activities that increase concern for the environment. To follow up on this, the company implemented a safety health and environment program so that activities to reduce waste, improve energy efficiency, and promote biodiversity can run continuously. The next variable included in Quadrant II is quality management. A section is needed to maintain work implementation standards for activities related to environmental sustainability. For example, the ISO 14001 Environmental Management System standard. This section is called quality management. In the dairy agro-industry studied, the implementation of quality management has been carried out properly. The implementation of quality management is carried out through quality assurance and quality control processes. Variables in Quadrant III are characterized by high dependency (dependent). These variables are dependent on changes in

variables in Quadrants I and II. These variables are influenced by variables in Quadrants I and II [11]. The variables in this quadrant are green transportation, renewable Energy, and Water Efficiency. In the dairy agro-industry studied, variables in Quadrant III are influenced or influenced by variables in Quadrants I and II, namely waste reduction, energy efficiency, biodiversity, safety health and environment and quality management. Green transportation activities are influenced by energy efficiency activities and safety health and environment activities. If energy efficiency and safety health, and environment activities run well, green transportation will be created. Renewable energy activity is the impact of waste reduction, energy efficiency, and safety health and environment activities. With better waste reduction, energy efficiency, and safety health and environment activities, renewable energy activities can take place well. Water efficiency activity is the impact of waste reduction, energy efficiency and safety health and environment activities. With good performance in waste reduction activities, energy efficiency, and safety health and environment, it will influence water efficiency activities.

4 Conclusion

The analysis in this study was carried out by identifying key variables using the MICMAC method, as well as identifying the influence and dependence between variables. The research results of the analysis of factors influencing environmental sustainability in a dairy agro-industry in Indonesia are as follows:

1. Influential variables/key drivers (influencing factors): waste reduction, energy efficiency, and biodiversity.
2. Relay Variables (a factor will influence or depend on another factor if there is intervention from another factor): safety health and Environment and quality management.
3. Dependent Variables (factors that depend on other factors): green transportation, renewable energy, and water efficiency.

The results of the MICMAC method analysis show that the key variables in the determinant and relationship quadrants have a strong influence on other variables, so they become the benchmark for companies in developing improvement strategies to maintain environmental sustainability in the dairy agro-industry in Indonesia.

According to the author, the factors that influence the environmental sustainability of a dairy agro-industry in Indonesia are waste reduction, energy efficiency, biodiversity, safety health and environment, green transportation, renewable energy, and water efficiency. So, in the future, it is necessary to analyze other factors that influence environmental sustainability.

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