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Circular Economy Concept at the Micro-Level: A Case Study of Taruna Mukti Farmer Group, Bandung Regency, West Java, Indonesia

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Abstract: The concept of a circular economy can be utilized in the process of starting a dairy cattle enterprise. A circular economy is not only a chance to lessen the amount of waste produced by dairy farms and cut down on the amount of pollution that is released into the environment, but also an attempt to maximize the number of advantages that are shared between the economy and the environment. A circular economy can be implemented at any level, from the micro-level (businesses and customers) to the meso-level (eco-industrial zones), and all the way up to the macro-level (city, province, or country). The identification of circular economy practices is possible through the use of Circular Performance Indicators (CPIs). The purpose of this research is to identify circular economy practices based on CPIs at the micro-level, with a focus on the Taruna Mukti Farmer Group in the Bandung Regency of West Java, Indonesia. Based on our research, it is found that the identified CPIs achieve an average score of 2.57, with an achievement level value of 85.5% (very good). The results of the MICMAC analysis show that the key indicator in the CPIs of livestock waste management in the Taruna Mukti Farmer Group is additional income/income from the processing of livestock waste (C1). There is a relationship between the management of livestock waste in the Taruna Mukti Farmer Group and the circular economy concept based on Circular Performance Indicators. Farmers see the aspect of economic profit (economic motive) as important in the management of livestock waste. Marketing and sales strategies will have a big influence on the system of converting livestock waste into organic fertilizer. The higher the sales volume, the higher the level of profit.

Keywords: dairy farm; circular economy; sustainability



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1. Introduction

Ecology and economy go hand in hand in instances where the economy grows without destroying the environment [1]. Balance between ecology and the economy can be achieved by minimizing externalities and environmental degradation caused by economic activities [2]. In dairy farming activities, the resulting livestock waste can be processed into new products that have added value and do not pollute the environment. One of the economic concepts that is currently popular is that of a circular economy [3]. A circular economy is an economic system that replaces the ‘end-of-life’ concept with reducing, alternatively reusing, recycling, and recovering materials in production/distribution and consumption processes [4]. A circular economy is not just an opportunity to reduce dairy farming waste and prevent environmental pollution, but also involves an effort to maximize mutual benefits between the economy and the environment [5].

Circular economy activities in the management of dairy farms can be identified, because livestock waste management can only be a recycling concept. The question in this study is related to the identification of circular economy practices at the micro-level. The

identification of circularity in dairy farm waste management can be based on Circular Performance Indicators (CPIs) [6]. CPIs consist of a short list of indicators which are based on the three circular economy principles. The categorization of CPIs is based on circular economy principles, namely, natural capital regeneration, keeping resources in use, and managing waste externalities (designing out waste externalities) [7]. However, each system is unique, with different components and processes. Therefore, the indicators can be modified based on the needs, goals, and specificity of the system [6]. The CPI indicators for circular economy identification on dairy farms in the category of the regeneration of natural resources are: water quality improvement [6], soil quality improvement [8], contribution to nitrogen and phosphorus balance (indicators used by the European Statistical Office), and income/savings from natural resource regeneration [9]; those in the category of keeping resources in use are: Circular Index [10], Circular Use [10], Circular Flow [10], and income/savings from keeping resources in use (an indicator that estimates the monetary impacts of the Circular Index) [6]; and those in the category of managing waste externalities are: additional income/revenue from the processing of livestock waste [6], total waste reduction [11], total reduction in soil pollution [12], total reduction in water pollution, and Waste Index [11].

A circular economy can be implemented at the micro-level (companies and consumers), the meso-level (eco-industrial areas), and the macro-level (city, region, or country) with the aim of achieving a sustainable economy, and creating good environmental quality, economic welfare, and social justice [4]. Basic research related to the circular economy in the livestock sector has been carried out, including circular economy-based livestock manure management at the macro-level [13], integrated livestock and agricultural industry systems towards a circular economy [14], alternative animal feed based on a circular economy [15], and circular business models in the dairy farming industry at the macro-level [16].

Referring to the previous description, there has been no research related to the identification of circular economy practices at the micro-level based on CPIs. Therefore, we aim to identify circular economy practices at the micro-level, especially in the management of solid waste dairy farms, with a research focus on the Taruna Mukti Farmer Group, Bandung Regency, West Jawa Province, Indonesia.

2. Materials and Methods

The method used in this study was a quantitative method conducted by distributing questionnaires. In addition, this research was also supported by secondary data related to CPIs. To identify the CPIs, an Interpretive Structural Modeling (ISM) approach was used, followed by data analysis using the MICMAC method. The ISM method and MICMAC analysis were used because they could analyze linkages between circular economy indicators and the hierarchy of indicators in the model, and could identify key indicators in the system such that it could be used for designing strategies for the sustainable management of dairy cattle waste in Taruna Mukti Farmer Group [17]. Respondents were selected using purposive sampling from various parties involved in the management of livestock waste by the Taruna Mukti Farmer Group. Purposive sampling was chosen because the research required competent respondents who understood the waste management system in the Taruna Mukti Farmer Group. The number of respondents was 30 and included administrators and members of farmer groups, people from the local government and non-governmental organizations, and farmer group partners.

2.1. CPI Factor Identification

The design of CPIs was carried out by identifying indicators or parameters related to the circular economy in the management of solid dairy cattle waste by the Taruna Mukti Farmer Group. The CPI indicators were compiled based on references to literature related to the circular economy. The CPI score was derived from a questionnaire that uses a rating scale. The CPI questionnaire was created to give a score to respondents related to the management of solid dairy farming waste in the Taruna Mukti Farmer Group. The

selected respondents were asked to evaluate the importance of each CPI using a three-point scale rating from low (1) to high (3). The designed questionnaire can be found in the Supplementary Materials. A good indicator is an indicator that has an average score of greater than 2. The relationships between indicators (VAXO matrix) was assessed by expert respondents [6]. The VAXO assessment was carried out through interviews by 3 experts who had been mentors of the Taruna Mukti farmer group [18]. The selected experts were people who understand the dairy cattle waste management system in farmer groups, and who understand problems in the areas of research and environmental economics.

2.2. Assessment of Relationships between CPI Factors

The ISM method was used to identify relationships between one element and other elements. The assessment of the relationship between CPI indicators in CE-based livestock waste management by the Taruna Mukti Farmer Group required expert respondents. This assessment was carried out based on the “influence” and “influenced” relationships (Structural Self-Interaction Matrix/SSIM). The value of each of these relationships was written in the VAXO matrix. Ratings for the VAXO matrix are shown in Table 1 [19].

Table 1. Ratings for the VAXO matrix.

Value in SSIM	Relationships between Variables	Information
V	$i \rightarrow j$	Variable i is more influential toward/influenced by variable j
A	$j \rightarrow i$	Variable j is more influential toward/influenced by variable i
X	$i \leftrightarrow j$	Variables i and j influence each other
O	$i \times j$	Variables i and j are not related

2.3. Substituting the Value of Each Variable

The assessment based on the VAXO matrix carried out in the previous stage (SSIM) was then substituted into a binary number matrix (reachability matrix). The reachability matrix (RM) was made by exchanging V, A, X, and O with the numbers 1 and 0. The rules for substituting these values are shown in Table 2 [20].

Table 2. Rules for Substituting Values.

Value in SSIM	Binary Numbers in the Reachability Matrix Column	Binary Number in the Reachability Matrix Row
V	1	0
A	0	1
X	1	1
O	0	0

2.4. Distribution of Reachability Matrix Levels

The importance of the indicators was divided into several levels based on the value obtained from the final reachability matrix results. The most influential indicator was at the peak level. The distribution of indicator levels was based on the Conical matrix. The conical matrix was developed by clustering indicators that were at the same level in the rows and columns of the final reachability matrix. The number of rows was added as a driven power factor, and the number of columns was added as a dependence power factor. Then, the values of the driven power and dependence power were calculated by giving the highest rating for the indicators that had the maximum number, namely, number 1 in the row and column. After obtaining the driven power and dependence power values, these values became the coordinate points for creating the MICMAC quadrant [21].

2.5. MICMAC Analysis

MICMAC analysis is a prospective analysis needed to determine the most influential variables in a system and determine the indirect relationship between variables. The

variables that have been obtained in the reachability matrix are then converted back into the MICMAC quadrant. There are 4 quadrants, namely, quadrant I, quadrant II, quadrant III, and quadrant IV. Quadrant I is the determining (independent) quadrant, which contains the determinant variable and has a strong influence. Quadrant II is the linkage quadrant, which contains variables that influence and are influenced at a very strong level. Quadrant III is the dependent quadrant, which contains the variables that are affected. Quadrant IV is an autonomous quadrant which contains variables with a weak degree of influence and a weak capacity to be influenced. The variables contained in quadrant I need to receive maximum attention in order to maximize the function of the system. The independent quadrant contains indicators that have strong driving power and weak dependence power against other indicators. The linkage quadrant contains an indicator that has strong driving power and dependence power. The dependent quadrant contains an indicator that has weak driving power and strong dependence power against other factors. The autonomous quadrant contains an indicator that has weak driving power and dependence power [22].

The data needed are the values of the Circular Performance Indicators (CPIs). CPIs consist of 3 categories, namely, natural capital regeneration, keeping resources in use, and managing waste externalities (designing out waste externalities) with a total of 14 indicators; these are included in Table 3 [6].

Table 3. Categories and Indicators of CPIs.

No	Category	Indicator
1.	Regeneration of natural resources	• Water quality improvement (A1) • Soil quality improvement (A2) • Contribution to phosphorus balance (A3) • Contribution to nitrogen balance (A4) • Income/savings from natural resource regeneration (A5)
2.	Keeping resources in use	• Circular Index (B1) • Circular Use (B2) • Circular Flow (B3) • Income/savings from keeping resources in use (B4) • Additional income/revenue from the processing of livestock waste (C1)
3.	Waste management	• Total waste reduction (C2) • Total reduction in soil pollution (C3) • Total reduction in water pollution (C4) • Waste Index (C5)

3. Results and Discussion

The Circular Performance Indicators (CPIs) are based on the conditions of the livestock waste management system of the Taruna Mukti Farmer Group. Each system has its own uniqueness so that the CPIs in one system can be different from those in other systems [6]. The indicators selected in the CPI questionnaire were related to livestock waste management. In the livestock waste management system at Taruna Mukti Farmer Group, the results of the indicator scoring were as follows:

Based on the results (Table 4), it was found that the average score for each indicator was more than 2. Using the ISM approach, CPIs that could be assessed by expert respondents resulted in scores of more than 2. The results showed that the use of all the indicators by expert respondents can be continued to assess the relationship between indicators [6].

In addition, the scoring results can also be analyzed to assess the respondents' achievement levels (TCRs) for each indicator. The analysis of the level of achievement of the respondents did not relate one indicator to another and did not compare one indicator to another. The analysis of the level of achievement of the respondents intended to describe the characteristics of each research indicator. The level of achievement of the respondents was calculated using the formula: average score divided by the maximum score multiplied by 100%. The results showed that the CPIs had an average TCR value in the very good cate-

gory. The value of the respondents' achievement levels (TCRs) can be classified into several categories, namely, very good (value interval of 81% to 100%), good (value interval of 61% to <81%), quite good (value interval of 41% to <61%), not good (21% to <41% interval), and bad (0% to <21%) [23].

Table 4. Scoring Results of Circular Performance Indicators (CPIs).

No	Indicator	Average Score	TCR Value
1	Additional income/revenue from the processing of livestock waste	2.70	90.0%
2	Total reduction in water pollution	2.70	90.0%
3	Total reduction in soil pollution	2.70	90.0%
4	Water quality improvement	2.70	90.0%
5	Income/savings from keeping resources in use	2.67	88.9%
6	Contribution to nitrogen (N) balance	2.60	86.7%
7	Income/savings from natural resource regeneration	2.60	86.7%
8	Total waste reduction	2.60	86.7%
9	Circular Use (CU)	2.60	86.7%
10	Circular Flow (CF)	2.60	86.7%
11	Contribution to phosphorus (P) balance	2.57	85.6%
12	Soil quality improvement	2.53	84.4%
13	Waste Index (WAI)	2.23	74.4%
14	Circular Index (CI)	2.11	70.5%
	Average	2.57	85.5%

3.1. Indicator of Income/Additional Income from the Processing of Livestock Waste

Based on the results of the tabulation of respondent data, the additional income/income indicator from the processing of livestock waste achieved a TCR value in the very good category. This is indicated by an average score of 2.70 with an achievement level of 90%. This indicates that this indicator received a positive response from respondents. The net income of the Taruna Mukti Farmer Group in 2017 was around IDR 217,500,000; in 2018, it was IDR 260,000,000; in 2019, it was IDR 45,000,000; in 2020, it was IDR 255,000,000; and in 2021, it was IDR 84,000,000. The total net income of the Taruna Mukti Farmer Group in 2017–2021 was IDR 861,500,000. The Taruna Mukti Farmer Group's income is influenced by the amount of fertilizer produced and the amount of fertilizer sold. The largest level of fertilizer production and sales was in 2018, with a total production level of 3700 tons and total sales of 3500 tons. Capital and sales affect the net profit of a company [24]. Working capital is the number of funds issued by the company to finance daily activities, such as purchasing raw materials, paying wages, and paying other costs. These funds are very influential in the production process, because the funds that have been spent are expected to be returned in the short term through the sale of merchandise. The higher the level of sales and the lower the costs incurred, the higher the profit that obtained by the company. Furthermore, strategies can be used to increase sales; these include expanding the marketing network and inviting people to start using organic fertilizers, improving product quality and quantity, and collaborating with the government in promoting products to the public [25].

3.2. Indicators for Total Reduction in Water and Soil Pollution

Based on the results of the tabulation of respondent data, the indicators for the total reduction in water pollution and the total reduction in soil pollution achieved TCR values in the very good category. This is indicated by an average score of 2.70 with an achievement level of 90%. Based on our research results, it is also known that there are waste management methods that have the potential to reduce water and soil pollution by dairy cattle because livestock waste is processed into organic fertilizer. In 2021, the percentage of livestock waste processed into organic fertilizer was 73% of the total waste produced, whereas in 2017, 2018, 2019, and 2020, all dairy cattle waste in Cibodas and Cisondari Villages was processed by the Taruna Mukti Farmer Group, which even purchased cow

dung from breeders in other villages to obtain raw fertilizer materials. Managing livestock waste, as the end result of a livestock business, for conversion into organic fertilizers such as compost can reduce the potential impact of pollution on the environment, and is useful for increasing the carrying capacity of the environment and increasing crop production [26].

3.3. Indicators for Contribution to Improving Soil Quality

Based on the results of the tabulation of respondent data, indicators for contribution to improving soil quality achieved a TCR value in the very good category. This is indicated by an average score of 2.53 with an achievement level of 84.4%. Based on our research results, it is also known that the organic fertilizer content of the Taruna Mukti Farmer Group's organic fertilizer products was almost in accordance with the quality standards of solid organic fertilizer enriched with microbes, based on the Decree of the Minister of Agriculture of the Republic of Indonesia (Number 261/KPTS/SR.310/M/4/2019) concerning the Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers, and Soil Improvers.

3.4. Total Waste Reduction Indicator

Based on the results of the tabulation of respondent data, the total waste reduction indicator achieved a TCR value in the very good category. This is indicated by an average score of 2.60 with an achievement level of 86.7%. This indicates that this indicator received a positive response from respondents. Based on the research results, it is also known that the estimated total reduction in dairy cow manure in 2017 led to the production of 3000 tons of fertilizer, with an estimated reduction of 4800 tons of wet cow manure. In 2018, fertilizer production was 3700 tons, with an estimated reduction of 5920 tons of wet cow manure. In 2019, fertilizer production was 2100 tons, with an estimated reduction in wet cow manure of 3360 tons. In 2020, fertilizer production was 3100 tons with an estimated reduction in wet cow manure of 4920 tons. In 2021, fertilizer production was 1280 tons, with an estimated reduction in wet cow manure waste of 2048 tons. The estimated total reduction in cow manure during 2017–2021 was 21,088 tons, whereas since the Taruna Mukti Farmer Group was founded in 2008, the total reduction in wet cow manure was 79,328 tons. Processing cattle waste into organic fertilizer is necessary not only because of the demand for a comfortable environment, but also because animal husbandry development takes into account the quality of the environment, so that its existence is not a problem for the surrounding community. The utilization of livestock waste by making organic fertilizer is a form of energy utilization that is very beneficial for life [27].

3.5. Indicator for Contribution to the Balance of Phosphorus (P)

Based on the results of the tabulation of respondent data, the indicator for contribution to the balance of phosphorus (P) achieved a TCR value in the very good category. This is indicated by an average score of 2.57 with an achievement level of 85.6%. Based on the results of this study, it is also known that the value of the phosphorus (P) content of the Taruna Mukti Farmer Group organic fertilizer product is 1.72%. Phosphorus is one of the macro-nutrients that are important for plant growth. Processing livestock waste into organic fertilizer contributes to supporting the availability of phosphorus for agricultural crops. Phosphorus is needed by plants for the formation of cells in growing root and shoot tissues and strengthens stems so that they do not easily collapse in their ecosystem [28]. Phosphorus functions as a creator of fat and protein, forms the nucleus of cells, and can accelerate root growth, strengthen plant stems, and increase the production and ripening of fruits and grains. P fertilization in Leguminosae can also stimulate the formation of root nodules and the symbiotic work of *Rhizobium* sp. Bacteria, thereby increasing the yield of N fixation by *Rhizobium* [29].

The quality standard for the phosphorus content of fertilizers is based on the Decree of the Minister of Agriculture of the Republic of Indonesia (Number 261/KPTS/SR.310/M/4/2019) concerning the Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers, and Soil Improvers, namely, the amount of phosphorus content plus nitrogen plus

a minimum of 2% potassium. Our results show that the phosphorus content of Taruna Mukti Farmer Group organic fertilizer is in accordance with quality standards, with a total content of phosphorus, nitrogen, and potassium of 4.18%. The amount of phosphorus in organic fertilizers is affected by the duration of fermentation. The longer the fermentation time, the more nutrients or food are used for the activities of microorganisms, so that over time, nutrients will run out, resulting in the death of microorganisms; in this phase, the activity of microorganisms in decomposing organic compounds will decrease, and farmers will obtain higher levels of phosphorus than before [30].

3.6. Indicators for Contribution to Nitrogen (N) Balance

Based on the results of the tabulation of respondent data, the indicators for contribution to nitrogen balance (N) achieved TCR values in the good category. This is indicated by an average score of 2.60 with an achievement level of 86.7%. Based on the research results, it is known that the value of the nitrogen (N) content of organic fertilizer products is 1.31%. The quality standard for the nitrogen content of fertilizers is based on the Decree of the Minister of Agriculture of the Republic of Indonesia (Number 261/KPTS/SR.310/M/4/2019) concerning Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers, and Soil Improvers, namely, the amount of nitrogen content plus phosphorus plus a minimum of 2% potassium. The results show that the nitrogen content of Taruna Mukti Farmer Group organic fertilizer is in accordance with quality standards, with a total content of phosphorus, nitrogen, and potassium of 4.18%. Nitrogen has an important role in plants, namely, encouraging rapid plant growth and improving yield levels and fruit quality, increasing the number of shoots, expanding leaf area, and encouraging seed formation and protein synthesis [31].

3.7. Waste Index

The Waste Index is the ratio of the amount of resources consumed by dairy cows to the amount of cow manure (solid waste) produced. Based on the results of the tabulation of respondent data, the Waste Index indicator achieved a TCR value in the good category. This is indicated by an average score of 2.23 with an achievement level of 74.4%. In a circular economy system, the smaller the value of the Waste Index, the better. The value of the Waste Index is obtained by calculating the amount of waste divided by the resource input [6].

3.8. Water Quality Improvement Indicators

Based on the results of the tabulation of respondent data, the water quality improvement indicator achieved a TCR value in the very good category. This is indicated by an average score of 2.70 with an achievement level of 90%. The Taruna Mukti Farmer Group area is part of the Ciwidey Sub-Watershed, which is included in the Citarum Watershed. Farmer Groups' activities contribute to maintaining river water quality by reducing the potential for the disposal of cow manure into the rivers. Dairy farm wastewater has a BOD content of 1250 mg/L and a COD content of 3460 mg/L [32]. Furthermore, baseline data for the 2019 "Citarum Harum" program states that the BOD pollution load from cattle in Bandung Regency is 1305.24 kgBOD/day.

3.9. Indicator for Income/Savings from Keeping Resources in Use

Based on the results of the tabulation of respondent data, the income/savings indicator from the application of a circular economy achieved a TCR value in the very good category. This is indicated by an average score of 2.67 with an achievement level of 88.9%. Income/savings from keeping resources in use can be obtained by extending product use, reducing the amount of waste produced, carrying out product repair and restoration, and recycling waste (recycling) or processing waste into new products (upcycling). At the Taruna Mukti Farmer Group, processing livestock waste into organic fertilizer generated a total profit of IDR 861 million in the period 2017–2021. In addition, the farmer group also

bought cow manure from breeders for a total of IDR 1.05 billion in the period 2017–2021. Implementing a circular economy has a positive impact on the environment, has economic benefits, maximizes resources associated with cleaner production, and increases the value of the technical and biological cycles of materials through a circular strategy [33].

3.10. Indicator for Income/Savings from Natural Resource Regeneration

Based on the results of the tabulation of respondent data, the income/savings indicator from natural resource regeneration achieved a TCR value in the very good category. This is indicated by an average score of 2.60 with an achievement level of 86.7%. This indicator focuses on the economic valuation of environmental services. The areas of Cibodas Village and Cisondari Village still have forest areas. The Taruna Mukti Farmer Group works together with environmental NGOs to reforest forests by supplying fertilizer needs. Forests provide ecosystem services in the form of carbon sequestration, biodiversity protection, and watershed protection. In addition, forests can also provide forage for dairy cows. Processing livestock waste into organic fertilizer also prevents economic losses caused by livestock waste pollution. The income/savings indicator from natural resource regeneration estimates a valuation for ecosystems, their services, and their loss impact (ecosystem accounting). Ecosystem accounting allows for the estimation of economic costs/losses stemming from ecosystem changes. Circular economy implementation must be able to reduce these costs and turn them into income [6].

3.11. Circular Use (CU), Circular Flow (CF), and Circular Index (CI) Indicators

Based on the results of the tabulation of respondent data, the Circular Use (CU) and Circular Flow (CF) indicators achieved TCR values in the very good category. This is indicated by a score of 2.60 each, with an achievement level of 86.7%. Meanwhile, the Circular Index (CI) indicator achieved a TCR value in the good category. This is indicated by an average score of 2.11 with an achievement level of 70.5%. Circular Index (CI) values are influenced by Circular Use (CU) and Circular Flow (CF). Circular Flow (CF) represents circularity in the flow of materials and energy. CU represents circularity with a product usage approach. Based on our research results, it is known that the flow of materials and energy in the management of livestock waste in the Taruna Mukti Farmer Group creates a Circular Flow, where dairy farms produce waste, which is then processed into organic fertilizer. Organic fertilizers are used in agriculture, plantations, and horticulture. Agricultural, plantation, and horticultural waste is used by members of farmer groups as forage for dairy cows. The availability of forage is very important for dairy farms. Circular Use (CU) considers the factor of product use by extending its life cycle. In farmer groups, used sacks are reused to wrap fertilizer. Farmers also repair damaged tools, such as hoes, sickles, shovels, and fertilizer transport carts, so that they can be used again, thus extending their use life. Circular Flow (CF) takes into account material and energy components in both the input and output phases. Circular Use (CU) considers the solutions adopted to extend the duration of use of an asset. Circular Use (CU) affects extended useful life (years) due to special actions taken in terms of design/maintenance, which can extend the useful life and time of use of assets, and the standard useful life of projects/products (without special actions) [6].

3.12. Reachability Matrix and Level Distribution

The indicators were divided into several levels based on the values obtained from the final reachability matrix results. The values obtained for each indicator were added up horizontally and vertically. Horizontally, the value of the driving power was obtained, and vertically, the value of dependence was obtained so that the ranking and hierarchy of each indicator could be obtained. Indicators that had known driving power values and dependence values were then divided into levels. Level division was carried out to classify elements into different levels of the ISM structure. The reachability set and antecedent set for each factor were obtained from the final reachability matrix. The reachability set

for a particular variable consisted of the variable itself and other variables to form the reachability set. The antecedent set of a particular variable also consisted of the variable itself and other variables. Next, the intersection of the set was derived for all variables. After the identification of the upper level variables, it was separated from the other remaining variables and continued until the level of each variable was obtained. The upper level indicator (1) is an indicator that does not influence/has weak driving force against other indicators [34]. The results of the distribution of the indicator levels are shown in Table 5.

Table 5. The results of the distribution of indicator levels of CPIs.

Level	CPIs
I	- Income/savings from natural resource regeneration (A5) - Circular Index (B1) - Circular Use (B2)
II	- Contribution to phosphorus balance (A3) - Contribution to nitrogen balance (A4) - Circular Flow (B3)
III	- Soil quality improvement (A2) - Income/savings from keeping resources in use (B4) - Waste Index (C5) - Water quality improvement (A1)
IV	- Total waste reduction (C2) - Total reduction in soil pollution (C3) - Total reduction in water pollution (C4)
V	Additional income/revenue from the processing of livestock waste (C1)

Based on our results, it is known that the additional income/income indicator from the processing of livestock waste (C1) is at the most important level, namely, level 5, with a driving power value of 13 and a dependence power of 5. The lower the indicator level, the more important the indicator is and the more influential it is on other indicators. The indicators for income/additional income from the processing of livestock waste (C1) are indicators related to the economy. This indicator is an important indicator in the system. The existence of additional income/income from the processing of livestock waste helps breeders to meet the economic needs of their families. Dairy cattle farming is the main source of livelihood for members of the Taruna Mukti Farmer Group. Its main purpose is raising livestock to meet economic needs. Increasing income is one of the main motivations of farmers [35].

The total waste reduction indicator (C2), the total reduction in soil pollution (C3), and the total reduction in water pollution (C4) are at the same level, namely, level 4. The total waste reduction indicator (C2) has a driving power of 12 and a dependence power of 13. The total indicator for reducing soil pollution (C3) has a driving power of 12 and a dependence power of 12. The total indicator for reducing water pollution (C4) has a driving power of 12 and a dependence power of 14.

The indicators at level 4 have a lower level of importance than the indicators at level 5. The total waste reduction indicator (C2) is related to the total reduction in soil contamination (C3) and the total reduction in water pollution (C4). The lower the level of livestock waste, the lower the potential for soil and water pollution with livestock waste. Processing livestock waste into organic fertilizer will reduce the potential for soil and water pollution. The waste reduction indicator directly measures waste that can be reduced by mass.

The indicators for improving water quality (A1), improving soil quality (A2), the Waste Index (C5), and income/savings from maintaining resource use (B4) are at level 3. The indicator for improving water quality (A1) has a driving power of 11 and a dependence power of 12. The indicator for improving soil quality (A2) has a driving power of 11 and

dependence power of 10. The indicator for income/savings from maintaining the use of resources (B4) has a driving power of 11 and a dependence power of 5.

Indicators at level 3 have a smaller effect on the system than indicators at level 4. Indicators at level 4 can affect indicators at level 3, for example, the indicator for total reduction in soil pollution (C3) affects soil quality improvement (A2) where the lower the pollution, the better the soil quality. A greater reduction in the total waste generated (C2) will also reduce the value of the waste index indicator (C5) at level 3. This also applies to the total indicator for reducing water pollution (C4), which affects the indicator for improving water quality (A1). Livestock waste that is not managed properly can cause water contamination. Groundwater and surface water can accommodate pathogens originating from livestock waste deposits [36]. For improved water quality, it is necessary to reduce pollution loads [37].

The indicators for contribution to nitrogen balance (A4), contribution to phosphorus balance (A3), and the Circular Flow indicator (B3) are at level 2. The Circular Flow indicator (B3) has a driving power of 10 and a dependence power of 14. The indicator for contribution to nitrogen balance (A4) has a driving power of 10 and a dependence power of 8. The indicator for contribution to phosphorus balance (A3) has a driving power of 10 and a dependence power of 8. Processing livestock waste into organic fertilizer has an effect on the indicators for contribution to nitrogen balance (A4) and phosphorus (A3). Indicators that are at level 2 have a lower level of importance in the system than the levels below. Processing livestock waste into organic fertilizer reduces the potential for river pollution and prevents the eutrophication of nitrogen and phosphorus (maintaining the balance of nitrogen and phosphorus levels in the river). Eutrophication is caused by the emergence of nutrients such as excess nitrogen and phosphorus into aquatic ecosystems [38]. It is feared that eutrophication will increase the water's ammonia content, which is toxic to aquatic biota [39].

The Circular Use (B2), Circular Index (B1), and income/savings from natural resource regeneration (A5) indicators are at level 1. The Circular Use indicator (B2) has a driving power of 9 and a dependence power of 12. The Circular Index indicator (B1) has a driving power of 9 and a dependence power of 12. The indicator for income/savings from natural resource regeneration (A5) has a driving power of 9 and a dependence power of 11.

The Circular Use indicator (B2) and Circular Index indicator (B1) have an interrelated relationship. Circular Use is an extension of the use of resources/assets that can be used to determine Circular Index values. Meanwhile, the indicator for income/savings from natural resource regeneration (A5) is related to the economic benefits derived from environmental services. Even though they are at level 1, these indicators have a driving power value difference of 9 or 4 points from the indicators at level 5. This shows that the indicators at level 1 still have quite large driving power, even though they also have large dependence power. The indicators that have high influence as well as high dependence are also included in the linkage quadrant [20].

3.13. The Key Indicator at the Micro-Level of Circular Economy in Taruna Mukti Farmer Group

The results of dividing the indicator levels were then converted back into the MICMAC quadrant, which is a prospective analysis needed to determine the most influential variables in a system and determine indirect relationships between variables. The results of converting the indicator levels into the MICMAC quadrant are as follows:

Based on the results of the MICMAC analysis (Figure 1), it is known that the CPIs are divided into two quadrants, namely, the independent quadrant and the linkage quadrant. The indicators for additional income/income from the processing of livestock waste (C1) and income/savings from keeping resources in use (B4) are included in the independent quadrant. These two indicators are the indicators that have the most influence on the livestock waste management system in the Taruna Mukti Farmer Group. Both indicators have high influencing power and low dependence. The indicator of income/additional income from the processing of livestock waste is closely related to the indicator for income/savings

from the application of a circular economy, where the higher the income derived from the processing of livestock waste, the higher the income from the application of a circular economy. Both indicators are indicators that describe aspects of economic benefits. This shows that breeders see the aspect of economic profit (economic motive) as important in the management of livestock waste. The economic advantage of processing livestock waste into organic fertilizer is influenced by production factors and organic fertilizer selling factors. Marketing and sales strategies have a major influence on the system of processing livestock waste into organic fertilizer. This is in accordance with our results, and thus, we recommend special attention to marketing.

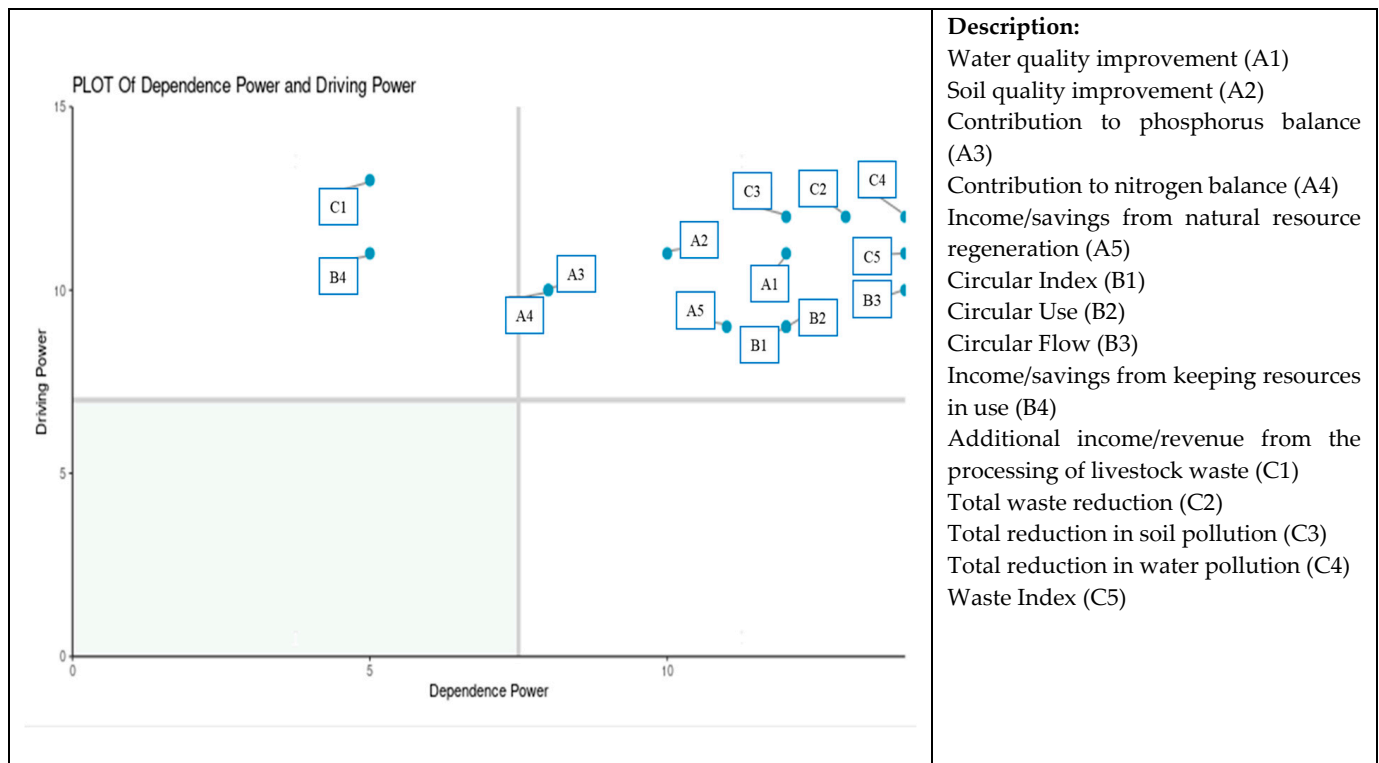


Figure 1. MICMAC quadrant analysis results.

The indicators included in the independent quadrant have high influencing power and low dependence. While indicators A1, A2, A3, A4, A5, B1, B2, B3, C2, C3, C4, and C5 are included in the linkage quadrant. The indicators in the linkage quadrant have high influence, as well as high dependence. The indicators that are included in the linkage quadrant have quite high driving power values, namely, between 9 and 11, and dependence values between 8 and 14. The indicators that are in the linkage quadrant cannot be used as key indicators because they have a high degree of dependence. The linkage quadrants have characteristics whereby every action exerted on them will have an effect on the variables above their level and a feedback effect on themselves [20].

The additional income/income indicator from the processing of livestock waste (C1) has a driving power of 13 and a dependence power of 5, and is at level 5, while the income/savings indicator from keeping resources in use (B4) has a driving power of 11 and a dependence power of 4, and is at level 3. This shows that indicator C1 is more influential than indicator B4. Thus, the key CPI of livestock waste management in the Taruna Mukti Farmer Group is the indicator of additional income/income from the processing of livestock waste indicator (C1). Farmers see the additional income from waste processing as motivation to convert waste into organic fertilizer. A farmer's motivation is influenced by economic encouragement [40]. Furthermore, the economic motives are very influential on breeders running a business. These motives serve as encouragement to obtain basic human needs [41]. In the agri-environmental scheme, one of the most important motivations for

farmers is economic motivation, in addition to environmental motivation [42]. Agricultural income significantly influences intrinsic motivation in the management of agricultural businesses [43].

4. Conclusions

Based on our research, it is found that the identified CPIs achieved an average score of 2.57, with achievement level values of 85.5% (very good). The results of the MICMAC analysis show that the key CPI of livestock waste management in the Taruna Mukti Farmer Group is additional income/income from the processing of livestock waste (C1). There is a relationship between the management of livestock waste in the Taruna Mukti Farmer Group and the circular economy concept based on Circular Performance Indicators. Farmers see the aspect of economic profit (economic motive) as important in the management of livestock waste. Marketing and sales strategies will have a big influence on the system of converting livestock waste into organic fertilizer. The higher the sales volume, the higher the level of profit.

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