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# Analysis of the Factors Affecting the Palm Oil Industry's Supply Chain with Consideration of Circular Economy

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## Abstract

The generation of solid waste and liquid waste from Indonesian palm oil processing factories tends to be increased. To overcome the problem, Indonesia must be able to implement a sustainable supply chain with the concept of circular economy, which focuses on reduction, reuse, and recycling areas. However, it is necessary to know in advance the factors that are the keys to the application of the concept. The purpose of this study is to identify the problem's profile of the key factors in the implementation of a circular economy in the Indonesian palm oil industry. The method in this study uses Interpretative Structural Modeling (ISM) to analyze the key factors in the implementation of a circular economy in the palm oil industry. This study will investigate three groups that influence the implementation of circular economy, namely objectives, participator, and problems with their elements. The results are identified that the key factors in implementing a circular economy in the palm oil industry are the factors of competitive advantage, farmer, and infrastructure from each group.

**Keywords**: *Circular Economy, ISM, Palm Oil, Supply Chain Management*



## INTRODUCTION

Indonesia is the largest producer of palm oil in the world, about 57% of the world's demand is supplied from Indonesia (Sequiño and Magallon-Avenido, 2015). Palm oil products are needed by several countries in the world such as Europe, China, and America as raw materials for making soap, resin, and margarine. The world's demand for palm oil in the last 5 years has experienced an increasing trend from 65 million tons in 2017 to 73 million tons in 2021 (US Department of Agriculture). This palm oil commodity is a very promising plantation commodity and still has an opportunity to be developed. The palm oil industry contributes 14% to Indonesia's gross domestic product and almost supports 41% of the welfare of the Indonesian people. Up to 2021, the area of oil palm land reaches 15.08 ha, producing 49 million tons of palm oil in 32 provinces (Central Bureau of Statistics, 2021).

The conditions of the potential palm oil industry must be supported by good supply chain performance from each chain actor. The palm oil supply chain is very complex (Rincón et al., 2015). Industry and plantations produce a lot of waste, such as empty shell waste, empty palm oil bunches waste, and Palm Oil Mills Effluent (POME) liquid waste (Munasinghe et al., 2019). This makes upstream and downstream chain communications challenging. It is estimated that the production of palm oil solid waste in 2020 is the production of 20 million tons of mesocarp fiber, 9 million tons of shells, 31 million tons of empty fruit bunches. The generation of solid waste and liquid waste from Indonesian palm oil processing factories tends to increase, this is directly proportional to the increase in the area of fresh fruit bunches (FFB) and oil palm plantations. In addition, several countries that use palm oil, especially in Europe, are already concerned about the sustainability of

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the palm oil industry by considering the environmental impact. By 2030 Europe will limit the consumption of palm oil because palm oil is considered less environmentally friendly (Russell, 2020).

To overcome these problems, Indonesia must be able to implement a sustainable supply chain with the concept of a circular economy in the palm oil industry. The circular economy is an industry concept that focuses on reducing, reusing, and recycling (Sarkar et al., 2022). The application of the circular economy concept can provide benefits for the palm oil industry, namely efficiency of raw materials, reduction of waste, and increased production of recyclable goods (Abdul-Hamid et al., 2021). However, it is necessary to know in advance the factors that are the key in the application of the concept. This study aims to find out what factors are key in implementing economic circulation in supply chain management (SCM) in the palm oil industry. Based on the problems discussed, there are research objectives that have been searched for, at the same time, identifying the related profiling actors that affect the application of circular economy in the Indonesian palm oil industry.

## LITERATURE REVIEW

*Supply Chain Management*

The supply chain is a collection of processes that involve the movement of goods, information, and money in order to satisfy customer desires (Deepu and Ravi, 2021). These processes occur within and between distinct stages along a continuum extending from the manufacturing department to the final consumer (Rotaru, Wilkin, and Ceglowski, 2014). SCM is the process of integrating and managing supply chain organizations and all organizational collaborations, as well as the effectiveness of business activities and information sharing, in order to create high-value systems with a sustainable competitive advantage (Nagurney, Yu and Floden, 2013). Collaboration strategies can be used to overcome SCM challenges, enabling businesses to develop responsive, sensitive, and agile supply chain capabilities(V. Talavera, 2014). SCM issues and challenges can also be resolved by implementing the triple-C "Cease-Control-Combine" strategy (Xia and Li-Ping Tang, 2011).

*Circular Economic*

A circular economy is a type of economy in which goods and services are exchanged in a closed loop (Becerra, Mula, and Sanchis, 2021). The goal of a circular economy is to create a system that maximizes the life of products and raw materials through optimal reuse, repair, remanufacturing, and recycling (Sarkar et al., 2022). The application of the circular economy to reimagine industry development and place a premium on broad social benefits rather than on sales profits. This is accomplished by decoupling economic activity from resource consumption and gradually eliminating waste generation from the system. A circular economy is based on the principle of design that minimizes waste and pollution, conserves products and raw materials, and promotes green manufacturing (Wu et al., 2022). Figure 1 illustrates how the circular economy can be applied to businesses by outlining the five primary capabilities that must be met.

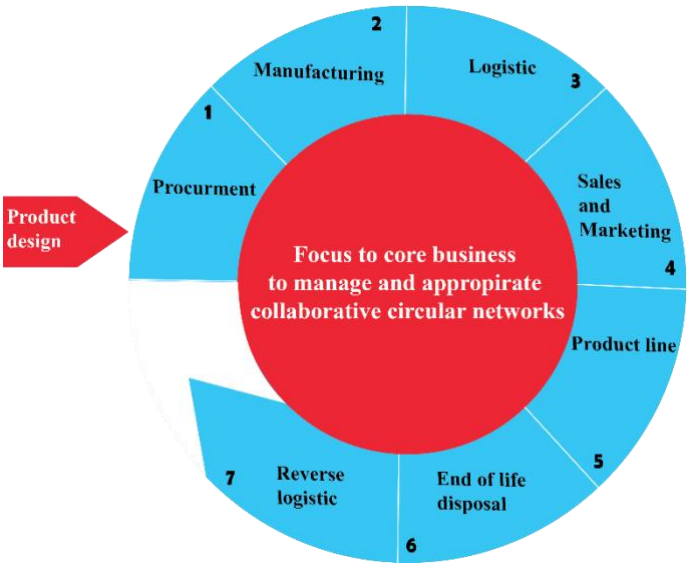


Figure 1. Circular economy concept (Accenture, 2014)

## METHODOLOGY

The ISM is used in this study to analyze the factors that promote the adoption of a circular economy in the palm oil industry. ISM is a collaborative learning process that generates structural models to depict complex aspects of a system using carefully designed patterns comprised of graphics and sentences. Because the output of ISM can be illustrated with a problem map and a hierarchical structure of the problem, it can aid in problem management. The stages of analysis involving ISM are as follows: the preparation of elements for each component of the aloe vera agribusiness development system. Then, examine the contextual relationship in which one element (element i) enables the existence of another element (element j). This study invites five experts to give opinions, including two academics, one government official, and two palm oil industry veterans.

In this study, three groups with their elements are involved in the ISM model, as shown in Table 1. To improve supply chain performance, it is necessary to focus on implementing a circular economy. In this study, 3 group factors and elements are identified from the literature.

Table 1. Identification of influencing factors with three groups and their elements.

| Group number | Group | Element | Element number |
|---|---|---|---|
| A | Objective | 1. Sustainability production | A1 |
| | | 2. Reduce waste | A2 |
| | | 3. Efficient production | A3 |
| | | 4. Increase benefit | A4 |
| | | 5. Competitive advantage | A5 |
| | | 6. Renewable energy | A6 |
| B | Participator | 1. Academics | B1 |
| | | 2. Farmer | B2 |
| | | 3. Manufacturer | B3 |
| | | 4. Customer | B4 |
| | | 5. Non-Government Organization (NGO) | B5 |
| | | 6. Distributor | |

| | | | |
|---|---|---|---|
| | | 7. Government | B6<br>B7 |
| C | Problem | 1. Local Government Policy | C1 |
| | | 2. Supply chain network | C2 |
| | | 3. Infrastructure | C3 |
| | | 4. Technology process | C4 |
| | | 5. Capital | C5 |
| | | 6. Human resources quality | C6 |
| | | 7. Business model | C7 |

## FINDINGS AND DISCUSSION

*Circular Economy Concept in Palm Oil Industry*

The circular economy is a new economic concept in which products and services are traded in a closed cycle system in which the value of a product, by-product, or other material is maintained as high as possible. The overarching objective is to maximize economic growth while preserving the value of a resource or to extend the life of a product or material through optimal reuse, renewal, and recycling. Figure 2 illustrates the application of circular economy principles in the palm oil industry's supply chain. Each actor in the palm oil supply chain generates waste, but the palm oil mill generates the most waste. According to Figure 1, palm oil mills generate waste in the form of empty fruit bunches, palm shell waste, and liquid waste. The waste generated as a result of their process can be reprocessed and redistributed by supply chain members in the palm oil industry. For instance, the utilization of palm oil liquid waste converts it to electrical energy, which can then be used to power palm oil mills. This can undoubtedly help reduce waste, lower production costs, and increase work efficiency. Additionally, a method of implementing a circular economy through the conversion of waste to renewable energy while reducing greenhouse gas emissions and the burden of environmental pollution is the capture of methane gas, the primary gas component of biogas produced by the decomposition of organic waste in anaerobic conditions. This method can significantly reduce odor and the risk of water pollution.

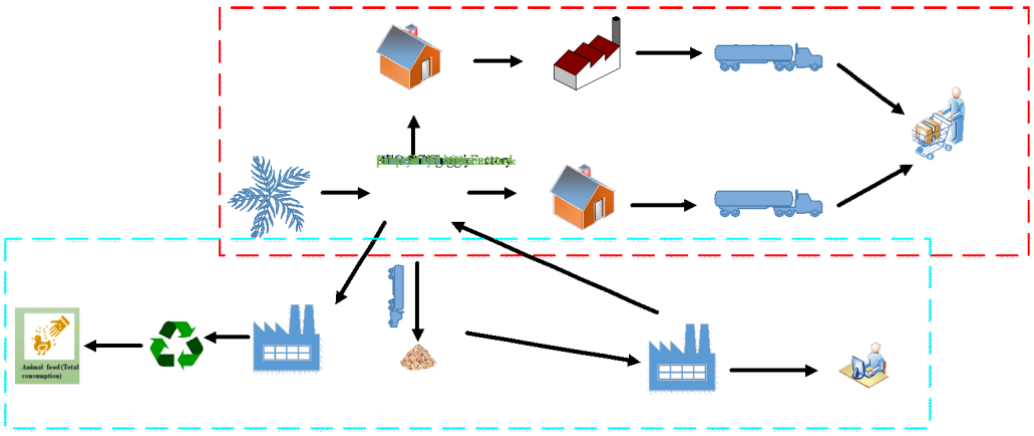

Figure 2. The circular economy concept in the palm oil industry

*Analysis of Interpretative Structural Modeling*

1. Objective group

Based on the results of discussions with experts and literature studies, this study identifies 6 elements of the objective group, which can be seen in Table 1. The results of the initial Structural Self Interaction Matrix (SSIM) of the program objective elements that have been made in the form of Reachability Matrix (RM), by replacing the letters V, A, X, O being the numbers 1 and 0, with a value of 1 to represent an effect while a value of 0 means no influence. The RM can be seen in Table 2. The results of the RM must be tested with the transitivity rule, and the RM becomes the revised RM, as shown in Table 3. In this table, the driving power and dependence of each element are also shown. The driving power or dependence of a particular element is the total number of elements, including itself, which it may help achieve. The one with the highest value is the key element.

Table 2. Reachability matrix for objective group

| Elements | A1 | A2 | A3 | A4 | A5 | A6 |
|---|---|---|---|---|---|---|
| A1 | 1 | 1 | 0 | 1 | 0 | 1 |
| A2 | 1 | 1 | 1 | 1 | 1 | 1 |
| A3 | 1 | 1 | 1 | 0 | 0 | 0 |
| A4 | 0 | 0 | 0 | 1 | 0 | 1 |
| A5 | 1 | 0 | 0 | 1 | 1 | 1 |
| A6 | 1 | 0 | 1 | 1 | 0 | 1 |

Table 3. Revised reachability matrix for objective group

| Elements | A1 | A2 | A3 | A4 | A5 | A6 | Driving Power |
|---|---|---|---|---|---|---|---|
| A1 | 1 | 1 | 1* | 1 | 1* | 1 | 6 |
| A2 | 1 | 1 | 1 | 1 | 1 | 1 | 6 |
| A3 | 1 | 1 | 1 | 1* | 1* | 1* | 6 |
| A4 | 1* | 0 | 1* | 1 | 0 | 1 | 4 |
| A5 | 1 | 1* | 1* | 1 | 1 | 1 | 6 |
| A6 | 1 | 1* | 1 | 1 | 0 | 1 | 5 |
| Dependence Power | 6 | 5 | 6 | 6 | 4 | 6 | |

From Table 3, the elements can be classified into four zones autonomous, dependence, linking, and independence, as shown in Figure 3. Referring to Figure 3, the elements in the objective group are located in quadrant 3 (linkage). Quadrant 3 is a linkage variable with higher driving power and higher dependence. Elements with lower dependence must be analyzed further because their change will influence other elements. Based on the driving power and dependence diagram as shown in Figure 3, we can obtain the ISM-based model for objective elements. Competitive advantage (A5) is the key factor and Increase benefit (A4) is the final goal.

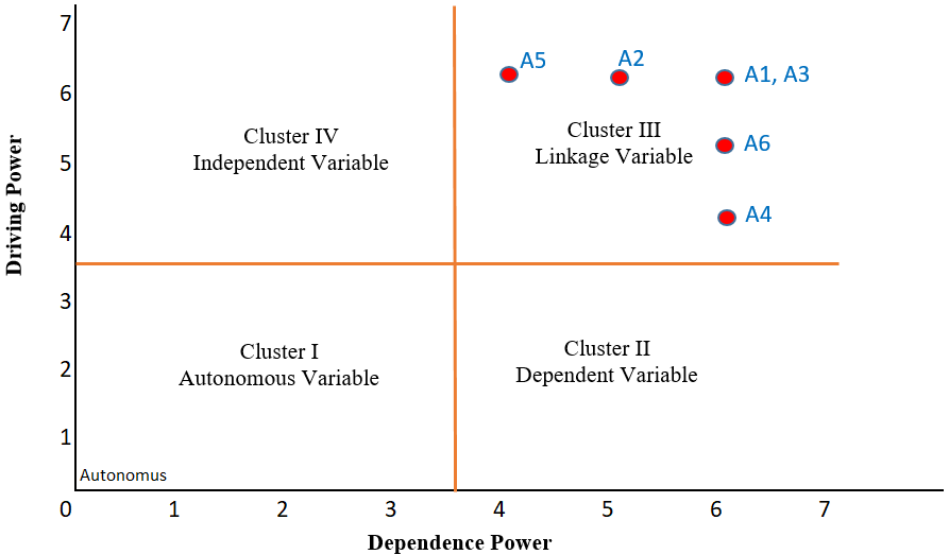


Figure 3. Driving power and dependence diagram for objective elements

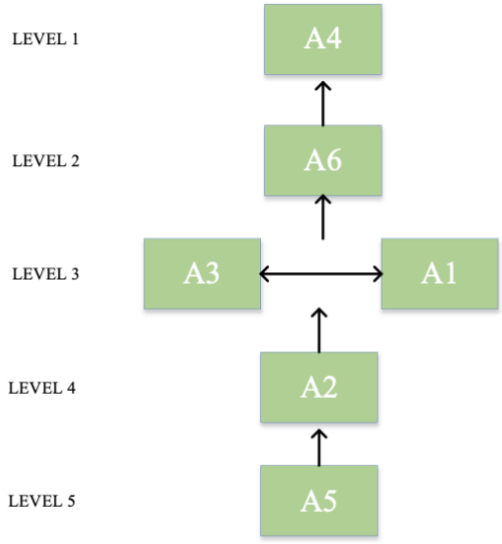


Figure 4. ISM-based model for objective elements

2. Participator group

Based on the findings of experts and literature studies, this study identifies 7 elements of the participator group, which can be seen in Table 1. The initial SSIM elements of participator that have been made in the form of RM, by replacing the letters V, A, X, O with the numbers 1 and 0, with a value of 1 representing an effect and a value of 0 representing no influence. The RM elements of

participators can be seen in Table 4. The results of RM must be tested with the transitivity rule, and the RM becomes the revised RM, as shown in Table 5. In this table, the driving power and dependence power of each element are also shown. The driving power or dependence of a particular element is the total number of elements, including itself, which it may help achieve. The key element is the one with the highest value. From the revised reachability matrix, we found the location elements of participator can be classified into four zones autonomous, dependence, linking, and independence, as shown in Figure 5.

Table 4. Reachability matrix for participator

| | B1 | B2 | B3 | B4 | B5 | B6 | B7 |
|---|---|---|---|---|---|---|---|
| B1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| B2 | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| B3 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| B4 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| B5 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| B6 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| B7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

Table 5. Revised reachability matrix for participator

| | B1 | B2 | B3 | B4 | B5 | B6 | B7 | Driving Power |
|---|---|---|---|---|---|---|---|---|
| B1 | 1 | 0 | 1 | 1* | 1 | 1* | 1 | 6 |
| B2 | 1 | 1 | 1 | 1* | 1 | 1* | 1 | 7 |
| B3 | 1 | 0 | 1 | 1 | 1 | 1 | 1* | 6 |
| B4 | 1 | 0 | 1* | 1 | 1 | 0 | 1 | 5 |
| B5 | 1 | 0 | 1 | 1 | 1 | 1* | 1* | 6 |
| B6 | 1 | 0 | 1 | 1* | 1* | 1 | 1 | 6 |
| B7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| Dependence Power | 6 | 1 | 6 | 6 | 6 | 5 | 7 | |

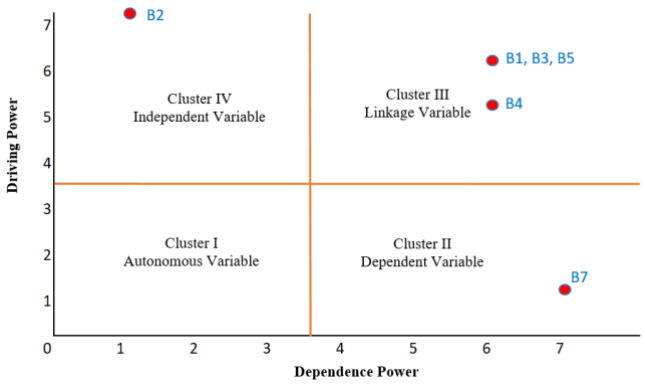


Figure 5. Driving power and dependence diagram for participators

Based on Figure 5, Farmer (B2) lies in the quadrant of the independent variables, the variables in this sector have a very low dependence on other factors. Therefore if there is a change from other factors then B2 will not be affected easily. B7 lies in the dependent variable, the factors located in this quadrant are not independent, when other factors change, and they affect B7. While the other elements are located in quadrant 3 (linkage). Based on the driving power and dependence diagram as shown in Figure 6, we can obtain the ISM-based model for objective elements Farmer (B2) is the key factor, and Government (A7) is the final goal.

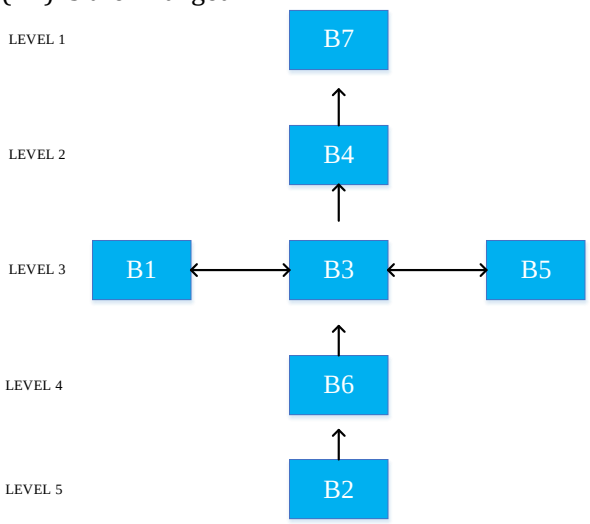


Figure 6. ISM-based model for participators elements

3. Problems group

According to the results of discussions with experts and literature review, this study identifies 7 elements of the problem group, which can be seen in Table 1. The expert fulfills the self-interaction matrix then transforms the letters V, A, X, O into numbers 1 and 0, with a value of 1 representing an effect, while a value of 0 means no influence. The RM for elements problems can be seen in Table 6. Using the transitivity rule the RM results were tested and caught the revised RM, as shown in Table 7. In this table, the driving power and dependence of each element are also shown. The total number of elements indicates the level of driving power or dependence power. The one element that has the highest value becomes the key element. From revised RM we transform the number of driving power or dependence to zones consisting of autonomous, dependence, linkage, and independence, as shown in Figure 5.

Table 6. Reachability matrix for problems

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 |
|---|---|---|---|---|---|---|---|
| C1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| C2 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| C3 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| C4 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| C5 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| C6 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| C7 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |

Table 7. Revised reachability matrix for problems

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | Driving Power |
|---|---|---|---|---|---|---|---|---|
| C1 | 1 | 1* | 1* | 1 | 1 | 1 | 1 | 7 |
| C2 | 1* | 1 | 1* | 1 | 1 | 1 | 1 | 7 |
| C3 | 1 | 1* | 1 | 1 | 1 | 1 | 1* | 7 |
| C4 | 1* | 1* | 1 | 1 | 1 | 1 | 0 | 6 |
| C5 | 1 | 1 | 0 | 1* | 1 | 1 | 1* | 6 |
| C6 | 1* | 1 | 0 | 1* | 1 | 1 | 1* | 6 |
| C7 | 1* | 1* | 0 | 0 | 1 | 1 | 1 | 5 |
| Dependence Power | 7 | 7 | 4 | 6 | 7 | 7 | 6 | |

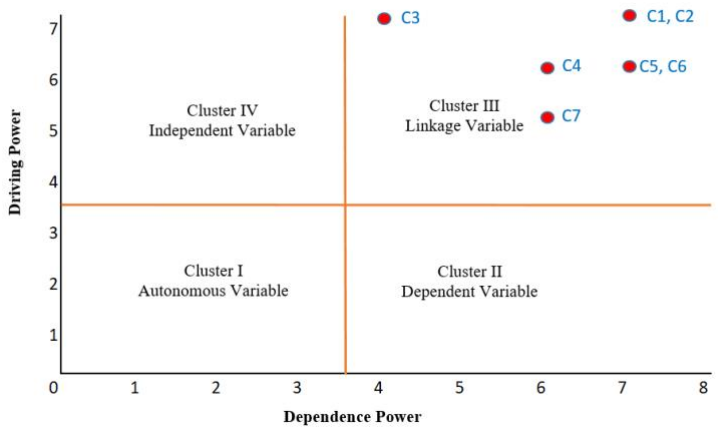


Figure 7. Driving power and dependence diagram for problems

According to Figure 7, the elements in the problems group are located in quadrant 3 (linkage). Quadrant linkage has a variable with higher driving power and higher dependence. Elements with lower dependence must be analyzed further because their change will influence other elements. According to the driving power and dependence diagram as shown in Figure 7, we can obtain the ISM-based model for problem elements. Infrastructure (C3) is the key factor and the Business model (C7) is the final goal.

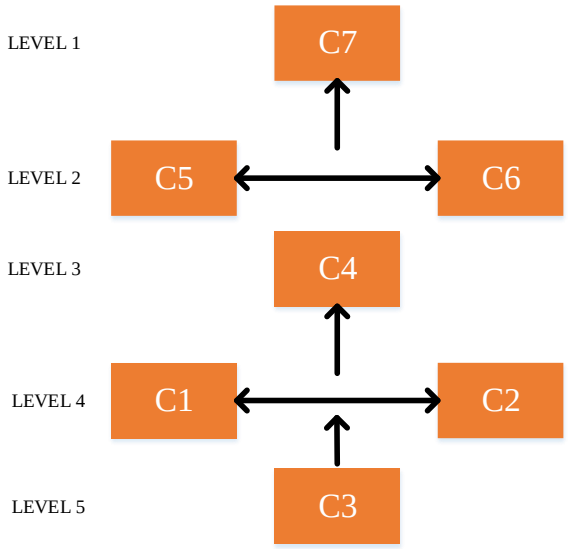


Figure 8. ISM-based model for problem elements

## CONCLUSION AND FURTHER RESEARCH

The circular economy is a new economic concept in which products and services are traded in a closed cycle system in which the value of a product, by-product, or other material is maintained as high as possible. The overarching objective is to maximize economic growth while preserving the value of a resource or extending the life of a product or material through optimal reuse, renewal, and recycling. There are elements that influence the implementation of circular economy, namely the elements of objective, participator, and problems. The results are identified that the key factors in implementing a circular economy in the palm oil industry are the factors of competitive advantage, farmer, and infrastructure from each group. For future research, it may wish to consider the multi-criteria decision making (MCDM) method in order to formulate and decide on multiple strategies that incorporate the circular economy concept

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