Asian Journal of Agriculture and Rural Development
Volume 15, Issue 2 (2025): 134-144

Identifying constraints and strategies for palm oil production in Indonesia: An interpretive structure model approach

Ida Rosada[a] †
Nurliani[a]
Achmad Amiruddin[b,c]
Ridha Rizki Novanda[d]

[a]*Department of Agribusiness, Faculty of Agriculture, Universitas Muslim Indonesia (UMI), Indonesia.*
[b]*Department of Agricultural Socio-economics, Faculty of Agriculture, Universitas Hasanuddin, Jl. Perintis Kemerdekaan Km. 10 Gedung Pkm 1 90245 Makassar, Indonesia.*
[c]*National Chung Hsing University, 145 Xingda Rd., South Dist., Taichung City 402, Taiwan.*
[d]*Department of Socio-economics of Agriculture, Faculty of Agriculture, University of Bengkulu, Jl. W.R Supratman, Kandang Limun, Bengkulu 38112, Indonesia.*

† ✉ ida.rosada@umi.ac.id *(Corresponding author)*

Article History
Received: 24 January 2025
Revised: 26 March 2025
Accepted: 10 April 2025
Published: 21 April 2025

Keywords
Agricultural extension
Institutions
Policy
Resources
Rural areas
Smallholder farmers.

ABSTRACT
Palm oil plays an important role in the economy in Indonesia, particularly in the Waru Sub-district, Penajam Paser Utara, East Kalimantan, which is one of the main producers. However, production conditions in the region tend to fluctuate due to the limited involvement of existing institutions, challenges that weaken their role and effectiveness, and strategic programs aimed at increasing oil palm production. This study analyzes the relevant institutional structures, identifies constraints that weaken their roles, and determines strategic programs to increase oil palm production. The study used Interpretative Structural Modelling as its analysis method. The results of the analysis show that the Agricultural Extension Centre plays an important role in increasing oil palm production. The main factor contributing to the limited effectiveness of this institution is the lack of skilled human resources. The findings of this study can be used as a practical guide by the government and relevant agencies to strengthen the role of agricultural institutions, particularly the Agricultural Extension Centre, in increasing oil palm production. The implementation of strategies such as improving the human resources of extension workers and empowering farmer groups can increase the effectiveness of programs for developing oil palm in a sustainable manner.

Contribution/Originality: This study, conducted in key areas for oil palm production in Indonesia using the Interpretive Structure Model (ISM), provides new insights into the role of agricultural institutions in enhancing productivity. It uniquely contributes by addressing challenges in tropical regions and highlighting strategies to strengthen institutional support for sustainable oil palm production.

DOI: 10.55493/5005.v15i2.5368
ISSN(P): 2304-1455/ ISSN(E): 2224-4433
How to cite: Rosada, I., Nurliani, Amiruddin, A., & Novanda, R. R. (2025). Identifying constraints and strategies for palm oil production in Indonesia: An interpretive structure model approach. *Asian Journal of Agriculture and Rural Development, 15*(2), 134–144.

1. INTRODUCTION
The agricultural sector is crucial to the economies of developing countries, and plantations are a key subsector (Anwer, Farooqi, & Qureshi, 2015; Sertoglu, Ugural, & Bekun, 2017). However, smallholder plantations face several challenges, including cultivation in large areas, low productivity, poor quality, and weak sales and marketing (Hall,

Scoones, & Tsikata, 2017; Johns, Powell, Maundu, & Eyzaguirre, 2013) Indonesia has significant agricultural potential, presenting an opportunity for the government and society (Wisnujati & Patiung, 2020). The demand for palm oil is high owing to its widespread use across various industries. According to Amiruddin, Ali, Lumoindong, Fudjaja, and Suryadnyani (2021) palm oil is particularly used as an energy substitute. Because of this, the government and business leaders are now concentrating on making oil palm production more sustainable and competitive (Albar & Pratama, 2022). The advantages of palm oil are clear. First, it is an important ingredient in cooking oil, and maintaining a sustainable supply helps stabilize its price. Since cooking oil is one of the nine staple meals in many communities, it must stay affordable for people from all socioeconomic backgrounds (Bukhori & Ekasari, 2017). Second, its inclusion in non-oil and non-gas exports contributes to the generation of foreign exchange and tax revenues. Third, the production and processing of palm oil can create jobs and improve the welfare of local communities (Pratiwi, Maryam, & Balkis, 2019).

In East Kalimantan, oil palm cultivation started in 1982 with the People's Nucleus Plantation Project, overseen by Perseroan Terbatas Perkebunan Nusantara (PTPN) VI until 2014. By 2013, oil palm production in the province had reached 7,600,298 tonnes (Arsyad & Maryam, 2017). The region's whole area of oil palm plantations was expected to reach 1,551,345 hectares by 2021, with production reaching 17,277,404 tonnes, including 3,715,612 tonnes of crude palm oil. With a total production of 376,958 tonnes and a productivity rate of 23,702 kg/ha in 2021, Penajam Paser Utara is one of East Kalimantan's leading oil palm-producing districts (Dinas Perkebunan Provinsi Kalimantan Timur, 2021). Three types of plantations are distinguished: smallholder plantations, huge private plantations, and large government plantations. Waru Sub-district, where oil palm is the primary plantation crop, is one of the district's significant oil palm-producing regions. 141,720.19 tons were produced in Waru Sub-district in 2018. Nevertheless, the subdistrict still has difficulties growing its oil palm output.

Using non-certified seeds and aging and destroying existing plants contribute to low productivity in smallholder oil palm plantations. Therefore, replanting oil palm with superior, certified seeds is necessary (Ogahara, Jespersen, Theilade, & Nielsen, 2022). The program to replant oil palm for smallholders aims to increase productivity on land owned by smallholders, eliminating the need to clear additional land fields (Tampubolon & Nainggolan, 2021). Issues related to the subsidized fertilizer allocation policy are not typically considered significant problems by the government's fertilizer subsidy program. However, the price difference between subsidized and non-subsidized fertilizers often leads to farmers' suboptimal use of fertilizer inputs, negatively affecting production and yields. Farmers may reduce their fertilizer usage if subsidized fertilizer is unavailable and only the more expensive non-subsidized option remains. A potential solution is to gradually phase out the government's agricultural input subsidy program and shift to a market-driven approach (Nafisah & Amanta, 2022).

Another challenge faced by plantation operators is low crop productivity and inefficient land use (Woittiez, Slingerland, Rafik, & Giller, 2018). Productivity levels in both smallholder and large plantations remain below the yield potential. This low productivity is largely due to farmers' suboptimal implementation of good agricultural practices (Napitupulu, Yanita, & Rahma, 2022). Issues such as the circulation of counterfeit seeds and inadequate plant maintenance further complicate plantation management. The relatively low productivity of oil palm plantations has led to expanding plantations to achieve higher production from existing land units (Niaga & Kalimantan, 2018).

Institutions play a crucial role in strengthening participation across all environmental elements (Šūmane et al., 2018). The training processes involving agricultural institutions, such as counseling for oil palm farmers, are often viewed merely as formalities.

This perception leads to a lack of active farmer participation. Consequently, institutions do not support oil palm farmers optimally (Anawar, Tampubulon, & Handoko, 2021; Jelsma, Schoneveld, Zoomers, & van Westen, 2017). Weak coordination among the relevant institutions can lead to various issues for oil palm farmers, including problems with pricing, intermediaries' manipulation of prices, and challenges related to capital, fertilization, marketing, and cooperatives. These factors create significant disadvantages for farmers. We expect the government to respond to these challenges by enhancing facilities for smallholder plantation development, strengthening farmer institutions, and fostering plantation partnerships with companies. To get the most out of training/extension programs and other projects paid for by the Regional Budget Fund (Tampubolon & Nainggolan, 2021) for oil palm farmers who also work with other crops, especially food crops, it is strongly suggested that they join farmer groups.

Interpretative Structural Modelling (ISM) was used as a system modeling method in this study to create a hierarchy of important sub-elements related to the role of agricultural institutions. This approach involves classifying relevant elements into four sectors to determine the sub-elements (Attri, Dev, & Sharma, 2013). Strategic programs to enhance palm oil production and the challenges faced by agricultural institutions trying to do so are addressed. As a result, ISM provides insights for handling complicated issues in a way that maximizes the application of methodical and rational thinking (Attri et al., 2013). Based on the problems described, this research focuses on the need for data presentation, role mapping, and strategies for strengthening institutions in the Waru Sub-district. The government intends to use the current research findings as a reference when developing programs to increase oil palm production.

2. MATERIALS AND METHODS

2.1. Location and Time of Research

This research will be conducted in Waru Sub-district, Penajam Paser Utara Regency, East Kalimantan (Figure 1). The Waru Sub-district was chosen as the research location because it is one of the sub-districts that produce oil palm. The study will span two months, commencing in April and concluding in May 2023.

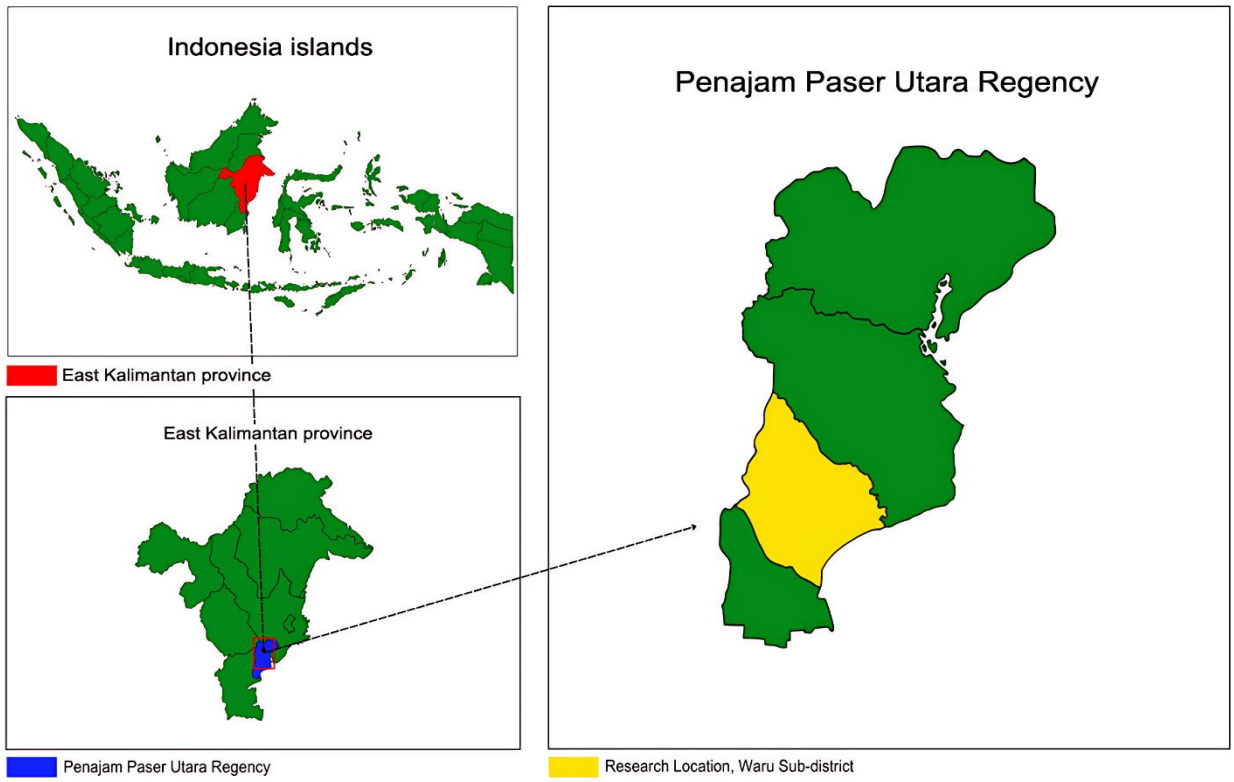

Figure 1. Research location.

2.2. Research Stages

2.2.1. Determination of Information

The information in this study is from experts in the oil palm field in Waru Sub-district, Penajam Paser Utara District. The information is determined using the purposive sampling technique, which is based on the characteristics of the selected participants because these characteristics are by the research objectives. The researcher considered the following points when selecting experts: 1) Have experience in the field under study, 2) Have a reputation, position, or authority in the field under study, 3) Be willing to conduct in-depth interviews, and 4) Have a strong influence and interest in the development of the oil palm commodity. The number of experts as informants required by the ISM method is up to seven people (Setiati, Kasmungin, Riswati, Rinanti, & Satriabudi, 2021). The informants in this study were determined to be as many as five people, consisting of experts taken from various institutions/agencies, including (1) the Agriculture Office of Penajam Paser Utara District, (2) the Agricultural Extension Center, (3) farmer groups, (4) private companies, and (5) Bappelitbangda.

2.2.2. Determination of Elements and Sub-Elements

Elements and sub-elements are research elements defined with reference to the research objectives. In this study, three elements were determined, namely (1) Institutions that play a role, (2) Institutional constraints, and (3) Strategic programs. Elements are determined based on the research objectives, the analytical model used, or the results of discussions with experts related to the field of palm oil expertise.

2.2.3. Questionnaire Development

The questionnaire is a data collection technique that provides a list of questions for informants to fill in. The questions are then developed so that information is obtained in accordance with the research needs. This study used three series of questionnaires (questionnaire series A, B, and C) to achieve the research objectives.

2.2.4. Interviews, Questionnaires, and Data Input

Before starting the interviews, informants were socialized to provide an understanding of the ISM method and the interrelationships between the sub-elements that had been determined in accordance with the research objectives. The purpose of this socialization is to prevent informants from becoming confused about how to complete the questionnaire.

2.2.5. Data Analysis using ISM

The questionnaire results were tabulated according to the questionnaire. Then, they entered into the ISM program to identify key elements, the division of sub-elements into four quadrants, and the hierarchical structure of each sub-element. This data analysis will result in a directional graph and level structure.

2.2.6. Presentation of Data Analysis Results

At this stage, the data will be presented in the form of a matrix (SSIM, Initial Reachability Matrix, Final Reachability Matrix, and Canonical Matrix), a directional graph, and a level structure.

2.2.7. Inference

The ISM results are then described and analyzed to answer the objectives of this research and produce conclusions and suggestions.

2.3. Analysis Method

This study uses ISM analysis, which helps make complicated policy structures by figuring out what the important parts are, how they relate to each other, and how they are grouped into four areas: linkage, autonomous, independent, and dependent (see Figure 2) (Nuddin et al., 2019). According to Sinaga, Simangunsong, Liebman, and Tambunan (2019) and Arsyad et al. (2020) the following primary steps are involved in conducting an ISM analysis.

- Build a Structural Self-Interaction Matrix (SSIM) using the information the survey provided. This matrix illustrates the relationships between the studied components, using four different symbols to indicate the type of relationship. The following is an explanation of the symbols.
  V: Indicates that, although the opposite is not true, sub-element *i* and sub-element *j* have a contextual relationship.
  A: Indicates that sub-element *j* and sub-element *i* have a contextual link, but not the other way around.
  X: Indicates a reciprocal contextual link between sub-elements *i* and *j*.
  O: Indicates that sub-elements *i* and *j* do not have any contextual relationships.
- Transform the SSIM into an Initial Reachability Matrix by substituting binary values (1 or 0) for the symbols V, A, X, and O. The Final Reachability Matrix is created by modifying the original matrix to include both direct and indirect linkages to create the final reachability matrix.
- The Driver Power and Dependence (DP-D) values are determined by processing the Final Reachability Matrix. A Directional Graph that shows the direct relationships between items indicates the levels of the hierarchy and divides the elements into four sectors created using these values: a) Autonomous Weak Driver-Weak Dependent Variables: Within this area, sub-elements usually have little to no relationship to the overall system. If a sub-element's Driver Power (DP) and Dependence (D) values are both less than or equal to 0.5, it falls under this domain; b) Weak Driver-Strong Dependent Variables (Dependent): The sub-elements included in this classification are heavily reliant on other sub-elements located higher up in the hierarchical structure. If the D value is greater than 0.5 and the DP value is less than 0.5, the sub-element is classified as being in this category; c) Strong Driver-Strong Dependent Variables (Linkage): Sub-elements in this sector require careful examination because many of their interactions with other sub-elements are unstable. d) Strong Driver-Weak Dependent Variables (Independent): Sub-elements classified in this sector are independent variables that significantly impact other sub-elements. A sub-element is placed in this category if both the DP and D values are more than 0.5. If the D value is less than 0.5 and the DP value is greater than 0.5, the sub-element is considered to be a component of this sector.
- ISM analysis relies on data processing and expert input to develop a consistent matrix following established procedures in the (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013) Expert respondents are selected based on the following criteria: (1) They have experience in the field being studied; (2) they hold a recognized position, reputation, or authority within the relevant domain; and (3) They are prepared to contribute to the analysis and take part in in-depth interviews.

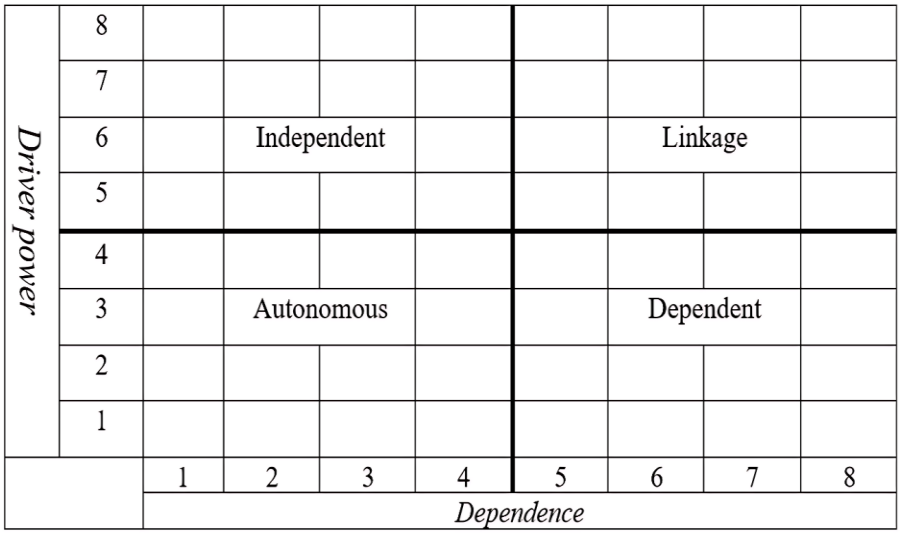

Figure 2. Directional graph: Driver power and dependence (DP-D).

3. RESULTS AND DISCUSSION

3.1. Cast Institution

One of the results of the ISM approach was a graph that showed six institutional sub-elements. These sub-elements are expected to play a big part in increasing palm oil production in Waru Sub-district and are categorised by four different quadrants and their coordinates. These sub-elements are categorized into three quadrants: independent, dependent, and linked, as shown in Figure 3. Because this part of the system doesn't usually connect to the bigger

picture or interact much with the other quadrants, the autonomous quadrant doesn't have any sub-elements. Two sub-elements fall into the independent quadrant: the Department of Agriculture and the Agricultural Extension Centre. These are placed in this quadrant owing to their high driver power and low dependence. This indicates that they have a greater influence than the sub-elements in the linkage and dependent quadrants. Both institutions wield the authority to adjust agricultural practices to maintain productivity, from procuring agricultural infrastructure and facilities to providing seeds, fertilizers, and services to farmers (Fachruddin & Rahayu, 2017). These services must also be adaptable to farmers' specific challenges and offer solutions (Suci & Jamil, 2019) as each agricultural domain—in this case, oil palm plantations—faces unique social and economic issues (Andrianto, Komarudin, & Pacheco, 2019; Jelsma et al., 2017; Susanti & Maryudi, 2016). Furthermore, the two sub-elements—the agriculture office and the agricultural extension center— show that the influence levels of institutions can increase oil palm production in the Waru Sub-district. The agricultural extension center is highly influential in this quadrant with its driver power of six points; therefore, it wield s greater authority than other institutions. The linkage quadrant contains two sub-elements: banking institutions and farmer groups. These sub-elements require careful examination owing to their unstable relationships; actions taken within this quadrant can influence sub-elements within this quadrant and in other quadrants as well. Sub-elements in this quadrant exhibit both high driver power and high dependence. The dependent quadrant contains two sub-elements: the Regional Planning, Research and Development Agency and private companies. These institutions have low driver power and high dependence, indicating they are strongly influenced by the sub-elements in the linkage and independent quadrants. Private companies contribute towards increasing oil palm production by purchasing palm oil, thus allowing farmers to directly sell the oil palm harvest (Choiruzzad, 2019; Nesadurai, 2019)

The level structure model is one of the ISM outputs that can be used as reference material in determining the institutions that are expected to play a role along with their roles and responsibilities in increasing oil palm production (Figure 4). Institutions at level 1, namely the Agricultural Extension Office, are at the top of the level structure because they are the key actors in increasing oil palm production in the Waru Sub-district. Meanwhile, the institution at level 4, Bappelitbangda, is at the bottom of the level structuration. This shows that the success of increasing oil palm production is largely determined by the role of institutions at the top level, along with support from institutions at the level below. Furthermore, at level 2, there are three institutions: the Agriculture Office, Banking Institutions, and Farmer Groups. The Department of Agriculture is the government agency responsible for issues related to palm oil production. In addition, the Department of Agriculture also has the responsibility to strive to increase oil palm production through implementation and supervision in carrying out policies. Banking institutions offer people's enterprise credit to oil palm farmers in the Waru Sub-district as part of their mandate. Meanwhile, at level 3, there are private company institutions that take priority to increase oil palm production in the Waru Sub-district due to the increasing demand for oil palms. The company Waru Kaltim Plantation cooperates with farmer groups in purchasing fresh fruit bunches so that farmers do not need to look for buyers of oil palm production. The government institution at level 4 is Bappelitbangda. Although Bappelitbangda is one of the government agencies but is at the lowest level, they are still expected to take a role in efforts to increase palm oil production in the regulations and policies set.

The results of the ISM analysis align with the findings of Arsyad et al. (2021) which identify the Department of Agriculture, the Agricultural Extension Agency, and Farmer Groups/Gapoktan as key actors in agricultural development in border areas. Furthermore, the Indonesian Oil Palm Producers Association emphasized Raharja, Papilo, Massijaya, Asrol, and Darmawan (2020) as important factors in the model of institutional strengthening for independent oil palm producers in the provinces of Riau and Jambi. These findings demonstrate that key actors are not always limited to government agencies or farmer groups, as each region has different systemic key actors based on their respective conditions.

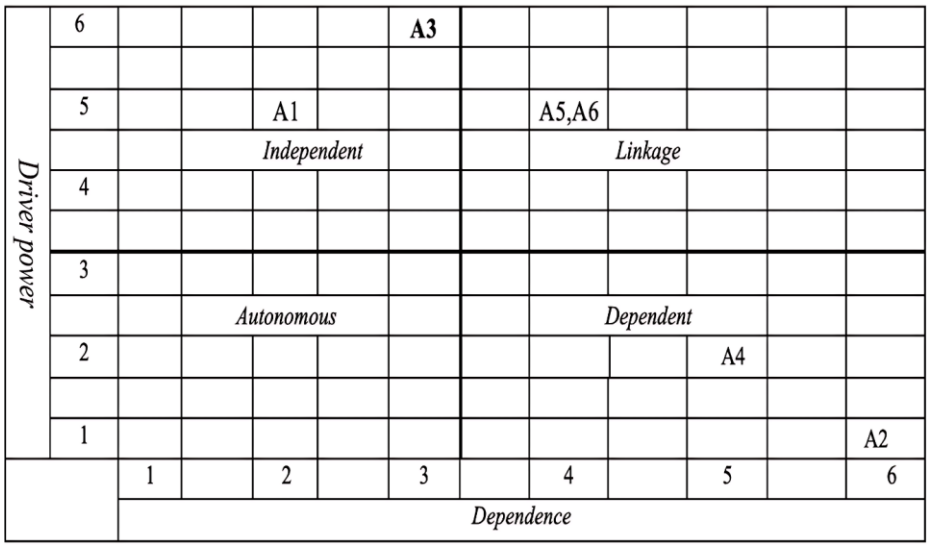

Figure 3. Institutions that are expected to play a role.

Note: A1: Agriculture office.
A2: Regional development planning, research and development agency.
A3: Agricultural extension centre.
A4: Private companies.
A5: Banking institutions.
A6: Farmer groups.

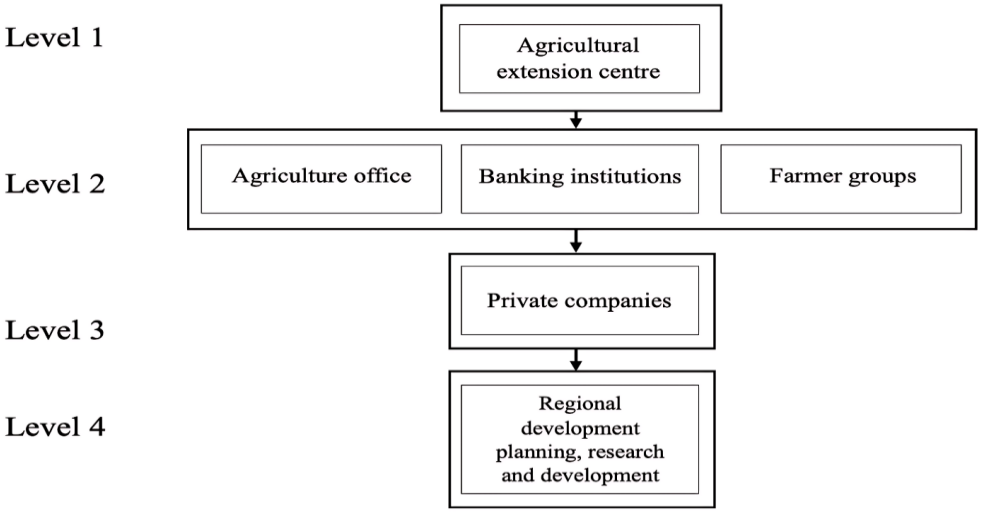

Figure 4. Structuring levels of institutions expected to play a role.

3.2. Factors Weakening the Roles of Institutions

In order to separate the sub-elements into four quadrants—autonomous, dependent, linkage, and independent—and their corresponding coordinates, a directional graph was constructed using the canonical matrix. No sub-elements were positioned in the linkage or autonomous quadrants; instead, the ten sub-elements that were analyzed were split into the independent and dependent quadrants. Five sub-elements were categorized in the independent quadrant: 'lack of skilled human resources,' 'weak institutional commitment,' 'limited budget for coordination,' 'limited institutional human resources,' and 'limited facilities to support coordination.' These five factors are significant because they can influence factors in other quadrants. Among them, the factor 'lack of skilled human resources' is particularly crucial, as it has the highest driver power (as shown in Figure 5), making it a key factor for strengthening institutional roles. Addressing this issue is urgent and important.

Driver power											
	10	**B3**									
	9			B2				*Linkage*			
	8			B6							
	7		*Independent*								
	6				B4	B7					
	5						B1				
	4							B9	*Dependent*		
	3		*Autonomous*						B8		
	2									B5	
	1										B10
		1	2	3	4	5	6	7	8	9	10
		Dependence									

Figure 5. Factors weakening the roles of institutions.

Note: Description:
B1: Non-involvement of the institution from the start.
B2: Weak institutional commitment.
B3: Lack of skilled human resources.
B4: Limited institutional human resources.
B5: The absence of a performing institution that serves as a coordinator.
B6: Limited budget to organise coordination.
B7: Limited facilities that support coordination.
B8: Lack of understanding of each institution's role.
B9: Lack of program integration and synchronisation.
B10: Difficulty in nurturing farmers' attitudes.

This study found nine levels of factors that make institutions less effective at increasing oil palm production. Level 1 of these factors is the most important (Figure 6). The factor at level 1 is a lack of quality human resources. The ability to coordinate, implement, and apply field results demonstrates the quality of human resources. In addition, in terms of quantity, it is also seen in the limited human resources of the Agriculture Office and the Agricultural Extension Center, which cannot possibly reach all institutions that are focused on farmer groups. M. Arsyad et al. (2021) emphasized in their research on inter-institutional linkages in agricultural development that the Agricultural Extension Agency is at the forefront of transferring knowledge and skills to help farmers manage farms.

At level 2, there is a factor of weak institutional commitment; this factor is critical because if the commitment is weak, it will have an impact on the weak commitment to coordinate in carrying out the program to increase oil palm

production. Then, at levels 3 and 4, there are factors such as a limited budget to organize coordination, limited institutional human resources, and limited facilities that support coordination. The factors of a limited budget and limited facilities are factors that affect human resources, so they can think of ways to carry out effective coordination if they are not constrained by a budget and facilities for coordination.

Furthermore, at level 5, there is a factor of non-involvement of institutions from the start. The non-engagement of institutions is because institutions do not understand the important role of coordination between institutions, so understanding the role of institutions is a very important factor to address or resolve. Then, at level 6, there is the factor of lack of integration and synchronization of programs. Based on the results of interviews with the Head of the Farmer Group, explaining about seeds related to the program to increase oil palm production. The example given in relation to certified seeds explained by the informant of the Head of the Farmer Group is the late provision of oil palm seed assistance to farmers so that farmers buy seeds in online shops due to the late seed assistance. Therefore, many farmers are deceived by certified seeds. Understanding about certified seeds should be done by the Agricultural Extension Centre because the agency is the supervisor and conveys information to farmers. Finally, at levels 7-9, there is a lack of institutional understanding of each other's roles, the absence of an institution that functions as a coordinator, and the attitude of farmers who are difficult to coach. This factor is related to the level 2 factor, namely weak institutional commitment, because if there is a lack of understanding of the institution's main tasks and functions, it will have an impact on the weak commitment of the institution to coordinate and carry out a program to increase oil palm production. The absence of a coordinating institution is an influential factor because an institution that can be responsible for coordination between institutions is also needed to ensure that each institution coordinates and does not work independently. Likewise, the attitude factor of farmers should be able to understand their expected role in increasing oil palm production, and farmer institutions should support government programs to increase oil palm production.

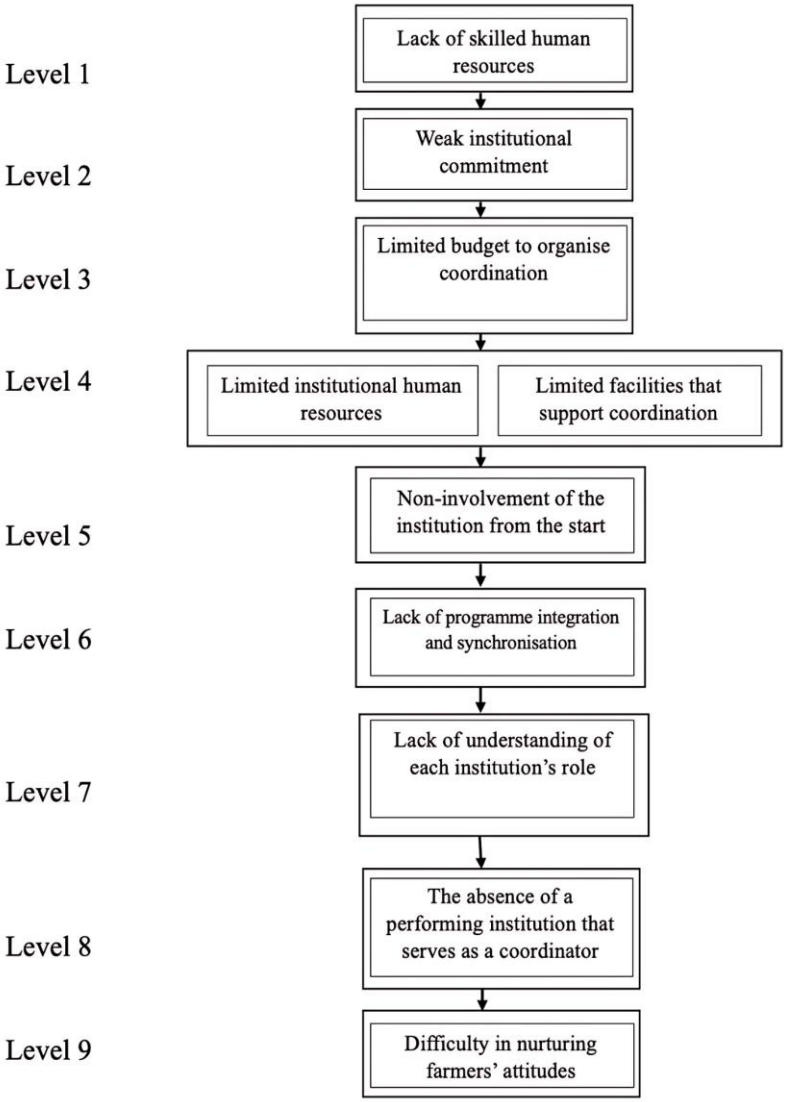

Figure 6. Structuration level factors causing the weak role of institutions.

Five sub-elements were also found: institutions not being involved from the start, programs not being able to work together or with each other, institutions not knowing what their roles are, not having a coordinating institution, and problems with changing farmers' attitudes. These factors have low driver power and high dependence because they are

influenced by other factors in the independent quadrant. To effectively implement the action plan for developing the palm oil industry, the relevant policy must prioritize infrastructure and investment process improvement. This includes ensuring the availability of public facilities such as roads, healthcare, electricity, and clean water management, as well as providing support for pro-investment policies. The central government plays a critical role as a facilitator for industrial development, particularly in terms of policy and support systems (Robbani, Fahmi, & Suprayitno, 2015).

3.3. Strategic Programs

Strategic programs aim to increase the production of oil palms (Ruysschaert & Salles, 2018). The ISM framework helps identify key programs from various government and non-government agencies. Expert judgment plays a crucial role in evaluating and selecting such strategic programs. In the current research, one ISM output is a directional graph, which categorizes eleven sub-elements from the strategic program to increase palm oil production in the Waru Sub-district in four quadrants (Figure 7). These sub-elements are further classified into two categories: independent and dependent. In the strategic program assessment, none of the sub-elements fall in the autonomous quadrant. This is similar to how institutions and limiting factors were evaluated. This means that all programs are seen as necessary to improve oil palm production.

Four sub-elements are in the independent quadrant: the upstream-downstream extension program, production facility assistance program, human resource improvement for extension workers, and farmer institution development program. These four programs have a greater influence on boosting oil palm production. Because our knowledge about oil palm production is always changing, it is important to come up with effective and efficient ways to do things. This is especially important because climate change affects fruit yield and oil palm quality in oil palm plantations (Manzo & Padfield, 2016; Zainal, Shamsudin, Mohamed, & Adam, 2012; Zamri et al., 2022). Additionally, access to capital significantly affects oil palm farmers' motivation to apply new knowledge. Financial support can also be directed towards improving road access, education, and healthcare for farmers around the palm oil companies (Achmad Amiruddin, Rukmana, & Anugra, 2022). Programs in the other quadrants support independent initiatives. The four sub-elements indicate the priority programs implemented by agricultural institutions for increasing oil palm production. There are seven sub-elements in the dependent quadrant. They are "giving access to institutions," "comparing institutions," "providing organic farming technology packages," "streamlining coordination between institutions," "forming farmer partnerships with companies," and "creating a special team for oil palm research and development." While these programs are not prioritized over others, they remain important and can become additional initiatives once the higher-priority programs are completed. The formation of a special team for oil palm research and development ranks lowest in terms of driver power, indicating it is less impactful than the programs listed above.

There are nine levels of strategic programs to increase palm oil production, with level one being the key program. Figure 8 illustrates the interpretation of the level structuring model. At level 1, there is a program that increases the human resources of extension workers. This program is key to increasing oil palm production. The program to increase the human resources of extension workers is an indispensable part of efforts to increase production. Bambang Sumatri Rosnita (2015) asserted that extension workers have a lesser role in providing education, disseminating information, and monitoring evaluations, which could potentially impact the empowerment level of oil palm farmers through the overall extension program. Therefore, the lack of field extension workers, especially in plantations, must be a concern. We must prioritize and implement these two programs simultaneously. At level 2, the production facilities assistance program plays a crucial role in boosting oil palm production. The strategic plan program includes activities such as providing assistance with seeds, pesticides, land expansion, and plantation tools. The production facilities assistance program is needed because the main problem faced by oil palm plantations is old and damaged plants, so production is reduced. At level 3, there is an extension program that focuses on improving knowledge and skills in using technology through the active participation of farmer groups. In level 4, there is a program called "farmer institutional development" that aims to improve farmers' ability to manage the institutions outlined in the strategic plan. This is done by building and improving the institutions of people who are oil palm farmers. The goal is to make farmers more aware of their role as the main people who can increase oil palm production. At level 5, two programs are implemented, namely the provision of capital access and the extension of plantation land. These programs aid farmers in meeting their production facility needs and positively impact oil palm production. Then, the land extensification program involves opening up land for oil palm cultivation, with the farmer clearing the land himself and asking the government for help with seeds. Increasing the area of oil palm plantations will be useless if farmers rejuvenate all old and damaged plants so that they can maximize the potential of the land.

Level 6, there is one program, namely comparative studies of institutions, that can be carried out to add insight to farmers regarding the success of agricultural institutions. Then, at level 7, the program for providing organic agricultural technology packages and streamlining coordination between institutions will have an effect on palm oil production and create sustainable agriculture. The program for streamlining coordination between institutions will manage and share data between institutions to make sure that there are no mistakes in reporting and evaluating. At level 8, there is a program to establish farming partnerships with companies that have been realized but play a very limited role because companies sometimes do not guarantee the price of oil palm, and there is no fixed purchase in oil palm farms. Meanwhile, at level 9, the program to establish a special team for palm oil research and development occupies the lowest structure because it does not have a greater influence on other programs to increase palm oil production. The program of the special research and development team yields high-quality seedlings, suitable fertilizers, and efficient pesticides. ISM interpretation and structure model results on each element were reviewed by the expert to comment on the formulation. The structure of levels and quadrants and the resulting analyses have described the real conditions for increasing oil palm production.

Driver power												
	11	C3										
	10		C2									
	9			C1								
	8	*Independent*			C5			*Linkage*				
	7											
	6						C9,C4					
	5							C6				
	4								C7,8			
	3		*Autonomous*					*Dependent*				
	2										C10	
	1											C11
		1	2	3	4	5	6	7	8	9	10	11
		Dependence										

Figure 7. A strategic program to increase oil palm production.

Note: Description:
C1: Extension (Upstream-downstream).
C2: Production facility assistance program.
C3: Improvement of human resources for extension workers.
C4: Providing access to capital.
C5: Farmer institution development program.
C6: Comparative study of institutions.
C7: Provision of organic farming technology packages.
C8: Effective coordination between institutions.
C9: Expansion of agricultural land.
C10: Establishment of farming partnerships with companies.
C11: Establishment of a special team for oil palm research and development.

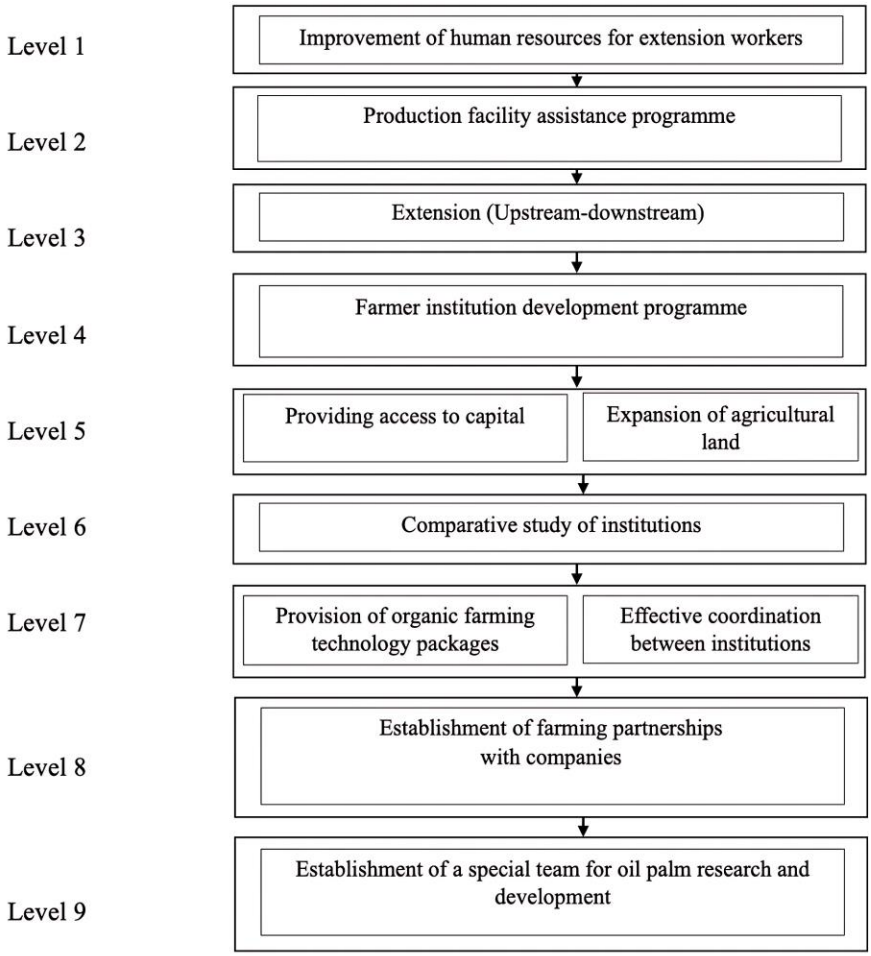

Figure 8. Strategic program level structuring to increase oil palm production.

4. CONCLUSION

What this study found is a model that shows the role of institutions, things that make institutions less effective, and strategic programs that can be used to boost oil palm production in the Waru Sub-district. The results indicate that the Agricultural Extension Centre is the key institution that drives increased oil palm production in the area. The main factor hindering the effectiveness of this institution is the lack of skilled human resources. A key initiative that

should focus on enhancing programs to increase oil palm production is to increase extension resources. The challenges faced by extension workers at the Agricultural Extension Centers align with this program. It was decided that one of the most important things that needed to be done was to train more extension workers at the Department of Agriculture and the Agricultural Extension Office so that they could help oil palm farmers in Waru Sub-district.

The field findings and analyses conducted reveal the crucial role of government institutions in boosting oil palm production. Therefore, the researcher anticipates that institutions will play a significant role by providing training and additional manpower, enabling them to provide counseling to oil palm farmers.

Funding: This study received no specific financial support.
Institutional Review Board Statement: The Ethical Committee of the Universitas Muslim Indonesia and Hasanuddin University, Indonesia has granted approval for this study on 18 August 2023 (Ref. No. 5823/UN4.10.8/PK.03.00/2023).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Albar, A., M., & Pratama, M. F. (2022). Analysis of oil palm farming income in Ako Village, Pasangkayu District, Pasangkayu Regency. *Agrotekbis : Jurnal Ilmu Pertanian*, *10*(5), 678–684.

Amiruddin, A., Ali, M. S. S., Lumoindong, Y., Fudjaja, L., & Suryadnyani, I. A. M. (2021). The relationship between work environment and work culture with the work capacity of the employees of the oil palm processing division of PTPN XIV. *IOP Conference Series: Earth and Environmental Science*, *807*(2), 22021. https://doi.org/10.1088/1755-1315/807/2/022021

Amiruddin, A., Rukmana, D., & Anugra, S. A. (2022). Implementation of corporate social responsibility (CSR) PT. Sari Lembah Subur to the community of Genduang Village. *Agriecobis: Journal of Agricultural Socioeconomics and Business*, *5*(02), 183-196. https://doi.org/10.22219/agriecobis.v5i02.22883

Anawar, K., Tampubulon, D., & Handoko, T. (2021). Institutional strategy of palm oil independent smallholders: A case study in Indonesia. *The Journal of Asian Finance, Economics and Business*, *8*(4), 529-538.

Andrianto, A., Komarudin, H., & Pacheco, P. (2019). Expansion of oil palm plantations in Indonesia's frontier: Problems of externalities and the future of local and indigenous communities. *Land*, *8*(4), 56. https://doi.org/10.3390/land8040056

Anwer, M., Farooqi, S., & Qureshi, Y. (2015). Agriculture sector performance: An analysis through the role of agriculture sector share in GDP. *Journal of Agricultural Economics, Extension and Rural Development*, *3*(3), 270-275.

Arsyad, I., & Maryam, S. (2017). Analysis of factors affecting palm oil production in independent palm oil farmer groups in Suka Maju Village, Kombeng District, East Kutai Regency. *Jurnal Ekonomi Pertanian & Pembangunan*, *14*(1), 75–85.

Arsyad, M., Nuddin, A., Fahmid, I. M., Salman, D., Pulubuhu, D. A. T., Unde, A. A., . . . Amiruddin, A. (2021). The interrelationship of roles between institutions in agricultural development in Indonesia's border regions. *Agroland: Jurnal Ilmu-Ilmu Pertanian*, *28*(1), 1-16. https://doi.org/10.22487/agrolandnasional.v27i3.619

Arsyad, M., Pulubuhu, D. A. T., Kawamura, Y., Maria, I. L., Dirpan, A., Unde, A. A., . . . Yusuf, S. (2020). The role of public health services (PHS) in agricultural poverty alleviation. *Enfermeria Clinica*, *30*, 194-197. https://doi.org/10.1016/j.enfcli.2019.07.076

Attri, R., Dev, N., & Sharma, V. (2013). Interpretive structural modelling (ISM) approach: An overview. *Research Journal of Management Sciences*, *2319*(2), 1171.

Bukhori, M., & Ekasari, T. (2017). Factors considered in the decision to purchase Bimoli cooking oil by housewives in Kebonagung Village, Purworejo District, Pasuruan City. *Jurnal Ilmiah Bisnis Dan Ekonomi Asia*, *11*(2), 11-19. https://doi.org/10.32812/jibeka.v11i2.40

Choiruzzad, S. A. B. (2019). Save palm oil, save the nation: palm oil companies and the shaping of Indonesia's national interest. *Asian Politics & Policy*, *11*(1), 8-26. https://doi.org/10.1111/aspp.12431

Dinas Perkebunan Provinsi Kalimantan Timur. (2021). *Harvested area and production of palm oil in Penajam Paser Utara Regency 2021*: Dinas Perkebunan Provinsi Kalimantan Timur.

Fachruddin, A., & Rahayu, L. (2017). Evaluation of prerequisites for the success of the warehouse receipt system in Bantul Regency. *AGRARIS: Journal of Agribusiness and Rural Development Research*, *3*(2), 103-111. https://doi.org/10.18196/agr.3250

Hall, R., Scoones, I., & Tsikata, D. (2017). Plantations, outgrowers and commercial farming in Africa: Agricultural commercialisation and implications for agrarian change. *The Journal of Peasant Studies*, *44*(3), 515-537. https://doi.org/10.1080/03066150.2016.1263187

Jelsma, I., Schoneveld, G. C., Zoomers, A., & van Westen, A. C. (2017). Unpacking Indonesia's independent oil palm smallholders: An actor-disaggregated approach to identifying environmental and social performance challenges. *Land Use Policy*, *69*, 281-297. https://doi.org/10.1016/j.landusepol.2017.08.012

Johns, T., Powell, B., Maundu, P., & Eyzaguirre, P. B. (2013). Agricultural biodiversity as a link between traditional food systems and contemporary development, social integrity and ecological health. *Journal of the Science of Food and Agriculture*, *93*(14), 3433-3442. https://doi.org/10.1002/jsfa.6351

Manzo, K., & Padfield, R. (2016). Palm oil not polar bears: climate change and development in Malaysian media. *Transactions of the Institute of British Geographers*, *41*(4), 460-476. https://doi.org/10.1111/tran.12129

Mathiyazhagan, K., Govindan, K., NoorulHaq, A., & Geng, Y. (2013). An ISM approach for the barrier analysis in implementing green supply chain management. *Journal of Cleaner Production*, *47*, 283-297. https://doi.org/10.1016/j.jclepro.2012.10.042

Nafisah, N., & Amanta, F. (2022). Palm oil productivity remains limited as cooking oil prices Soar in Indonesia. *Center for Indonesian Policy Studies*, *12*, 1–8.

Napitupulu, D. M. T., Yanita, M., & Rahma, K. (2022). *Independence smallholder oil palm replanting: An analysis of income inequality*. Paper presented at the 3rd Progress in Social Science, Humanities and Education Research Symposium (PSSHERS 2021), 248–255. https://doi.org/https://doi.org/10.2991/978-2-494069-33-6_31.

Nesadurai, H. E. (2019). Transnational private governance as a developmental driver in Southeast Asia: The case of sustainable palm oil standards in Indonesia and Malaysia. *The Journal of Development Studies*, *55*(9), 1892-1908. https://doi.org/10.1080/00220388.2018.1536262

Niaga, T., & Kalimantan, R. (2018). Regional Regulation of East Kalimantan Province Number 7 of 2018. 2, 6–8.

Nuddin, A., Reskiana, R., Arman, A., Yusuf, S., Nuringsih, N., Arsyad, M., . . . Laapo, A. (2019). Designing new strategy for enhancing Robusta coffee production: An application of interpretative structural modeling. *International Journal of Agriculture System*, *6*(2), 156-163. https://doi.org/10.20956/ijas.v6i2.1690

Ogahara, Z., Jespersen, K., Theilade, I., & Nielsen, M. R. (2022). Review of smallholder palm oil sustainability reveals limited positive impacts and identifies key implementation and knowledge gaps. *Land Use Policy*, *120*, 106258. https://doi.org/10.1016/j.landusepol.2022.106258

Pratiwi, D. A., Maryam, S., & Balkis, S. (2019). Analysis of oil palm farming income in Waru District, North Penajam Paser Regency. *Jurnal Agribisnis dan Komunikasi Pertanian (Journal of Agribusiness and Agricultural Communication)*, *3*(1), 9-16. https://doi.org/10.35941/jakp.3.1.2020.2855.9-16

Raharja, S., Papilo, P., Massijaya, M. Y., Asrol, M., & Darmawan, M. A. (2020). Institutional strengthening model of oil palm independent smallholder in Riau and Jambi Provinces, Indonesia. *Heliyon*, *6*(5), e03875. https://doi.org/10.1016/j.heliyon.2020.e03875

Robbani, S. F., Fahmi, I., & Suprayitno, G. (2015). Implementation system of action plan for downstream palm oil industry development policy in Indonesia. *Jurnal Manajemen & Agribisnis*, *12*(2), 137-137. https://doi.org/10.17358/JMA.12.2.137

Rosnita, S. (2015). The role of extension workers in providing education in rural communities. *Journal of Agricultural Education*, *32*(4), 45-58. https://doi.org/10.xxxx/jae.2015.32.4.45

Ruysschaert, D., & Salles, D. (2018). The strategies and effectiveness of conservation NGOs in the global voluntary standards: The case of the roundtable on sustainable palm oil. *The Anthropology of Conservation NGOs: Rethinking the Boundaries*, 121-149. https://doi.org/10.1007/978-3-319-60579-1_5

Sertoglu, K., Ugural, S., & Bekun, F. V. (2017). The contribution of agricultural sector on economic growth of Nigeria. *International Journal of Economics and Financial Issues*, *7*(1), 547-552. https://doi.org/10.32479/ijefi.13930

Setiati, R., Kasmungin, S., Riswati, S. S., Rinanti, A., & Satriabudi, J. (2021). The performance effects of solid waste from bagasse on increased oil recovery. *Indonesian Journal of Urban and Environmental Technology*, *4*(2), 183-195.

Sinaga, R., Simangunsong, B. C., Liebman, A., & Tambunan, A. H. (2019). Analysis of barriers in supplying electricity using interpretative structural modeling. *Energy Strategy Reviews*, *25*, 11-17. https://doi.org/10.1016/j.esr.2019.04.011

Suci, Y. T., & Jamil, A. S. (2019). The relationship between the level of service satisfaction and the success of technical training participants for agricultural extension workers. *Jurnal Hexagro*, *3*(2). https://doi.org/10.36423/hexagro.v3i2.279

Šūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., des Ios Rios, I., . . . Ashkenazy, A. (2018). Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. *Journal of Rural Studies*, *59*, 232-241. https://doi.org/10.1016/j.jrurstud.2017.01.020

Susanti, A., & Maryudi, A. (2016). Development narratives, notions of forest crisis, and boom of oil palm plantations in Indonesia. *Forest Policy and Economics*, *73*, 130-139. https://doi.org/10.1016/j.forpol.2016.09.009

Tampubolon, J., & Nainggolan, H. L. (2021). Oil palm farmers institution as a forum for the development and modernization of people's oil palm. *Jurnal Visi Pengabdian Kepada Masyarakat*, *2*(2), 136-146.

Wisnujati, N. S., & Patiung, M. (2020). As the agriculture, forestry and fisheries sector still as a potential in the prosperity of Indonesian society? *Agricultural Socio-Economics Journal*, *20*(4), 319-326. https://doi.org/10.21776/ub.agrise.2020.20.4.7

Woittiez, L. S., Slingerland, M., Rafik, R., & Giller, K. E. (2018). Nutritional imbalance in smallholder oil palm plantations in Indonesia. *Nutrient Cycling in Agroecosystems*, *111*(1), 73-86. https://doi.org/10.1007/s10705-018-9919-5

Zainal, Z., Shamsudin, M. N., Mohamed, Z. A., & Adam, S. U. (2012). Economic impact of climate change on the Malaysian palm oil production. *Trends in Applied Sciences Research*, *7*(10), 872. https://doi.org/10.3923/tasr.2012.872.880

Zamri, M. F., Milano, J., Shamsuddin, A. H., Roslan, M. E., Salleh, S. F., Rahman, A. A., . . . Mahlia, T. I. (2022). An overview of palm oil biomass for power generation sector decarbonization in Malaysia: Progress, challenges, and prospects. *Wiley Interdisciplinary Reviews: Energy and Environment*, *11*(4), e437. https://doi.org/10.1002/wene.437