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Analysis of Obstacles for Mangosteen Agro-industry Revitalization in Karacak Agropolitan Area, Indonesia: An Interpretive Structural Modeling Approach

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ABSTRACT

This study aims to analyze the obstacles for the investment process of mangosteen agro-industry revitalization in Karacak agropolitan area in Bogor Regency using a structural model. This issue was examined through science, technology, engineering, mathematics (STEM) and innovation approach, which were then formulated and analyzed using the Interpretive Structural Modeling (ISM) method. Primary data were collected through expert-based surveys and questionnaires from seven relevant and representative government agencies to formulate policy studies. This study resulted in nine sub-elements of obstacles, which were arranged hierarchically based on their importance level. Then, one key sub-element was identified, namely the political will of local governments towards agro-industrial development incentives and disincentive programs in agropolitan areas. This study recommends that the government initiate a revitalization program for agropolitan areas by focusing on the integrated use of local biological resources from upstream to downstream activities. The adoption of agro-industrial technology in agropolitan areas needs to be aligned with local knowledge and wisdom so that it can be accepted with full awareness and implemented responsibly towards better social and environmental aspects. The structural model approach will facilitate sustainable development in agropolitan areas, encouraging inclusive economic growth and resilience of local communities..

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I. INTRODUCTION

Mangosteen (*Garcinia mangostana* L.) is one of the high value crops (HVC) that has a high export market share and potential derivative products. The HVC category includes various types of fruit, vegetable, ornamental plant, herb, and spice (Temu & Temu, 2005; Bac et al., 2014). These types of HVC will produce high economic value and absorb significant labor if planted and managed on conserved land that includes soil and water conservation (SWC) in the ecosystem (Malisa et al., 2016). Several Indonesia's mangosteen export destination countries include Thailand, Hong Kong, Malaysia, France, the Netherlands, Saudi Arabia, Japan, Taiwan, and Singapore (Yudha & Nugraha, 2022; Narakusuma et al., 2013). In addition to the potential use as fresh fruit, previous studies also revealed that the phytochemical content of mangosteen, namely various types of antioxidant compound, are high enough so that they are very potential to be utilized as raw materials in various industries, such as drug and vaccine.

However, In Indonesia, mangosteen-based agro-industry to produce valuable derivative products has not yet been optimally developed, as many farmers still prefer to export fresh mangosteen fruit. This should be avoided because the export of mangosteen fruit's valuable derivative products plays a major role in increasing Indonesia's foreign exchange and farmers' income (Narakusuma et al., 2013). However, by exporting fresh mangosteen fruit, it will be processed in the destination country into various kinds of food, health, and cosmetic products, then being spread worldwide, including Indonesia being one of its consumers. This means this fresh mangosteen export activity has caused Indonesia to miss out on value-added opportunities. Therefore, integrated management based on local biological resources, including mangosteen, is very urgent to do.

This study explores the potential of local mangosteen through the development and revitalization of an integrated agro-industry in an agropolitan area. The research located in Karacak agropolitan area, Leuwiliang Subdistrict, Bogor Regency, West Java. An important aspect in the development of mangosteen agro-industry is the creation of added value, competitiveness, and sustainability of the mangosteen business ecosystem from upstream to downstream. This is align with the aims of the agropolitan program, namely to encourage the transformation process of rural areas in economic, social, and environmental aspects. Rural transformation includes transformation in the structure of on-farm and off-farm agriculture (Huang, 2018).

Rural transformation initially changed the economic pattern of subsistence agriculture to a more modern and diversified participatory form of agriculture and other economic activities (Rustiadi et al., 2023). The development of mangosteen-based agro-industry is a type of economic transformation in Karacak agropolitan area, as it previously focused on the natural resource management and on-farm agriculture sectors.

In Karacak agropolitan area, mangosteen has been cultivated for generations by the local community. Mangosteen cultivation in this area has its historical chronology, as initially no one planted it, and now it is part of forest biodiversity. Because mangosteen cultivation is sufficient to support the community's economy, this activity is still preserved conventionally through nurseries at the farmers' group level. The majority of mangosteen development is still conducted in the upstream agribusiness sector. Post-harvest mangosteen is conducted by warehouse storing and product marketing, both locally and globally. The processing units of mangosteen derivative products still run on a small scale. Similarly, several locally processed mangosteen products from this area are also still produced on a small scale and are not yet considered sustainable. In addition, the feasibility analysis results revealed that these several products are feasible to develop but are still constrained by the agro-industrial investment process in the region.

There were nine factors identified as obstacles for the revitalization of integrated agro-industrial agropolitan areas, which were then analyzed using the Interpretive Structural Modeling (ISM) method. Primary data were collected through surveys, focus discussion groups (FGD) attended by farmers and local communities, experts, and stakeholders; as well as ISM questionnaire-based interviews. Secondary data were collected by ex-

amining the existing literature, previous research results, activity program reports, and related publications disseminated in Bogor Regency. This study discovered key sub-elements and generate an obstacle structure model, which plays an important role in determining the relevance and importance of each obstacle, which ultimately forms the basis to formulate policies to overcome obstacles for revitalization.

II. ANALYTICAL FRAMEWORK

There are nine obstacle factors that need to be studied for further decision making regarding regional development that is integrated with local agro-industry. The assessment of these obstacles was carried out through a literature study, which was then verified based on the opinions of several experts, local governments, and related stakeholders who were actively involved in policy planning for the development of Karacak agropolitan area. The research framework is presented in Figure 1.

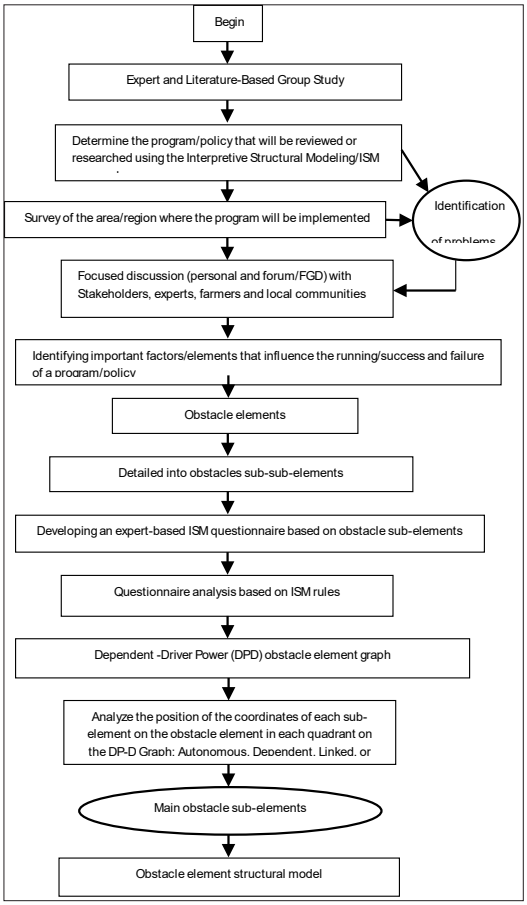

Figure 1. The obstacle structure model of mangosteen agro-industry revitalization in Karacak agropolitan area, Bogor Regency using the ISM method

III. METHODOLOGY

The study was conducted in Karacak agropolitan area, which has the potential for mangosteen gardens as a source of livelihood for the local community. Geographically, this area as a 'Growth Center Village' located in Karacak Village (Figure 2), Leuwiliang Subdistrict, Bogor Regency, at a coordinate position of 106039'00"–106036'00" East Longitude and 06039'00"–06034'30" South Latitude. The agropolitan area program in Bogor Regency is implemented through the establishment of an agropolitan working group with strengthening government policies as a basis for cooperation between the government and the community for the preparation and development of agropolitan areas.

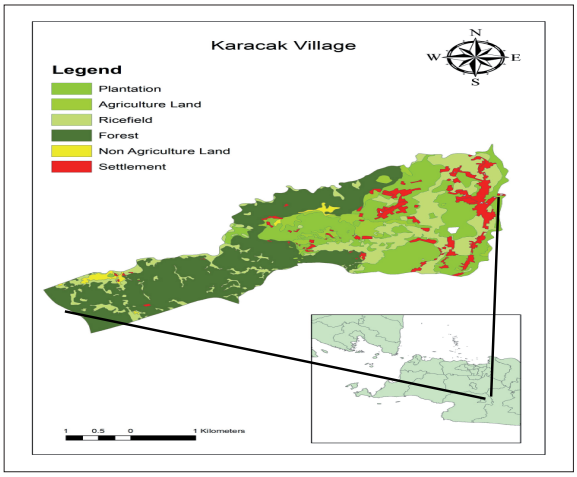

Figure 2. Karacak Village location in Bogor Regency, West Java, Indonesia

The ISM method integrates and categorizes complex experts' opinions into system sub-elements and multilevel structural models (Warfield, 1974; Saxena et al., 1992; Machfud, 2001). The structural elements of obstacles for mangosteen agro-industry revitalization in Karacak agropolitan area were identified using the ISM method, which is displayed in Figure 3.

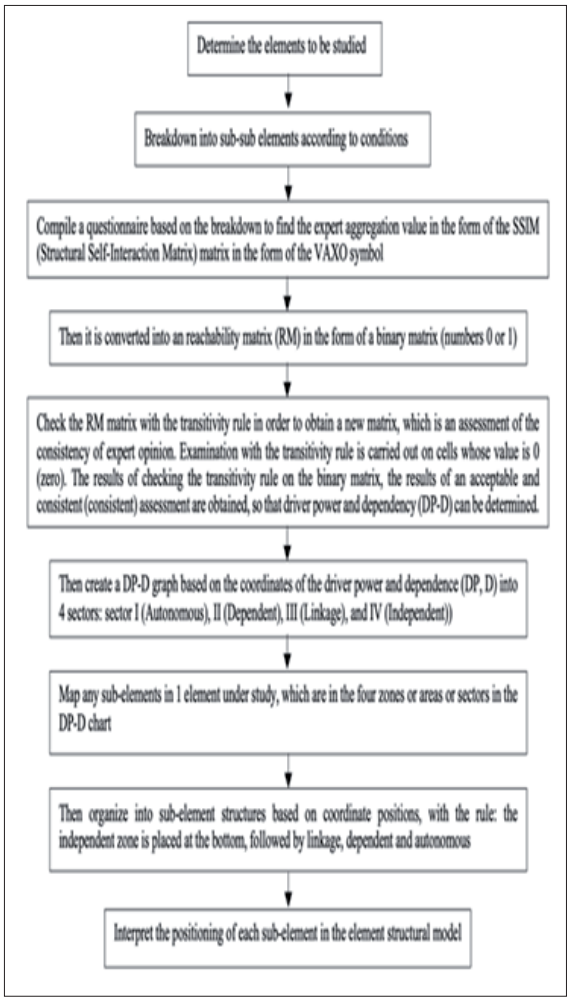

Figure 3. Stages of development of the Karacak agropolitan area revitalization program structure model based on mangosteen agroindustry using the ISM method.

Based on the ISM method, sub-elements with codes A1 to A9 were then compiled into an ISM questionnaire in the form of a paired comparison matrix with symbols V, A, X, or O. This study elaborates the experts' opinions from seven government agencies, namely the Horticulture and Food Crops Office, Environmental Office, Small and Medium Enterprises (SMEs) Cooperative Office, Trade and Industry Office, Regional Planning and Development Agency, and Food Security Office of Bogor Regency; as well as researchers in the fields of economics, policy and regional development at National Research and Innovation Agency, Indonesia.

Issues concerning the obstacles in agricultural development were assessed using the ISM method in previous studies (Lamba & Thareja 2021; Kumar et al., 2021; Vishwakarma et al., 2022; Tuni et al., 2022). In some energy cases, ISM was applied to identify obstacles to the implementation of solar power in thermal power plants and to find contextual relationships between the main obstacles (Nandal et al., 2019), as well as to explore the roots of obstacles and solutions in the development of renewable energy resources (Rezaee et al., 2019).

However, issues concerning the obstacles for the investment process in agricultural development have not been fully examined. Thus, this study interprets the investment obstacles and formulates the solutions to overcome these obstacles so that the Karacak agropolitan area revitalization scheme can be implemented accordingly. Using the ISM method, system elements were evaluated by dividing them into several sub-elements, analyzing their impact on program's success and finding one key sub-element. Then, the score of the most important sub-element was also used as a useful knowledge base for planning the integrated and multi-disciplinary agro-industry development strategies (Machfud, 2001). Structural models adopted in this study aim to capture the complex themes of a system through patterns and sentences designed to interpret contextual relationships among sub-elements (Eriyatno, 2012; Tuni et al., 2022).

IV. RESULTS

A. Utilization of Karacak Mangosteen

The population in Karacak is predominantly Sundanese Javanese and knows mangosteen by the local name 'manggu'. Mangosteen is cultivated for generations by the local community and used as a source of fruit food, while the rest is sold in the local market or exported if it meets the global market criteria. In general, mangosteen commodities at the farmer and collector levels are categorized into three levels of quality (Figure 4), namely super quality (*grade* A), *falcon* quality or medium (grade B), and BS quality (waste goods or *grade* C) (Narakusuma et al., 2013).

Based on Figure 4, the majority of local mangosteens produced by farmers in Karacak are categorized as Grade B and Grade C quality, and make up about 90% of total production. This means these products are considered not feasible

Quality of Mangosteen Fruit	Characteristic	Picture
Super quality (Grade A)	The flesh of the fruit is pure white, the skin of the fruit is clean, and the petals are still green	
Falcon quality (Grade B)	The flesh of the fruit is pure white but slightly pale, the skin of the fruit is slightly rough, and the petals are still green	
BS Quality (Grade C)	The flesh of the fruit is pale white, some are grayish, the skin of the fruit is a lot of blur, and the green petals are slightly brownish	

Figure 4. Quality classification of mangosteen fruit (Kastaman, 2007b)

Figure 5. Local mangosteen (*Garcinia mangostana* L.) cultivated in Karacak agropolitan area

for export, while the rest (about 10%) are considered feasible. This is thought to be due to the inability to meet global market criteria (Firdaus & Wagiono, 2009; Narakusuma et al., 2013). The opportunity to utilize grade B and C mangosteen for downstream products through agro-industrial activities will have a multiplier impact on the local community and all related parties. The existence of Karacak's local wisdom in the SME-scale downstream activities of mangosteen is reflected through the production of mangosteen 'dodol' and mangosteen syrup (food products), as well as floor-cleaning soap from mangosteen peel extract (non-food products).

Mangosteen in Karacak agropolitan area has been registered under the name 'Manggis Raya', known for exhibiting unique characteristics in terms of taste, aroma, texture, and peel color (Figure 5). There are various use of mangosteen in this area: being directly consumed by the local community, being sold in local markets at fresh condition, being exported through a collection system, and being temporarily processed into SME-scale mangosteen dodol products by women's farmers group at the Karacak Independent Agricultural and Rural Training Center. Women's contribution in these activities is very important, especially in improving agricultural production values and environmental sustainability (Doss et al., 2018).

The potential for sustainable mangosteen production in Karacak is supported by farmers who have carried out mangosteen breeding businesses, such as by establishing 'Karya Mekar' Farmers Group (Figure 6). This potential exist in the form of utilize raw materials for the processing of mangosteen-based products so that this utilization and management of mangosteen can be integrated from upstream to downstream. This study examines science, technology, engineering, mathematics (STEM) and innovation approach regarding mangosteen agro-industry revitalization in Karacak agropolitan area. It is expected from this revitalization that the added value of mangosteen will be beneficial for all related parties in Karacak agropolitan area.

Figure 6. Mangosteen breeding by farmers in Karacak agropolitan area

Mangosteen (*Garcinia mangostana* L.) is one of the tropical agricultural commodities that belongs to the Guttiferae family and is also known as "*the queen of fruits*" because all of its parts are beneficial for health (Yudha & Nugraha, 2022; Iswari & Sudaryono 2007; Kalick et al., 2023). The main constituent of mangosteen peel is α-Mangostin (α-MG), namely a natural xanthone compound that other fruits do not have. This compound is advantageous as anti-cancer, neuro-protective, antimicrobial, antioxidant, anti-inflammatory, and apoptosis benefits (Alam et

al., 2023; Pinto et al., 2023); also, beneficial as anti-odor, antibacterial, blood clotting agent, and wound healing agent (Kibria et al., 2022).

Mangosteen can be processed into various products, such as fruit juice, xanthone juice, fruit syrup, cocktails, xanthones capsules or tablets, dietary supplements, and coloring agents (Kastaman, 2007a). Based on analysis results of local mangosteen in Karacak agropolitan area, several mangosteen derivative products have high economic value, such as capsulated mangosteen peel extract, mangosteen peel nano tea, and mangosteen powder (Oryzanti et al., 2018a; Nugroho et al., 2020). The existing mangosteen products in Karcak agropolitan area have been developed by 'Karya Mekar' Women's Farmers Group and 'Kriya Kita' SME, namely being processed into mangosteen dodol and floor-cleaning soap from mangosteen peel extract (Figure 7). However, the existence of advanced technology, business capital, and marketing constraints causes these SMEs to be less sustainable and therefore unable to compete with the other mangosteen products on the market.

Sources: Research Documentation

Figure 7. The existing mangosteen products in Karacak agropolitan area are still not sustainable compared to several other mangosteen products on the market.

Mangosteen with the high content of xanthone is a raw material for the functional food industry, in which the valuable derivative products from it has not been widely developed domestically, but has already been widely produced abroad. The irony is that the raw material used is fresh mangosteen from Indonesia, which is exported. Whereas, developing mangosteen agro-industry domestically in Indonesia will increase its added values so that the income received is more widely spread in various sectors, such as the labor of mangosteen processing units/SMEs, distributors, farmers, and local communities. Based on the feasibility analysis results on the added value of mangosteen dodol products, namely floor-cleaning soap from mangosteen peel extract, capsulated mangosteen peel extract, mangosteen peel nano tea, mangosteen powder, and mangosteen syrup with local mangosteen raw materials, these products were declared feasible (Table 1).

The results in Table 1 reveal that Karacak's local mangosteen-based processed products are financially feasible and have added value potential. Recently, the existing products developed are mangosteen dodol and floor- cleaning soap from mangosteen peel extract. Several other products, such as capsulated mangosteen peel extract, mangosteen peel nano tea, mangosteen powder, and mangosteen syrup have prospects to be developed. Mangosteen agro-industry as a scheme to increase the business scale of mangosteen-based products requires technological innovation, development projects and financing. The financing component in the business scale-up process is used to assess whether unit costs will increase or decrease as the scale increases (T. Mosquera-Vasquez ´ et al., 2022).

The question is 'how to attract investors to develop mangosteen agro-industry in Karacak agropolitan area?'. Based on previous study by Oryzanti (2019a), there are four elements that influence the mangosteen agro-industry investment process, namely actors, changes, goals, and obstacles (Oryzanti, 2019a). This study focuses on the obstacle element, while the next study will examine the other three elements.

Table 1. The potential feasibility and added value of local mangosteen-based derivative products in Karacak agropolitan area

Investment Criteria	Potential Value of Local Mangosteen Processed Products					
	(1)	(2)	(3)	(4)	(5)	(6)
PBP (Year)	1.03	2.12	0.46	0.75	1.83	2.35
NPV (IDR)	4,914,291,007	2,968,910,412	68,369,956,937	66,829,633	24,970,427	18,348,703
B/C Ratio	1.18	1.11	2.13	1.61	1.50	1.34
IRR (%)	111	47.9	223.4	147.9	151.4	149.1
BEP (IDR)	42,967,849,791	44,310,168,798	60,914,477,799	128,024,404	69,485,104	75,129,281
BEP Unit (Pcs)	1,432,262	2,954,011	870,207	1,828,920	992,644	1,073,275
Net Profit (IDR)	8,595,277,500	5,772,787,200	114,569,200,000	114,385,720	45,093,820	35,513,520
Added Value (IDR/kg)	53,677	13,164	60,601	106,791	33,67	227,916
Feasibility Status	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible

Source: Data analysis (Oryzanti et al., 2019b; Nugroho et al., 2020)

Description:
(1) Mangosteen Dodol
(2) Floor-Cleaning Soap from Mangosteen Peel Extract
(3) Capsulated Mangosteen Peel Extract
(4) Mangosteen Peel Nano Tea
(5) Mangosteen Powder
(6) Mangosteen Syrup

B. Analysis of Obstacles for Mangosteen Agro-industry Revitalization

The agro-industry investment process in agropolitan areas still faces several obstacles. Obstacles can be categorized into internal and external obstacles (de Oliveira et al., 2022). Internal obstacles or institutional factors (mindset, competence, resources, organizational structure) arise within a firm, while external obstacles (education system, availability of specialized human resources, financial system) are caused by external factors and largely cannot be controlled by a firm (Sandberg & Aarikka-Stenroos, 2014; de Oliveira et al., 2022). Several obstacles to the implementation of agriculture 4.0 in general based on farmers' knowledge include lack of infrastructure, lack of solutions that can be accessed by farmers, the need for research and development and innovative business models, age group risks, and lack of effective data regarding the rural environment (F. da Silveira et al., 2023)

In this study, several obstacles related to the investment process in Karacak agropolitan area were identified and analyzed hierarchically using the ISM method so that these obstacles could be overcomed through a structural scheme. Agropolitan area can function as a forum for developing integrated upstream and downstream agribusiness activities (Agustina & Artiningsih, 2017).

Revitalization of agropolitan areas implies economic development integrated with the socio-cultural and ecological fields of rural areas. This is because village communities in general still instill and preserve socio-cultural values, such as by practicing biodiversity management using traditional spatial zoning systems (Purwanto, 2022). Agricultural productivity growth will have a greater impact on improving the welfare of farming families if there is expansion of the business scale and it is not only concentrated on agricultural (land) productivity (Darko et al., 2018). The appropriate level of diversification is a question of scale, which can be resolved using a larger set of variables to estimate the role of market access and agricultural technology (Kopmair et al., 2017).

The contribution of agro-industry in many developing countries is very significant due to its role in enhancing various potentials in the agricultural sector (Austin, 1992). Agro-industry is highly potential to be developed in agropolitan areas because these areas are the sources of raw materials for agricultural products, human resources, and are able to provide a high multiplier impact through agro-industry if these resources

are leveraged effectively (Suwandi et al., 2022). Thus, as a result, a well-executed agro-industry can provide several benefits: create new job opportunities, reduce post-harvest losses, leverage foreign exchange, extend products' shelf life, and ensure food availability through product diversification and distribution (Wulandari & Alouw, 2021).

Analysis of obstacles for mangosteen agro-industry revitalization in Karacak agropolitan area is part of a dissertation study entitled "Policy Study on Sustainable Development of Karacak agropolitan Area Based on Mangosteen Agro-industry". The decision to develop investment program for mangosteen agro-industry in Karacak agropolitan area is supported by the analysis results using the Analytical Hierarchy Process (AHP) method, in which the item of "providing incentives for agro-industrial investors in agropolitan areas" generated the highest criteria score, namely 0.306 (Figure 8).

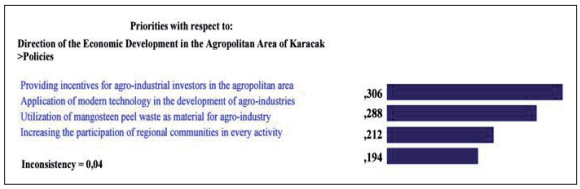

Figure 8. Hierarchy of decisions for mangosteen agro-industry investment development program in Karacak agropolitan area

The process of hierarchical analysis as expert-based decision support was first proposed by Saaty (1977, 1980) through discussion groups and expert-based questionnaires (Aczél & Saaty, 1983). The priority of agro-industry incentive policy plays a role in supporting the investment process in the context of revitalizing mangosteen agro-industry in Karacak agropolitan area. Based on the investigation, several obstacles were identified (Table 2), which needed to be resolved so that the revitalization could run smoothly. These obstacles were determined based on a literature review, experts' opinion, as well as focus group discussions (FGD) involving the government and stakeholders.

The division of tasks and their description (job description) is a set of construction management responsibilities that can be seen both from individual and organizational perspectives (Puolitaival et al., 2023); also from parties involved in the program compiled (Arditi & Alavipour, 2019). The obstacle sub-element of A2, namely "the political will of local governments in the incentive and disincentive programs for the development of agropolitan areas is still weak" is associated with the revitalization program. The context of government political will is important for governments and politicians, not only concerning their opinions, but also including their strong encouragement and desire to invite public participation in planning and decision-making activities (Nederhand & Edelenbos, 2023).

C. Obstacle Structure Model

The ISM analysis using *ISM professional software version 5.0* (Figure 3) produced output in the form of a Driver Power-Dependence (DP-D) graph (Figure 9) and a structural model diagram of revitalization obstacles (Figure 10). Methodologically, in the ISM analysis stage, all experts' opinions that had been collected were then compiled and searched for expert aggregation values in the form of SSIM (Structural Self-Interaction Matrix) matrices on VAXO symbols. The VAXO matrix was then converted into an *affordability matrix* (AM) in the form of a binary matrix (number 0 or 1). The examination and transitivity rules results obtained a new matrix, which is a revision of the *reachability matrix* (RM). The rule of transitivity is an attempt to assess the consistency of experts' opinion. A check with the rule of transitivity was carried out on cells whose value is 0 (zero). The results of checking transitivity rules on the binary matrix obtained the assessment results that are acceptable and meet the criteria (consistent), meaning that the determination of thrust (Driver Power) and dependence (Dependence) can be done.

Table 2. Identification of obstacles for mangosteen agro-industry revitalization in Karacak agropolitan area

Label	Sub-sub Elements of Obstacles	Related References	Keyword
A1	Job description between the working group of Karacak agropolitan area and the government of Bogor Regency is not yet clear	Arditi & Alavipour, 2019; Banerjee, 2008; Jacob, 2015; Kovacs, 2008; Lantos, 2001; Latapi et al., 2019; Puolitaival et al., 2023	Responsibilities; Construction management
A2	The political will of local governments in incentive and disincentive programs for agropolitan area development is still weak	Nederhand & Edelenbos, 2021; Goodin & Dryzek, 2006; Johnson, 2015; Michels & Binnema, 2018; Føllesdal, 2006; Klijn & Edelenbos, 2013; Bekkers & Arthur, 2007; Klijn & Koppenjan, 2016; Scharpf, 1999; Espinosa, 2023	Public participation; Local decision making; Output legitimacy; specific authoritative bodies, procedures, or persons; Balancing societal, economic, political, and environmental needs.
A3	Currently, the condition of agropolitan areas do not have independent and business-oriented area management	Olorunfemi et al., 2020; Fukuda, 2019; Cipi et al., 2023; Nagy & Hajrizi, 2019; Rustiadi et al., 2023a; Asmaraa & Kusumastutib, 2021	Society 5.0; Business model; Positive multiplier effect; Innovation Policy
A4	The investor/company is still difficult to disclose the reality of cash flow of the company's financial management in relation to determining the amount of tax	Shen et al., 2023; Wang et al., 2023; Dong & Zheng, 2022; Grashuis & Dary, 2017; Sgroi, 2022; Iotti & Bonazzi, 2023.	Regulation of environmental incentives and disincentives; Financial cycle; Cash flow and profit; Market mechanism
A5	At the local government level, the majority still have not implemented the tax amnesty policy	Sundari et al., 2022; Baer & La Borgne, 2008; Angeli et al., 2023	Tax amnesty; Taxpayer Compliance; State revenue
A6	Transaction costs in doing business are still quite high	Coggan et al., 2013; Fadhiela et al., 2018;	Transaction costs, agri-environment; Mechanisms and coordination between parties
A7	Incomplete spatial planning to support sustainable agro-industrial development in agropolitan areas	Friedmann & Douglas 1978; Kumar et al., 2021; Rustiadi et al., 2023b; Oryzanti, 2019	Agricultural management programs in Asia, sustainability, Agribusiness integrated area planning
A8	Procedures related to the allocation of agropolitan area development are still unclear	Kazemi et al., 2016; Saleh et al., 2017; Rustiadi et al., 2023b; Oryzanti, 2019	Biophysical conditions of agricultural land, Agropolitan development, Agro-industrial investment
A9	Cross-sectoral laws and regulations at the level of government are still inconsistent, and legal protection in maintaining business is still limited	Dirman et al., 2018	Legal protection, government, agriculture

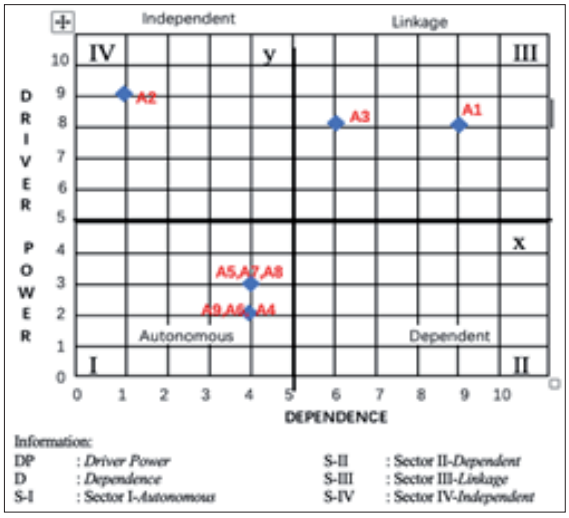

Figure 9. Driver Power-Dependence (DP-D) graph of obstacle elements

As seen in the DP-D graph, there are six sub-elements in Quadrant I, namely A5, A7, and A8 in coordinate (4.3); and A9, A6, and A4 in coordinate (4.2). Quadrant I describes these sub-elements as *Weak Driver-Weak Dependent Variables*, meaning that the role of these variables as drivers of programs is weak, and their dependencies on variables in other sectors are also weak.

In Quadrant III, there are two obstacle sub-elements, namely A3 in coordinate (6.8) and A1 in coordinate (9.8). Quadrant III describes these sub-element as *Strong Driver-Strongly Dependent Variables* (*Linkage*). A1 sub-element has a greater degree of *dependence*, but its thrust level is the same as that of A3 sub-element. Based on the

analysis results, resolving barriers in this quadrant will ensure the success of incentive programs for agro-industrial investors in agropolitan areas.

In Quadrant IV, there is only one obstacle sub-element, namely A2 in coordinate (1.9), which describes the power of thrust and low dependency value (independent). Thus, the sub-element contained in this quadrant is referred to as free modifier or key element. Sub-element A2 as a key sub-element has the highest driver power value (9) and lowest dependency value (1). Figure 10 displays a diagram of structural model of incentive policy obstacles for agro-industrial investors in agropolitan areas.

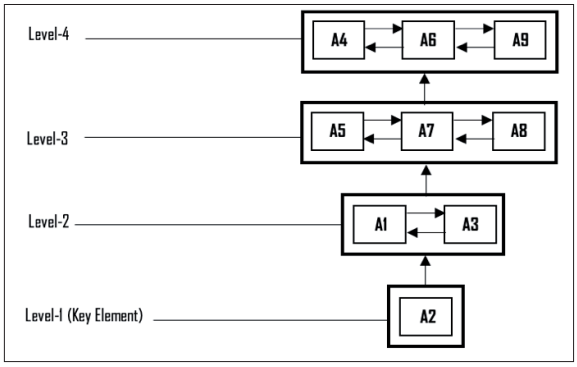

Figure 10. Structural model of obstacles for mangosteen agro-industry revitalization in Karacak agropolitan area

Political will from all parties, especially governments, is needed to realize the following things: strong collaboration among stakeholders, such as farmers, policy makers, and experts; the implementation of agribusiness programs and strategies; and the investment in agricultural commodity downstream activities in developing countries (Traore et al., 2022). Solution obstacles in A2 sub-element (level 1) will have an impact on unraveling problems at the next level (A1, A3) and at the same time encourage the formulation of policies towards sustainable agropolitan area governance through the agro-industrial sector. Table 3 displays the solutions recommended to each obstacle for developing mangosteen agro-industry revitalization in Karacak agropolitan area.

Table 3. Formulation of solutions to obstacles for mangosteen agro-industry revitalization in Karacak agropolitan area

Types of Obstacles Based on Level	Label/ Symbol	Dependency (D) Value	Driver Power (DP) Value	Level of Urgency	Solution	Collaborating Parties
The political will of local governments in incentive and disincentive programs for agropolitan area development is still weak.	A2	1	9	1 (Key Element of Obstacle)	Strengthening the nationalism, defending the country, so that there is political will of the government (Central and Regional) to strengthen the position of biological natural resources as Indonesia's original wealth that must be managed independently from upstream to downstream as outlined in the leader's vision-mission; Realized into programs based on government regulations (central and regional)	Government, Researchers, Stakeholders, Investors
The current condition of agropolitan areas does not have independent and business-oriented area management.	A3	6	8	2	Based on government regulation (point 1), the next step is to institutionalize the revitalization of agropolitan areas based on agro-industry	Government, Researchers, Stakeholders, Local Communities

Types of Obstacles Based on Level	Label/ Symbol	Dependency (D) Value	Driver Power (DP) Value	Level of Urgency	Solution	Collaborating Parties
The job description between the agropolitan area working group and the government of Bogor Regency is not yet clear.	A1	9	8	2	Referring to the institutional structure in point 2, it is then necessary to create a regional work program equipped with the implementation of standard operation procedure (SOP) and task details (job description) of each element (teamwork)	Government, Researchers, Stakeholders, Local Communities
At the local government level, the majority still have not implemented the tax amnesty policy.	A5	4	3	3	The next solution is coordination regarding the agro-industrial investment process in agropolitan areas	Government, Stakeholders, Local Society, Investor
Incomplete spatial planning to support sustainable agro-industrial development in agropolitan areas.	A7	4	3	3	Assessment and revitalization of the grand design of regional planning, including spatial planning of agro-industry integrated agropolitan area	Government, Stakeholders, Researchers, Agro-industrial Companies
Procedures related to the allocation of agropolitan area development are still unclear.	A8	4	3	3	Follow-up from point 3, coordination at the government level is needed, referring to the vision-mission for strategic planning and detailed plans for agro-industry-based agropolitan areas	Government, Investors, Stakeholders, Researchers, Local Communities
The investor/company is still difficult to disclose the reality of cashflow of the company's financial management in relation to determining the amount of tax.	A4	4	2	4	Follow-up from point 4 and 6, it requires the coordination and mediation of regional teams, governments, stakeholders, investors, related to company management for *win-win solutions* after identifying certain opportunities	Government, Stakeholders, Investor, Agro-industrial Companies
Transaction costs in doing business are still quite high.	A6	4	2	4	Follow-up from point 2, 6, and 7, its necessary to prepare work steps in running agro-industry in certain agropolitan areas	Government, Agro-industrial Companies, Market Place/E-Commerce
Cross-sectoral laws and regulations at the level of government are inconsistent, and legal protection in maintaining business is still limited	A9	4	2	4	Follow-up from points 1-8, then, requires a collaborative effort from all parties	Government, Stakeholders, Researchers, Local Community, Agro-industrial Companies

V. DISCUSSION

The development of rural agro-industry still faces main constraint, namely the inequality of various resources, including agricultural industry technology. These inequalities need to be addressed through local policy support. Such policies need to be developed to encourage coordination in developing comparative advantage in the region (McCann et al., 2023; Zhou et al., 2023), especially concerning native biological resources. Mangosteen's potentials as a native commodity in Karacak agropolitan area need to be optimalized so that the development is not only concentrated in the cultivation and marketing sector of fresh mangosteen, but also in the agro-industrial sector to optimize the absorption of local mangosteen raw materials. In this study, the science, technology, engineering, mathematics (STEM), and innovation approach aimed to provide information for investors and the government to pave the way for realizing agro-industry-based mangosteen management in Karacak agropolitan area. Systems thinking in a broad sense is considered comprehensive enough for balanced analysis in the field of economics, which is integrated into the fields of physics, chemistry, biology, and ecology (Aghion et al., 2009). In this study, the obstacles in the agro-industrial investment process were broken down into several sub-elements and determined systematically and hierarchically based on criteria scoring using the ISM method.

Agricultural development in rural areas requires support from local government through regulations and policies, which are useful as the basis to solve various problems related to area management so that the farmers and related parties can be independent and have an orientation to run local resources-based regional business (A3). For this reason, institutional arrangement of agropolitan areas is one of the necessary programs. To overcome A2 and A3 obstacles, multistakeholder collaboration among the government, private sectors, researchers, stakeholders, local communities, and investors is required. Furthermore, a clear job description can be prepared between Karacak agropolitan area working group and the government of Bogor Regency (A1), which is equipped with standard operating procedures (SOPs) to facilitate the implementation.

Revitalization of agropolitan areas is an important part of agricultural development because of its overall social impact and fundamental role in reducing poverty and increasing economic growth (de Marinis & Sali, 2020). However, it is also necessary to pay attention to environmental and ecological aspects by preserving biological resources based on local wisdom in order to achieve sustainability goals. Traditional ecological knowledges are acquired through long-term relationships between communities and place-based environments with high levels of biodiversity (Purwanto, 2022).

An agricultural innovation system oriented towards agro-industrial projects is one of the contexts for sustainable transformation of local biological natural resources owned by a country. In facing structural barriers to the knowledge of a community, it is essential to include a diversity of expertise such as agroecological systems and biodynamic agriculture in innovation and transition processes (K.P.W. Kok and L. Klerkx, 2023).

Management of biodiversity in agricultural areas requires political will from the government to realize an integrated and sustainable agro-industrial development. The adoption of agro-industrial technology into the practices of agropolitan areas needs to be aligned with local knowledge and local community wisdom so that it can be accepted with full awareness and implemented responsibly towards better social and environmental aspects.

VI. CONCLUSION

Agro-industrial development requires an investment process that needs to be coordinated in a structured manner based on resolution priorities in order to collaboratively overcome the emerging obstacles. In this study, the examination of policy direction in the context of mangosteen agro-industry investment adopts the STEM and innovation approach using the AHP, ISM, and The Feasibility methods. The integration of sustainable agro-industry in agropolitan areas brings various positive impacts, such as creating extensive job opportunities, fostering the creativity

of farmers and local communities, preserving the local biological or natural resources and their ecosystems, as well as increasing regional income and economic condition. Nonetheless, this study has limitations in the agglomeration process of experts' opinions concerning the political will of local governments, especially parliamentary parties that have core activity in the political field. Biodiversity management in agricultural areas requires political will from the government to realize sustainable and integrated agro-industrial development. The adoption of agro-industrial technology into the practices in agropolitan areas needs to be harmonized with local knowledge and local community wisdom so that it can be accepted with full awareness and implemented responsibly towards better social and environmental aspects.

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