Journal of Engineering and Technology for Industrial Applications

ISSN ONLINE: 2447-0228

ITEGAM-JETIA

Manaus, v10. n.50, p. 86-95. November/ December., 2024.
DOI: https://doi.org/10.5935/jetia.v10i50.1314

RESEARCH ARTICLE OPEN ACCESS

MULTI CRITERIA MODEL OF SUPPLY CHAIN SUSTAINABILITY EVALUATION & DEVELOPMENT STRATEGY FOR AGRITECH START-UP

Thabed Tholib Baladraf[1], Nita Kuswardhani [2], Winda Amilia[3], Mohammad Rondhi [4], and Yuli Wibowo [5]

[1] IPB University, Bogor, Indonesia
[2,3,4,5] University of Jember – Jember, Indonesia

[1] https://orcid.org/0000-0002-4953-1318, [2] https://orcid.org/0000-0001-7019-4590, [3] https://orcid.org/0000-0002-5098-5456, [4] https://orcid.org/0000-0002-6860-4957, [5] https://orcid.org/0000-0002-8825-7550

Email: thabedtholib@apps.ipb.ac.id, nita.ftp@unej.ac.id, winda.ftp@unej.ac.id, rondhi.faperta@unej.ac.id, yuliwibowo.faperta@unej.ac.id

ARTICLE INFO

Article History
Received: September 29, 2024
Revised: November 6, 2024
Accepted: November 10, 2024
Published: November 30, 2024

Keywords:
Agritech start up,
Multidimensional scaling,
Soft system methodology,
Supply chain management,
Sustainable supply chain.

ABSTRACT

The presence of agritech startups has successfully become a visionary solution at the agriculture supply chain to make it more efficient. Unfortunately, the supply chain in agritech start-ups is not sustainable and has various disadvantages. Therefore, this study aims to 1) analyze the current situation of supply chain at agritech start-ups, 2) analyze the sustainability index at agritech start-ups, and 3) analyze the strategy formulation needed by agritech start-ups through a soft system methodology approach. The research methods used were mixed methods. The stages of the research consisted of identifying current supply chain conditions, determining supply chain performance indicators by involving experts, assessing the supply chain sustainability index, and designing a conceptual model. The results showed the quality of the commodities produced did not meet standards and became a waste. The results of sustainability analysis in multidimensional results show a value of 48.84, economic 58.51, social 46.93, ecological 32.61, technology 42.36 and institutional 63.80. The results of the soft system methodology show that the strategies include contract farming, periodic coordination between stakeholders, GAP and OHS assistance, preparation of SOP for cultivation, application of borrowed tools under supervision, application of socialization of environmental literacy, and implementation of reserve supply chain.

I. INTRODUCTION

The supply chain has an important role, especially in the agricultural sector and fresh ingredients which are potential in Indonesia. The supply chain is fully responsible for the commodities distributed from upstream to downstream. According to Somapa et al. the supply chain consists of several components, namely purchasing, manufacturing, distribution, and storage [1]. A good supply chain has the characteristics of being visible, has the lowest possible costs, and is sustainable [2]. To meet these needs, innovations from agritech start-ups emerged that shortened the supply chain and helped farmers get more reasonable prices [3]. Agritech start-ups provide a marketplace for farmers, so that it is easier for farmers to sell agricultural products because they have direct market access.

Farmers as commodity suppliers in this case benefit because they get good market access. However, this solution is not balanced with the sustainability aspects of the process. This is because agritech start-ups want commodity quality with high standards without intensive and good cultivation assistance. This causes the majority of the commodities produced are not standardized and become waste. Based on the results of information from farmers, every time they make a commodity deposit to a company, ±20% of the commodity is returned to the farmer because it is not up to standard and ends up as food waste that cannot be sold. In addition, other problems were encountered, such as the absence of a guaranteed formal agreement and technological adoption, which was quite difficult. This shows that the existing supply chain is still not sustainable and threatens the sustainability of agritech start-ups and even causes agritech start-ups to go out of business [4]. To overcome these problems, further studies are needed to determine the root causes and the right strategies using sustainability analysis and soft system methodology to realize sustainable supply chain management.

According to Fahimnia et al. sustainable supply chain management (SSCM) is a supply chain that integrates social, environmental, economic, institutional, and technological pillars [5]. SSCM aims to protect the environment, advance the social condition of the community, and provide benefits to various parties [6]. The application of SSCM is proven to be able to overcome various problems and bring various benefits such as creating a circular economy that is prosperous and minimizing waste generation [7], increasing marketing, improving product image, and certainty [8]. On the other hand, soft system methodology (SSM) involves the development of system models related to problem situations. These models are used as a medium of discussion to bring changes to the actual situation.

Research related to SSCM in recent years has increased significantly in business and academia due to its positive impact [9-11]. However, SSCM research in developing countries, especially in agriculture, is still very limited and only recently considered important [12]. Research on the application of SSCM with SSM in agritech start-ups considering economic, social, environmental, technological, and institutional aspects has never been reported, so researchers in this case want to fill this gap. In this research, a study and analysis were conducted regarding the current condition of the supply chain, measurement of supply chain sustainability, and application of the soft system methodology. The calculation results will be used to formulate best strategy. Therefore, this study aims to 1) analyze the current situation and condition of supply chain at agritech start-ups, 2) analyze the sustainability index for each dimension at agritech start-ups, and 3) analyze the conceptual model and strategy formulation needed by agritech start-ups to create a sustainable supply chain through a soft system methodology approach.

II. THEORETICAL REFERENCE

II.1 AGRITECH START-UP

Agritech start-ups are start-up companies specifically engaged in the field of agricultural technology to solve various agricultural problems [13]. The presence of agritech start-ups during the current pandemic era plays an important role in meeting food needs and absorption of agricultural production [14]. According to Klerkx and Vilalobos, based on the business model and solved problems, agritech start-ups can be divided into four major groups, namely (1) financial group, (2) education and coaching group, (3) e-commerce group, and (4) technology development group [15].

II.2 SUPPLY CHAIN

The supply chain is a network of companies that are interconnected to produce and deliver products to consumers. Existing networks are generally grouped as suppliers, processing industries, distributors, shops, or retail, as well as supporting companies such as logistics service companies, packaging providers, and others. The supply chain has three kinds of flows that must be controlled, including the flow of goods that flows from upstream to downstream, the flow of finance that flows from downstream to upstream, and the flow of information from upstream to downstream and vice versa. According to Munizu, the goal of the supply chain is to maximize the value generated as a whole [16]. An integrated supply chain will increase the value generated. Supply chain management applications have the main objectives of increasing efficiency, reducing costs, reducing capital, improving service, and improving customer satisfaction. However, the supply chain applied to agriculture is currently not sustainable and causes various losses, so a strategy is needed to achieve this goal by implementing SSCM.

II.3 SUSTAINABLE SUPPLY CHAIN MANAGEMENT

Sustainable supply chain management (SSCM) is a network of companies that pays attention to the environment, advances the social condition of society and can still provide profit to various parties. SSCM consists of five pillars consisting of economic aspects, social aspects, environmental aspects, technological aspects, and institutional aspects. SSCM was created due to the many problems arising from unsustainable supply chains such as lack of access to reserve markets [17], improper handling of agricultural products [18], high food waste [19], unmet commodity needs [20], and material losses [21]. This is exacerbated by the fragmented pattern of relationships between actors [22]. The illustrative description of SSCM is presented in Figure 1.

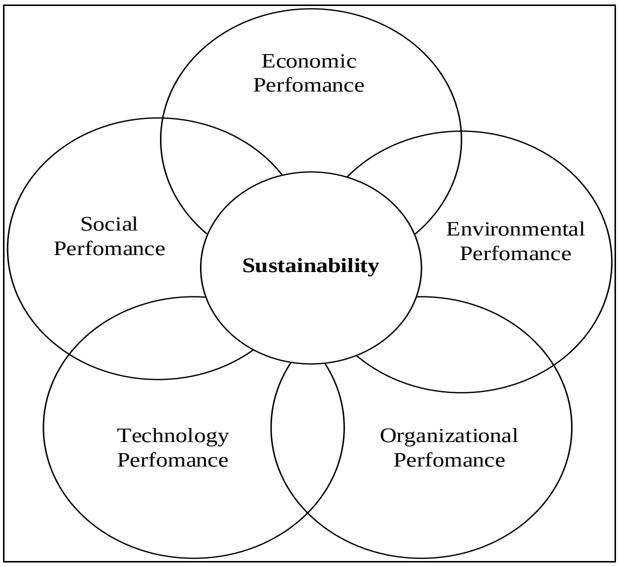


Figure 1: illustration sustainable supply chain management.
Source: [22].

II.3 MULTIDIMENSIONAL SCALING

Multidimensional Scaling Analysis (MDS) is an analytical model that can model nonlinear variables that can be used on nominal or ordinal data [23]. MDS is divided into two based on the scale of measurement of similarity data, MDS on a metric scale, which assumes that the data is quantitative, and MDS on a nonmetric scale, which assumes that the data is qualitative (nominal and ordinal). MDS has characteristics where comparisons will be made using diagrams or maps or graphs, so it can also be called a perceptual map. The application of MDS is done by calculating the shortest distance from the Euclidian Distance. In practice, MDS is an application derivative that is often used to measure the level of sustainability, namely Rapfish. According to previous research, MDS-Rapfish is often used in various sectors such as fisheries [24], agriculture [25], and supply chain [26]. The MDS-Rapfish analysis carried out will produce a sustainability index that is visualized in a two-dimensional image with a rating scale range of 0-100%.

II.3 SOFT SYSTEM METHODOLOGY

Soft system methodology is an approach used to deal with management problems that arise from human activity systems [27]. SSM can also be defined as a problem-solving framework where the nature of the problem is difficult to define [28]. The essence is to build a system model through understanding in depth the problem situation according to the phenomena encountered. SSM provides a coherent approach to group and individual thinking about context, complexity, and policy ambiguity [27]. This method is very reliable to be used to solve problems in various fields ranging from health [29], and engineering [30].

III. MATERIALS AND METHODS

The research was carried out in collaboration with several agritech start-ups and was carried out in three areas with relatively high agricultural and fishery productivity, namely Malang Regency, Jember Regency, and Banyuwangi Regency. The research begins with the identification of current supply chain conditions by describing the chain structure, chain management, chain resources, and chain business. The next step is to identify sustainability indicators through field observations, literature studies, and discussions with the six experts involved to obtain valid indicators. After identifying sustainability indicators, the supply chain sustainability index was then measured by involving ninety partner farmers using a Likert scale of 0-2 so that a sustainability value would be obtained. The sustainability value scale is presented in Table 1.

Table 1: Sustainability index scale.

Index	Sustainability Indicator
0-25,00	Bad
25,01-50,00	Less
50,01-75,00	Quite
75,01-100	Good

Source: Authors (2024).

In this study, several additional analyses were also carried out, including leverage and suitability analysis. Leverage analysis enabled us to determine the most sensitive/influential indicators. The indicator with the highest value is considered the most sensitive indicator. The suitability analysis consists of monte carlo analysis, s-stress, and R2. The results of a good monte carlo analysis have insignificant differences [31]. The results of a good stress value analysis have a value of less than 0.25 [32]. While the results of a good R2 have a value close to 1 [33]. The last stage is the preparation of a soft system methodology conceptual model to solve complex unstructured problem situations based on holistic analysis through a forum group discussion with experts.

IV. RESULTS AND DISCUSSIONS

IV.1 CURRENT CONDITION OF SUPPLY CHAIN

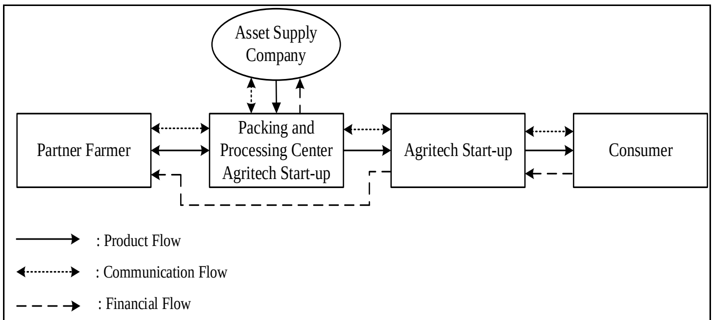


Figure 2: Current supply chain flow at agritech start-up.
Source: Authors (2024).

The supply chain structure in an agritech start-up consists of several members including primary and secondary members. Primary members in the supply chain are main actor that consist of partner farmers, agritech start-ups, and consumers. Secondary members consist of asset supply companies but are not directly involved in the process (Figure 2).

Supply chain management describes contractual agreements, transaction systems, and supply chain collaboration. In the contractual agreements, it was found that the majority of agritech start-ups still have not entered written and formal contractual agreements with partner farmers. This of course causes losses because according to Rustiani et al. relationships that are not formal have the potential to cause fraud and losses [34]. In the transaction system, it was found that the system applied between agritech start-ups and farmers is a credit transaction system. Partner farmers will receive payment after the partner farmers send the commodity. In supply chain collaboration, it was found that agritech start-ups were already transparent to partner farmers regarding price information. However, agritech start-ups do not provide regular assistance related to cultivation activities, causing many products that do not meet the criteria and become food waste.

The business process chain describes the business relationships between members of the supply chain through two perspectives, namely the cycle view and the push pull view. The cycle view in the supply chain business process consists of four stages, namely procurement, which is the stage of ordering raw materials. Manufacturing is the management of raw materials into ready-to-sell materials. Replenishment is the stage of replenishing the product or commonly known as the anticipation stage. Customer order is the stage of ordering by consumers. On the other hand, supply chain business processes, when viewed from a push or pull view, will be divided into two. The push stage has unknown consumer demand characteristics, while the pull stage has certain consumer demand characteristics. The agritech start-up supply chain business process is presented in Figure 3.

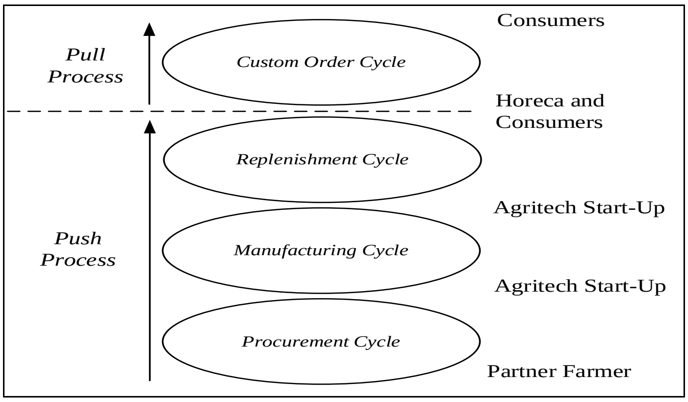


Figure 3: Agritech start-up supply chain business process.
Source: Authors (2024).

IV.2 MULTIDIMENSIONAL SUSTAINABILITY

In the sustainability analysis, 40 sustainability indicators are used based on the reality/observation on the ground and discussed with experts. The sustainability analysis was conducted multidimensionally in terms of the economic dimension, social dimension, ecological dimension, technological dimension, and institutional dimension. Multidimensional analysis was conducted in order to find out which dimensions must be improved and which dimensions must be maintained in performance. The results of multidimensional sustainability analysis are presented in Figure 4 and suitability testing using monte carlo, s-stress, and R^2 are presented in Table 2.

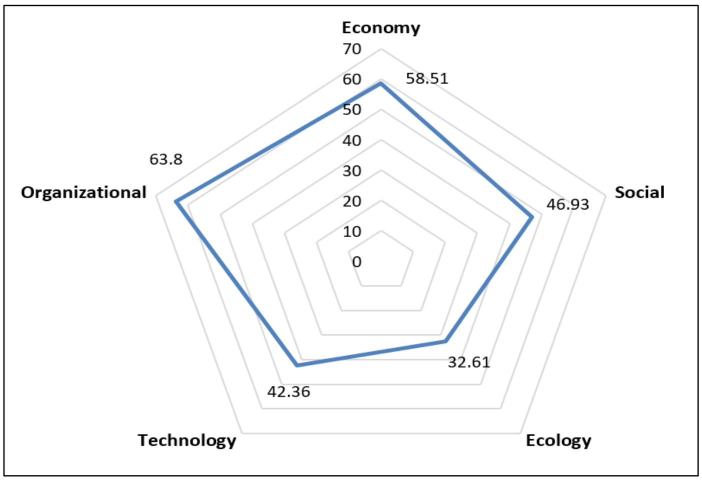


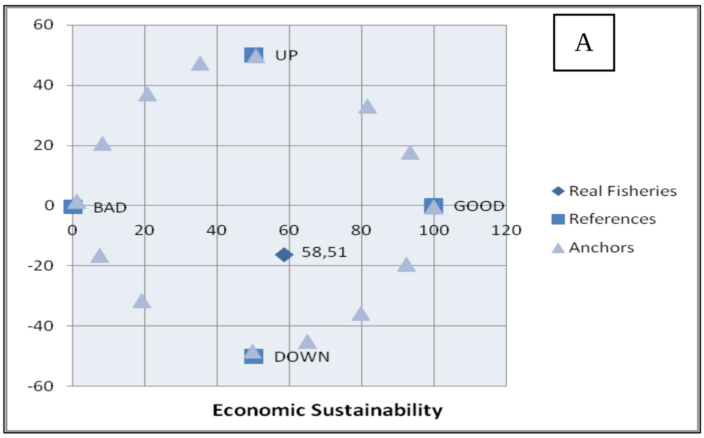
Figure 4: Multidimensional sustainability index kit chart.
Source: Authors (2024).

Table 2: Multidimensional and suitability analysis.

Dimension	MDS	Monte Carlo	S-Stress	R^2
Economy	58.51	57.47	0.143	0.946
Social	46.93	47.28	0.152	0.942
Ecology	32.61	33.16	0.138	0.943
Technology	42.36	42.26	0.148	0.944
Institutional	63.80	63.38	0.152	0.942
Multidimensional	**48.84**	**48.71**	**0.147**	**0.943**

Source: Authors (2024).

Based on Figure 4 and Table 2, it can be seen that the multidimensional scaling value on the economic is 58.51, the social is 46.93, the ecological is 32.61, the technological is 42.36, the institutional is 63.80, and multidimensional is 48.84. The ecological has the lowest value, followed by technological, social, economic and institutional. This shows that the principle of sustainability has not been balanced in the supply chain at agritech start-up. The results of the monte carlo analysis obtained values in the range 33.16-63.38 which showed no significant difference. The s-stress value gets in the range of 0.138-0.152 which means that the indicator has a reliable level of confidence because it is <0.25. The value of R^2 is in the range of 0.942-0.946 which means it is good. In order to find a more detailed explanation, sustainability analysis is then explained on the economic, social, ecological, technological, and institutional.



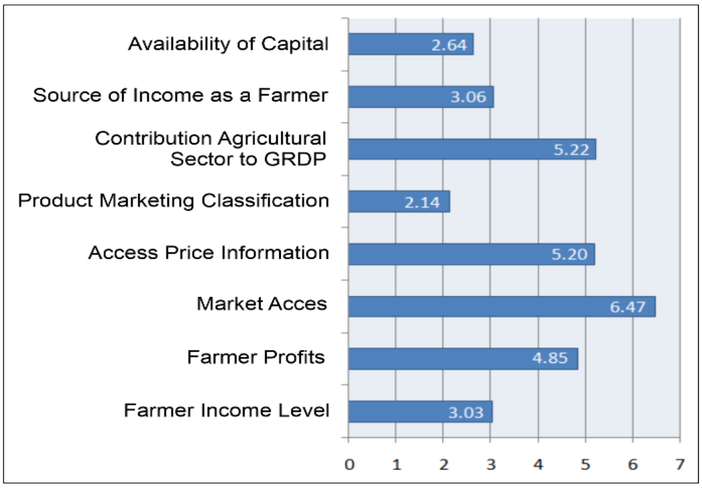
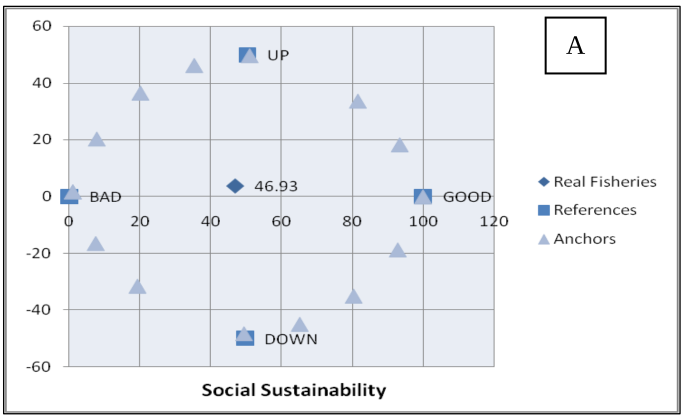


Figure 5: Sustainability index (a) and leverage analysis (b) on economic dimension.
Source: Authors (2024).

Figure 5 explains the sustainability index and leverage analysis of the economic dimension in the agritech start-up supply chain. The results of the economic dimension sustainability index get a value of 58.51, which is classified as quite sustainable. This is in line with the facts on the ground where agritech start-ups have succeeded in streamlining supply chains that were originally long and complex to become shorter and more efficient. According to Dolfsma et al. which states that the presence of agritech start-ups has succeeded in cutting supply chains to become more efficient [35]. Based on the results of the leverage analysis performed, the three most influential indicators were selected. The three indicators include market access (6.47), contribution agricultural sector to GRDP (5.22), and access price information (4.85). The first indicator is market access. The existence of flexible market access will certainly make it easier for farmers to sell their commodities. The presence of an agritech start-up has succeeded in making it easier for farmers to market their commodities because partner farmers can sell their commodities only through the application. According to Kanellos et al. sales through applications can reach a broad market and increase profits [36]. The second indicator is contribution agricultural sector to GRDP. The higher the contribution of a sector to GRDP, the more natural resources and potential livelihoods that exist in that area can be identified. Based on the facts on the ground, the majority of partner farmers are in the East Java region. The third indicator is price access. The more transparent access to price information, the easier it will be for farmers to run their business. This is in line with research conducted by Lam, which states that the easier it is to access price information, the easier to farming activities [37].



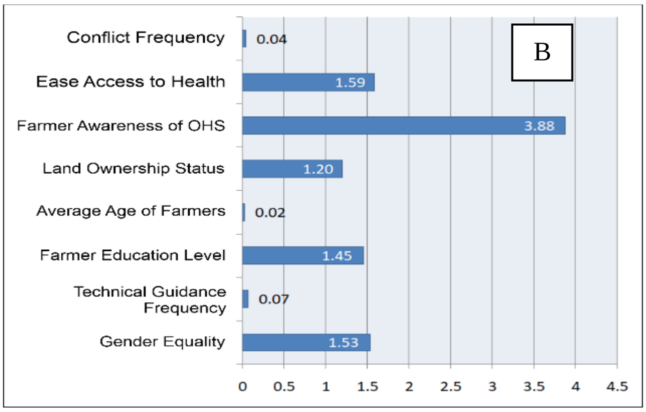
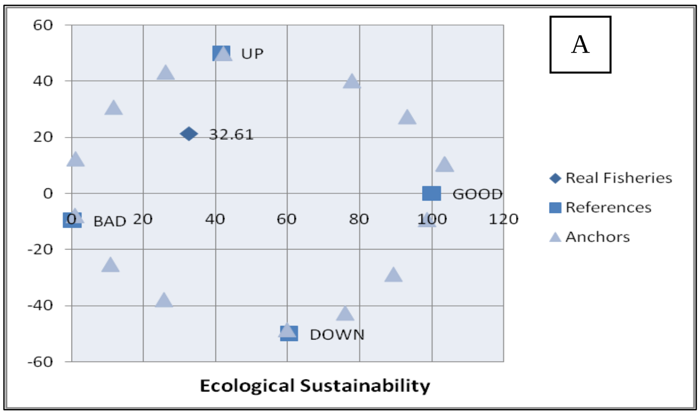


Figure 6: Sustainability index (a) and leverage analysis (b) on social dimensions.
Source: Authors (2024).

Figure 6 explains the sustainability index and leverage analysis of the social dimension in the agritech start-up supply chain. The results of the social dimension sustainability index get a value of 46.93, which is classified as less sustainable. This is caused by agritech start-ups that are still too focused on profits and are not yet intensive in providing assistance to farmers. This is further strengthened by the education level of farmers who are classified as lacking. According to Cook et al. the assistance provided to farmers plays an important role so that farmers can be relevant to developments [38]. In addition, debriefing can be a means of non-formal education for farmers. Based on the results of the leverage analysis performed, the three most influential indicators were selected. The three indicators include farmers' awareness of OHS (3.88), ease of access to health (1.59), and gender equality (1.53). The first indicator is farmers' awareness of occupational health and safety (OHS). Based on the facts in the field, it was found that the partner farmers did not have knowledge about OHS so they always ignored it. This is in line with research, which states that farmers do not apply OHS due to knowledge factors and no training has been carried out [39]. Of course, in the short and long term it will be detrimental to the health of farmers while at the same time hindering the process of production being carried out. The second indicator is easy access to health. Access to health needed by farmers can be in the form of health centers or personal protective equipment. Facts on the ground show that the majority of farmers are in rural areas and ease of access to health depends on the area or location of the farmer, however, partner farmers still feel that they do not have access to good health because they are far away. This is linear with research by Abaku and Odimarha, which states that ease of access to health is the most sensitive indicator for farmers, because farmers are often found to be sick but have difficulty access to health [40].



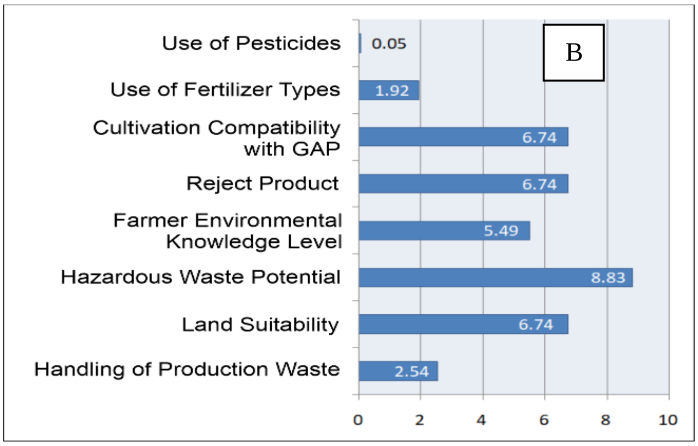


Figure 7: Sustainability index (a) and leverage analysis (b) on ecological dimensions.
Source: Authors (2024).

Figure 7 explains the sustainability index and leverage analysis of the ecological dimension in the agritech start-up supply chain. The results of the ecological dimension sustainability index get a value of 32.61, which is classified as less sustainable. This is because agritech start-ups have very high standards for the quality of commodities but are not matched by the implementation of training on cultivation, the environment and market provision by the company. According to Arifin, farmers need market certainty in order to have income, because commodities are perishable [41]. The lack of certainty and the provision of a reserve market from the company causes high product rejection and becomes food waste. This certainly causes losses for farmers and based on the results of direct observations in the field, partner farmers often complain about this. Based on the results of the leverage analysis performed, the three most influential indicators were selected. Some of these indicators include the potential for hazardous waste (8.83), and technical suitability of cultivation with GAP (6.74), and rejected products (6.74).

The first indicator is the potential for hazardous waste. The potential for hazardous waste will arise if farmers use inorganic fertilizers and pesticides because they will have an impact on soil health. Inorganic fertilizers and pesticides cause degradation of macronutrients such as potassium, nitrogen and phosphorus. In addition, according to El-Dewiny and Zaghloul. the use of inorganic fertilizers and pesticides affects soil fertility and health [42]. Based on the facts in the field, it was found that there is no potential for hazardous waste, because farmers use organic fertilizers and pesticides combined with inorganic within reasonable limits. The second indicator is the suitability of cultivation with GAP. GAP is a general guideline in carrying out correct cultivation to ensure product quality, safety for farmers and consumers. The application of GAP is very important because it acts as a quality assurance system as well as a series of sustainable supply chain management. However, the facts on the ground show that partner farmers still do not know and apply the GAP, causing the quality of the commodities produced to be not up to standard. The third indicator is reject product. Reject products are commodities that are returned to partner farmers because they are not up to standard. Facts in the field show that the reject product that occurs is still high. This is thought to be caused by the lack of supplies to partner farmers, as well as the absence of a reserve market. According to Beullens and Ghiami the high number of food waste is caused by products that do not meet demand criteria and there is no provision of a reserve market as an alternative option [43].

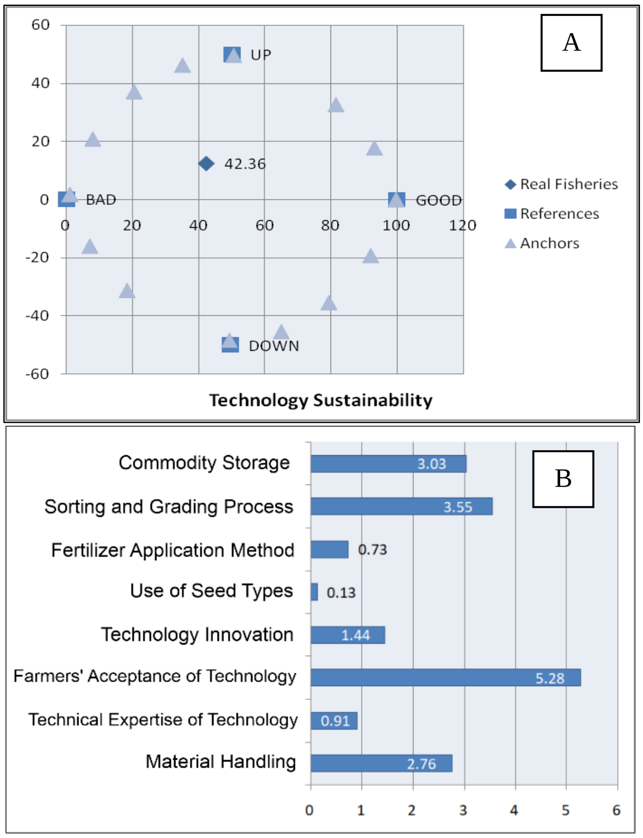


Figure 8: Sustainability index (a) and leverage analysis (b) on technological dimensions.
Source: Authors (2024).

Figure 8 explains the sustainability index and leverage analysis of the technology dimension in the agritech start-up supply chain. The results of the technology dimension sustainability index get a value of 42.36, which is classified as less sustainable. In its implementation, Agritech start-up has a mission to create a digital agricultural ecosystem. Digitalization in agriculture can increase productivity and cost savings [44]. However, the implementation of agricultural digitization encountered obstacles including the lack of knowledge by farmers, and infrastructure. In order to find out which indicators have the most influence, leverage analysis is then carried out. Based on the results of the leverage analysis conducted on the technology dimension, the three most influential indicators were selected. The three indicators include farmers' acceptance of technology (5.28), sorting and grading processes (3.55), and commodity storage (3.03).

The first indicator is farmers' acceptance of technology. Farmers' acceptance of technology is a basic thing that is needed. Facts on the ground show that partner farmers can accept technology well, this is reflected in the use of the applications provided. This is supported by Oktavia and Fathin who state that the applications used by agricultural start-ups in Indonesia are well received by farmers and make the farming process easier [45]. The second indicator is the process of sorting and grading. This process is a basic process that always exists in every agricultural commodity to ensure the quality of the criteria. If the commodity meets the standard criteria and market demand, then the commodity will be followed up and sent to PH and PPC and then distributed to consumers. Meanwhile, if the commodity does not meet the standard criteria, the commodity will be returned to the farmer. The facts in the field show that the majority of sorting and grading processes are still done manually, causing a less accurate level and longer time. This is in line with the research of Mhaski et al. which states that sorting and grading using machines is faster and more efficient than manual ones. The third indicator is commodity storage [46]. Commodity storage should ideally be placed in a refrigerator to extend shelf life and maintain quality. According to Muncan et al. storage at low temperatures can anticipate the occurrence of rot and prevent shrinkage in weight [47]. The fact is that partner farmers do not have a refrigerator after harvesting and only put it at room temperature.

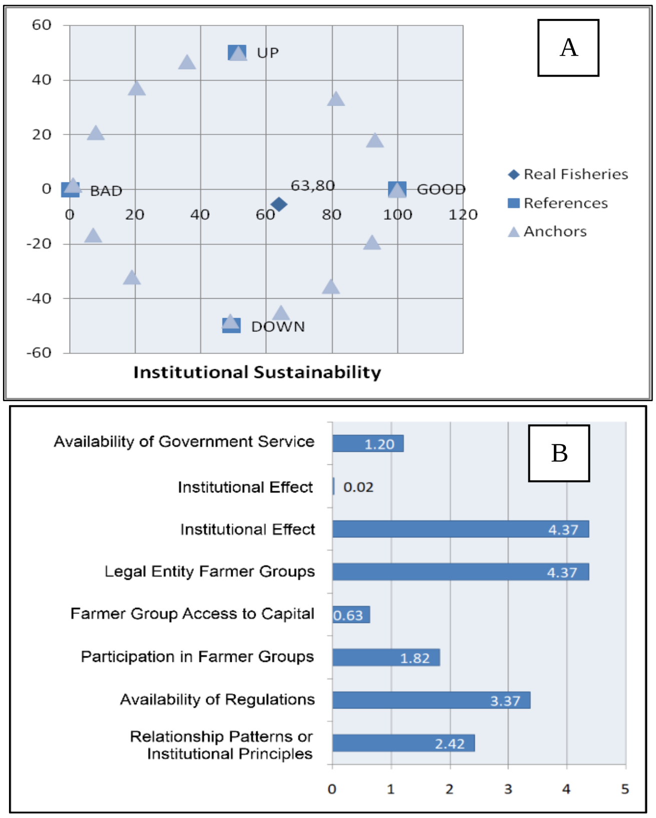


Figure 9: Sustainability index (a) and leverage analysis (b) on institutional dimensions.
Source: Authors (2024).

Figure 9 explains the sustainability index and leverage analysis of the institutional dimension in the agritech start-up supply chain. The results of the technology dimension sustainability index get a value of 63.80, which is classified as quite sustainable. According to Kusnandar et al. it is hoped that the presence of farmer institutions can help farmers in various aspects [48]. In its implementation, agritech start-ups are targeting farmer institutions because they are considered to be able to absorb more commodities. Based on the results of the leverage analysis, it was found that the three most influential indicators included the existence of farmer groups (4.37), legal entity farmer groups (4.37), and availability of regulations (3.37).

The first indicator is the existence of farmer groups. The existence of farmer groups has a fairly good effect on the development of farmers, because it can be a forum for farmers to work together with intra-institutions, fulfill aspects of capital, fulfill production facilities, assist marketing and provide information [48]. Facts on the ground show that partner farmers in the research area are all members of farmer groups and are actively partnering with agritech start-ups. The second indicator is legal entity farmer groups. According to Kusnandar et al. an ideal farmer group has several things, including (1) having a complete organizational structure, (2) being open to partnerships, and (3) having training and capacity building [49]. Facts on the ground show that all farmers are members of farmer groups that are legal entities, but there are no regulations governing farming activities. The third indicator is the availability of regulations. Rules or regulations in farmer groups have several weaknesses, including unclear rules and procedures for membership, the unclear profitability status of Gapoktan. Based on the facts in the field, it was found that the farmer groups studied had unclear rules so they were not implemented/implemented. The combined farmer groups only carry out partnership duties with external parties, in this case agritech start-ups.

IV.2 SOFT SYSTEM METHODOLOGY CONCEPTUAL

Based on the sustainability analysis carried out and combined with observations, several main issues were found that became problematic and presented in Figure 10.

1. There is no reserve supply chain provided for rejected commodities causing food waste. According to Crawford (2006), food waste can be mitigated by flexible market, one of which is the provision of market options.

2. The GAP cultivation system has not yet been implemented, causing the commodities produced to be non-standard. According to Vittersø et al. cultivation that applies GAP will produce quality commodities, good standards, and minimize food waste [50].

3. The cooperation that is implemented is still based on trust so that the cooperation that is established can cause fraud between the two parties which is mutually detrimental. This is reinforced by Putri and Rondhi's research which states that the application of contract farming has succeeded in reducing the risk of fraud by up to 39% [51].

4. The level of environmental knowledge and literacy possessed by partner farmers is still low, causing partner farmers to ignore ecological factors. This is supported by research by Yu et al. and Li et al. which states that environmental literacy in farmers has a significant relationship with sustainable production carried out in farming [52], [53].

5. There is no application of modern technology such as automatic sorting machines and refrigerators. The absence of technology such as automatic sorting machines and refrigerators causes low efficiency. Mhaski et al. states that the existence of technology using machines will increase efficiency while extending the shelf life of commodities [46].

6. Cultivation that pays attention to OHS and lack of access to health has not yet been implemented so that it risks harming the health of partner farmers. Riswal et al. states that the awareness of OHS farmers in rural areas is very low, so they are at high risk of health problems [54].

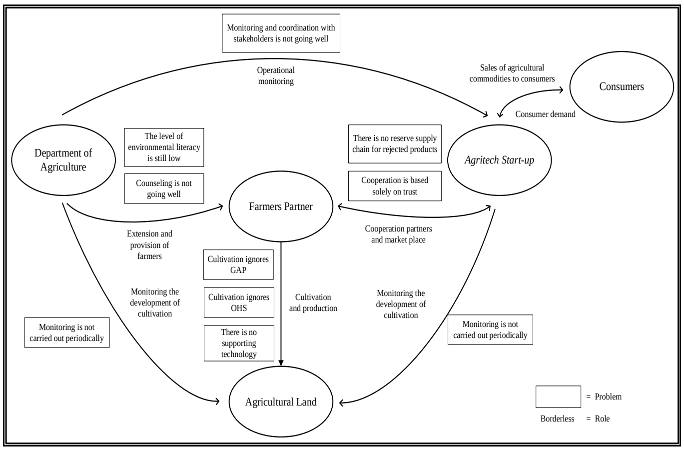


Figure 10: Rich picture agritech start up supply chain.
Source: Authors (2024).

Root definition and conceptual model development are the steps taken to identify the problem and determine the right solution in industry. After defining the problem in detail, then a catwoe analysis is carried out to find out in more detail the role of each supply chain actor involved in this case. This stage begins with Catwoe analysis (customers, actors, transformation, worldview, owner, environment constraints). The resulting Catwoe analysis at agritech start-up supply chain will be presented in Table 3.

Table 3: Catwoe analysis agritech start up supply chain.

Category	Explanation
Customers	Farmers partner
Actors	Farmers partner and agritech start-up
Transformation	Application of a contract farming system, farming assistance based on GAP and OHS, and application of a reverse supply chain
Worldview	Increasing the profitable cooperation system, knowledge of partner farmers, sustainability and reliability agritech start-up supply chain
Owner	Agritech start-up and government
Environment constraint	Low technology adoption and partner farmer acceptance of new knowledge

Source: Authors (2024)

The results of the Catwoe analysis are then arranged into several activities packaged in the form of a conceptual model that is called a purposeful human activity system (PHAS). The core of system thinking is the creation of conceptual model as intellectual tool used to discuss situation in the real world that is deemed problematic. Through the conceptual model, it is hoped that real conditions and ideal conditions can be compared. Based on Catwoe's analysis presented above, a conceptual model aimed at increasing the sustainability of agritech start-up supplies is presented in Figure 11.

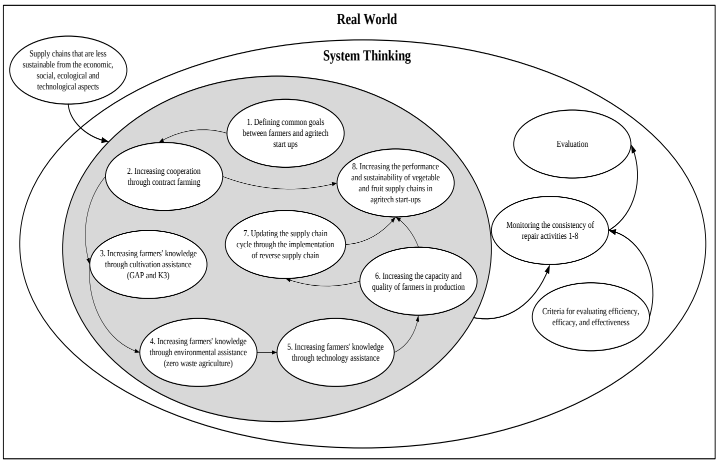


Figure 11: Conceptual model agritech start up supply chain
Source: Authors (2024)

In the comparison stage of the real conditions with the conceptual model (ideal conditions) an elaboration of current activities, gaps that occur, and action plans that can be carried out are carried out. It is hoped that this comparison of conceptual models can become a recommendation for agritech start-ups to implement the action plans that have been prepared and hope can improving performance and sustainabolity. In detail, current activities, gaps, and action plans are presented in Table 4.

Table 4: Current realities, gaps and plans of action.

Current Realities	Gaps	Plans of Action
The cooperation established between the parties is still based on trust. This creates the potential for fraud.	• There is no binding cooperation • Bad coordination between parties • Not yet optimal role of government institutions as supervisors	• Application of contract farming to partner farmers and agritech start ups • Implementation of periodic coordination between government as supervisor and agritech start up as operator
The knowledge of cultivation, technology and environment owned by partner farmers is still low so that it has a big impact on the farming process and the commodities produced	• Partner farmers have not implemented GAP and OHS-based cultivation • It is still quite difficult for partner farmers to adopt technology • Partner farmers still do not understand environmental literacy in agriculture	• Implementation of GAP and OHS assistance for partner farmers • Preparation of standard operating procedures for the cultivation process so that it complies with GAP and OHS • Application of borrowing tools • Application of socialization on the importance of environmental literacy for agricultural sustainability
The supply chain that is run is still not sustainable due to high waste	• The current supply chain does not provide a reserve market for reject products	• Provision of reverse logistics by agritech start ups in order to create a sustainable supply chain

Source: Authors (2024

V. CONCLUSIONS

Based on the research conducted, the following conclusions were obtained:

1. Analysis of the current condition of the supply chain descriptively shows that the supply chain is not working well. In the chain structure, it was found that the quality of the commodities produced by the majority did not meet standards and became a waste. In addition, it was found in chain management that contract agreements qwere not made with partner farmers.
2. The results of the sustainability analysis show that the multidimensional results show a value of 48.84 (less sustainable), economic 58.51 (quite sustainable), social 46.93 (less sustainable), ecological 32.61 (less sustainable), technology 42.36 (less sustainable) and institutional 63.80 (quite sustainable).
3. The results of the soft system methodology analysis show that there are three main problems, namely cooperation is still based on trust, farmers' knowledge (cultivation, technology, and the environment) is still low, and the supply chain that is being carried out is still not sustainable. The strategy formulated includes implementing contract farming, implementing regular coordination between stakeholders, assisting GAP and OHS, preparing standard operating procedure for cultivation, applying borrowed tools with supervision, implementing environmental literacy socialization, and implementing a reverse supply chain.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Thabed Tholib Baladraf, Nita Kuswardhani
Methodology: Thabed Tholib Baladraf, Nita Kuswardhani
Investigation: Thabed Tholib Baladraf, Winda Amilia
Discussion of results: Thabed Tholib Baladraf, Nita Kuswardhani
Writing – Original Draft: Thabed Tholib Baladraf
Writing – Review and Editing: Thabed Tholib Baladraf
Resources: Nita Kuswardhani, Winda Amilia.
Supervision: Nita Kuswardhani, Winda Amilia, Mohammad Rondhi, Yuli Wibowo
Approval of the final text: Nita Kuswardhani, Winda Amilia, Mohammad Rondhi, Yuli Wibowo

VII. ACKNOWLEDGMENTS

The authors acknowledge the support from the agritech start up for its willingness to be the object and location of the research, as well as the data and information support and discussion. The author also acknowledges to Dr. Nita Kuswardhani, S.TP., M.Eng., IPM, Winda Amilia, S.TP., M.Sc., M. Rondhi, S.P., M.P., Phd., and Dr. Yuli Wibowo, S.TP., M.Sc., IPM for his guidance and direction in carrying out the research.

VIII. REFERENCES

[1] S. Somapa, M. Cools, and W. Dullaert, "Characterizing supply chain visibility – A literature review," *Int. J. Logist. Manag.*, vol. 29, no. 1, pp. 308–339, 2018, doi: 10.1108/IJLM-06-2016-0150.

[2] U. D. Apeji and F. T. Sunmola, "Principles and Factors Influencing Visibility in Sustainable Supply Chains," *Procedia Comput. Sci.*, vol. 200, pp. 1516–1527, 2022, doi: 10.1016/j.procs.2022.01.353.

[3] D. Rafi and M. Mubeena, "Role of Agritech Start-Ups in Supply Chain—An Organizational Approach of Ninjacart," in *The Digital Agricultural Revolution*, 2022, pp. 289–299.

[4] E. Koberg and A. Longoni, "A systematic review of sustainable supply chain management in global supply chains," *J. Clean. Prod.*, vol. 207, pp. 1084–1098, 2019, doi: 10.1016/j.jclepro.2018.10.033.

[5] B. Fahimnia, J. Sarkis, A. Gunasekaran, and R. Farahani, "Decision models for sustainable supply chain design and management," *Annual Operation Research*, vol. 250, no. 2, pp. 277–278, 2017, doi: 10.1007/s10479-017-2428-0.

[6] R. Dubey, A. Gunasekaran, S. J. Childe, T. Papadopoulos, and S. Fosso Wamba, "World class sustainable supply chain management : critical review and further research directions" *Int. J. Logist. Manag.*, vol. 28, no. 2, pp. 1–42, 2017. doi: 10.1108/IJLM-07-2015-0112

[7] C. L. Martins and M. V. Pato, "Supply chain sustainability: A tertiary literature review," *J. Clean. Prod.*, vol. 225, pp. 995–1016, 2019, doi: 10.1016/j.jclepro.2019.03.250.

[8] C. R. Carter, M. R. Hatton, C. Wu, and X. Chen, "Sustainable supply chain management: continuing evolution and future directions," *Int. J. Phys. Distrib. Logist. Manag.*, vol. 50, no. 1, pp. 122–146, 2020, doi: 10.1108/IJPDLM-02-2019-0056.

[9] M. H. Islam, M. R. Sarker, M. I. Hossain, K. Ali, and K. M. A. Noor, "Towards Sustainable Supply Chain Management (SSCM): A Case of Leather Industry," *J. Oper. Strateg. Plan.*, vol. 3, no. 1, pp. 81–98, 2020, doi: 10.1177/2516600x20924313.

[10] A. Rajeev, R. K. Pati, S. S. Padhi, and K. Govindan, "Evolution of sustainability in supply chain management: A literature review," *J. Clean. Prod.*, vol. 162, pp. 299–314, 2017, doi: 10.1016/j.jclepro.2017.05.026.

[11] V. Kiousis, E. Nathanail, and I. Karakikes, "Assessing traffic and environmental impacts of smart lockers logistics measure in a medium-sized

municipality of Athens," *Adv. Intell. Syst. Comput.*, vol. 879, no. January, pp. 614–621, 2019, doi: 10.1007/978-3-030-02305-8_74.

[12] R. . Sánchez-Flores, S. . Cruz-Sotelo, S. Ojeda-Benitez, and M. Ramírez-Barreto, "Sustainable Supply Chain Management—A Literature Review on Emerging Economies," *Micro Macro Mark.*, vol. 12, no. 6972, pp. 1–27, 2020, doi: 10.3390/su12176972.

[13] K. E. R. Heerman, "Technology, ecology and agricultural trade," *J. Int. Econ.*, vol. 123, p. 103280, 2020, doi: 10.1016/j.jinteco.2019.103280.

[14] Central Bureau of Statistics, *Indonesia Statistic 2023*, vol. 1101001. 2023.

[15] L. Klerkx and P. Villalobos, "Are AgriFoodTech start-ups the new drivers of food systems transformation? An overview of the state of the art and a research agenda," *Glob. Food Sec.*, vol. 40, no. December, p. 100726, 2024, doi: 10.1016/j.gfs.2023.100726.

[16] M. Munizu, "The Effect of Trust, Commitment, and Information Technology on Supply Chain Performance (Case Study of Passion Fruit Processors in Makassar City)," *J. Manaj. dan Agribisnis*, vol. 14, no. 1, pp. 32–42, 2017, doi: 10.17358/jma.14.1.32.

[17] M. M. Magesa, K. Michael, and J. Ko, "Access and use of agricultural market information by smallholder farmers: Measuring informational capabilities," *Electron. J. Inf. Syst. Dev. Ctries.*, vol. 86, no. 6, pp. 1–21, 2020, doi: 10.1002/isd2.12134.

[18] A. Mrówczyńska-Kamińska, B. Bajan, K. P. Pawłowski, N. Genstwa, and J. Zmyślona, "Greenhouse gas emissions intensity of food production systems and its determinants," *PLoS One*, vol. 16, no. 4 April, pp. 1–20, 2021, doi: 10.1371/journal.pone.0250995.

[19] K. Schanes, K. Dobernig, and B. Gözet, "Food waste matters - A systematic review of household food waste practices and their policy implications," *J. Clean. Prod.*, vol. 182, pp. 978–991, 2018, doi: 10.1016/j.jclepro.2018.02.030.

[20] M. Bhatia and G. M. J. Bhat, "Agriculture Supply Chain Management-An Operational Perspective," *Brazilian J. Oper. Prod. Manag.*, vol. 17, no. 4, pp. 1–18, 2020, doi: 10.14488/bjopm.2020.043.

[21] N. Wani, L. Li, X. Wu, and J. Fan, "Coordination of a fresh agricultural product supply chain with option contract under cost and loss disruptions," *PLoS One*, vol. 16, no. 6 June, pp. 1–15, 2021, doi: 10.1371/journal.pone.0252960.

[22] E. M. Meemken and M. F. Bellemare, "Smallholder farmers and contract farming in developing countries," *Proc. Natl. Acad. Sci. U. S. A.*, vol. 117, no. 1, pp. 259–264, 2020, doi: 10.1073/pnas.1909501116.

[23] B. Manjunatha *et al.*, "Multidimensional Scaling Method and Some Practical Applications," *Arch. Curr. Res. Int.*, vol. 24, no. 6, pp. 586–599, 2024, doi: 10.9734/acri/2024/v24i6814.

[24] A. Laapo, D. Howara, S. Kassa, H. Sultan, and A. Rahim, "A Multidimensional Approach to Assessing the Leverage Factors of the Sustainability of Seaweed Farming in Coastal Area of Parigi Moutong District, Indonesia," *J. Aquac. Fish Heal.*, vol. 10, no. 3, p. 271, 2021, doi: 10.20473/jafh.v10i3.24281.

[25] I. Mucharam, E. Rustiadi, A. Fauzi, and Harianto, "Assessment of rice farming sustainability: Evidence from Indonesia provincial data," *Int. J. Sustain. Dev. Plan.*, vol. 15, no. 8, pp. 1323–13332, 2020, doi: 10.18280/ijsdp.150819.

[26] Whidya Utami *et al.*, "Supply Chain Model of Fresh Fisheries in the Waters of Fakfak, West Papua: An Overview from the Perspective of Evaluation of Performance and Sustainability of Supply Chain," *Int. J. Entrep. Res.*, vol. 3, no. 4, pp. 95–101, 2020, doi: 10.31580/ijer.v3i4.1537.

[27] R. Françozo, A. Paucar-Caceres, and M. C. N. Belderrain, "Combining Value-Focused thinking and soft systems methodology: A systemic framework to structure the planning process at a special educational needs school in Brazil," *J. Oper. Res. Soc.*, vol. 73, no. 5, pp. 994–1013, May 2022, doi: 10.1080/01605682.2021.1880298.

[28] E. Martin, B. Winarno, H. Purnomo, and N. Wijayanto, "Managing Conflict-Risk Forest Areas Through a Soft Systems Methodology Approach: The Case of Benakat Research Forest, South Sumatra," *J. Penelit. Sos. dan Ekon. Kehutan.*, vol. 5, no. 3, pp. 179–202, 2008, doi: 10.20886/jpsek.2008.5.3.179-202.

[29] H. Augustsson, K. Churruca, and J. Braithwaite, "Change and improvement 50 years in the making: a scoping review of the use of soft systems methodology in healthcare," *BMC Health Serv. Res.*, vol. 20, no. 1, pp. 1–13, 2020, doi: 10.1186/s12913-020-05929-5.

[30] F. Chukwunonso, "Soft Systems Methodology (SSM) as a Viable Methodology for Knowledge Engineering: A Literature Review," *Int. J. Informatics Commun. Technol.*, vol. 5, no. 1, p. 1, 2016, doi: 10.11591/ijict.v5i1.pp1-10.

[31] Suharno, N. Anwar, and E. Saraswati, "A technique of assessing the status of sustainability of resources," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 250, no. 1, 2019, doi: 10.1088/1755-1315/250/1/012080.

[32] A. Eunike, D. Hardiningtyas, S. I. Kartika, and D. Andronicus, "Sustainability Analysis of Beach and Mangrove 1 Tourism in Clungup," *ECSOFiM Econ. Soc. Fish. Mar. J.*, vol. 06, no. 01, pp. 1–13, 2018, doi: 10.21776/ub.ecsofim.2018.006.01.01.

[33] M. Suresha Adiga, P. S. Ananthan, V. Ramasubramanian, and H. V. Divya Kumari, "Validating RAPFISH sustainability indicators: Focus on multi-disciplinary aspects of Indian marine fisheries," *Mar. Policy*, vol. 60, pp. 202–207, 2015, doi: 10.1016/j.marpol.2015.06.032.

[34] A. Arouna, J. D. Michler, and J. C. Lokossou, "Contract farming and rural transformation: Evidence from a field experiment in Benin," *J. Dev. Econ.*, vol. 151, no. January, p. 102626, 2021, doi: 10.1016/j.jdeveco.2021.102626.

[35] W. Dolfsma, G. Isakhanyan, and S. Wolfert, "Information Exchange in Supply Chains: The Case of Agritech," *J. Econ. Issues*, vol. 55, no. 2, pp. 389–396, 2021, doi: 10.1080/00213624.2021.1908800.

[36] N. Kanellos, P. Karountzos, N. T. Giannakopoulos, M. C. Terzi, and D. P. Sakas, "Digital Marketing Strategies and Profitability in the Agri-Food Industry: Resource Efficiency and Value Chains," *Sustain.*, vol. 16, no. 14, pp. 1–25, 2024, doi: 10.3390/su16145889.

[37] M. E. Lam, "The Ethics and Sustainability of Capture Fisheries and Aquaculture," *J. Agric. Environ. Ethics*, vol. 29, no. 1, pp. 35–65, 2016, doi: 10.1007/s10806-015-9587-2.

[38] B. R. Cook, P. Satizábal, and J. Curnow, "Humanising agricultural extension: A review," *World Dev.*, vol. 140, p. 105337, 2021, doi: 10.1016/j.worlddev.2020.105337.

[39] A. Farid, A. Pratiwi, and A. D. A. Fitri, "The Relationship of Farmers Characteristics and Perception of the Occupational Health and Safety (OHS) Application in Farming Activities in Wonosalam District, Jombang Regency, East Java," *Sodality J. Sosiol. Pedesaan*, vol. 7, no. 2, pp. 153–158, 2019, doi: 10.22500/sodality.v7i2.26974.

[40] Emmanuel Adeyemi Abaku and Agnes Clare Odimarha, "Sustainable Supply Chain Management in the Medical Industry: a Theoretical and Practical Examination," *Int. Med. Sci. Res. J.*, vol. 4, no. 3, pp. 319–340, 2024, doi: 10.51594/imsrj.v4i3.931.

[41] A. Rente, "Introduction to Agroindustry," *Bandung CV Mujahid Press*, vol. Cetakan 1, no. 23, pp. 301–316, 2016.

[42] C. El-Dewiny and A. Zaghloul, "Behavior of inorganic contaminants associated with agricultural fertilizers and their impact on soil and plant ecosystems," *Int. J. Environ. …*, vol. 6, no. 1, pp. 13–27, 2023.

[43] P. Beullens and Y. Ghiami, "Waste reduction in the supply chain of a deteriorating food item – Impact of supply structure on retailer performance," *Eur. J. Oper. Res.*, vol. 300, no. 3, pp. 1017–1034, 2022, doi: 10.1016/j.ejor.2021.09.015.

[44] F. da Silveira, F. H. Lermen, and F. G. Amaral, "An overview of agriculture 4.0 development: Systematic review of descriptions, technologies, barriers, advantages, and disadvantages," *Comput. Electron. Agric.*, vol. 189, no. August, p. 106405, 2021, doi: 10.1016/j.compag.2021.106405.

[45] H. F. Oktavia and S. Fathin, "Agriculture Start Up in Indonesia," *AGRISIA-Jurnal Ilmu-Ilmu Pertan.*, vol. 14, no. 2, pp. 51–60, 2022.

[46] R. R. Mhaski, P. B. Chopade, and M. P. Dale, "Determination of ripeness and grading of tomato using image analysis on Raspberry Pi," *Int. Conf. Commun. Control Intell. Syst. CCIS 2015*, pp. 214–220, 2016, doi: 10.1109/CCIntelS.2015.7437911.

[47] J. Muncan, S. Anantawittayanon, T. Furuta, T. Kaneko, and R. Tsenkova, "Aquaphotomics monitoring of strawberry fruit during cold storage – A comparison of two cooling systems," *Front. Nutr.*, vol. 9, no. December, pp. 1–21, 2022, doi:

10.3389/fnut.2022.1058173.

[48] K. Kusnandar, O. van Kooten, and F. M. Brazier, "Supporting self-organisation in farmer organisations in developing countries: A case with a group of farmer groups in Indonesia," *J. Co-op. Organ. Manag.*, vol. 11, no. 2, p. 100214, 2023, doi: 10.1016/j.jcom.2023.100214.

[49] K. Kusnandar, O. van Kooten, and F. M. Brazier, "Empowering through reflection: participatory design of change in agricultural chains in Indonesia by local stakeholders," *Cogent Food Agric.*, vol. 5, no. 1, 2019, doi: 10.1080/23311932.2019.1608685.

[50] G. Vittersø *et al.*, "Short food supply chains and their contributions to sustainability: Participants' views and perceptions from 12 European cases," *Sustain.*, vol. 11, no. 17, 2019, doi: 10.3390/su11174800.

[51] A. T. R. Putri and M. Rondhi, "Contract Farming And The Effect On Price Risk In Broiler Farming," *E3S Web Conf.*, vol. 142, pp. 1–5, 2020, doi: 10.1051/e3sconf/202014205002.

[52] L. Yu, W. Liu, S. Yang, R. Kong, and X. He, "Impact of environmental literacy on farmers' agricultural green production behavior: Evidence from rural China," *Front. Environ. Sci.*, vol. 10, no. November, pp. 1–19, 2022, doi: 10.3389/fenvs.2022.990981.

[53] S. Li, X. Huo, R. Si, X. Zhang, Y. Yao, and L. Dong, "Exploring the role of environmental literacy and social norms in farmers' LMTT adoption: evidence from China," *Int. J. Clim. Chang. Strateg. Manag.*, 2022, doi: 10.1108/IJCCSM-12-2021-0138.

[54] M. Riswal, F. Mallapiang, and A. Multazam, "Occupational Safety and Health Behaviors among Agricultural Workers in Rural Area Indonesia," *J. Aafiyah Heal. Res.*, vol. 2, no. 2, pp. 1–13, 2021, [Online]. Available: https://doi.org/10.52103/jahr.v2i2.558