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IMPLEMENTATION OF SOFT SYSTEM METHODOLOGY DEVELOPMENT OF A DECISION SUPPORT SYSTEM BASED ON THE INTERNET OF THINGS INTHE SUNFLOWER AGRO-INDUSTRY SUPPLY CHAIN

IMPLEMENTASI *SOFT SYSTEM METHODOLOGY* PENGEMBANGAN SISTEM PENDUKUNG KEPUTUSAN BERBASIS *INTERNET OF THINGS* PADA RANTAI PASOK AGROINDUSTRI BUNGA MATAHARI

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ABSTRAK

Bunga matahari (Helianthus annus. l) memiliki potensi nilai tambah ekonomi yang tinggi untuk dikembangkan. Indonesia memiliki peluang untuk mengembangkan agroindustri bunga matahari yang diolah menjadi minyak goreng. Penelitian terkait rantai pasok agroindustri bunga matahari belum banyak dilakukan. Rancangan perbaikan terhadap rantai pasoknya juga belum dapat dilakukan, karena situasi yang terjadi pada rantai pasoknya belum dielaborasi secara komprehensif. Oleh sebab itu, penelitian ini bertujuan untuk menganalisis situasional rantai pasok agroidustri bunga matahari, Metode yang digunakan adalah soft system methodology yang dikembangkan oleh Checkland. Penelitian ini telah berhasil merancang model konseptual yang menghasil dua aktivitas manusia, yaitu: (1) Pengembangan perangkat produksi untuk proses pengeringan biji hasil panen bunga matahari berbasis internet of things, (2) Pemanfaatan aplikasi Blynk untuk mendukung keputusan pada jaringan rantai pasok agroindustri bunga matahari, dan (3) Pengembangan prototipe platform digital sistem pendukung keputusan pada perangkat produksi berbasis internet of things. Ketiga aktivitas ini sekaligus menjadi rekomendasi yang diberikan sebagai tindakan perbaikan untuk meningkatkan produktivitas agroindustri bunga matahari. Tindakan rekomendasi juga telah berhasil dinilai melalui RE3IS. Pengembangan penelitian ini di masa datang adalah membangun prototipe digital platform sistem pendukung keputusan berbasis internet of things yang dapat diakses dengan mudah oleh pengelola agrodindustri bunga matahari. Tahapan di penelitian ini masih terbatas pada tahap rekomendasi untuk tindakan perbaikan. Tahap implementasi dapat dijadikan sebagai pengembangan penelitian di masa datang. Selain itu, analisis situasional masih terbatas dilakukan pada jaringan rantai pasok hulu dan antara. Oleh sebab itu, analisis situasional pada jaringan rantai pasok hilir dapat dilakukan pada masa yang akan datang

Kata kunci: biji bunga matahari, internet of things, minyak goreng, rantai pasok agrindustri bunga matahari, soft system metholodogy

ABSTRACT

Sunflower (*Helianthus annuus* L.) has the potential for high added economic value to be developed. Indonesia has the opportunity to develop a sunflower agro-industry which is processed into cooking oil. There has not been much research related to the sunflower agro-industry supply chain. A plan for improvements to the supply chain cannot yet be carried out, because the situation in the supply chain has not been comprehensively elaborated. Therefore, this research aimed to analyse the situational supply chain of the sunflower agribusiness. The method used was soft system methodology developed by Checkland. This research has succeeded in designing a conceptual model that produces two human activities, namely: 1) Development of production devices for the drying process of sunflower seeds based on the Internet of Things, (2) Utilization of the Blynk application to support the decisions on the sunflower agro-industry supply chain network, and (3) Development of the prototype digital platform decision support system on the production device based on internet of things. These three activities are also recommendations given as corrective actions to increase the productivity of the sunflower agro-industry. Recommended actions have also been successfully assessed through RE3IS. Future development of this research is to build a digital prototype of an internet of thongs-based decision support system platform that can be easily accessed by sunflower agro-industry managers. The stages in this research are still limited to the recommendation stage for corrective action. The implementation stage can be used as research development in the future. Apart

**Coressponding Author*

from that, situational analysis is still limited to upstream and intermediate supply chain networks. Therefore, situational analysis of the downstream supply chain network can be carried out in the future.

Keywords: cooking oil, internet of things, soft system methodology, sunflower seed, sunflower agro-industry supply chain

INTRODUCTION

The sunflower plant (*Helianthus annuus L.*) in its morphology belongs to the Asteraceae family and has 65 species (Fernández-Luqueño *et al.*, 2014). Physically, sunflower plants have coarse hairy stems 1-4.5 meters high. Sunflowers have flower crowns 7.5-30 cm wide (Das *et al.*, 2019). This plant has rough, hairy stems, wide, leathery leaves, and a round flower crown (Khaleghizadeh, 2011)

Sunflower has a high economic added value. This plant can be processed into fried oil and herbal oil, while its by-products are waste, which are useful as vitamins for livestock. (Nurhasanah *et al.*, 2023). Most of the world's oil production comes from grain, and the sunflower is the fourth largest producer of grain oil in the world after palm coconut and soybeans (Kaur *et al.*, 2023).

The world's sunflower seed oil production data show an increase from 2017 to 2020 as shown in Figure 1 (FAO, 2023). There seems to be fluctuations, but by the end of 2020 there is an increase in production of 625,39 tons. It indicates that the production of sunflower seeds has increased. Nevertheless, Indonesia is not yet registered as a producer of sunflower oil from sunflower seeds. Ukraine and Russia were recorded as the largest exporters of sunflower seed oil by 2022 with an average of 3.675 million tons.

The world's production of sunflower seeds has not yet been able to meet the demand (consumption) for sunflower seeds. World's consumption of sunflower seed in 2013 to 2023 with an average increase of 0.49 million tons per year (FAO, 2023).

There is a significant gap between production and consumption. Currently, sunflower oil production only meets 0.26% of the demand. This means that 99.74% more sunflower seeds production is needed to meet the demand for sunflower seed users to process them into derivative products.

Currently, there are not many agro-industries in Indonesia that are based on sunflowers. Some agro-industry managers who have begun developing it are scattered in West Java, namely: Ciwidey, Banjaran, Lembang, Cihanjuang, Pasir Himpun, Arjasari, and Tasikmalaya; Central Java is Rawa Pening; East Java is Lamongan; and North Sumatra field. The total area of sunflower fields planted is 23.8 Ha with a target harvest of 8 tons or 8,000 kg per Ha. Therefore, the estimated total yield of sunflower seeds for one planting cycle is 190.4 tons

Some managers today are still focused on producing in the chain of supply chains, namely, ready-made sunflower seeds processed into their derivatives. Research on energy technology continues to produce sunflower superior seeds. Independent seed production is necessary to avoid the dependence of Indonesian fielders on imported seeds which are currently produced only by Kazakhstan and China.

Therefore, this study aims to analyse the situation of the supply chain system of the sunflower renewable industry in order to be able to propose a plan of improvement for the present and future agro-industries.

Soft system methodology (SSM) developed by Checkland (Checkland, 2000; Checkland *et al.*, 2010; Checkland *et al.*, 1999) used in this study to analyse the situation of the agroindustry supply chain of sunflower. (Nurhasanah *et al.*, 2020). SSM has been much implemented by researchers in the technology management (Small *et al.*, 2014), in the coffee agro-industry (Fadhil *et al.*, 2018), in the energy industry (Ngai *et al.,* 2012), and in the *batik* industry (Novani *et al.*, 2014).

The implementation of SSM in this research is integrated with the Internet of Things (IoT) based Decision Support System (DSS). Internet of Things aims to develop and connect devices through a computer network (Velu *et al.*, 2020). Hardware connected to the IoT becomes more efficient for users because it can reduce energy consumption requirements, besides wire can control and monitor devices through microcontrollers using built-in sensors as needed. (Atzori *et al.*, 2010).

Some of the research that has been developed with DSS is integrated with IoT, including for kidney disease detection. (Alsuhibany *et al.*, 2021), water quality measurement monitoring system with sensor (Fakhrurroja *et al.*, 2023), planting power management (Sharma, 2020), and a combination of computer-based monitoring technology and IoT technology to develop DSS in production or service systems with multiple servers facilitated operations in parallel (Cho *et al.*, 2016).

Previous research has demonstrated the implementation of DSS that can effectively support decision-makers in various fields (Hao *et al.,* 2021). Several applications that implement DSS in the agroindustry field (Petkovics *et al.*, 2017), on business in the implementation of Enterprise resource planning (Fleig *et al.*, 2018), on the use of crane-robots (Khan *et al.*, 2020), software engineering requirements determination (Li *et al.*, 2020), in the health industry to identify and diagnose Parkinson's disease and chronic kidney failure (Alsuhibany *et al.*, 2021; Karni Jusufi *et al.*, 2022).

Based on the results of the library study, it is stated that IoT is the use of Internet network connected to smart wires to control and monitor hardware used in the world of industry, services, as well as households through microcontroller implanted sensors according to the needs of the user. On the other hand, DSS is a decision-making supporter that uses computer technology and soft computing data processors such as artificial intelligence (genetic algorithms, fuzzy logic, simulated neural networks), metaheuristics, and optimization, as well as working on database management systems, model database management system, and knowledge base management system.

Based on the definition of IoT and DSS, this study stated that IoT-based DSS on agroindustry supply chains are supporting decision-making based on data, models, and knowledge processed through soft computing using computer technology using remote-controlled and monitored Internet networks through prototype digital platforms on smart wires using Android operating systems.

This research is still limited only to the recommendation work for human activities outlined on the conceptual model. This is because the implementation phase will be part of the discussion on future research related to the deployment of drying shelves, the Blynk application to accommodate the IoT, and the prototyping of digital platforms with DSS.

RESEARCH METHODS

The research methods visualized through the research thinking framework are presented in Figure 1. The research thought framework is developed based on the SSM stages developed by Checkland. This research carries out three human activities consisting of: (1) Development of production devices for the Internet of Things-based seed-drying process of sunflower crops, (2) Using the Blynk application to support decisions on the agro-industry supply chain, and (3) Development of a prototype digital platform decision-support system on Internet of things-based production devices. These three human activities are visualized on the SSM conceptual model.

The stake holders involved in providing this research information are (1) sunflower fielders, (2) agroindustry managers, (3) traders, and (4) academics (researcher). Sunflower farmers are farmers located in the field of Cihanjuang, Ciwedey, and Banjaran. Traders are actors who offer seed products and sunflower oil to prospective buyers. The academic (researcher) is the actor who will analyse the situation of the agroindustry supply chain of sunflower, develop production devices, embellish the Blynk applications, and develop prototypes of digital platforms.

The thinking framework has been created, then developed in the implementation of research activities. The stage of research activity is presented in Table 1 as done in the previous study (Nurhasanah *et al.*, 2020). This study still limits the SSM stage to the sixth stage, not to the implementation stage. At the recommendation stage, the study performs an assessment based on RE3IS. (Nurhasanah *et al.*, 2021). RE3IS is relevance, efficiency, effectiveness, efficacy, impact, and sustainability.

RESULTS AND DISCUSSION

This research uses the method of soft system methodology. In compiling the results of the research needed data such as production cycles, supply chains of sunflower. The results of the research were rich pictures, CATWOE, conceptual models, and use case diagrams.

Unstructured Problem Description

Descriptions of unstructured problems in agroindustry sunflower supply chain networks are based on the results of visits, observations, and interviews in related field research. This visit took place in Banjaran Village, South Bandung district.

The agricultural industry has seven fields locations that are located in the Arjasari Village (4 Ha), Pinggirsari Village (1 Ha), Pasir Himpun Village (1 Ha), Cihanjuang Village (1 Ha), Sariwangi Village (400 m), Lembang Terrace (400 m), and Ciwidey Village (2 Ha). The location of the field of the village of Banjaran is the land granted by the Percikan Iman Mosque Foundation to be managed, and used by the owner of sunflower agro-industry. This agro-industry still belongs to small and medium-sized industries. The location of the field in the village of Banjaran has other facilities besides the sunflower field. The facilities concerned are the shelling area (Figure 2), the grilling area of the crown of the post-harvest sunflowers (Figure 3), the seed drying area (Figure 4), and the green house (Figure 5).

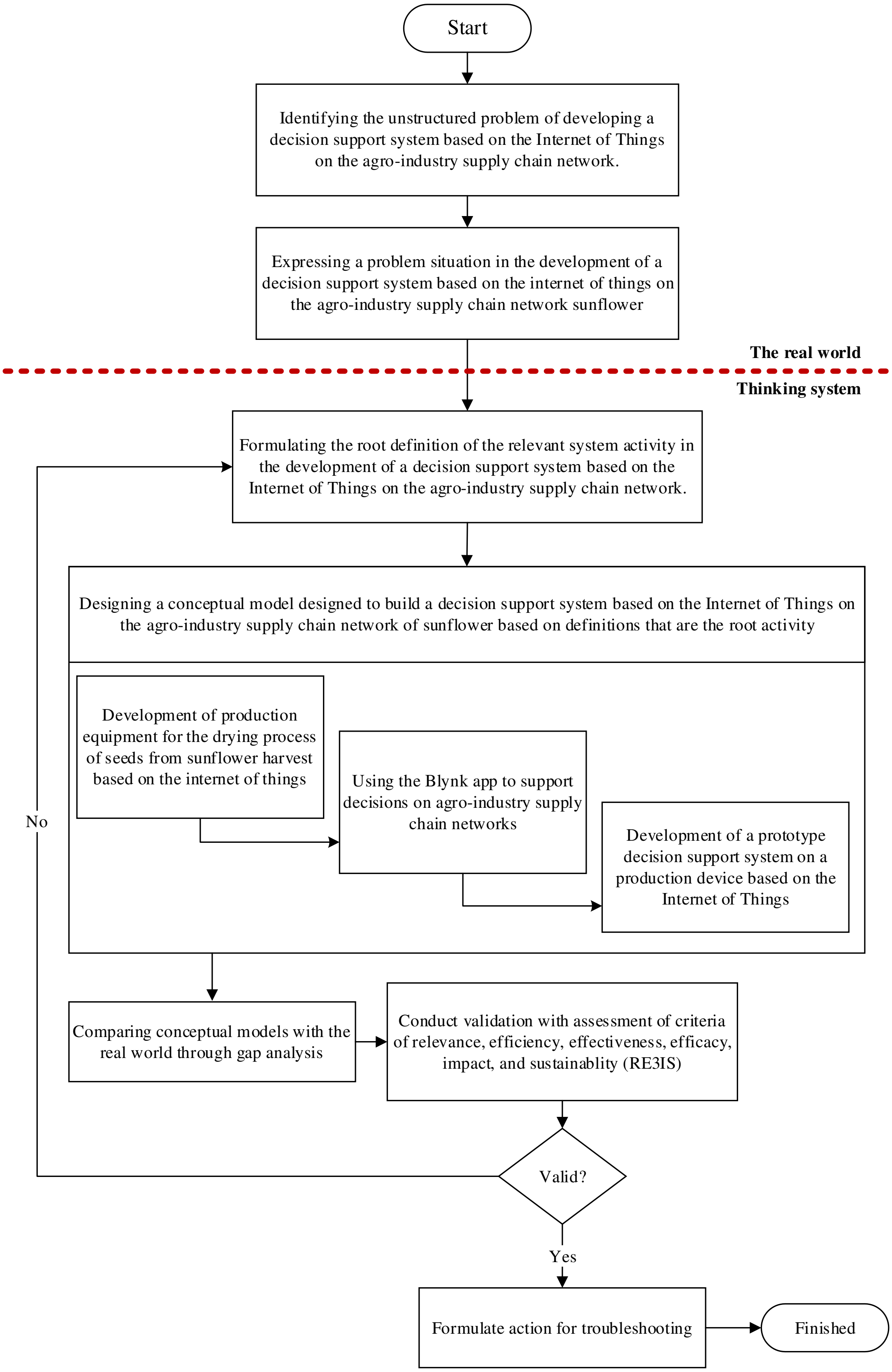

Figure 1. Research framework

Table 1. Research stages

No	SSM Stage	Description	Solutions for research
1	Describe the problem situation of an unstructured problem	Describe the entire outcome of observations and interviews in the agro-industry sunflower supply chain, as well as elaborate the role of stakeholders involved in the renewable energy industry	Conducting observations and interviews with all stakeholders in the agro-industry sunflower supply chain.
2	Visualize the problem situation	Visualize a rich picture as a result of describing an unstructured problem situation through the role of each stakeholder	Generate rich picture
3	Formulation root definition	Formulate root definitions based on observations, interviews, and rich picture visualizations based on real-world conditions as a thinking system.	Generate CATWOE
4	Conceptual model	Generating human activity carried out as a result of a situation analysis on the agro-industry sunflower supply chain network	Human activity presented in a conceptual model
5	Comparison	Comparing real-world conditions with conceptual models resulting from system thinking	Contribution to the conceptual model
6	Recommendation	Gives recommendations based on model contribution to be applied to the real world, and its evaluation is based on RE3IS	Developing a decision support system based on the Internet of Things on the agro-industry supply chain network sunflower

Figure 2. Shelling area

The marketing activities are currently handled by the marketing partners. The partners are responsible for marketing on their marketing networks and social media. On the marketing network Social Media managed are Facebook, Instagram, and TikTok.

The resulting product is fried oil with packages of 250 mL, 500 mL, 1 Lt, and 5 Lt. The other product is a cold-pressed processed herbal oil, and packed in a 30 mL bottle. The process of pressing produces a by-product (waste) in the form of dregs.

Figure 3. Crown drying area

Figure 4. Seed drying area

Figure **5**. Green house

The actors involved in the production of sunflower are the suppliers of fertilizer, the supplier of seed, the processor of seeds of the harvest, the laborers of the field, the seed mowers, the workers who process seed into oil, and the distributors. The seed supplier is an improviser of sun seed which is currently still monopolized by one improviser. The F1 seeds supplied are sunflower seeds imported from China and Kazakhstan.

The labor force that peels sunflower seeds is the housewife worker. These workers also have the task of cleaning the seeds of flowers from dirt by way of peacetime. The workforce is four people. The salary paid for one person's workforce is IDR60,000 per day with working hours from 08.00 to 15.00. The labor of the peasantry is the labor of two men who work in the field, and the labor of the plantation of the sunflower, from the production of fertilizer to the harvest.

In the supply chain of seed processors, there are workers who operate the press machine. The operator in this chain is only one person, because the machine used is a assembled press machine by the worker, and operated manually. The current engine capacity is 30 kg. The machine worked for eight working hours to produce 30% of the oil drip, and 70% of the by-product are sold as vitamin feed for livestock.

For one hectare of sunflower field, three kilograms of sunflower seeds and 20 tons of fertilizer are needed. The planting is done on a medium of soil that has been covered with each sunflower is given an area of 40 x 40 cm. The expected yield of 1 Ha of field is 8 tons of sunflower seeds. The yield produced from 1 Ha of field is 30% oil or about 2400 liters. The remaining 70% of non-oil products are by-products that are sold as vitamin feed for livestock.

The drying process of sunflower seeds takes place in the fields and factories located in Cihanjuang, Bandung. In the drying process still use conventional methods where sunflower seeds are dried in areas exposed to sunlight and to check the seeds can be taken, but no system or device that show any kind of informations, so currently still use estimates from workers.

Rich Picture

The rich picture developed in this research is based on stake holders who have roles along the upstream network and between the sunflower supply chain. The stakeholder that plays a role in the upstream supply chain network is the sunflower agro-industry which manages the cultivation and production of sunflower oil. The sunflower agroindustry is supported by marketing partners and fielders. Seed importers play an important role in supporting agro-industry managers, because currently there is only one F1 seed importer institution located in Lembang, West Bandung. Seeds are the main factor in producing quality oil products. Therefore, agro-industry managers are still very dependent on it. As long as the manager cannot produce quality seeds independently, during that time the manager will be dependent on importers.

Currently, managers are starting to think about strategies to obtain F1 seeds through research carried out together with academics. However, while quality F1 seeds have not been produced independently, managers still order seeds from importers. Sellers or traders have an important role in informing the demand for sunflower seeds to agro-industry managers. This is often not able to be fulfilled by managers, due to limited harvest yields. Therefore, sellers will submit requests to other producers to be able to fulfill the requests they receive. A decision support system will really help activities to fulfill requests from local to global levels. This is also a strategy for developing the sunflower agro-industry in the future.

The main problem faced by sunflower agro-industry managers is the sub-optimal harvest yield of 8 tons for planting 1 Ha of land. This has an impact on the unproductive sunflower oil products produced. The second problem is that there is still high humidity in the sunflower seeds that are ready to be pressed. The condition of seeds that are ready to press is at a water content of approximately 12%. The conventional method currently used is drying with solar energy in open fields as presented in Figure 4. This research develops production devices that are controlled and monitored through an IoT-based decision support system.

Root Definition

The root definition is determined based on the description results identified from the CATWOE elements as presented in Table 2. The rich picture visualization results are decomposed based on system thinking into root definitions via CATWOE.

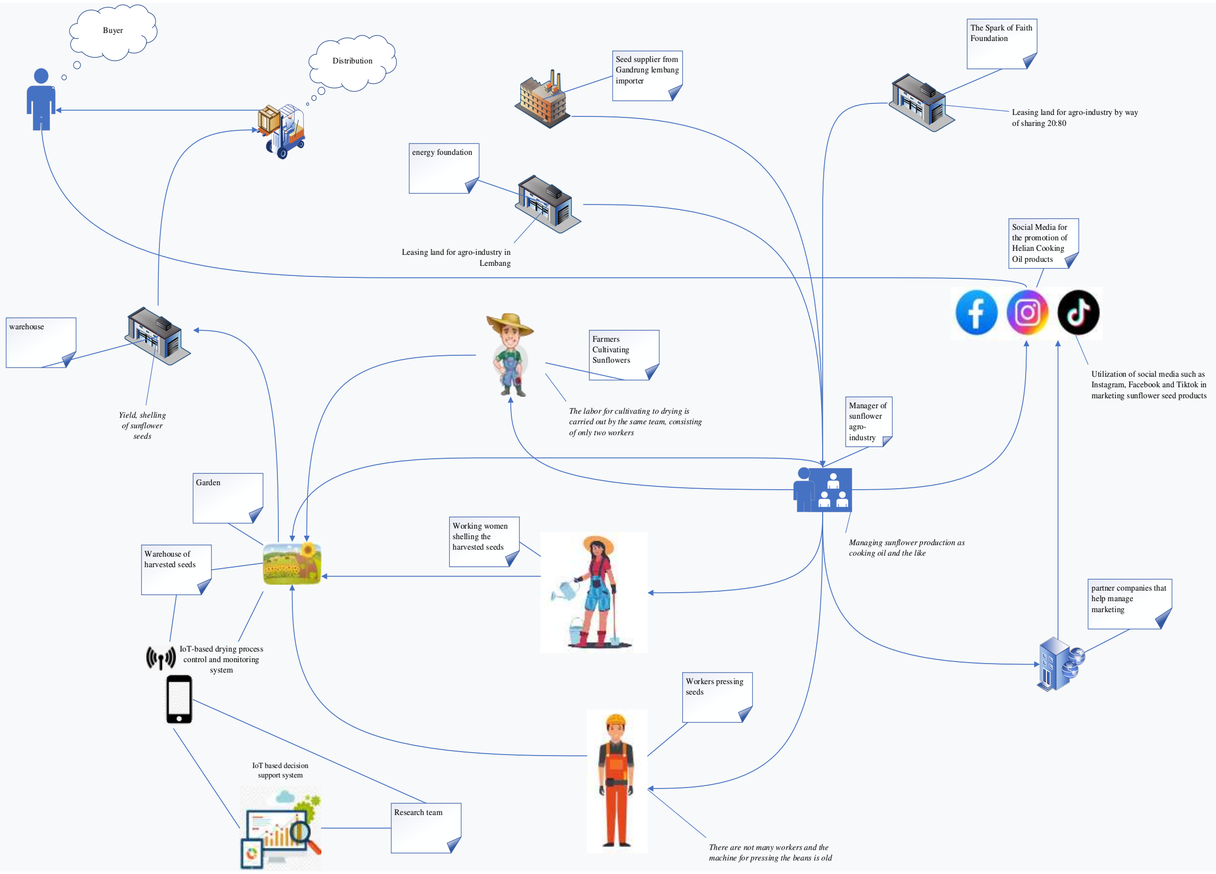

Figure 6. Rich Picture of sunflower agroindustry

Table 2. CATWOE elements and descriptions

Element CATWOE	Description Results
Client	• Sunflower seed processing agro-industry
	• Sunflower seed threshing farmer
	• Farm worker
	• Consumer
Actor	• Sunflower agro-industry manager
	• Farm worker
	• Sunflower seed threshing farmer
	• Marketing partners
	• Investors
	• Consumer
Transformation	• Drying process using production devices controlled by a decision support system platform based on the Internet of Things
	• Processing sunflower seeds to produce cooking oil, herbal oil, and animal feed
Weltanschauung	• Increasing the productivity of sunflower products through an Internet of Things-based drying process
Owner	• Sunflower agro-industry
Environment	• High-quality seeds can only be obtained from a single supplier
	• There is only one press machine, and it is used every day for 8 hours
	• Product distribution approval from BPOM has not yet been obtained
	• The factory layout is still limited
	• Moisture content control technology for the seed drying process is not yet available

The root definition for the development of an internet of things-based decision support system in the sunflower agro-industry supply chain is: "A sunflower agro-industry system; carried out by sunflower agro-industry managers, sunflower seed thresher worker, farm worker, consumers, investors and marketing partners; through the drying process using digitally controlled production devices, an internet of things-based decision support system platform, as well as the processing of sunflower seeds to produce cooking oil, herbal oil and animal feed products; to meet the needs of laboring fielders, shelling fielders, the sunflower seed processing industry, and consumers; in order to increase the productivity of sunflower products through an IoT-based drying process; in the condition that quality seeds can only be obtained from a single supplier, there is only one press machine and it is used every day for 8 hours, this product has not yet been licensed by BPOM, the layout of the factory area is still limited, and there is no technology available to fulfill the seed moisture content in the seed drying process.

Conceptual Model

The first human activity visualized through a conceptual model in systems thinking is building production equipment that will be used to increase the productivity of sunflower seed processing. The production device for the drying process is made in order to produce a water content of press-ready sunflower seeds at 12%. Once the moisture content is 12%, the humidity in the surrounding room must be maintained through a drying process controlled by a digital decision support system platform based on the IoT. Therefore, the second and third activities visualized through the conceptual model of systems thinking are developing a digital platform for an IoT-based decision support system. Figure 7 presents a visualization of the conceptual model that will be carried out in future research.

In the conceptual model it appears that there are only three human activities. This is because the conceptual model development factor is based on the research road map. The research roadmap for 2023 is focused on designing production equipment for the sunflower seed drying process which is equipped with an IoT-based control and monitoring system, and at the same time this tool is integrated with a digital platform through an IoT-based decision support system. In the research road map in 2024, the green productivity index for the sunflower supply chain will be measured, and the design of an institutional model for the sunflower agro-industry in order to realize the concept of sustainability in this agro-industry supply chain.

Comparison of Models In Systems Thinking With The Real World

Comparison of the model with real world conditions is described through the results of human activities, real world conditions, and the contribution of this research. The contribution made through designing and building production equipment as well as developing digital platforms based on the internet of things is increasing productivity. This is as presented in Table 3.

The activities carried out are recommendations given to the sunflower agroindustry. Furthermore, Table 4 describes the recommendations, indicators of the success of the recommendations, and the actors implementing the recommendations. These three human activities will be carried out by sunflower agro-industry managers and academics (researchers).

Recommendation Assessment

The assessment of the two recommendations was carried out based on relevance, efficacy, efficiency, effectiveness, impact and sustainability (RE3IS). The assessment is presented in Table 5.

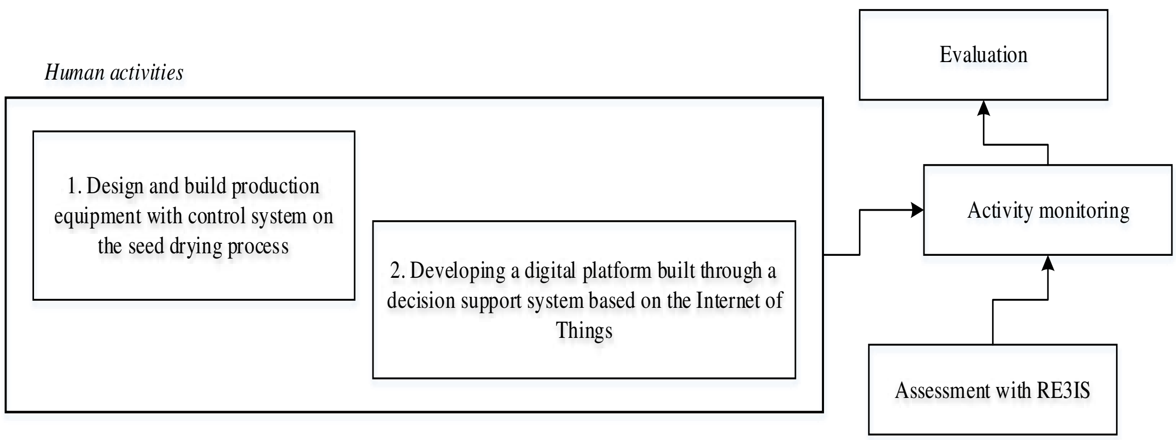

Figure 7. Conceptual model

Table 3. Comparison of models with real world conditions

Activities	Real World Conditions	Contribution
1. Design and build production equipment with a control system for the seed drying process	The sunflower agroindustry does not yet have production equipment to guarantee the water content of sunflower seeds and the humidity of the sunflower seed storage room	The design and construction of production equipment contributes to increasing the productivity of processing sunflower seeds into cooking oil, herbal oil and animal feed
2. Utilizing the Blynk application to support decisions in the sunflower agro-industry supply chain network	The sunflower agroindustry has not utilized an internet of things-based seed dryer control and monitoring system	Development of coding for a sunflower seed dryer control and monitoring system to support an internet of things based control and monitoring system
3. Develop a digital platform built through an internet of things-based decision support system	The sunflower agroindustry does not yet have a digital platform with an internet of things-based decision support system to control and monitor the drying process of harvested sunflower seeds.	The development of this digital platform contributes to increasing the productivity of press machine work using seed raw materials that have a moisture content of 12%, so that an optimal yield of 30% sunflower oil and 70% by-products is obtained.

Table 4. Recommendations, performance indicators, and actors

Recomendation	Success Indicators	Actor
1. Design and build production equipment with a control system for the seed drying process	Increased productivity of processed sunflower seeds into cooking oil, herbal oil and animal feed	Sunflower agro-industry managers and academics (researchers)
2. Utilizing the Blynk application to support decisions in the sunflower agro-industry supply chain network	Increasing the utilization of production equipment for the sunflower seed drying process	
3. Develop a digital platform prototype built through an IoT-based decision support system	Increased productivity through controlling harvested sunflower seeds at 12% moisture content	

Table 5. Evaluation of recommendations

Recommen-dation	Relevance	Efficiency	Efficacy	Effectiveness	Impact	Continuity
Design and build production devices with control systems on the seed drying process	Planning will increase the productivity and well-being of fielders	Production cost efficiency increases farmers' income	The production equipment and control system on the seed drying process was successfully designed and built to improve productivity and farmers' well-being.	Percentage of efficiency of production devices and control systems	There must be training of the user of the production device and the control system.	Production equipment can be used well and device repairs are done periodically
Developing a digital platform built through the Internet of Things-based decision support system	The digital development of the platform will guarantee seed water levels and seed moisture stored, thus impacting on increased productivity	The seed-ready press efficiency is 12% water	IoT-based digital DSS platform successfully deployed to improve product productivity	Percentage of use of digital platforms to increase productivity	There must be training in the use of digital platforms	Agro-industry managers have the ability to leverage digital platforms

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

In this research, three human activities were successfully designed in a conceptual model. These three activities are: (1) Development of production equipment for the Internet of Things-based sunflower seed drying process, (2) Utilization of the Blynk application to support decisions in the sunflower agro-industry supply chain network, and (3) Development of a digital platform prototype supporting system decisions on Internet of Things based production devices. These three activities are also recommendations given as corrective actions to increase the productivity of the sunflower agro-industry. Recommended actions have also been successfully assessed through RE3IS. Future research is to build a digital prototype of an IoT-based decision support system platform that can be easily accessed by sunflower agro-industry managers.

The SSM stages in this research are still limited to the recommendation stage for corrective action. The implementation stage can be used as a basis for future research. Apart from that, situational analysis is still limited to upstream and middle stream supply chain networks. Therefore, situational analysis of the downstream supply chain network can be carried out in the future.

Recommendation

It can be improved for further studies by putting it into practice so that actors can operate the system.

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