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Understanding circular economy implementation in the agri-food supply chain: the case of an Indonesian organic fertiliser producer

Ruth Nattassha*, Yuanita Handayati, Togar M. Simatupang and Manahan Siallagan

Abstract

Background: One of the most important issues in the agri-food industry and its supply chain is the existence of by-products, treated as wastes and discarded immediately to waste disposal. This treatment might lead to loss of possibility in gaining economic value from them. Implementation of a circular economy could prevent the economic value loss, since the circular economy utilises said wastes as resources for other processes. However, the enforcement has obstacles and a lack of explanation in the literature, particularly in the case of an organic fertiliser producer.

Results and conclusions: This research develops a conceptual model of an organic fertiliser producer through the soft systems methodology approach. The results shed light on the ongoing literature by identifying the overall system and relevant components. Further, this study highlights several issues, the most important of which is the lack of interaction between the company and the farmers, which decrease the farmers' desire to purchase the organic fertiliser. For better implementation of circular economy in this particular supply chain, it is suggested that the company establish better communication with their customers, the farmers, especially to gain better understanding of their wants and needs.

Keywords: Circular economy, Agri-food supply chain, Soft systems methodology, Organic fertiliser

Background

The matter of food waste has become increasingly crucial for the East Asia and Pacific region, as reported by The World Bank. This region generated 468 million tonnes of waste in 2016, with 53% of this being organic, especially from the food industry, making it the region with the highest amount of generated waste globally [1]. However, despite this high amount of generated waste, the majority of these wastes are immediately disposed to the landfill (46%) or incinerated (24%). This issue concerning wastes has also been acknowledged as one of the characteristics in the supply chain of the agri-food industry, in which, generally, by-products are considered as mere wastes instead of viewed as a new resource to be utilised [2]. As the wastes are immediately disposed, the failure to gain economic value from the by-products is inevitable and might cause economic loss. While some of these wastes can impact the environment positively, such as organic food waste being the natural fertilisers for plants as time goes on, they might harm the environment in the process. Food wastes generate methane when they are decaying, which might contribute to climate change in the form of greenhouse gas emission. Other than the generation of methane from decaying food wastes, the greenhouse gas emission might also come from the food production and distribution activities in the supply chain.

*Correspondence: ruth_nattassha@sbm-itb.ac.id
School of Business and Management ITB, Jl. Ganesa No. 10, Bandung, Jawa Barat 40132, Indonesia

To improve the efficiency in the supply chain process and increase the performance of waste management, the implementation of circular economy is perceived as being of significant importance. Circular economy is an economic system in which the wastes of one process are not discarded directly, but, instead, become the resources for other means [3, 4]. The circular economy delineates a closed-loop system in which the resources retain in the loop, enabling them to be sustainable by prolonged waste into new value [5]. Circular economy application is commonly found in agri-food sectors, as the problems that have tried to be solved by the circular economy are embedded and have systemic relevancy. Agricultural waste can be turned into bio-products such as fertilisers, energy, materials and compounds [6]. Curbing and converting the agri-food waste into new materials or products that instil the principles of reuse, repair and recycling could help local economies by generating a stream of profit and, in the long term, by reducing environmental damage [7]. These processes will possibly provide resources for the original process, mirroring the feedback-rich living system. However, despite this positive impact of the circular economy concept, there is also the fact that applying them in a supply chain increases the operating cost [8], though this cost might be justifiable if there is pressure for improved environmental performance from the government regulations. Thus, the worth of applying circular economy concepts might be different from case to case.

Through the implementation of this circular economy concept, there is the possibility of gaining economic value from many by-products in the agri-food industry. There is also an opportunity for this implementation to be conducted in Indonesia. In 2016, Indonesia contributed food waste of up to 300 kg per person in 1 year [9]. Indonesian Environmental Statistics stated that Jakarta, the state capital of Indonesia, produces up to 3233 cubic metres of organic waste, most of which results from activities in the agri-food industry [10]. This amount is the second highest in the world, topped only by Saudi Arabia with 427 kg of food waste per person in 1 year. Also, according to the report, methane from food waste in the landfill is 21 times more damaging than carbon dioxide as a greenhouse gas emission. Thus, other than gaining economy value from the high amount of food waste, there is also an opportunity to decrease the greenhouse gas emissions from food waste.

A literature review has been conducted to 35 articles of existing research related to the implementation of circular economy concepts. The majority of the relevant literature regarding circular economy takes place in the countries of Europe and America (Northern and Southern America combined), some of them are [11–13]. The high amount of research in Europe might be caused by the government initiative to adopt a circular economy in Europe. As for Asia, there are only two studies, which took place in India and China [14, 15]. This shows that there is a research gap on actors' interactions in the circular supply chain in the context of Asia, especially in developing countries such as Indonesia. Meanwhile, in the industrial context, only 15 of the 35 studies were concerned about the agri-food industry, showing that there is an opportunity to specifically tackle problems in the agri-food industry. There are several approaches to implement circular economy concepts in the supply chain. The majority of them, 23 articles out of 35, utilise the reuse, remanufacturing and recycling process. There is also an approach by composting organic wastes to become fertiliser [16–19]. The fertiliser can then be used in the farming processes, which can be done to either produce feeding for livestock farming or food sources for the plant-based food product supply chain. Feeding production from wastes is also a highly used waste handling process in the agri-food industry, such as the utilisation of wheat co-products for animal feed [20]. Another possible approach for implementing circular economy is by giving the waste to other industries to be utilised, such as the utilisation of pig blood and butter [16]. There is also a method to resell the products without the whole remanufacturing processes [21], and, finally, there is the sustainable use of resources through energy and resource recovery [19, 22]. The number of these approaches is far lower than the mostly used reuse–recycle–remanufacture approach.

With that being said, there is an opportunity to address circular economy concepts implementation in the agri-food industry, especially in the approach, other than the reuse-recycle-remanufacture one. This leads to the case of OrganicFe Co., an organic fertiliser producer based in Bekasi, Indonesia. While there are many organic fertiliser companies in Indonesia, this company is the one specifically stating than they are supporting the circular economy concepts in their processes. With the input resources of organic wastes, mainly composed of vegetable and fruit wastes, they can produce organic fertiliser and livestock feed by utilising the black soldier fly larvae. The larvae consume vegetable and fruit wastes, and then their biological wastes are processed to become organic fertiliser. The larvae later can also be processed to become fish and livestock feed. As they utilise the wastes from other agri-food supply chains and provide resources for said supply chain, it can be said that OrganicFe Co. is a key actor for implementation of circular economy concepts in the Indonesian agri-food supply chain.

However, OrganicFe Co. has encountered problems in their interaction with farmers as their customers. The

company admitted that, while they gave farmers their fertiliser samples and also give information regarding its benefits, especially how it supports the circular economy implementation, there are farmers who will not purchase it. For example, they stated that farmers in area A had bad experience with other organic fertiliser, thus, perceiving OrganicFe Co.'s fertiliser as equally bad. On the other side, the farmers in area B are so prideful that they would not purchase the fertiliser if they saw their neighbours already using it first, because they do not want to be seen as following them. With this, they suspected that the characteristics of farmers in specific areas might have something to do with their reluctance to purchase their products. However, is that really the case? Or is there an underlying issue in the interaction between OrganicFe Co. and the farmers?

This case demonstrates several problems regarding the behaviour of supply chain actors and the interaction between them. This research aims to gain better understanding of the issues found in the case, as well as to conceptualise the possible solutions to the issues. The conceptualisation of the OrganicFe Co. case in implementing circular economy in the agri-food supply chain is conducted in soft systems methodology steps.

The results contribute by adding new value to the circular economy concept through the lens of an Indonesian organic fertiliser producer by developing a comprehensive conceptual model and pinpointing the problems that have occurred, which is rarely found in the literature. Further, this study offers several insights, such as (1) the case of the organic fertiliser producer, OrganicFe Co., which demonstrates problems regarding the behaviour of supply chain actors and the interaction between them. These aspects are considered as the behavioural and societal dimension in circular economy research [23]. (2) The methodology used in this research is soft systems methodology, considered suitable to comprehend the implementation of circular economy in the agri-food supply chain; and (3) the results suggest possible change that should be organised to improve the system of the agri-food supply chain, such as the utilisation of farming insurance and improvement of interaction between OrganicFe Co. and the farmers.

Literature review

The circular economy concept is adapted from the living systems, which are called feedback-rich systems [4]. The term feedback-rich is used to describe living systems, as, naturally, there are no wastes which would remain as wastes. In nature systems, when wastes return to nature, they are further processed by the organism to become resources for other living organisms. An example of this would be the lifecycle of animals. When animals defecate or die, their wastes or corpses are processed by bacteria to become nutrients in soils. The nutrients are used by the plants to grow and, later, the plants become feedings for the animals. Such a concept is the goal of circular economy, in which the wastes from one process should be utilised as much as possible to become resources for other processes. With this, the number of wastes that are really not useful and have to be disposed to the landfill would be minimised. Other than decreasing the amount of waste, this system would also lead to a sustainable system, the final goal of the circular economy concept. A system is called sustainable when, by having diversity of flowing materials and processes within the system, it can provide for itself indefinitely.

The supply chain in the agri-food industry has several unique characteristics that make it different from other industries [2]. First, there are the constraints of time for almost all stages of the supply chain: there are some crops that can only be grown in a specific season; also, the procurement process for both crops and livestock resources generally takes time. There is also the fact that the crops and livestock, both as materials for further food producing processes, along with the products, are highly perishable and require special treatment for shelving and inventory, other than the obvious time limitation. There is also uncertainty for both the quality and quantity of produces, as there are various factors involved, such as biological variations and possible hazards due to the bad weather and pests. Other than this, agricultural processes often produce undesired by-products, such as manures from livestock and the unused leaves and stems from crops, which are mostly considered as wastes and are disposed of right away to the garbage disposal.

With the sure existence of such wastes, the agri-food industry would benefit considerably from the implementation of circular economy, both economically and environmentally. Economically, there is the possibility to produce biomass and biofuel from animal digestion [24], as well as organic fertiliser from the manure [16, 25]. Environmentally, the implementation of circular economy has the potential to decrease greenhouse gas emissions, along with enriching the fertility of soil [26, 27]. The implementation of circular economy in this supply chain has the final goal of sustainability, in which the whole food supply chain system would be able to provide for itself due to the diversity of processes contained within the system. Thus, it is important to consider the aspects of sustainable food supply chain and to find out whether the implementation of circular economy could fulfil such aspects.

The agri-food supply chain is pivotal in terms of the production process of staple products and the financial valuation of the industry itself [27]. The agri-food

supply chain describes the implications of supply chain management in the agri-food sector. Five key elements for agri-food supply chain are further identified: the food production, distribution, commerce, consumption and finally disposal [28]. Previous scholarly discussion emphasised on merging the concept of circular economy with supply chain management [29–31]. Circular economy in the agri-food supply chain could be seen as a business strategy [32], a residue valorisation [33], an economic growth driver [34], or a multifaceted sustainability effort [35]. By utilising circular economy, the agri-food supply chain could guarantee efficiency of agri-food processing. Further, it could guarantee food security and striving for sustainability in cross fields [36].

The food production actors are those involved in the procurement of food resources, such as livestock and crops [37]. The agri-food supply chain generally comprises suppliers, processors, traders, retailers and consumers [38, 39]. The suppliers, such as farmers and agri-industry, are considered as part of the upstream supply chain. The distribution actors, such as traders, processors and retailers, are involved in all parts of the supply chain. They are the ones who handle the transportation of livestock and crops to the processing facilities, and the final food products to the commerce or directly to the consumers. Then, there is the commerce that handles the food market, considered as the one with the most bargaining power, hence their role as the focal company. They are connected in the downstream supply chain to the consumers, who consume the product. Lastly, there is a stakeholder that handles the disposal of the products, having a role in every phase of the supply chain, since all stages of the supply chain generate wastes.

The scheme of farming insurance has been stated as one of possible solutions to the problem between OrganicFe Co. and the farmers. In Indonesia, the existence of such scheme is actually mandated by law, as the government has to protect the weak economic communities, the farmers in this case [40]. The farmers are required to pay IDR 36,000 for each hectare of land and will receive up to IDR 6,000,000 of compensation should a harvest failure happen. This scheme has been gaining more interest in recent years, as the amount of insured land keeps increasing. The existence of insurance gives a sense of security for the farmers in case there is crop failure caused by pests, plant diseases, or drought and flooding. Thus, it is understandable if OrganicFe Co. sees this scheme as a possible solution for insecure farmers who are afraid of crop failure if they use OrganicFe Co.'s fertiliser.

Methods

This research utilises a method that is able to model a complex system, along with analysing the issues: soft systems methodology developed by Checkland [41]. The soft systems methodology is utilised when there is a complex system that has several issues from various perspectives from the stakeholders involved within the system. Soft system methodology is in an approach that could help model a system that has an elaborate issue and involves various actors from different perspectives within the system [42]. The objective of the method is to understand the problem deeper, solve the issue and create a change in the form of policy or managerial transformation. Research that uses soft system methodology in the field of circular economy is limited to a specific case, such as systems engineering and logistics engineering [43], furniture [44] and automotive [45]. We argue that this research is the only research that addresses circular economy in agri-food using soft system methodology. This method is suitable to help in identifying the issues in the implementation of circular economy concepts in the agri-food supply chain, possibly from the perspective of various actors involved within the supply chain. It is worth noting that, by using this method, it might be possible to identify the mismatched perspectives from the actors, as there might be several issues that come from the lack of understanding between the actors [46].

The workflow of soft systems methodology is illustrated in Fig. 1. First, the problematic situation is considered and expressed. The problematic situation is the condition of the existing complex system which is considered to have issues and has to change. The existing condition of the system should be described, along with parts of the system, the problem situations, which are considered to be making the system worse than it should be. The problem situations can be presented in the form of a list of the situations. To further illustrate this situation, a tool called rich picture is also used [46]. While the list of problem situations enumerates the situations, rich picture illustrates these situations along with the entities related to the situations. These entities can be represented with symbols, detailed with their roles in the problem, and the relationships among entities are represented with arrows. With this rich picture, it is possible to consider the problem situations differently from the perspective of each concerned entities, as different entities might have different interpretation regarding the problem situations.

Subsequently, the root definition of those relevant systems should be defined. As the situations considered problematic are already listed, the next step is to determine which part of the system is involved in the situation. These parts, also called the subsystems, are given a unique name to identify with. The root definitions of

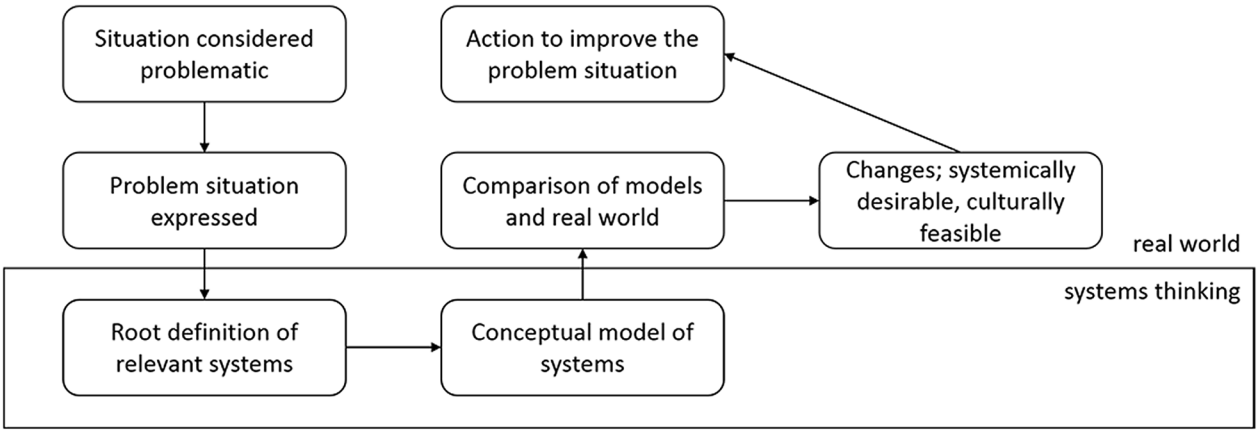

Fig. 1 Workflow of soft systems methodology [41]

these subsystems are described by utilising the CATWOE framework [41]. The CATWOE framework is the abbreviation of Customer, Actor(s), Transformation, Weltanschhaung/Worldview, Owner, and Environment. The definition of these elements is explained by [46] as such:

- Transformation is the transformation processes of the subsystem. This describes the general processes which considered something as input and resulting in an output. These processes will be broken down into activities in the later stage of SSM.
- *Weltanschhaung* is the German word of Worldview, which describes the general consensus that generally makes sense to the majority of people, justifying the root definition. According to [46], it is not solely the belief of any one individual, but the majority of people.
- Customers are the entities that receive the output of transformation processes. The output can either benefit them or do harm to them, thus it should also be described how they are affected by the output.
- Actors are the entities conducting the processes described in the transformation element. How they conduct it, as well as the effect of their characteristics on the system, can be described in this part.
- Owners are the entities which are not involved in the transformation processes, but they have authority over the system and, thus, are concerned with the performance of the system.
- Finally, environment defines the environmental constraints which are considered to significantly affect the system, especially regarding the output.

The next stage is creating the conceptual model of systems. This is basically the workflow of transformation processes previously defined in the CATWOE system. However, this is done in a more detailed way, containing what kind of activity is conducted by a certain entity in a certain process, instead of merely describing the whole process. The input and output of the system should also be considered, along with how the system ends and the result from the system, possibly something other than end products.

Afterwards, the resulting model should be compared with the physical complex system being used as reference. This is conducted to ensure that the model actually resembles the actual real life system that would be researched. The comparison could be conducted by confirming the system with experts and stakeholders related to the system. Once the model is considered to illustrate the actual system clearly, it can be utilised to make proposals for changes considered to improve the system for the better, and later applying those proposals to actual change in real life practice. This research, however, only stops at giving suggestions for improving the situations and not yet introducing those suggestions to the real systems.

To gain the necessary knowledge for conducting the soft systems methodology, we have conducted interviews with several of OrganicFe Co.'s stakeholders: some field employees of the company and also the officials having data regarding the company's promotion to several areas in Indonesia. Other than them, the interview was also conducted to researchers, who are also working as farmers who have already tried OrganicFe Co.'s fertilisers. There was difficulty in contacting the farmers who are not researchers and had already tried OrganicFe Co.'s

fertiliser, thus the conceptual model could be improved in the future by adding their perspective.

Results and discussion

This section contains the result of soft systems methodology stages.

Definition of problem situations

OrganicFe Co. is a company that produces organic fertiliser. The name of the company was deliberately disguised for confidentiality. The company is located in Bekasi, a city located on the eastern border of Jakarta, Indonesia. The organic fertiliser produced by this company utilises the input of organic wastes, mainly vegetable and fruit wastes. The company aims to solve this problem by utilising black soldier fly larvae. The process is quite simple in theory: the larvae of black soldier fly eat the organic (fruit and vegetable) wastes, and then the biological wastes produced by the larvae are processed to become organic fertiliser. According to the stakeholders in OrganicFe Co., the process of producing organic fertiliser utilising the black soldier fly larvae is faster than the regular process of producing organic fertiliser utilising bacteria. While, with black soldier fly larvae, the fertiliser can be produced in 4–5 days, with the organic wastes already degradable in just 24 h, producing the organic fertiliser utilising bacteria takes up to 7 days. There are various benefits from the utilisation of this organic fertiliser in farming activities, some of them being: it is absorbed quickly and effectively by plants; being an organic fertiliser it could increase the activity of positive microorganisms in the soil, increase the growth of root and stem, and also suppress the possibility of pests and plant disease [47, 48].

The utilisation of black soldier fly larvae also has the possibility of revenue coming from the larvae itself, as the larvae could be processed to become animal feed. The larvae could be processed into maggot flour, in which the maggot flour could be utilised as an alternative protein source. This maggot flour could be included in feed for fishes and poultry, which usually utilise the fish flour imported from other country. OrganicFe Co. says that the larvae contain 45% protein and 35% fat, with complete amino acid.

The OrganicFe Co. production process implements circular economy concepts in the way that organic wastes, coming from the vegetable and fruit supply chain, could be further utilised by other processes, as illustrated in Fig. 2. In this case, the process utilising these wastes is the production using black soldier fly larvae. The output of this production process could later provide resources for other systems, back to the vegetable and fruit supply chain in the form of organic fertiliser or to the poultry and fish supply chain instead in the form of maggot flour to become resources for feed. Thus, the case of OrganicFe

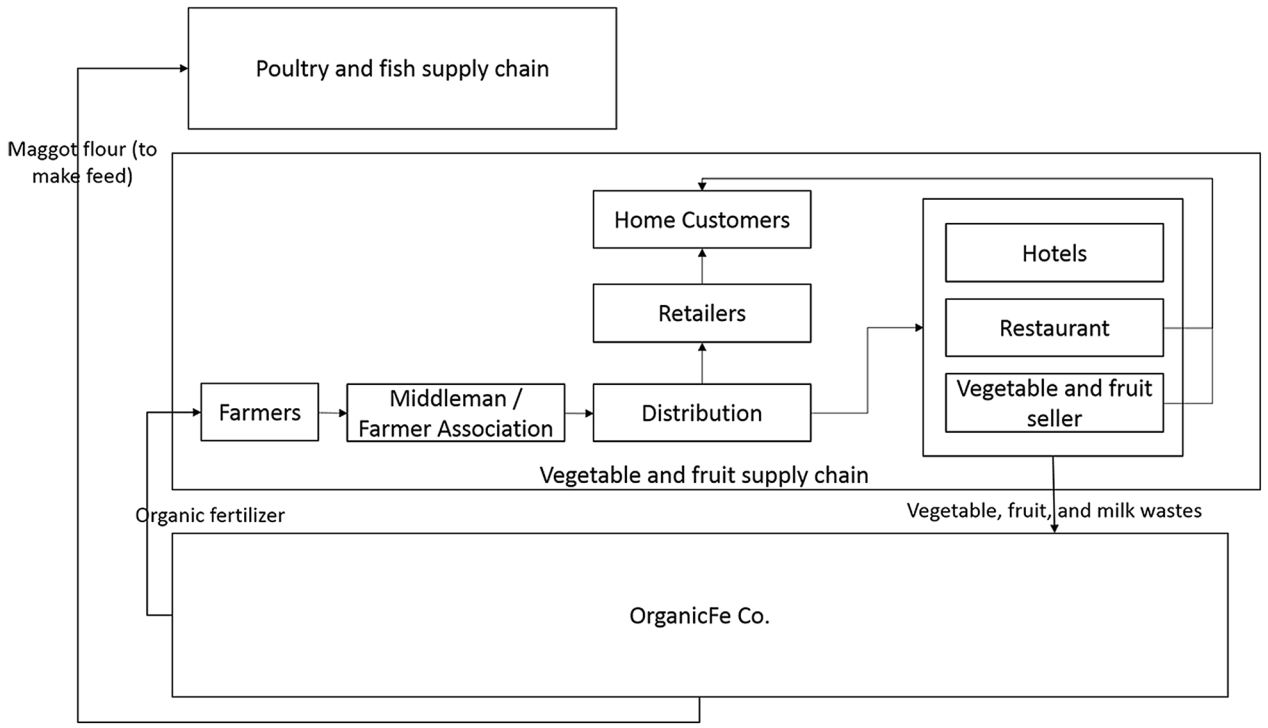

Fig. 2 OrganicFe Co.'s position within the agri-food supply chain, supporting the implementation of circular economy concepts

Co. is suitable to become a reference for research in the agri-food supply chain system, as it implements the concepts of circular economy.

From the interview with an officer of OrganicFe Co., a farmer and a supplier, there are several problems that ought to be addressed in their supply chain, especially in relation to their interaction with their customers, the crop farmers. It should be noted that these problems are viewed from the perspective of OrganicFe Co., which later might oppose the perspective from other stakeholders.

The first problem is that there are farmers who would not even try their product because of the label of 'organic fertiliser'. It has been the general perspective of local farmers that synthetic fertiliser is more effective than organic fertiliser, demonstrating a faster effect of improving the plants' conditions compared to organic fertiliser. The short delay of the fertiliser's effect to show up on plants drives them more towards synthetic fertiliser, even more so the imported synthetic fertiliser, as the general perspective of Indonesians is that the imported products are usually better than the locally produced ones. This happens even though the price of OrganicFe Co.'s organic fertiliser is far cheaper than the imported synthetic fertiliser; OrganicFe Co.'s fertiliser is Rp 70,000 for each litre and the imported synthetic fertiliser is Rp 300,000 for each litre. While this kind of behaviour is mostly influenced by the general perspective regarding organic and synthetic fertilisers, there are some farmers that actually have poor experiences with other organic-labelled fertilisers, promising great results while in fact resulting in poor harvest.

The second problem is the existence of opportunistic farmers. These farmers accept the free fertiliser samples offered by OrganicFe Co. However, they do not buy the fertiliser continually, even though they admit that the utilisation of organic fertiliser produced by OrganicFe Co. gives their crops positive results. Instead, they only want to receive free samples from any fertiliser company, completely ignoring what kind of result they would gain from the utilisation of these samples. This implies that these farmers want to obtain the highest profit possible by eliminating the cost of fertiliser altogether.

While there are farmers that could be convinced by some actual demonstration of fertiliser utilisation ending with good harvest result, some farmers in a specific area are hindered from using the fertiliser by their pride. In this area, should there be successful demonstration of OrganicFe Co.'s fertiliser utilisation conducted by one farmer, the other farmers would not want to use the fertiliser. This is caused by their pride, which makes them not want to be seen as bandwagoning by using the fertiliser. As these kinds of farmers could not be convinced by demonstration of fertiliser utilisation, another way to convince them is needed, such as the words of a charismatic leader in the area.

Another problematic situation arising from this case is the existence of farmers that blame poor harvest results on OrganicFe Co.'s organic fertiliser. They claim that the utilisation of this organic fertiliser caused them to have poor quality and quantity of harvest. However, when further investigation was conducted, it was found that the cause of the poor harvest was the careless selection of seedlings to be used in the farming. To avoid this case being repeated again, the company provides a scheme for the farmers, assisted by the Regional Development Bank, in which the seedlings and other resource providers are selected carefully, along with the existence of insurance in the event of a harvest failure due to the occurrence of natural disasters.

There is also the problem regarding the low support they have obtained from the government. As they are a waste processing company, the officer of OrganicFe Co. claimed that they should have been given incentives and should have received the waste resources for their processes for free. However, due to the complicated bureaucracy in Indonesia, they opt out of this and buy the wastes from their supplier instead. The waste supplier would not give the wastes for free, requiring incentive in the form of money. This also demonstrates that the concern towards reducing the organic waste in Indonesia, from many parties involved in the agri-food business, is still low.

Finally, the officer from OrganicFe Co. admitted that they are not aware of quality standards for crop produces being sold in the market. Thus, it could be stated that, in measuring the performance of their fertiliser up until now, they do not use the measurements utilised by the farmers to measure the performance of the fertiliser they are using. This could create a problem; if the measurements used by OrganicFe Co. do not match the measurements used by farmers, then there might be a chance that the farmers will not consider OrganicFe Co.'s fertiliser as being very useful for their farming practices.

The problem situations raised by OrganicFe Co. were later confirmed by a researcher who also works as a farmer in Bandung, Indonesia. Apparently, it seems that there is a possibility that OrganicFe Co. misunderstood the characteristics of the farmers. While there is also the possibility that there exist opportunistic farmers, there is a chance that the farmers rejecting to buy the fertiliser is not opportunistic. Rather, they find the fertiliser from OrganicFe Co. not very useful for them, as it does not improve the crops based on the measurement they are using—a weakness described in the previous paragraph.

In their promotions and socialisation, OrganicFe Co. usually claims that the success of their fertiliser is from

the increased quantity of production. However, it is never stated how much of this increased quantity is actually to be sold to the market, often also referred to as the amount of on-grade products. It would be no use if the acclaimed increased quantity is all of the off-grade products, meaning that they could not even be sold. The misunderstanding of the quantity being used by farmers to measure the performance also proved to be critical when OrganicFe Co. claimed that the usage of this fertiliser in bok choy increased the quality of the leaves being bigger. Even though their bok choy leaves are bigger, it does not make their product more marketable. Instead, it might not be sellable, as the taste would probably be bitter. The on-grade quality of bok choy is measured, not through the length of leaves, but through the sweetness and the crunchiness of the vegetable instead.

There is also the fact that OrganicFe Co. might not understand all of the conditions that should be fulfilled for their product to function effectively. For example, the researcher stated that there should be evaluation of the pH scale of the soil. The fertiliser cannot function well when the necessary pH condition is not fulfilled. Other than the pH condition of the soil, the nutrient status within the soil should also be first evaluated. This is to ensure that the fertiliser is not used in a nutrient-filled soil, as it would become redundant.

Another problem regarding the condition of OrganicFe Co.'s case from the perspective of the farmer is about the price of the fertiliser. OrganicFe Co.'s fertiliser is sold for Rp 70,000 for each litre and they aim to sell for Rp 150,000 for each litre when certified. While it is cheaper than the imported synthetic fertiliser, the price is far more expensive compared to another locally produced organic fertiliser, which is sold for around Rp 35,000 to Rp 60,000 for each litre. The performance of this fertiliser is not that far behind OrganicFe Co.'s. However, OrganicFe Co. still has the advantages of shorter production time and the quality of recycling, as this organic fertiliser is produced using bacteria instead.

Thus, the problem situations of OrganicFe Co.'s case in selling their fertiliser could be summarised in several points:

1. The behaviour of several farmers (opportunistic, high pride) preventing them from buying the fertiliser continuously;
2. Lack of trust from several farmers;
3. Lack of government support;
4. Possibility of crop failure from other causes;
5. OrganicFe Co.'s fertiliser is actually not the cheapest one on the market;
6. OrganicFe Co. lacks knowledge of the crop quality desired by farmers;
7. Incomplete standard of procedure from OrganicFe Co.

The problematic situations are then illustrated in a rich picture, presented in Fig. 3. In the figure, the problems from the perspective of each stakeholder are stated. From the side of OrganicFe Co., they are concerned about farmers not trusting their product, farmers not buying their product continuously, crop failure from other causes being blamed on their product, lack of knowledge concerning crop quality and lack of government support. From the side of the farmers, they consider that the OrganicFe Co.'s fertiliser is not the cheapest one with the best effect, they do not want to bandwagon the usage of the fertiliser, they blame the fertiliser for crop failure, they do not trust the fertiliser as being more effective than synthetic fertiliser, the incompleteness of OrganicFe Co.'s standard of procedure and OrganicFe Co.'s fertiliser not delivering the quality they desire from their crops.

Root definition of relevant systems

The root definition of the relevant systems is produced by conducting CATWOE analysis on the problem situations. In this research, the relevant system is defined first and connected to a specific problem situation. Afterwards, the CATWOE analysis is conducted on the said system. In CATWOE analysis, all six of CATWOE elements should not be defined; only the necessary items for the systems are defined in this subchapter. Although the overall system of OrganicFe Co.'s activities is not limited to these activities, there are two main systems related to the problem situations expressed in this section. Each of them is given their own CATWOE analysis.

The first system relevant to the problem situation is the interaction between OrganicFe Co. and farmers. The problem situation being faced in this system is the lack of knowledge concerning qualities of crops desired by farmers, the lack of trust from farmers preventing them from trying the fertiliser at all, the fact that OrganicFe Co.'s fertiliser is not the cheapest fertiliser on the market and the pride of farmers preventing them from bandwagoning in utilising the fertiliser. Then, there is also the problem that OrganicFe Co.'s fertiliser is not the cheapest in the market. Other than that, there is also the incompleteness of SOP (Standard Operating Procedure) provided by OrganicFe Co. which might cause the farmers to not get the result they desire. There are also farmers that only try the product, but do not buy it continuously. Lastly, there is also the possibility of crop failure from other causes, such as the careless selection of seedlings. These problems are all connected because they deal with the interaction between OrganicFe Co. and the farmers.

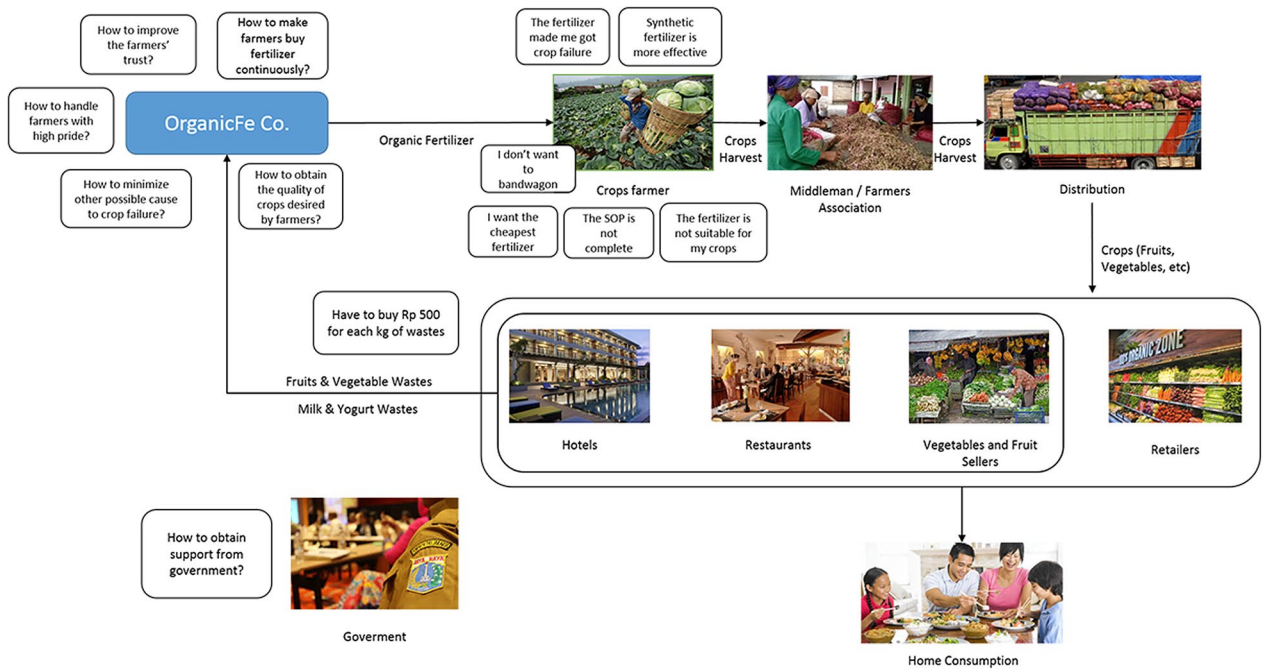

Fig. 3 Rich picture of OrganicFe Co.'s case

This system consists of three transformation processes: researching for the fertiliser, promoting and socialising the fertiliser to farmers, selling the fertiliser to farmers, and finally using the fertiliser for the farming practices. For the fertiliser research process, the main problem being faced by OrganicFe Co. is that they lack the knowledge of what qualities farmers desire when they utilise the fertiliser. Thus, when measuring performance of fertiliser in the research, they do not use the quality measurement used by the farmers. As a result, the fertiliser produced from the research might not improve the crops' quality in the way desired by the farmers. If not handled correctly, this problem would be fatal to the integrity of OrganicFe Co.'s claim regarding the success of their product.

The second transformation process is the selection of the right promotion and socialisation method for the farmers, depending on the characteristics of the targeted farmers. As mentioned before in the problem situations, there are areas that have unique characteristics of farmers: some being too prideful to bandwagon the usage of fertiliser, and some have lost trust in organic fertiliser due to poor past experience with other brands. There is also the problem of the fertiliser's price not being the cheapest on the market, so the promotion and socialisation method should highlight the benefits from utilising the fertiliser, which justifies the price. Moreover, the company could also demonstrate the properties of the fertilisers and show the real effect on the crops, thus it could solve the trust issue of farmers.

Finally, there are the processes of selling the fertiliser and how it is utilised by the farmers in farming practices. The utilisation by farmers in actual farming practices is especially important, because it is the stage that affects the necessary aftersales service to be conducted by OrganicFe Co. The problems related to these processes are the lack of trust from farmers, incompleteness of standard operation procedure from OrganicFe Co., farmers not wanting to purchase the fertiliser continuously and the possibility of harvest failure from other causes.

For all these processes, OrganicFe Co. acts as the actor who conducted the transformation processes. The farmers also become actors in the process of utilising the fertiliser, because they are the ones that conduct the activity. It should be noted that, while in the final process, OrganicFe Co. can actually become the customer of farmers by gaining information input from them (regarding their experience in utilising the fertiliser or their expectation of the fertiliser), this does not happen, thus, leading to the problem of OrganicFe Co. lacking knowledge about the farmers' wants.

For the joint scheme of OrganicFe Co., farmers, Regional Development Bank and other farming resources providers, the owners of this system are the providers of other resources for farming activities. This is especially to handle the issues of the possibility of crop failure

from other causes, such as the seedling quality. In this scheme, the resource providers for the farming activities are regulated within the scheme, along with the necessary standard of procedure to be conducted by the farmers. The execution of the scheme is then observed by the stakeholders. Should there be harvest failure due to other causes, such as natural disaster, the Regional Development Bank would pay insurance to the farmers and stakeholders. In this kind of system, the Regional Development Bank would also be involved in the system as the owner. Subsequently, the environment element for this system would be the farmers' place.

These transformation processes take place in the research facilities of OrganicFe Co., fertiliser testing ground and the farmers' dwellings. The summary of CATWOE analysis for the system of interaction between OrganicFe Co. and farmers can be found in Table 1.

The next relevant system for the problem situation is the system in which OrganicFe Co. obtains the vegetable and fruit wastes to be utilised in their production processes, using the CATWOE analysis in Table 2. From an interview with a company officer, it was stated that OrganicFe Co. obtains such wastes from vegetable and fruit sellers, hotels and restaurants. They usually buy the unsold vegetables and fruit that could not be sold the previous day. From hotels and restaurants, other than the vegetable and fruit wastes, they also gather milk and yogurt wastes to produce oilcake, media to hatch the black soldier fly larvae. Usually, they buy the wastes at cheaper price, IDR 500 (around 3 cent USD) for each kilogramme. As previously mentioned, the black soldier fly larvae only consume fresh wastes, thus requiring the company to obtain these wastes daily. After they buy the wastes, they sort and process the wastes in their facilities, such as cutting them to smaller pieces, before they give the wastes as feed for black soldier fly larvae.

The problem situation related to the system concerns the lack of government support for OrganicFe Co. It was stated that a waste processing company should have incentives from the government, as they are taking the government's responsibility of maintaining the environment by processing wastes. However, because of the bureaucratic complexity, OrganicFe Co. decided not to pursue the matter and, instead, buy the wastes. For this system, while OrganicFe Co. might seem the customer, as they do the purchase process, they should actually be considered as the actor because they are the ones doing the transformation processes. The customers of this system are, instead the vegetable and fruit sellers, along with the hotels and restaurants from whom OrganicFe Co.

Table 1 CATWOE analysis of interaction between OrganicFe Co. and farmers

Relevant systems	Problem situation	CATWOE analysis	
Interaction between OrganicFe Co. and Farmers	Lack of knowledge about qualities desired by farmers Lack of trust from farmers Pride of farmers, not wanting to bandwagon OrganicFe Co.'s fertiliser is not the cheapest in the market Incompleteness of SOP provided by OrganicFe Co. Farmers would not buy the fertiliser continuously Possibility of crop failure from other causes	Transformation	Research for composition of organic wastes to get the best quality of fertiliser for specific crops Selection of the right promotion and socialisation method for specific type of farmer Selling the fertiliser and utilising the fertiliser in farming to improve produce conditions
		Actor	OrganicFe Co., Farmers
		Customer	Farmers
		Owner	Provider of other resources for farming activities, Regional Development Bank
		Environment	Research facilities of OrganicFe Co., testing grounds, Farmers' place

Table 2 CATWOE analysis of obtaining waste resources

Relevant systems	Problem situation	CATWOE analysis	
Obtaining vegetable and fruit wastes for production resources	Lack of government support	Customer	Vegetable and fruit sellers, hotels, restaurant
		Actor	OrganicFe Co.
		Transformation	Buying the vegetable and fruit wastes from seller, hotels and restaurant
		Owner	Government
		Environment	Seller, hotel and restaurant's place, later processed in OrganicFe Co.'s facilities

buys the wastes. The transformation process itself is the process of purchasing the vegetable and fruit wastes, and then later processing them to become feed for black soldier fly larvae. The government is also concerned about the system as the owner, because the matter of waste recycling should actually also be one of their concerns. The problem of wastes is a capital concern, and the fact that there is little effort and support for food recycling demonstrates that, currently, the government is not too concerned with it. As for the environment element of the system, the purchase is conducted in the sellers', restaurant and hotel places, while the processing of wastes is conducted at OrganicFe Co.'s facilities.

Conceptual model of relevant systems

Previously analysed in this section, there are two relevant systems that are related to the problem situations in the case of OrganicFe Co. The first system is the interaction between OrganicFe Co. and farmers, which consists of several transformation processes. The second system is concerned with the resource gathering for OrganicFe Co.'s production process, the vegetable and fruit wastes. A conceptual model for each of these two systems has been developed, as presented in Fig. 4.

For the first system, interaction between farmers and OrganicFe Co., there are three transformation processes which have been broken down into several activities: (1) fertiliser research, (2) fertiliser promotion and socialisation, and (3) fertiliser purchase, usage and after sales. For the fertiliser research, OrganicFe Co. selects a certain composition of vegetable and fruit wastes. The selection of wastes is then given to the black soldier fly larvae as feed, producing test fertiliser. Afterwards, the fertiliser is tested for a certain type of crop. As of now, it is not known whether the test is conducted at a test ground in OrganicFe Co.'s facilities (though their main factory in Bantargebang does not have this kind of test ground) or in the field of a farmer. The result of this test determines the marketability of the produced fertiliser. If the fertiliser is suitable for the certain type of crop, as in the fertiliser would successfully improve the conditions of the crop, then the fertiliser can be marketed for the crop. In this stage, OrganicFe Co. has no inputs from other actors regarding whether the fertiliser can be stated as successfully improving the conditions of the crop or not, thus leading them to mistake what attributes of crops should be observed.

The second transformation process is the fertiliser promotion and socialisation process. Initially, OrganicFe Co. only used the basic strategy of promotion and providing samples for the farmers. However, after the result of promotion and socialisation to several locations, it was found that farmers in different areas might have different characteristics, and as such would respond differently to various promotion and socialisation strategies. Farmers in one area could be convinced by a demonstration of fertiliser usage in their location, whereas farmers in another area might have to be convinced by a local charismatic leader to try the fertiliser, instead of seeing their neighbour utilising the same fertiliser. These differences

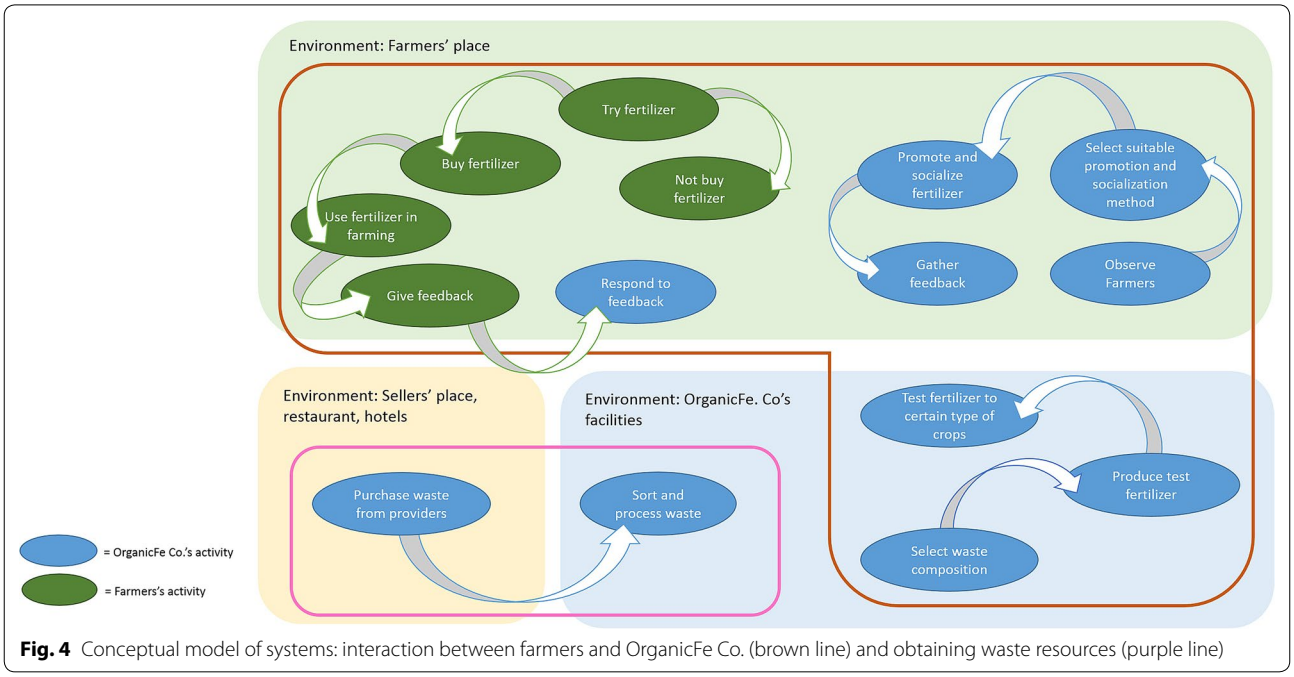

Fig. 4 Conceptual model of systems: interaction between farmers and OrganicFe Co. (brown line) and obtaining waste resources (purple line)

make the careful selection of a promotion and socialisation strategy a must. Afterwards, OrganicFe Co. could offer samples to the farmers and let the farmers use the samples. After the samples are utilised by the farmers, OrganicFe Co. would then later gather the feedback from the usage of its fertiliser.

Then, there is the process of fertiliser purchase, usage and after sales. Basically, if the farmers have a good experience with the fertiliser from the trial usage, the next event that would happen is determined by the characteristic of the farmers. If the farmers are opportunistic farmers, then they would not want to buy the fertiliser. They would, instead, wait for another fertiliser company to give them free samples. If they are not opportunistic farmers, the good experience of the fertiliser trial usage will, in turn, make them want to buy the fertiliser. In an ideal system for OrganicFe Co., the farmers would buy the fertiliser from them continuously, as long as the farmers need fertiliser in their farming activities. In the farming activities, it should also be noted that farmers would utilise other farming resources from other providers. As there has been the case of other resources causing harvest failure and the blame has been shifted to OrganicFe Co. Indonesia's fertiliser instead, the utilisation of other farming resources should also be monitored carefully. Afterwards, the farmers should give feedback to OrganicFe Co. from the utilisation of the fertiliser. OrganicFe Co. should then respond to the feedback, whether by improving their fertiliser or assisting the farmers.

The second system is the obtaining waste resource system. The system is notably simpler than the other systems. At first, OrganicFe Co. purchases the wastes from the providers, who consist of vegetable and fruit sellers, restaurants and hotels. The wastes are bought at Rp 500 for each kilogramme. Afterwards, the wastes are delivered to the working facilities of OrganicFe Co., where they are sorted and further processed to become the feed for black soldier fly larvae.

The issue with this short system lies at the beginning. As OrganicFe Co. is a waste processing company, it should have been given the wastes for free and gotten incentives from the government instead. However, the company decided to buy the wastes when they encountered the complicated bureaucracy. As the matter of waste is the government's concern, this issue should not be overlooked. It should also be noted that, while OrganicFe Co. views the purchasing of organic wastes at Rp 500 for each kilogramme as an issue, this particular system is what allows their activity to support the implementation of circular economy concepts in the agri-food supply chain. This is demonstrated in the way in which the vegetable and fruit sellers, restaurants and hotels gain economic value from the wastes that they usually directly dispose of to the landfill. If OrganicFe Co. desires support from the government for this particular issue, the support should also include the economic y value that could be gained by the waste providers from the activity.

Changes to the system

As previously defined in "Definition of problem situations" section, especially in Fig. 2, OrganicFe Co. is a key actor in implementing the circular economy concepts within the agri-food supply chain. OrganicFe Co. utilises the wastes of the agri-food supply chain, specifically vegetable and fruit wastes, to become resources for the agri-food supply chain: fertiliser for the crops supply chain and feed resource for the poultry and fish supply chain. However, there are several issues faced by OrganicFe Co. in their activities, especially in building the market for their fertiliser product. Suggestions of change to the system will be made based on whether these suggestions can possibly handle these issues or not.

The actual main issue is the lack of interaction between OrganicFe Co. and the farmers before the promotion, socialisation and sales processes of the fertiliser are conducted, causing the company to misunderstand several farmers' characteristics and the quality of crops desired by the farmers. The misunderstanding of several farmers' characteristics happens when OrganicFe Co. believes that all farmers in some specific area are opportunistic, as they only want to get free fertiliser samples from companies without buying any. While there might be some farmers with these characteristics, the farmer-researcher interviewed in this research argued that some farmers are actually rational. These farmers only buy a product that has a positive effect on their crops, specifically on the qualities required by the market. It could be that OrganicFe Co.'s fertiliser works nicely, but it does not give the farmers the qualities they desire of the crops. This is caused by OrganicFe Co.'s lack of understanding of the qualities of marketable on-grade crops. In the example described in subchapter 4.2, OrganicFe Co. believes that the fertiliser successfully improves the condition of bok choy vegetable by the result of wider leaves and stems. However, the marketable on-grade bok choy is actually measured from the crunchiness of the leaves and the sweetness of the vegetable.

Other than the lack of understanding of the qualities of marketable on-grade products, the lack of interaction also seemingly affects OrganicFe Co.'s knowledge about the standard of procedure to utilise their product. Apparently, according to research, the fertiliser functions effectively only at pH 7–9 of the soil. However, the monitoring of pH status of the soil is not included in the standard of procedure provided by OrganicFe Co. Another issue regards the nutrient contents of the soil. If the soil already

has enough nutrients, the fertiliser should not be used, as it would be redundant. However, OrganicFe Co. does not state this matter in their standard of procedure either.

While there are several possible solutions to the problems of interaction between OrganicFe Co. and the famers, it is possible to solve them by implementing a service science concept: the value co-creation process [49]. Value co-creation has been used as a tool for collaboration between customers and company in defining, delivering and communicating values as demonstrated in several researches [50, 51]. For this particular case, the important processes of value co-creation would be the co-definition and co-experience process. The co-definition process is applied when the farmers and OrganicFe Co. together define what is actually needed by the farmers, thus making an interaction between them prior to the development of fertiliser a requirement. Other than that, farmers should also give feedback to OrganicFe Co. regarding the usage of the fertiliser, so the company knows whether the fertiliser matches the needs of farmers or not. Also, OrganicFe Co. should observe farmers during their trial and farming period while using the fertiliser, collecting information about the seedlings, soil quality and standard of procedure gone through by the farmers in the farming practices when they use the fertiliser.

Through the utilisation of service science concepts in the system, OrganicFe Co.'s lack of understanding of the farmers' needs and characteristics could be minimised. As OrganicFe Co. would be the ones reaching out to the farmers, it would also be possible that the farmers' trust in the company would be improved. However, regarding the incomplete standard of procedure, OrganicFe Co. might have to expand the interaction, not only with the farmers, but also with the researchers working with the farmers. This is especially important because, while farmers might not have the means to recognise the possible lacking parts of standard of procedures, the researchers might be able to recognise it.

Another issue highlighted by the farmers is that the organic fertiliser is actually not the cheapest fertiliser on the market. While priced at Rp 70,000 for each litre, it is cheaper than imported synthetic fertiliser, priced at Rp 300,000 for each litre; this is significantly more expensive than another brand of locally produced organic fertiliser which is priced at Rp 35,000 for each litre. Thus, OrganicFe Co. should not compete by relying on price competition. Instead, it should highlight its ability to support circular economy and decrease the amount of organic wastes. The last one should especially be highlighted to catch the attention of the government.

It was previously mentioned that one of the issues in this case is the lack of government support for the activities of OrganicFe Co. As concern towards the environment has been growing, the utilisation of wastes has become the concern of governments in other countries. With the amount of wastes produced in Indonesia, especially organic wastes, it should be stated that the matter of wastes is critical for Indonesia at the moment. While attention from the government might have been poor, it is not too late to bring the case to them and highlight how the activities and utilisation of the products from OrganicFe Co. could help them in handling this critical issue. Hopefully, when they are finally concerned with the case, they will provide OrganicFe Co. with the necessary incentives and programmes. The incentives and programmes could possibly decrease the cost of activities (especially the cost of purchasing wastes), and, in turn, could possibly reduce the price of fertiliser.

In other countries, companies that specialise in managing wastes are usually given special incentive programmes. It would not hurt to conduct a similar programme in Indonesia. The incentive could come in the form of a tax reduction for the company or a programme in which the organic wastes for OrganicFe Co. are to be given for free, while the government gives incentives to OrganicFe Co.'s waste providers. If this programme is implemented for the OrganicFe Co., the company could assuredly minimise their production cost. This would possibly result in the reduction of price and their organic fertiliser would be able to compete by highlighting both the waste reducing value and the affordable price.

Based on our analysis, government bodies are significant to push and support to implement circular economy concept in supply chain practices—in line with various research [14, 52, 53]. The lack of regulation on circular economy implementation from the government might hinder the success of implementation, as it can also affect the aspect of incentives for supply chain actors [54]. In relation to the dimensions of circular economy, the impact of these aspects could be addressed from technological and environmental aspects, and then the governmental and economic aspects, in the manner of a bottom-up approach [19]. Through this approach, the required technology, environmental impact, required government policies and possible economic benefits and barriers could be derived as further measures to ensure the required societal and behavioural aspects. The remaining question would be how far the government would be willing to participate.

There is also a case in which the fertiliser is blamed for harvest failure, when, in fact, it is caused by other factors, such as the careless selection of seedling provider. This has prompted OrganicFe Co. to develop a scheme with the Regional Development Bank to prevent such an accident from happening again. The scheme regulates the providers of all other farming resources, especially

the seedling providers, the standard of procedure to be conducted by the farmers and insurance in the case of harvest failure. As the insurance will only be paid if the cause of harvest failure is an unexpected cause, such as natural disaster, the farming activities are closely monitored to prevent the possibility of harvest failure from controllable causes. This scheme is still being trialled, but it is hoped to be able to handle the opportunistic type of farmers. On another note, existing research regarding farming insurance shows that the existence of insurance does give a sense of security for the farmers, thus leading to the growing number of insured land up to date [40]. However, it should be noted that OrganicFe Co. was not aware of the extra standard of procedure that should be gone through if they want to use the fertiliser effectively. It would be fatal if the time scheme is running and the harvest failure happens because of the lack of specific steps in the standard of procedure from OrganicFe Co., such as the monitoring of the soil's pH status.

Conclusions and future research

The circular economy concept on the supply chain on agri-food is a crucial and novel issue. The role could vary, starting from decreasing food waste, improving the efficiency of the production system and even to fulfilling the sustainability purpose. However, there are only a few studies focusing on the societal and behavioural aspects of the implementation. Meanwhile, prior research has demonstrated that the actors' interaction and behaviour could affect the outcome of the supply chain. Thus, it has come to attention that research regarding the societal and behavioural aspects of circular economy implementation in the agri-food supply chain is important to ensure the success of the supply chain.

In this research, OrganicFe Co. was chosen as the case study for the circular economy implementation in the agri-food supply chain. OrganicFe Co. is a company which produces organic fertiliser and maggot flour from processing vegetable and fruit wastes by utilising black soldier fly larvae. While they obtain resources from the vegetable and fruit supply chain, OrganicFe Co., in turn, provides resources for the crops supply chain in the form of organic fertiliser, and also for the poultry and fish supply chain in the form of maggot flour, which could be processed to become poultry and fish feed. With its role as a waste processing actor that provides back resources to the original resources, OrganicFe Co. is one of the key actors in the implementation of circular economy concepts in the agri-food supply chain. However, the company also has issues in its activities.

The company stated that they had difficulties in selling their fertiliser to the farmers because there are different characteristics of their target market: some farmers have had bad experience with other organic fertiliser and, therefore, suspect OrganicFe Co.'s fertiliser to do the same, some farmers have high pride and do not want to be seen as followers if they use the fertiliser after other farmers already use it, and there are also farmers who would not buy the fertilisers because they are opportunistic and only want to get fertiliser samples. While these aspects might have some effects to OrganicFe Co.'s case, analysing the situation through the soft systems methodology actually gives more insights to the problem: there is a chance that the problem lies in OrganicFe Co.'s inability to recognise the farmers' expectations from the fertiliser, thus showing that there are some problems in the interaction between OrganicFe Co. and the farmers. Thus, it has been suggested to utilise other methods for improving their interaction, such as the value co-creation process [49]. For the farmers afraid of harvest failure, the insurance scheme provided by OrganicFe Co. aided by the Regional Development Bank, might help in improving their trust, as the scheme will be able to provide a safety net for farmers in case of harvest failure [40].

This research not only identifies the actors, but also looks at the linkage between stakeholders in the system. Therefore, the conceptual model of fertiliser producer supply chain connected with the circular economy concept is established. The aforementioned rich picture could further broaden our comprehension. The seven issues presented in the study depict the real situation and call for policy improvement and agri-food managerial enhancement.

There are several future directions research could take based on this result. First, there is the implementation of various solutions to the problem of OrganicFe Co.'s case which could become future research. The first possible future research concerns the utilisation of service science concepts to handle the lack of communication between OrganicFe Co. and the farmers. With the utilisation of such concepts, especially the value co-creation framework, OrganicFe Co. would be able to overcome its weakness of not knowing the qualities of on-grade marketable crops desired by the farmers, and also obtain the trust from farmers and gain feedback regarding their products.

Other possible future research should concern several scenarios of incentives from the government for OrganicFe Co. and the stakeholders within the supply chain, especially the providers of organic wastes. The implementation of incentives could likely minimise the production cost that OrganicFe Co. has to spend, and, in turn, would provide a chance to decrease the price at which OrganicFe Co.'s fertiliser is being sold. A cheaper price would attract more farmers to use the fertiliser, which would promote the utilisation of the product that is produced by utilisation of wastes.

Alternative future research should regard the execution of a scheme between OrganicFe Co., farmers, the Regional Development Bank and various stakeholders for a farming period, backed up by insurance. The effectiveness of this scheme, especially concerning the lacking standard of procedure provided by OrganicFe Co., could be observed to give further insights. Also, there is possible research involving other actors with similar roles to OrganicFe Co., possibly in other types of agri-food supply chain, for example, the meat supply chain and the fish supply chain. While OrganicFe Co. can provide feed ingredients for the fish supply chain in the form of maggot flour, it does not process the wastes from the supply chain. The model could be modified based on the actor that would process wastes from the supply chain, including the issues found in that supply chain, which might differ from the issues faced by OrganicFe Co.

More research about the concept of circular economy in any sectors is still open to be explored. There is paucity in the literature about which economic sector predominantly contributes to a country's growth in a circular economy. The reason might be because sustainability is still in the embryonic stage. Therefore, it would be not very easy to determine which sector of the supply chain could be categorised as circular economy. A new study could address the mechanism to execute the implementation of circular economy of agri-food in other nations or in a cross manner. The findings might offer different systems and different values from the various stakeholders. Moreover, with different methodologies, such as quantitative, analytical hierarchy process, fuzzy set theory, or modelling tools, an effective proposed policy could be developed.

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RN and YH conducted the investigation and wrote the research article. TMS and MS were in charge of supervising, reviewing and editing the research article. All authors read and approved the final manuscript.

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