The application of soft system methodology to design the conceptual model for intelligent supply chain model of natural fibre agroindustry

by Nunung Nurhasanah

The Application of Soft System Methodology to design the Conceptual Model for Intelligent Supply Chain Model of Natural Fibre Agroindustry

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Abstract. Soft system methodology in designing an intelligent supply chain is defined as a system-based method that is holistically constructed without reduction, according to representation from the real world, coming from stakeholders interacting one to another to gain value added and improve profits through data training and data saving on cloud presented from human to system of real-world database. This study aimed to apply a soft system methodology approach in designing an intelligent supply chain model of natural fibre agroindustry. A conceptual model was successfully developed and produced eight activities which were compared though assessment criteria of efficiency, efficacy, and effectiveness. The eight activities mentioned are productivity improvement, data mining to predict demand and stock, development of a collaborative planning forecasting and replenishment model, development of an intelligent decision support system, digital platform construction, value added improvement, enhancement of efficiency and response to buyers, as well as improvement in supply chain performance. This study has not yet carried out the stages of taking action to improve the problem situation, and will be carried out in further study.
Keyword: Collaboration, intelligent decision support system, performance, value added, data mining

1. Introduction

Indonesia shows the potential for plant fibre processing industries. However, their market is not able to compete with Malaysia, and some other Asean kenaf fibre (KF) producing countries [1]. Kenaf (*Hibiscus cannabicus L.*) is a fibre plant which potentially contributes to economical and environmental benefits [2]. However, the plantation area is currently increasingly shrinking to 3,344 Ha in East Java [2]. Its largest producers worldwide include India, Bangladesh, and USA at 970,000 ton [3]. FAO claimed that Indonesia is the third largest kenaf importing country [4], [5]. Improvement in kenaf value added (VA) during transformation process to produce innovated products deals with lack of raw material supply [2]. In order to ensure VA improvement in the supply chain network, availability of KF is supposed to be maintained. This is achieved through an availability system managed with information sharing in the form of collaboration [6] in an intelligent supply chain (ISC) model.

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Over 86 titles of scientific relevant paper studied, there were 31 titles related to supply chain, 55 titles related to ISC. From of all these articles, no article has been found uses SSM in developing ISC models for natural fiber cases [6]. Therefore, this research would specifically review soft system methodology (SSM) on an ISC model of natural fibre.

SSM is an approach to organize problems that are unstructured, complex, and difficult to define [7] [8] [9] [10] [11] [12] [13]; which contains interaction between components of humans and technology [14], and assisting to comprehend perception in the minds of people whom are involved in the situation [12]. SSM uses systems thinking in the research action cycle [12], dividing perspective on the real world and existing systems, the model is considered a learning tool rather than a tool for predicting, and an organized search for situations [15]. It is performed through Focus Group Discussion (FGD) [16]. SSM consists of human activities as it involves a number of stakeholders with different point of views, interests, and understandings [17]. It offers a systemic framework according to logical steps [18] that produce a process analysis. Issues of technology and decision maker are independent, with a number of conflicting stakeholder-related world's view and objectives [10]. Some research found to implement SSM in power plant construction [14], health industries [7], retailer [15], government offices for community service [8], construction [12], coffee agroindustry [19], wood-processing industries [16], tuna fishery businesses [9], education [20] [11], batik industry [17], *high techonology* industry [21], and textile industry [13]. It is concluded that SSM is a systemic approach which requires in-depth discussion, such as Forum grup discussion (FGD), in depicting complex and unstructured problems in order to be transformed into real-world data as database from an ISC model of natural fibre agroindustry (ISCMNA). In this approach, behaviour of the real-world system is modelled in system thinking into a conceptual model through CATWOE elements.

Collaborative planning, forecasting and replenishment (CPFR) is a business process that manages demand uncertainty, point of sale data, promotion and replenishment plans [22], a strategy that combines the intelligence of several trading partners in planning and fulfilling customer demand [23]. Stated by [24] CPFR as a business that combines the efforts of business partners in planning and meeting customer demand with the aim of increasing efficiency in the entire supply chain.

2. Method

Method employed in this study was according to that designed by Checkland [25]. Table 1 presents the research stages of this study.

Table 1. Research stages

No	SSM	Description	Solution by this research
1	Situation of unstructured problems	Describing roles of stakeholders and aspects related to ISCMNA in the real world	Observing and discussing with stakeholders
2	Expression of problem situation	Designing rich picture to express the problems, as well as collecting data and information	
3	Formulation of root definition from system activities	Constructing definition on expression of problem situation related to ISCMNA in the real world and on system thinking	Formulating ISCMNA root definition model by identifying CATWOE elements
4	Conceptual model	Depicting real ISCMNA problems derived from root definition	Formulating a conceptual model
5	Comparison	Comparing design of ISCMNA model on system thinking in the real world according to efficiency, efficacy, and effectiveness (3E)	Comparing the conceptual model with the real world, according to database, using 3E principal
6	Recommendation	Developing ideas of ISCMNA design in order to be applied in the real world	Determining an ISCMNA model design

Figure 1 shows the research framework. Identification of unstructured problem would be conducted based on interview and direct observation using two categories. The output was database that would be stored for comparison between real-world behaviour and real-world system thinking.

3. Result and discussion

3.1. The complex, problematic and unstructured problem of supply chain of natural fibre agroindustry
Review on complex, problematic, and unstructured problems was conducted based on field observation and FGD, starting at Balittas as a seed supplier; continued at Agriculture Agency of Garut Regency; kenaf fibre agroindustry (KFA) of Cibiuk Sub-district Garut Regency as cultivation and KF producing area; Cikutra of Cibeunying Kidul Bandung City as a producing and marketing area of woven fabric; and Indonesian tree community (ITC) Office in Bandung City as a Non Government Organization.

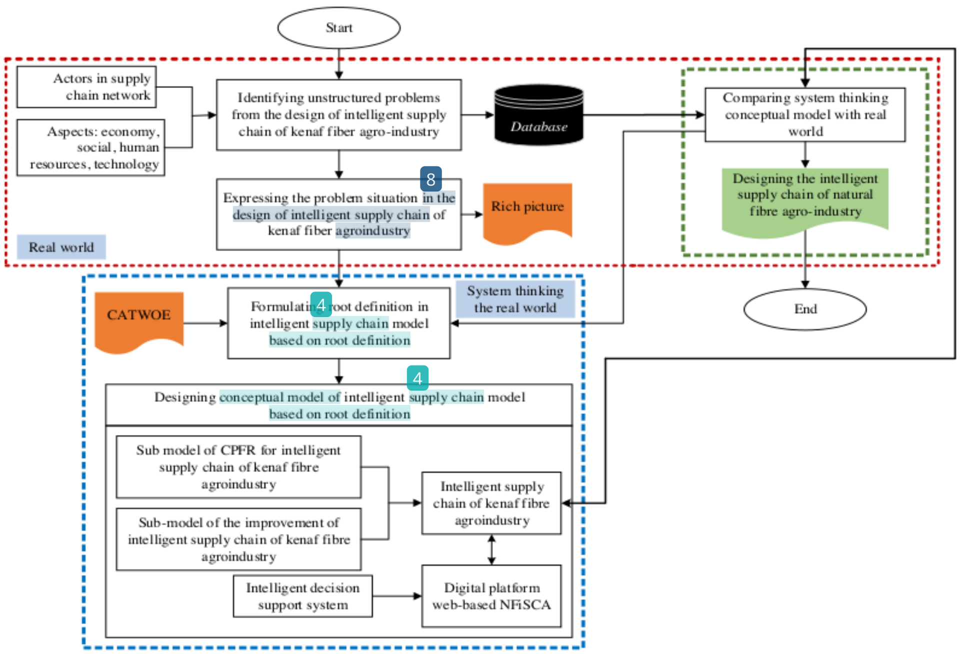

Figure 1. Research framework.

Kenaf fibre supply chain (KFSC) involves a number of actors in its network, i.e. KFA in upstream network, woven fabric manufacturing industry (WFMI) in middle-stream network, textile and textile product (TTP) industries in downstream network, kenaf farm workers, retting workers, weaving craftsmen, Balittas, investors, transportation service, seed suppliers, banks, exhibitors, and buyers, which include human resources, technology, economy, and social.

International price for dried KF is considerably promising for KFA, however this price is not applicable in purchase and sale agreement as there is monopoly power from foreign-owned company in East Java. Accordingly, KFA was unwilling to continue the agreement, considering that it was detrimental for kenaf farm workers and retting workers. This resulted in non-continuous business operation and non-optimal response to buyers. KFA has not gained VA of KF derived from core stem, that is further processed into core chip and kenaf core powder [26], as marketing in upstream supply chain network was not assured, although demand for these two products have existed in free market. This occurred since there was not a stock system managed well by KFA. Therefore, model design of ISCMNA is considered important to improve performance of KFA in responding as well as behaving efficiently and transparently during purchase and sale.

Low fibre productivity in local free market and high fibre price in global free market led to difficulty for Innatex and buyers to obtain high quality KF. WFMI in the middle network was not assured with availability of dried fibre raw material. Accordingly, they could not deal with urgent demands as buyers have to wait for the availability of raw material. Their incapability to respond to buyers properly may be prevented by enhancing collaboration in implementing an intelligent-based platform digital technology of Natural Fibre Supply Chain Analytics (NFiSCA) [8] between fibre traders and woven fabric buyers. High import of kenaf dried fibre [6] [7] became a global competition challenge for KFA, WFMI, and TTP actors along the supply chain network. In addition, monopoly power of KF production impacts on difficulty of kenaf industry actors to develop and compete. The presence of an intelligence-based Internet of Things (IoT) system which allows optimum response and facilitation of collaboration between demand and stock along the supply chain will assist improvement in performance and competitiveness of agroindustry.

In relation to technological aspect, problem addressed is manual harvesting. In addition, KFA has not employed digital device of information technology. Employment of an intelligent system-based information technology digital device is able to enhance sensitivity and collaboration between KFA and buyers at local and global levels. Collaboration which promote sales rate of dried KF will increase VA of KF. Collaboration is used to identify availability of fibre to deal with unexpected demand from buyers. Currently, KFA has not owned a system which is able to record stock and demand rate of fibre. The presence of an intelligent system in managing stock and demand system will facilitate improvement in VA. Besides of an intelligent system, each actor in the supply chain definitely needs to act optimal according to their respective tasks and functions.

WFMI developed 55 industrial houses in Pekalongan. These industries provide processing service of fibre into woven fabric in traditional manner. They actively follow exhibition events, such as *Ina Craft* and *Market Craft*. The exhibitions facilitate Innatex to come across with foreign buyers as they have not owned marketing human resources to promote and publish the products. Innatex is not able to use digital facility, rather relying on orders from phone and social media channel. Furthermore, they have not initiated to invest on loom machine, rather handing over the work to a traditional woven production houses, leading to an increased income for the production houses. The weaving process is performed manually, without machine that involves electricity and fuel, while dyeing process is carried out with manual dyeing aid. Low quality of KF will result in increased production costs for involvement of scouring process. Footwear industries which become an illustration of TTP industries in downstream network produce 200 pair of shoes per month through a handmade process, which requires more time. However, the price is relatively high, targeted for upper and middle classes. These products rely on digital marketing for their export to Canada, France, Sweden, England, Hongkong, Philippines, Singapore, and Malaysia. In addition to using online facility, these products are marketed directly through offline shops and exhibitions for IDR355,000-IDR1,800,000 per pair. As is the case for WFMI, these industries use exhibition events to introduce their products to foreign buyers. Since these products are still produced in a limited number, orders are frequently made from offline buyers. However, more buyers come from online media such as website, Instagram, and Facebook. They have been assisted with skilled marketing human resources who apply IoT-based devices, and therefore there is only minimum use of machine. Industries are able to minimize the use of glue and synthetic dye, and replace them with natural yarn and dye.

Social aspects in downstream include consumer's understanding towards an environmentally friendly concept. Consumers are actors who gain benefits from this transformation system. Introducing these products to middle and upper as well as premium consumer classes are easier as compared to lower consumer class. Thus, the challenge faced is educating consumers about environmentally friendly shoes products being offered.

3.2. *Expression of problem situation of supply chain of natural fibre agroindustry*

FAO [4], [5] recorded a gap between consumption and production of natural fibre by 90.38% [27]. According to expression of problem situation, it is obvious that a synergic collaboration was not built among supply chain network. This is noticed from weakness shown by KFA, i.e. low responsiveness to consumers, since an ISC model and a digital device to facilitate the collaboration process have not been implemented. Currently, agroindustry has not been able to optimally respond to overseas orders. Each of stakeholders should detect incompatibility in the process and products produced. Monitoring process to detect incompatibility can be performed by establishing a system that is able to recognize and control occurrence of incompatibility by intelligent decision making along the supply chain network.

There were 4 problems related to kenaf agroindustry development that were identified through literature study, i.e. unfulfillment of domestic demand for kenaf natural fibre [4], [5]; high import level of kenaf natural fibre [4], [5]; unstable price of international kenaf natural fibre; uncertainty of kenaf natural fibre fulfilment to industries, giving a impact on stock costs and shipment schedule distructive; as well as in-optimum utilization of available land [28]. Problems identified in upstream supply chain network include absence of marketing network to penetrate global market, un-implemented international price for KF, and unavailable access to free market, except for *PT XYZ*. In middle-stream network, there are still unassured availability of raw materials, long processing steps, and in-optimum response to global market. Meanwhile, problems identified in downstream supply chain include unassured fulfilment of demand from buyers due to seasonal raw materials. Based on observation of real-world situation, decisions regarding demand-based production and availability level taken by ASK have not been through a precise calculation and certain approaches.

Accordingly, an ISC model to overcome complex demand and availability problems in the real world should be developed. Supply chain flow along upstream to downstream network has been established, however decisions taken in every supply chain flow currently did not employ an ISC which is able to assure effectiveness and responsiveness of supply chain actors. In addition, this model is essential in promoting intelligent system-based decision making which is able to prevent issues of demand and stock rapidly, accurately, and dynamically. The rich picture diagram has shown in Figure 2.

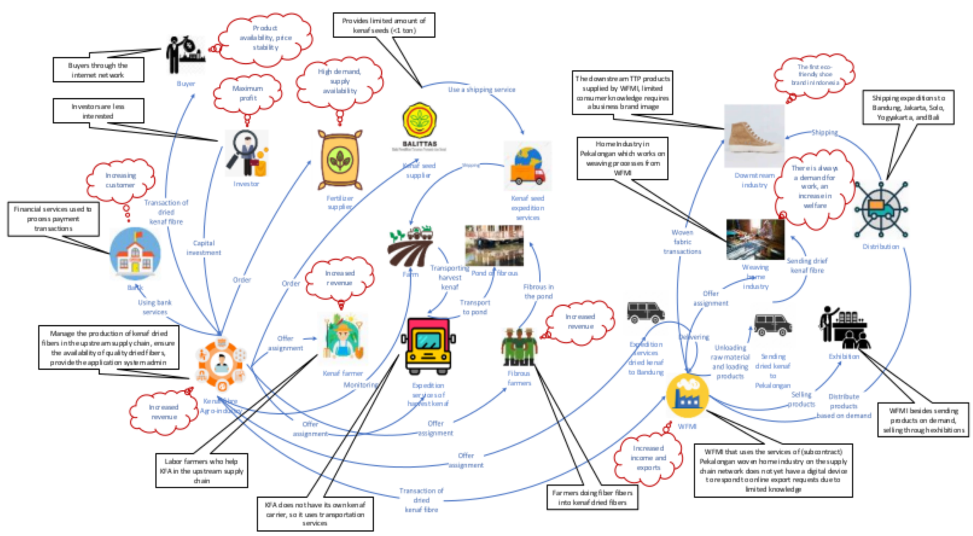

Figure 2. Rich picture of intelligent supply chain model of natural fibre agroindustry

3.3. Root definitions related to the situation of the supply chain of natural fiber agroindustry
Formulation of core definition from description of CATWOE elements is a concept which represents terms as presented in Table 2, and has been developed by [13].

Table 2. CATWOE elements and their descriptions

CATWOE Elements	Results of Description
Client	Woven fabric-manufacturing industries; woven fabric-processing industries; buyers
Actor	Kenaf farm workers; kenaf retting workers; KFA; WFMI & TTP industries; weaving craftsmen
Transformation	(1) Process of kenaf cultivation to produce dried KF; (2) Stock planning system of woven fabric and TTP products; and (3) NFiSCA web-based digital platform information system
Weltanschauung	(1) Improvement in VA of KF will enhance welfare of kenaf farm workers, retting workers, and KFA in the upstream supply chain network; (2) Improvement in efficiency and response to buyers by assuring stock of woven fabric and textile products in the supply chain network; and (3) Improvement in supply chain performance (SCP) by implementing an ISC model
Owner	Kenaf fibre agroindustry
Environment	(1) Low productivity of KF in Indonesia; (2) Wide distribution of low quality seeds in the market; (3) Low assurance of marketing; (4) Industry 4.0 force to the actors to produce highly competitive products; and (5) Government policy to encourage potential excellence of Indonesian KF in order to create competitiveness of local products that are able to play a role in global market

Establishment of root definition according to elaboration of CATWOE elements in [29] by means of an *O* system; operated by *A*; in *T* problem situation; to satisfy *C*; by *W*; in *E*. Results of root definition are as follows: “An agroindustrial system of KF; which is run by kenaf farm workers, retting workers, KFA, WFMI and processing industries, as well as weaving craftsmen; through kenaf processing, stock planning system, and information system of NFiSCA web-based digital platform; in order to meet demand from woven fabric manufacturing industries, and buyers; to improve VA, efficiency, and response towards consumers, and performance through an ISC model; on conditions of low kenaf productivity in Indonesia, wide distribution of low quality seeds in the market, low assurance of marketing, demand for industry 4.0, and in-optimum government policy in encouraging potential excellence of Indonesian KF in global competitiveness”.

3.4. Conceptual model of intelligent supply chain model of natural fiber agroindustry

Conceptual model presented in Figure 3, was established based on root definition which produces important activities in the model design of ISCMNA. Activities referred are improvement in kenaf productivity, construction of NFiSCA digital platform, data mining for prediction of demand and stock, VA improvement, development of an ISC model, improvement in efficiency and response to buyers, and improvement in SCP. These eight activities would create two models developed in an ISCMNA model design. The first sub-model, CPFR, would be developed to achieve an objective of value addition activities, as well as improvement in efficiency and response to consumers. The second sub-model, performance improvement, would be developed to achieve an objective of improvement in SCP. These two sub-models are expected to be integrated in the ISCMNA model in order to support decisions developed by NFiSCA web-based digital platform. The digital platform is developed through an IDSS, which defines management of database and model.

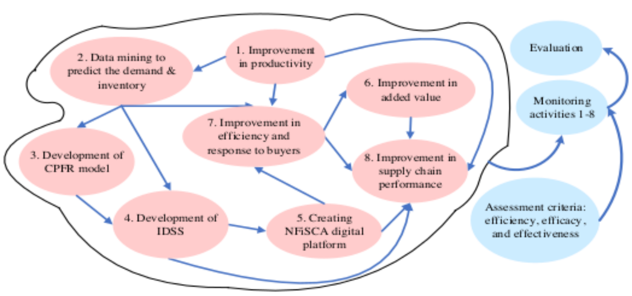

Figure 3. *Conceptual model of intelligent supply chain model of natural fiber agroindustry*

3.5. Identification of gap analysis between ideal situations and the real world

Table 3 presents a gap analysis as adopted from table [13]. Gap analysis is done by describing the activities in the conceptual model, current practice, and the contribution of the model that will be implemented.

Table 3. Gap analysis of conceptual model and problem situation

Activity	Current practice	Contribution of model
Improvement in kenaf productivity	Purchase of seeds has been performed from certified suppliers	• Scheduling planting time to predict harvesting time
Data mining to predict demand and stock	ASK and Innatex have not carried out prediction of dried KF demand & stock	• Predicting demand and stock of dried KF
Development of CPFR model	The current supply chain has not utilized CPFR model	• Identifying the supply chain business process • Analyzing the supply chain network • Developing CPFR model
Development of IDSS	The current supply chain has not utilized IDSS	• Developing IDSS
Development of NFiSCA digital platform	Unemployment of information system along supply chain to facilitate business process	• Developing NFiSCA digital platform • Carrying out user acceptance test on KFA and Innatex
VA improvement	• KFA has not optimally conducted improvement in kenaf fibre VA • WFMI and downstream industries have created variation in products • Collaboration for information sharing of product demand and stock has not existed	• Publishing KF-based products through NFiSCA digital platform
Improvement in efficiency and response to buyers	Not being able to optimally respond to buyers	• Developing a collaboration system through information sharing facilitated with NFiSCA digital platform
Improvement in SCP	Performance evaluation along supply chain network is never performed	• Presenting performance of each stakeholder in real time • Presenting solution to improve performance

Table 4 shows assessment criteria based on 3E of ISCMNA model design from eight activities elaborated in the conceptual model.

Table 4. Assessment criteria of intelligent supply chain model based on 3E

Activity	Efficiency	Efficacy	Effectiveness
Productivity improvement	Efficiency of production costs will impact on increased productivity	Improvement in productivity of supply chain and agroindustry revenue	Performance improvement is affected by a productivity improvement value
Data mining to predict demand and stock	Efficiency of stock costs	Increasing VA	Success percentage of prediction will improve SCP
Development of CPFR model	Efficiency of production and inventory costs	Improving SCP and agroindustry revenue	Success percentage of development of this model will improve SCP
Development of IDSS	Efficiency of supply chain of KFA	Improving SCP and agroindustry revenue	Success percentage of development of intelligent decision support systems
NFiSCA digital platform development	Being able to reduce production costs through time efficiency in processes of collaboration, marketing, publication, and performance monitoring	Improving performance of supply chain and agroindustry performance	Success percentage of the platform and readiness for implementation will improve SCP
VA improvement	Efficiency of production time will improve productivity and revenue	Improving SCP and agroindustry revenue	VA of products becomes a success value of agroindustry SCP
Improvement in efficiency and response to buyers	Time efficiency will improve SCP and revenue	Improving SCP	High efficiency and responding success become a success value of agroindustry SCP

Table 4. Assessment criteria of intelligent supply chain model based on 3E

Activity	Efficiency	Efficacy	Effectiveness
Improvement in SCP	Efficiency of time and costs will be achieved by performance improvement	This activity impacts on improvement in KFA competitiveness	Value of performance improvement becomes a success indicator of agroindustry development

Results of conceptual model in real-world system thinking has been evaluated with all data contained in real-world database. Deserved and desirable changes for an ISCMNA model were established, which consist of eight activities, i.e. improvement in kenaf productivity; data mining to predict demand and stock; development of CPFR model; development of IDSS; construction of NFiCSA digital platform; improvement in VA; improvement in efficiency and response to buyers; and improvement in SCP.

4. Conclusion

The conceptual model was developed and produced eight activities which were assessed for each activity with the criteria of 3E. The conceptual model produces eight activities, namely improvement in kenaf productivity; data mining to predict demand and stock; development of CPFR model; development of IDSS; construction of NFiCSA digital platform; improvement in VA; improvement in efficiency and response to buyers; and improvement in SCP. The limitation of this study is that the SSM stage has only been carried out until stage 6, while the seventh stage, which is to take corrective action to the problem, has not been carried out in this study. Future reaserch of this study is developing the detail of the models, the models are: CPFR, developing IDSS, and creating NFiSCA digital platform. This study recommended that the government should provide assistance and issue policies to support the development of kenaf fiber that has the potential to be favored into competitive products that support Indonesia making 4.0.

Acknowledgment

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