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Agent-Based Simulation Model for the Sustainability of Minapolitan: A Case Study of Shrimp Agroindustry

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Abstract

Minapolitan is defined as an effort to accelerate the development of marine and fisheries in the fishery production centers. (KKP, 2010). Minapolitan can be considering as an effort to implement equitable and sustainable economic development through rural development focussing on fisheries as a cluster developing point. There are many elements that should be accommodated in the development of Minapolitan due to the complexity and the social dynamic of this program. Thus, to develop a sustainable Minapolitan cluster model in an shrimp agroindustry, an agent-based approach is needed. The result of simulation model shows that the current Minapolitan program can be considered sustainable since the supply of shrimp raw material reaches 557 kg per hectare and the average profit is about IDR 6 million. Fisherman's behavioural changes in choosing shrimp seeds, optimizing fishpond area, and improving aquaculture managerial skills could increase the production of shrimp and the profit. Improving the management of post-harvested shrimp conducted by middleman could increase the percentage of the product bought by agroindustries in the Minapolitan zone.

Keywords: Sustainable Minapolitan, Agent-based Simulation Model, Agroindustry, Shrimp

1. Introduction

Minapolitan is a rural area designated to support the development of agroindustry through an establishment of cluster developing point in a sustainable fishery agribusiness system. (CPRI, 2010). In 2010, based on marine and fisheries ministerial degree No. 32/Men/2010 and No.39/Men/2011, 223 Minapolitan zones have been established in 33 provinces. However, the development of Minapolitan zone has not had significant positive impact. According to Grahardyani (2010), Minapolitan has been underdeveloped since local government is not ready yet in implementing the program. There are many elements that should be accommodated in the development of Minapolitan leading to the complexity and the social dynamic of this program. Thus, to develop a sustainable Minapolitan cluster model in an shrimp agroindustry, an agent-based approach is needed.

Agent-based model approach in the development of Minapolitan in sustainable shrimp agroindustry will produce a simulation model for the sustainability of Minapolitan constructed from interaction among each autonomous agent within a cluster. The agent-based approach is started from identifying agents within Minapolitan cluster of shrimp agroindustry, the agent's behaviour, the interaction between agent, the agreements among agents, and the interaction between agent and the environment. The next step is constructing a cluster model based on the principles of sustainability.

The simulation model resulted from this study not only has ability to determine the sustainability, but also has ability to simulate policy scenario to predict changes in agent interaction and the impact of the changes to the sustainability of Minapolitan. The analytical ability and the policy scenario simulation will be useful for decision makers in formulating strategies of Minapolitan cluster's sustainability.

2. Methods

This study was conducted through two systematic and structured stages. The first stage was the analysis of existing cluster system. The second stage was the design of alternative cluster model. The alternative cluster model was developed through agent identification, the analysis of cluster sustainability, and the formulation of strategies to improve the sustainability of simulation model. Figure 1 shows the analytical framework of study.

Bergenti and Paola (2002), state that the main purpose of agent-based analysis is to identify main actor interacting with the system, the way they interact, and the activities within the system. The next step is formulating role, responsibility, and the capability of agent and how they interact with one another. An agent has behavioural characteristic, strategies and procedure use to response to the environment (Smith and Conrey, 2007).

The Minapolitan for shrimp agroindustry has four main agent namely shrimp farmers, middleman, wholesaler, and agroindustries. Each agent has specific activity related to each position within a cluster. Shrimp farmers play a role as producers, i.e. how produce shrimp, middleman and wholesaler do trading, and agroindustry processes the shrimp to be sold domestically or internationally.

The activities of farmer sin the cluster comprise analysing the prospect of shrimp business. When it comes to harvesting time the farmers will look for middleman to sell the shrimp with an agreed prize. Table 1 show the complex activity shrimp farmers. The activities of middleman and wholesaler comprise identifying shrimp prize and quality that are required by the buyer, analysing the areas and volume of harvest, buying the shrimp and sorting it base on size.

The result of sorting activity done baying middleman is sold to wholesaler, shrimp that is not qualified for wholesaler is usually sold directly to the market. Table 2 show the activity middleman and wholesaler

The activities of agroindustry comprise analysing the demand of shrimp product at the international market. The result of identification activities is use to establish shrimp production plan. The other activities is acquiring row material from wholesaler how can profit required quality and prize. The next activity is processing shrimp commodity in to several food products. Table 3 show the activities conducted by agroindustry agent

After identifying the agent activities. the next step is translating the activities into a simulation model using spot oriented agent role simulator (SOARS). This application was introduced by Takuma *et al* (2005) to bridge the gap between functional and bottom up approach. The concept of SOARS was established from agents that have several embedded variables. The stages of the analysis consist of initial stage, main stage and terminal stage. The analysis of the Minapolitan development in shrimp agroindustry using soars is shown by Figure 2.

3. Results and discussion

3.1 Situational Analysis

The sustainability of improving shrimp Minapolitan agroindustry is done through the implementation of several scenarios. The scenarios related to the activity of agents in shrimp Minapolitan agroindustry. Changing in scenario is more focused on the efforts related to the activities of farmers in increasing the production of shrimp. The increase of shrimp production is very important because the activity in the cluster Minapolitan closely related to the volume of shrimp production. Supriyati and suryani (2006) mentions that one of the obstacles in the development of agroindustry is lack of continuity in agricultural commodities, as a raw material for agroindustries. Actor's activities in the Minapolitan cluster will be increase in line with the increasing volume of shrimp production. The increase will affect the Minapolitan sustainability. The Minapolitan sustainability could be assess from the economic, social and environmental dimensions.

The main constraint in the activity of Minapolitan is low of production of Vannamei shrimp done by farmers. Production of Vannamei shrimp in the study area was around 400 to 600 kg/hectare using traditional plus cultivating patterns. However, some research and field trials were able to produce shrimp around 800 to 900 kg per hectare. Erfan et al. (2007) implement the cultivation of Vannamei shrimp using traditional plus patterns in Maros District where 80,000 seeds per hectare produced 835 kg of shrimp. The trials conducted by the Center for Development of Brackish Water Aquaculture in Jepara using the same pattern of cultivation could produce 950 kg/ha of shrimp from 75,000 seeds (Sapto, 2011).

Marketing of Vannamei shrimp in the study site showed no constraints where each agent obtains enough profit depends on the volume of traded shrimp and supported by an open market system of Vannamei shrimp. The transparency of shrimp price can be seen by all of agencies, so that they will estimate the profit and the manipulation of shrimp price can be minimized. All shrimp production can still be absorbed by agroindustry of frozen shrimp. The condition in the field shows the shortage of Vannamei shrimp supply.

Environmental issues, particularly water waste generated by Minapolitan activity, do not bring many impacts on the sustainability of Minapolitan shrimp agroindustry. Waste of shrimp cultivation produced by farmers are not overly concerned because the production technique applied by the farmers is traditional plus system with a little input of feed. The shrimp feed is one of the main components that contribute to the production of solid wastes in Vannamei shrimp cultivation. The awareness of the use of shrimp cultivating system is not found in the case Minapolitan in Gresik District. However, the subject needs to be observed is the water waste from rinsing activity of the shrimp carried out by a small traders and wholesalers. Water waste as the result of shrimp rinsing will increase as the volume of purchased by the traders increases.

3.2 Simulating the Scenarios of Minapolitan Sustainability

The scenarios of the sustainability of Minapolitan shrimp agroindustry will change some variable, then do the simulation process. Shrimp aquaculture activities will integrate several farmers who have different size of the fishponds, different use of quality seeds, and different shrimp survival scenario. At the level of traders, both small and large traders, sorting scenario will be simulated by changing the percentage of shrimp quality resulted by the sorting process.

The simulations were run using eight farmers where each farmer has different size of fishpond ranging from 1 hectare to 4 hectare. Each farmer uses quality of seeds based on present real conditions. The initial capital was set according to the present conditions of planting costs amounted around IDR 15 million per hectare. The number of seeds in accordance to the current traditional cultivation system and survival rate was also adjusted to current conditions, e.g. 30%. Traders were simulated using four small traders, two wholesalers and each trader has ability in handling shrimp commodities. Simulation process was set up to a period of 5 years and every year has four times harvest seasons. The output of simulation was assessed using sustainability indicators. These indicators are profit of actors cluster, labour absorption, the shrimp production volume, and the potential waste.

3.3 Materials Supply

The sustainability of the supply from the simulation shows that the average production of shrimp in current condition is 557 kg per hectare. Those conditions shows after verification process, so the simulation model can be implemented because the output I s available with field condition. The current sustainability of the raw material is far from the expected value when the sustainability is compared to the conditions that have been done by previous research. The simulation of seed usage is conducted using survival rate based on research by Center for Development of Brackish Water Aquaculture in Jepara. The result shows that the average shrimp production is 943 kg per hectare. This means more than 1.5 times from the average current output. The details are shown in Figure 3.

The simulation model developed shows that using of quality seeds, production of shrimp reaching 4.758 kg of 4 hectare. It shows that using of quality seeds is greatly influence production of Shrimp.

3.4 Profit for Cluster Actors

The simulation model to assess the sustainability of Minapolitan economic region describes the benefit that can be obtained by each actor as shown in Figure 4. The fluctuation of the profit rate indicates that farmers with an area of 1 hectare faces lower risks compared to the farmers with an area of 4 hectare as well as the area of 2 hectare and 3 hectare. The advantages of farmers that use moderate seeds with the area 1 hectare with average production 568 kg is that they were able to gain profit about 6 million rupiah, compared to the same area but using different seeds where they were able to get an average profit of 18 million rupiah with the level of shrimp production reaching 959 kg.

Similar to the previous simulation, models for benefit of traders depends on the volume purchased and the accuracy in predicting the quality of shrimp. The higher the volume purchased, the higher the quality of sorted shrimp, the higher the percentage, the larger the profit that can be obtained. Small traders can make a profit between 286 to 350 rupiah per kilogram, while the larger trader can make a profit of shrimp around 229 to 245 rupiah per kg.

3.5 Potential Waste

Potential wastes generated from Minapolitan activities are solid and liquid wastes. The more shrimp sorted, the more liquid waste produced, leading to the higher demand for water. In the area of 20 hectare the average liquid waste produced can reach 57 thousand litres for each harvest period. The simulations shows that the highest potential of liquid waste could reach 61 thousand litres. The liquid waste generated from the Minapolitan is shown in Figure 5.

Solid waste is mainly food wastes that are not consumed by the shrimp, which stay within the water. Approximately 35% of shrimp feed will stay within the water pond, if the feed is increased then the amount of total solids will be more and causing the pollution. This condition is usually found in the intensive shrimp farming system with highly depend on feed input. Soewardi (2002) suggested that intensive shrimp cultivating activities with land area of 5000 m^2 and a total of 3.6 ton of feed input for 120 days of maintenance could produce waste in the form of Total Soluble Solid (TTS) as much as 1,230 kg. The result of the simulation of potential solid waste from shrimp feed is shown in Figure 6.

Potential of average solid waste average per planting period of 1.131 kg feed for 20 hectare is between 1.078 to 1.174 kg. Compared to intensive system, the solid waste generated by the system is about 43 times less intense. Thus, traditional plus system is more environmentally when viewed from the aspect of environmental sustainability.

5. Conclusion

The Minapolitan agroindustry cluster development model is designed to predict the sustainability of shrimp Minapolitan area by doing some simulations that may occur in the real system. The result of the simulation shows that current Minapolitan program can be considered sustainable as indicated by the supply of shrimp row material reaching at 557 kg per hectare and the average profit reaching IDR 6 million. Fisherman's behavioural changes in choosing shrimp seeds, in optimizing fishpond area, and in improving aquaculture managerial skill could increase the production of shrimp and the profit. Improving the management of post-harvested shrimp conducted by middleman could increase the percentage of the product purchased by agroindustries in the Minapolitan zone.

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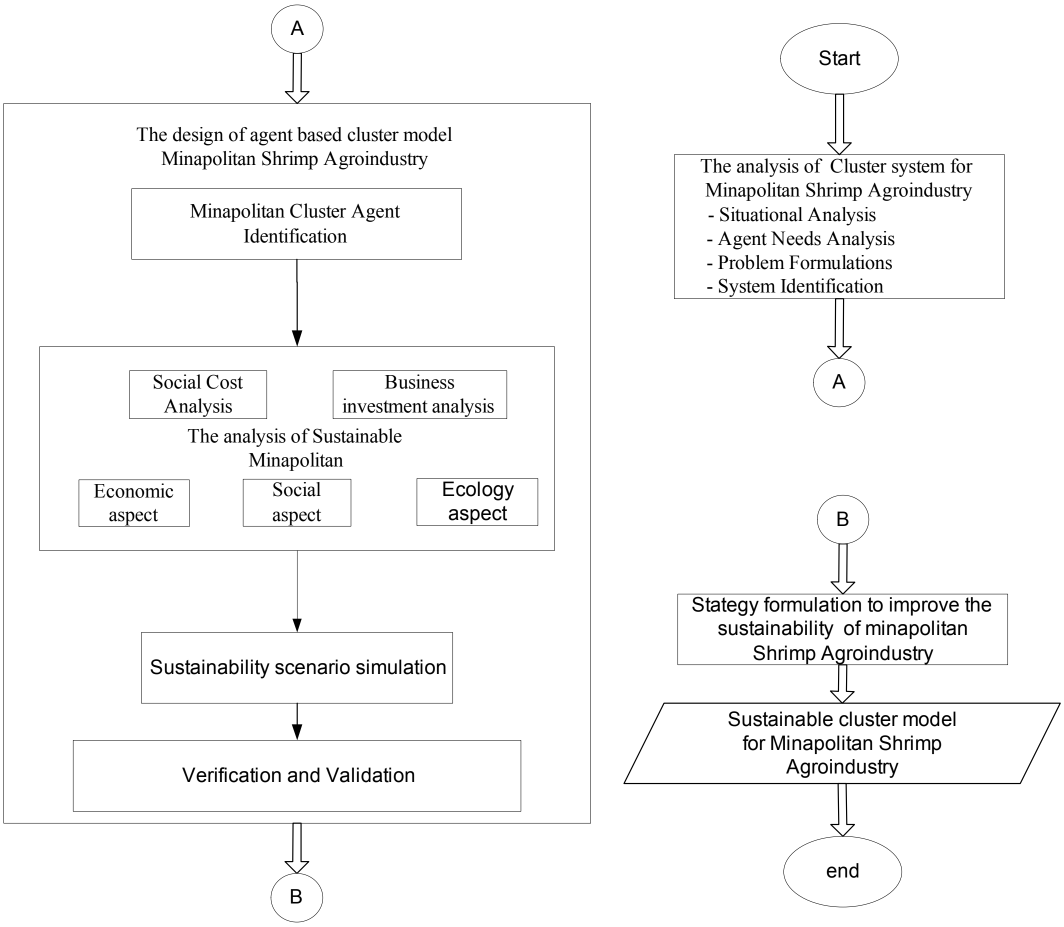

Figure 1. The analytical framework for development of agent-based cluster model in Minapolitan shrimp agroindustry

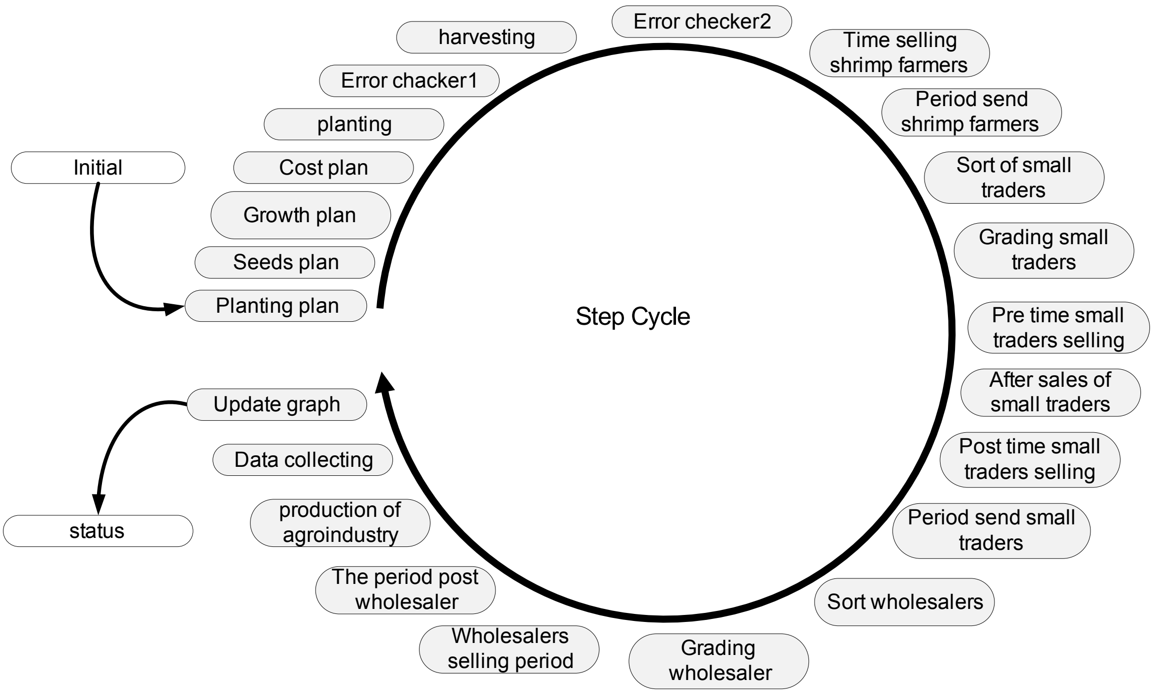

Figure 2. Cycle Simulation of Agent Activity in SOARS (Deguchi, 2006)

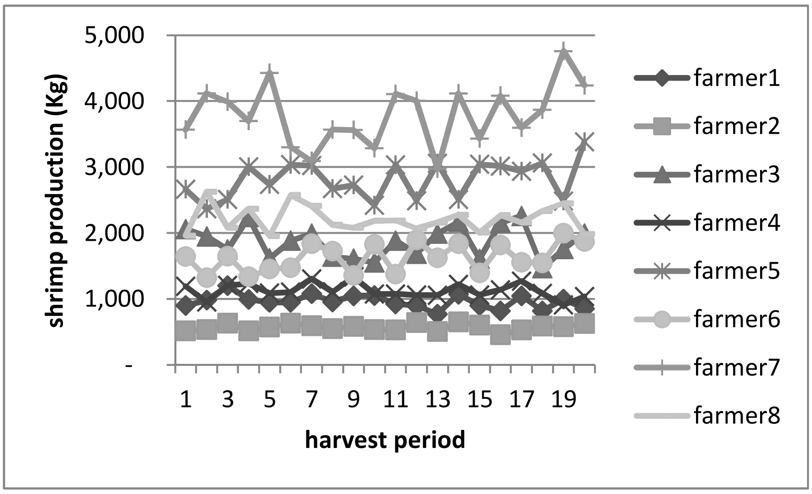

Figure 3. Production of shrimp farmers

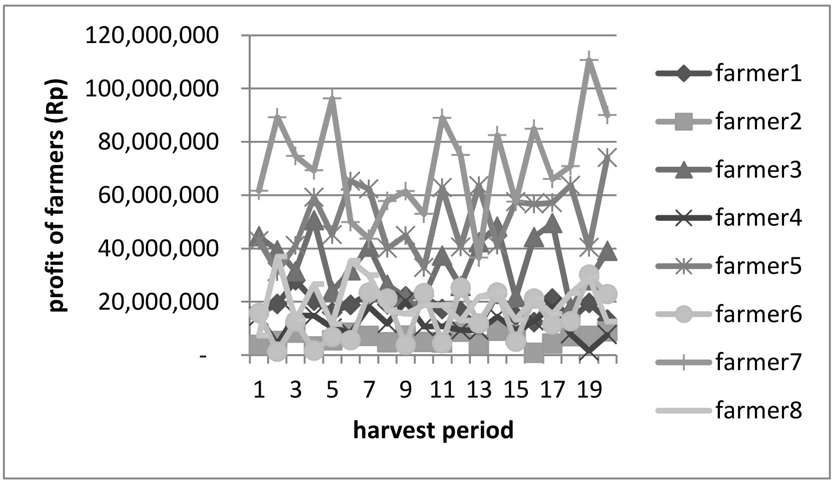

Figure 4. profit farmers

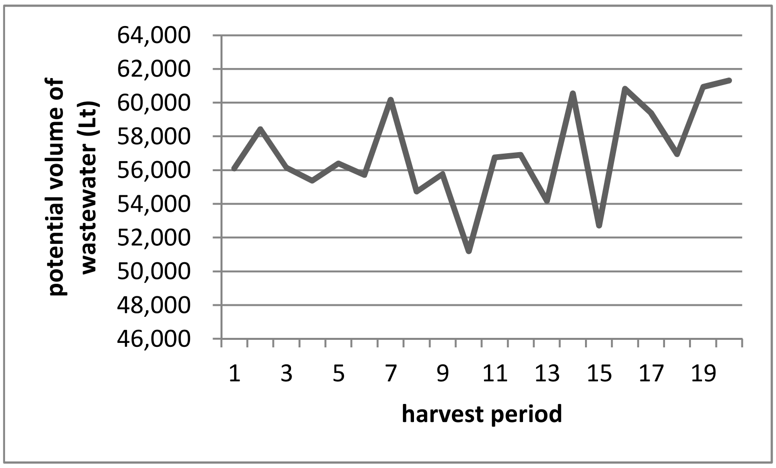

Figure 5. The potential volume of wastewater

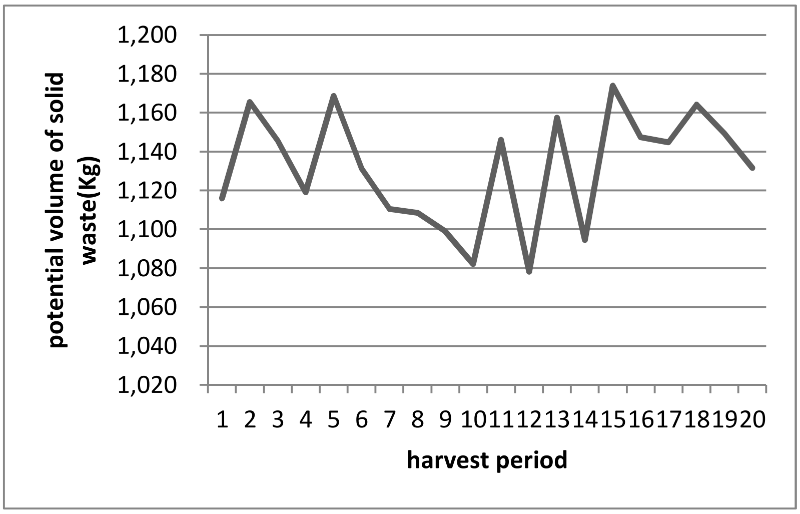

Figure 6. The potential for regional solid waste Minapolitan

Table 1. Activities of shrimp farmers

No	Activities
1.	Responding to demand for shrimp commodity
2.	Planting shrimp seeds
3.	Marketing shrimp commodity
4.	Finding the best price
5.	Harvesting
6.	Selling to middleman

Table 2. Activities of middleman and wholesaler

No	Activities
1.	Responding to demand for shrimp commodity
2.	Identifying crop farmers and traders as buyers shrimp
3.	Determining the amount of shrimp that will be purchased
4.	Purchasing shrimp farmers
5.	Sorting
6.	Finding the best price
7.	Selling the product
8.	Receiving the payments

Tabel 3. Activities of Agroindustry

No	Activities
1.	Analysing shrimp commodity demand
2.	Responding to demand
3.	Planning production
4.	Determining the volume of shrimp to be acquiring
5.	Selling the products
6.	Receiving the payments