Exploring the farmer productive behavior of cassava in effort of developing value-chain linkages to improve smallholder cassava production systems in North Sumatera, Indonesia

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Abstract
Cassava farming in North Sumatera is prominently for cash crops as feedstock to the tapioca starch factory. Multiple stakeholder engagement is needed to develop the value chain linkage to improve the smallholder cassava production system in North Sumatera. The project activity started in 2018 to improve the cassava farming system by introduced new cassava varieties, training on soil and fertilizer management, and linkage between multiple stakeholders to support the smallholder cassava farming. A Focus Group Discussion (FGD) and household surveys were conducted in 2019 to evaluate the changes in farmers' behavior and perspective toward the improvement of the farming system. The results showed that most of the farmers had improved their farming system, and consequently, the cassava tuber yield than in turn, increased the tapioca starch company productivity. However, several issues need to be solved in order to effectively upscaling the smallholder cassava farming in the region.

1. Introduction
One of the key successes of integrating the value chain system in the agricultural sector is the productive behavior of the farmer itself [1]. Productivity is a measure that states how much many inputs needed to produce some outputs, specifically in the Cassava production, productivity is defined by a ratio between the measurement output with input or input [2] usually a measurement the average represented by the total output divided total input from specific resources [3]. Productivity implies that mental attitude quality of life must be better than before. In the case of cassava farmer in North Sumatera of Indonesia, attention to
increasing the productivity of the farmers it is necessary not only from increasing productivity through the management of land agricultural and production facilities such as boosting with hybrid seed, the use of fertilizers, use of new varieties and expansion of irrigation – however, but others efforts also need to take places such as to improve the business management of the farmers and more importantly in enhancing the value-chain linkages to improve the sustainability of cassava production. The project to improve smallholder cassava farming was done in the Simalungun district of North Sumatra province of Indonesia.

Simalungun is a district in the North Sumatra Province of Indonesia, and the regional capital is the city of Pematang Siantar. The total population of Simalungun district is 1.1 million, with a density of 253 persons/km$^2$. The terrain is a mountainous range and is having a humid tropical climate, with an annual rainfall of 2,894 mm distributed evenly throughout the year. This wet climate condition is vital for agricultural activities in the region. Agriculture is the main activity in the region, with various plantations (palm oil, rubber, cassava). Simalungun is also one of the main cassava producers in the North Sumatra Provinces, where smallholder farmers are continuously planting cassava all year around. Smallholder cassava farmers applied inappropriate fertilizer, averaging around 30 t/ha, and planting the local varieties of cassava in which has relatively low productivity (20-25 ton/ha/year of fresh cassava tuber).

Unfortunately, cassava is not prioritized as the main crop for the local government, and consequently, little efforts and support from the government to develop the smallholder cassava farming. Therefore, this study uses Focus Group Discussion (FGD) and a structured interview with farmers (household surveys) in the Simalungun district of North Sumatera province in that connection the main problems to be studied can be formulated as follows:

1. What is the trend of the farming system after new varieties introduced?
2. Is there any significant production gap after new variety introduced?
3. What are the implications of different fertilizer management impacting the new varieties?
4. What is the trade connection between the farmer and relevant stakeholders?
5. What are the main challenges to improve smallholder cassava farming?

2. Research Methods

The study was carried out in the Simalungun District, North Sumatra, in September 2019. The respondents are farmers that already involved in the activities to improve the farming system (25 farmers) and their neighbors that were not involved but interested to follow the activities (10 farmers). By adopting Ashby [4] farmer participatory research method, the survey for this study using targeted scale farmer that involves in the study. The activities to improve the farming system were introduced to farmers since 2018, including the use of a new cassava variety, fertilizer management, and multi-stakeholder engagement.

3. Results and Discussion

3.1. Stakeholders engagement

The project to improve smallholder cassava farming in Simalungun focused on how to improve the farming system through a series of new cassava variety introduction, better soil and fertilizer management, and stakeholder’s engagement to support farmers. The project worked with a significant starch factory in Pematang Siantar, which is the sole buyer of fresh roots for most cassava smallholders in the district. The factory mostly produced tapioca starch for the domestic market. The results from the FGD and survey showed that multiple stakeholders are connected to improve the smallholder cassava farming in the Simalungun district. The stakeholder engagement model is presented in Figure 1. Each stakeholder holds an important role in supporting smallholder farmers to achieve the sustainable production of cassava.

The tapioca starch company has a model that works with agents to coordinate the supply of fresh cassava tuber from local traders, that collect the cassava from their network of farmer-suppliers. As what
[5] suggested, the company also work with agents to provide small loans to support the farmers, although there was no formal contract established with the farmers. The nature of the market is monopsonistic due to the concentrated selling of cassava tuber to the factory and the high degree of personal trust among traders [6]. However, if there is an excessive supply of cassava, the company will allow traders to sell elsewhere. However, from the FGD, the factory confirmed that at the moment, the company only works with 40% of capacity. Hence most of the cassava tubers in the region went to their factory.

As mentioned above, cassava is not the priority crop in the region; hence there was little support from the government. The company was supportive of the farmers in terms of providing information regarding soil and fertilizer management, albeit the limited knowledge they have. Through the project, the company was supportive of the fertilizer trials conducted and soil management to increased yields. Results from FGD and household survey showed that farmers acknowledge the role of the company in providing knowledge and information for better soil and fertilizer management. Unfortunately, there were problems for farmers to obtain the recommended fertilizer, due to the limited availability of appropriate fertilizer for cassava in the region. This was in fact that the government-subsidized fertilizer that available in the region was intended for rice; hence it was challenging to tailor-made the fertilizer for cassava.

**Figure 1. Cassava stakeholder engagement**

![Cassava stakeholder engagement diagram]
3.2. Farmer’s perception of the new variety and farming system

Results of the impact survey showed that the age of the farmers was in the range of 28-69 years, with educational status starting from elementary school (SD) - high school (SMA), and a land area of 0.16--0, 84 ha. The majority of farmers were aware of the project to improve the farming system, and 86.7% of farmers are felt the benefit from involving with the project.

Through the project activity, a new variety was introduced, namely, Malang-4 variety, which was developed by ILETRI (Indonesian Legume and Tuber Crops Institute). The Malang-4 variety was known for high yield characteristic as well as high starch content [7]. Since 2018, farmers that involved in projects planting the Malang4 variety, and there was a 53% increase of new farmers that planting the new variety in 2019. Consequently, after realizing the potential yield of Malang4, farmers begin to plant more of the Malang4 variety with more than 73% of cassava variety in their field, while 27% of the old varieties still planted by the farmers. This was due to the limited availability of Malang-4 planting materials, which the company helped to obtain from ILETRI.

With the existence of new varieties Malang-4, the impacts felt by farmers are: (1) For additional household needs around 73.3%; and (2) There was an increase in production of about 26.7%. After the cassava harvest, around 13.3% of the respondent's farmers stated that they were not used to selling cassava stems or cuttings; hence they will keep the new varieties for their use. However, around 86.7% of farmers said cassava or cuttings could be sold at IDR 500-1,000 per stem.

In regards to soil and fertilizer management, 70% of farmers were attending the soil and fertilizer training by the project, and 80% of them felt the benefit from the training. The characteristic for farmers to the soil and fertility management is presented in Table 1. Almost 95% of farmers applied inorganic fertilizer to their cassava field; however, only 37% of the farmers fully understand fertilizer management. This showed that although farmers understand the benefit of applying fertilizer for their cassava, farmers might entirely appropriately apply the correct amount of fertilizer. In the implementation of cassava cultivation in North Sumatera, it was revealed that the majority of farmers using a combination that is always available is Urea and Ponska fertilizer with varying doses (Urea ranges from 156-333 kg/ha, Ponska 156-333 kg/ha). About 32.61% of farmers use manure (goat manure). In contrast, those using TSP fertilizer were only about 6.7%, with a dose of 100 kg/ha.

Table 1. Farmers respond to the soil and fertilizer management

| Fertilizer Use                                                                 | Percent |
|-------------------------------------------------------------------------------|---------|
| Do you apply an organic fertilizer to your cassava?                           | 32.61%  |
| Do you apply inorganic fertilizer to your cassava?                           | 94.93%  |
| Do you understand what the NPK values mean on the fertilizer you apply?      | 36.23%  |
| Have you ever seen a fertilizer trial on cassava?                            | 12.32%  |
| Are you interested in visiting a fertilizer demonstration trial to see the result of production and returns? | 82.61%  |
| Are you interested in conducting a trial on your own land?                   | 60.14%  |

The majority of cassava yields by farmers are sold to agents and then to the factories (86.7%) [8] proposed that the selling of cassava in small scale is mostly trade to the agents. The remainder is sold to other traders in the village. The relationship between farmers and agents can be explained as follows: Farmers get seeds of new varieties Malang-4 from the agent. After harvesting the cassava is sold back to the agent, the stem or cuttings are replanted, and the rest is taken back by the agent. The cuttings by agents planted on another more extensive land and some are sold. The agent also helps lend money and fertilizer.
If further specified, the role of the agent (besides distributing Malang-4 cuttings to cooperator farmers) is as follows: (1) Selling cuttings as much as 33%; (2) Selling cuttings and lending 44% of money; (3) sell cuttings, lend money and provide fertilizer as much as 23%. Almost all farmers were not related to other traders and stated that their relationship with traders was relatively good and improved compared to before.

There are three changes felt by farmers in cassava cultivation after an experimental collaboration with the research team, namely: (1) Regarding the spacing and fertilizing, as much as 60% of farmers; (2) Regarding plant spacing, 26.7 farmers; and (3) Regarding planting distance + fertilizer + making mounds, as many as 13.3% of farmers. The majority of farmers (86.7%) said that there were no problems encountered in carrying out cassava cultivation in North Sumatra. The rest say that there are a few problems faced, namely the length of time waiting for the tractor to till the soil. This is because it takes a while to rent a tractor. After all, they have to wait their turn (the number of tractors leased is relatively limited).

4. Conclusions
The local government, agricultural extension field officer, and industry should develop collaboration to help farmers in developing the smallholder cassava farming: All production chain agrees to take more action for increasing cassava production. However, there was still unclear share, responsibility, and advantage for each actor involved in the program. The project concluded that the government should become more active in taking a role in the program, especially in proving cassava variety and technology. The local government was also expected could solve the price fluctuation, for example, by mediating farmers and processors for getting the agreement or insurance. Agents, traders, and collectors willing to take part in multiplying and providing cutting materials as far as clear what the advantage they got.

Fertilizer companies should engage the farmers and industry: One of the key investments in the facilitation of the effective use of inorganic fertilizer for cassava production will be for fertilizer companies to develop appropriate formulations for cassava. Technological adoption may also be introduced to the farmer for sustainable farming climate in making the project successful in the future [9].

The project can make trial results from 2017 to 2020 available to assist farmers in choosing the correct fertilizer type and also the timing of the application. Furthermore, based on the trial and farmer's engagement, there is a possibility for collaboration between fertilizer company, government, and industry to ensure the availability of fertilizer to the farmers.

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