Technology improvement strategy of cassava farming to support local food development: case study in Warung Kiara, Sukabumi Regency, West Java

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Abstract. The opportunity to increase cassava productivity can be done through cultivation technology improvement. The research aimed to obtain information on the suitability of agroecology, agro-economy, and strategy planning for developing cassava as local food. Research was carried out in 2021 in the form of survey and field experiment in Sukabumi Regency, West Java. Data analysis that was used is Random Block Design for field experiment and SWOT analysis for survey data. The results indicated that fertilization significantly increased the growth of Manggu and Adira 1. Adira 1 can be accepted by farmers as an alternative to Manggu because it has higher starch content. Dominant factors identified as potentials for cassava-based local food development are the suitability of cultivation location and increasing demand. There are four important strategies, i.e.: (1) *maxi-maxi strategy,* by exploiting strengths and opportunities in cassava development, (2) *mini-maxi strategy,* by overcoming the weaknesses of cassava resources owned to take advantage of existing opportunities, (3) *maxi-mini strategy*, by trying to find the strengths of the cassava farming and used to ward off the threats with coordination between parties, and (4) *mini-mini strategy*, where the threats and weaknesses of cassava farming can be faced by well-targeted and steady policies.

1 Introduction

Cassava is a multipurpose commodity, as a source of food ingredient and raw material for various industries (food, non-food, feed, and fuel) [1]. As food ingredient, cassava can be consumed directly and/or processed into various preparations which may vary for each

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country and even among communities in one country [2–4]. Indonesia ranked third as the world's largest producer of cassava (20 million tons), after Nigeria (55 million tons) and Thailand (31 million tons) [5,6]. The area of cassava in Indonesia is around 950,000 ha with a productivity of 23 t/ha. To outperform Thailand in terms of production, the productivity of cassava in Indonesia must be increased to at least an average of 25 t/ha. Meanwhile, if our cassava productivity is increased by at least 50 t/ha, it can match Nigeria's cassava production.

The current developing world situation and the ongoing COVID-19 pandemic, food availability is a very crucial problem, especially if you only depend on rice dishes. Each country seeks secure availability and sustainability of food stocks for its citizens [7]. President Joko Widodo stressed that this pandemic must be used as a momentum make major changes or reformation in the food sector. Therefore, availability and guarantee of food safety have a very strategic role. Readiness of the post-harvest processing industry, food supply chain and distribution also require serious attention [8].

During the COVID-19 pandemic, it is difficult to import rice because each country maintains food stocks for the needs of its people, so we must try to change our mindset and re-invigorate the importance of non-rice local food ingredients. The Minister of Agriculture invited local food diversification movement because local food is the wealth and culture of the nation. For the fulfillment of carbohydrates, products other than rice could be chosen which also have high nutritional value such as various tubers. Non-rice food commodities are encouraged and developed according to their potential and specific locations [9] - one region has one commodity advantage.

In 2018, planted area of cassava in Indonesia was around 697,000 ha, decreased by 33.2% from 2016 [10,11]. Cassava production in 2017 was 19 million tons from an area of 772,975 ha and productivity of 24.6 t/ha. The need for cassava in 2020 for feed is estimated at 547,000 tons, food ingredients at 12.7 million tons, and to be processed into food is at 8.5 million tons or total 21.7 million tons [12]. It means that 97.5% of cassava is used for food. It showed that cassava production is only sufficient to meet domestic demand. Considering that planted area tend to decrease, productivity needs to be increased to ensure sufficient supply.

In line with the increasing demand for food and industrial materials, it is demanded that the availability of raw materials with the quantity and quality in accordance with the wishes of each request. Strategies that can be carried out include providing superior varieties that are suitable for agro-ecology by improving cassava cultivation, especially fertilization and pest and disease control. In addition to increasing the quantity of production, there is also an increase in the quality of cassava based on market preferences (utilization). For example, as raw material for flour, cassava must have dry matter and starch content > 20% [13]. Cassava for the food industry, in addition to the high starch content, also need the low HCN content (<50 mg/kg) [14].

The government has so far placed rice sociologically as better than other food ingredients, as a motivation for people to consume normally and permanently. Society has placed cassava as an inferior food ingredient (not prestigious) so that consuming cassava is a setback [15]. Re-introduction efforts must be carried out through the changes in food patterns in synergistic, comprehensive, cooperative, and educative nature. The process of cultural change can be carried out through learning both formal and informal education to make cassava as a staple food [3,16,17].

2 Methodology

The research was conducted in 2021 planting season, namely by conducting survey and field experiment in Sukaharja Village, Warungkiara Sub-Sub-district, Sukabumi Regency,

West Java. Survey was carried out using Participatory Rural Appraisal (PRA) approach to obtain information on the suitability of agro-ecology, agro-economy, and plan strategies to develop cassava as local food. In addition to PRA, field experiment was also designed to assemble technology, namely by combining the technological component of cassava varieties (local Manggu and Adira 1) and three doses of fertilization and soil amelioration which expected result in the maximum cassava yield. The field experiment was covering 6 ha of farmers' field involving 16 cooperative farmers. The treatments were tested using randomized block design and replicated according to the number of cooperating farmers and of harvest plots for each treatment (Table 1). Before planting, soil was processed according to farmer's existing cultivation. Seeds (cassava cuttings) were planted upright with spacing of 1 m x 1 m. The field activities aimed to identify the cassava variety and appropriate doses of fertilizers to achieve high productivity. The result can give a solution to fulfill the supply of cassava as local food.

Table 1. Treatment of cassava cultivation technology.

Treatment	Variety	Doses of fertilization and soil amelioration				
		Phonska (kg/ha)	Urea (kg/ha)	KCl (kg/ha)	Dolomite (kg/ha)	Manure (kg/ha)
T1M	Local Manggu	250	100	-	-	5,000
T2M		250	100	50	750	5,000
T3M		250	200	50	750	5,000
T1A	Adira 1	250	100	-	-	5,000
T2A		250	100	50	750	5,000
T3A		250	200	50	750	5,000

Notes: Variety: M = local Manggu, A = Adira 1. Treatment of fertilization: T1 = existing technology, T2 and T3 = improved technology

Besides that, Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was also used to identify the potential opportunities and issues of developing cassava as local food, so that development strategies and action plans can be drawn up [18]. The SWOT analysis technique is influenced by the decision making of farmers and stakeholders. The influencing factors are internal and external factors. In the SWOT analysis, internal factors are translated into strengths and weaknesses in making business process decisions, while external factors are described as opportunities and threats [19].

3 Results and Discussion

3.1 Cassava farming performance

Planted area of cassava in Warungkiara Sub-district is around 1,000 ha every year with production of about 20,000 tons. With that fact, despite the selling price that fluctuate, farmers will always cultivate cassava. The planting season is generally carried out at the beginning of the rainy season (usually October-November), and small part in December-January. The cassava variety used is local Manggu with the characteristics of not bitter and has good taste. The main advantage of this variety is that it can be consumed or processed directly as food and is also sold as raw material for tapioca. Farmers don't like bitter varieties because they can only be sold as raw material for tapioca, and the selling price is cheaper than those with the good taste.

Marketing of cassava is very easy. Traders will come to farmers at harvest time. The good taste characteristic of local Manggu cassava is in accordance with the preference of food processor/industry for snack production purpose. This variety will also be accepted

and used by tapioca flour industry. As much as 80% of cassava production in Sukabumi is marketed outside Sukabumi, such as Bogor, Bandung, Tasikmalaya, Cianjur and Indramayu Regencies in West Java Province for raw materials of food industries. Meanwhile, 20% is marketed to meet tapioca industry in Sukabumi Regency itself. There are 30 registered tapioca industries/craftsmen with the average need of cassava is 150-200 tons/day. However, the lack of supply of raw materials for tapioca industry requires solution.

Planting improved cassava varieties released by Indonesian Agency for Agricultural Research and Development (IAARD) such as Adira 1 can be a solution to meet the preferences of food industry, both directly for processed food that has good taste and high starch content for tapioca industry. Adira 1 has a good taste so it can be processed for food and categorized as sweet cassava with HCN content of <40 mg/kg of fresh tubers [20].

3.2 Improvement of cassava technology for local food supply

The solution for the lack of raw material supply for industry is to improve existing cassava technology. Details of improvement are the use of local variety of Manggu and Adira 1 with fertilization doses of 250 kg/ha Phonska + 100-200 kg/ha Urea + 50 kg/ha KCl + 750 kg/ha dolomite + 5 t/ha manure. The improvement resulted in tuber yield up to 51.8 t/ha and 48.9 t/ha (Table 2). The productivity increased by 107–159% (for local Manggu) or 96–144% (for improved variety of Adira 1) compared to the existing cultivation. At this level of tuber yield, improving fertilization by adding 50 kg/ha of KCl fertilizer and 750 kg/ha of dolomite is economically feasible because it can increase the income up to 1.71 times for the use of local Manggu and 4.16 times for Adira 1 compared to the existing technology application. Increasing the dose of Urea fertilization from 100 kg/ha to 200 kg/ha is also economically feasible because it can increase the income up to 2.12 times for the use of local Manggu and 6.41 times for Adira 1 (Table 2).

Table 2. Partial budget of fertilizer application of local Manggu and improved variety of Adira 1.

Variety	Treatment	Yields (kg/ha)	Cost of fertilizers (IDR)	Benefit (IDR 000)	Incremental B/C (Δ B/ΔC)	Notes (Δ B/ΔC)
Local Manggu	T1M	48,600	925,000	47,675	-	-
	T2M	50,700	1,700,000	49,000	1.71	T2M-T1M
	T3M	51,800	1,950,000	49,850	2.12	T3M-T1M
Adira 1	T1A	41,300	925,000	40,375	-	-
	T2A	45,200	1,700,000	43,600	4.16	T2A-T1A
	T3A	48,900	1,950,000	46,950	6.41	T3A-T1A

Notes: Price of Phonska IDR 2,700/kg, Urea IDR 2,500/kg, KCl IDR 8,000/kg, dolomit IDR 500/kg; Price of tuber IDR 1,000/kg. Variety: M = local Manggu, A = Adira 1. Treatment of fertilization: T1 = existing technology, T2 and T3 = improved technology

3.3 Cassava farming economic analysis

Results of economic analysis for cassava technology improvement is presented in Table 3. Based on B/C ratio analysis, cassava farming is profitable as consideration of economic indicators > 1 at price level of IDR 1,000 per kg (Table 3). Food processing industry which needed the direct fresh tuber does not prefer Adira 1 because of its yellow-fleshed color. Even though the taste is good, it does not meet the specification for the raw material need like the existing local Manggu which has white-fleshed color. However, Adira 1 is highly favored by tapioca industry because of its high starch content.

Table 3. Cassava farming economic analysis of local Manggu and improved variety of Adira 1.

Components	Local Manggu	Improved variety of Adira 1
Yield (ton)	48.6	41.3
Price per kg	1,000	1,000
Revenue (IDR)	48,600,000	41,300,000
Cost (IDR)	18,870,000	18,870,000
Benefit (IDR)	29,730,000	22,430,000
B/C ratio	1.58	1.19

3.4 Potentials and constraints of cassava-based local food

SWOT analysis systematically identifies strengths (S) as reinforcing factor and weaknesses (W) as weakening the internal influences. In addition, the external influences or environment are in form of opportunities (O) that reflect the potentials and threats (T) as obstacles. By identifying the potentials and obstacles, the alternative strategies for improving farming can be made to support local food development in Sukabumi (Table 4).

3.4.1 Internal influences: Strengths (S)

S1 = Location is suitable for cassava cultivation. For years, Warung Kiara Sub-district has been used for cassava farming and production center in Sukabumi Regency. Cassava's land condition in Sukabumi area is mountainous, but farmers have managed cropping pattern quite well by following conservation principles. The average area of cassava planting in this sub-district range of 800-1,000 ha with average production of 25,459 tons per year.

S2 = Farmers are used to growing cassava and cassava is easy to cultivate. The people's livelihood is almost 80% farming. Farmers pay more attention to cassava cultivation because they always plant it every year, whether the selling price is high or low.

S3 = Cassava produces main product as well as by-products (waste). Economic potential value of cassava is relatively high in terms of farming, raw food materials, feed and industry aspects. The potential of by-products reaches about 29.7% of main product of cassava but has not been optimally utilized yet. It is a bio-economic value in form of bio-mass that can support integrated agriculture in the future [21].

S4 = The availability of technology for cassava production and processing. The IAARD developed modified cassava (mocaf) flour production technology by improving the quality parameters of cassava flour. The technology is the manufacture of Biologically Modified Cassava Flour (Bimo-CF) consisting of a carrier and an active ingredient of lactic acid bacteria. The Bimo-CF starter is made from a raw carrier material in form of flour added with a certain concentration of nutrient-enriching ingredients to increase effectiveness and stability [22]. Mocaf flour is healthier because it does not contain gluten, low in protein, and has the similar benefits as wheat flour. Mocaf flour is suitable for various processed of cakes, biscuits, and noodles.

3.4.2 Internal influences: Weaknesses (W)

W1 = Productivity of local Manggu is low. The average productivity of farmers at the research location is 20 t/ha. Meanwhile, the potential productivity of high-yielding varieties can reach 60 t/ha.

W2 = The farmer institution and local government attention to cassava is weak. Cassava is a superior commodity in Sukabumi. However, it has not been handled properly both on the on-farm and off-farm aspects. The farmer institution and role of local government are needed to improve bargaining position of farmers as producers for continuity of regional superior commodities. Supposedly, farmer institution can become an economic institution that can increase economic scale, business efficiency, and bargaining power of cassava farming.

W3 = Limited capital for cassava farming. Most of cassava farmers in research location lack capital for their farming. The application of improved cassava cuttings and Good Agricultural Practices (GAP) are rarely done, unless there is a financial assistance for production inputs and properly technical guidance for cassava cultivation.

W4 = Cash flow from cassava farming is narrow. Generally, farmers can make money from cassava farming within 10-12 months after planting. The time length to the income earned made existing cassava cultivation not optimal.

W5 = The lack of knowledge of farmers on cassava innovation technology. The application of GAP is required to obtain high yield. Therefore, it needs adequate knowledge of farmers on cultivation technology [23], including cassava.

3.4.3 External influences: Opportunities (O)

O1 = Cassava demand will increase greatly in the future regarding the utilization of cassava for food and industrial products. Cassava planted area indicated the increase to keep up with the demand. However, the increase in demand is not in line with the stagnant trend of cassava price at low level of between IDR 600-1,100 per kg.

O2 = The application of improved varieties and cassava cultivation technologies will improve productivity and increase farmers' cash flow. Farmers who prioritize cassava yield, but want to obtain additional incomes from legumes, upland rice, or corn, can apply double-row cultivation techniques [24]. By doing the double-row arrangement, it is possible to plant legume crops twice a year without reducing cassava yield. Farmers can obtain cash flow faster from corn and legumes while waiting for cassava harvesting by doing this technique.

O3 = The establishment of partnerships with cassava business actors in form of cooperation agreement on cassava marketing between Bima Agrotama Sukses Company as a buyer and Sukabumi Association of Legumes and Tubers Farmers (JPP AKABI) as an association of cassava farmers. With this agreement, farmers will have price and market guaranteed because the company is willing to buy cassava with the lowest price benchmark of IDR 1,200 and the highest of IDR 1,500 per kg of cassava received in the warehouse. On the other hand, the company will also obtain the guarantee on the quality of cassava sold by farmers because the standard for starch content of at least 25 %.

O4 = The movement setting of local food diversification by the Government of Indonesia (GoI). Local food is the nation wealth and culture. To fulfill carbohydrates, commodities other than rice with high nutritional value can be chosen, including various tubers [2,8].

3.4.4 External influences: Threats (T)

T1 = The dynamics of market preference. There is no improved variety of cassava yet as a substitute for the local Manggu in terms of market preferences for snack industry. The criteria for acceptable cassava in food processing industries such as chips and

crackers in Bandung and Bogor is good taste with the minimum diameter of 4 cm, and white in color. Meanwhile, tapioca industries which are widely spread in Warung Kiara Sub-district does not apply the specific standard of cassava for their raw material. All kinds of cassava can be accepted because the tapioca industries pay more attention to starch content.

T2 = The stigma of a low image of cassava as a local food. Only a small number of Indonesian people still consume foods made from cassava, corn, sweet potato, and sago as their staple food. In the community, there is a growing opinion that if people consume cassava, it means they are poor or there is a food shortage or scarcity [25].

T3 = Supply of raw materials from outside Sukabumi Regency as a competitor for crackers, chips, and tapioca industries. This condition triggers the low price of cassava in Sukabumi. The cassava-based food industries often import raw materials from outside Sukabumi when the price of cassava from Sukabumi increase.

T4 = There are competitors of imported starch. Starch from Indonesia's cassava has weak competitiveness because the production level is not quite high to achieve its economic scale. Indonesia exports cassava with poor quality and domestic cassava starch production is still lower than domestic demand. As a result, imported starch often flooded the domestic market which caused the local starch price to drop [26].

Table 4. Identification of internal and external factors of cassava-based food development.

Internal factors		**External factors**	
Strengths (S)	**Weaknesses (W)**	**Opportunities (O)**	**Threats (T)**
Location is suitable for cassava cultivation	Productivity of local Manggu is low	Cassava demand may increase greatly in the future	The dynamics of market preference
Farmers are used to growing cassava and it is easy to do	The farmer institution and local government attention to cassava is weak	The application of improved varieties and cassava cultivation technologies may improve productivity and increase farmers' cash flow	The stigma of a low image of cassava as a local food
Cassava produces main product as well as by-products (waste)	Limited capital for cassava farming	The establishment of partnerships with cassava business actors	Supply of raw materials from the outside on Sukabumi Regency as a competitor
The availability of technology for cassava production and processing	Cash flow from cassava farming is narrow	The movement setting of local food diversification by the GoI	There are competitors of imported starch
	The lack of knowledge of farmers on cassava innovation technology		

3.5 Potentials and constraints of cassava-based local food

From the results of SWOT analysis, the formulation of cassava improvement strategies was developed based on analysis of internal factors and dominant external factors that influenced it. The strategies are described in detail in Table 5.

Table 5. The implemented strategies for cassava faming improvement in Sukabumi Regency.

Internal Factor / **External Factor**	**Strength (S)** S1 = Location is suitable for cassava cultivation	**Weakness (W)** W3 = Limited capital for cassava farming
Opportunity (O) O1 = Cassava demand may increase greatly in the future	Intensify cassava planting by using technological innovations in the form of the application of improved cassava varieties, for example Adira 1 and improving cropping pattern and fertilization to increase the quantity and quality of production	Capital assistance for cassava farming with easy scheme for the optimal use of production inputs on the application innovative cassava technology in order to achieve maximum yields in meeting the supply of raw material demand for food industries
Threat (T) T1 = The dynamics of market preference	Guidelines on cassava technology and education to users (stakeholders) about the utilization of various characteristics of improved cassava varieties and the strengthening of partnerships that are open, mutually beneficial and sustainable	Technical guidelines on cassava cultivation technology as well as food processing technology for farmers and industries considering market preferences (product diversification)

There are four types of strategies resulting from the SWOT analysis for local food development in Sukabumi, *First,* The Strength-Opportunity Strategy (S and O or *maxi-maxi*), **namely 'Intensify cassava planting by using technological innovations in form of the application of improved cassava varieties and improving cropping pattern and fertilization to increase the quantity and quality of production'**. In this strategy, cassava farming is at production growth level condition, therefore it is necessary to carry out offensive stages to achieve maximum goal.

Second, The Weakness-Opportunity Strategy (W dan O or *mini-maxi*), namely **'Capital assistance for cassava farming with easy scheme for the optimal use of production inputs on the application innovative cassava technology in order to achieve maximum yields in meeting the supply of raw material demand for food industries**. The strategy requires the support of new cassava technology and financial institutions to produce maximum yields.

Third, The Strength-Threat Strategy (S and T or *maxi-mini*), namely **'Guidelines on cassava technology and education to users (stakeholders) about the utilization of various characteristics of improved cassava varieties and the strengthening of partnerships that are open, mutually beneficial and sustainable'**. The strategy finds the strengths of cassava farming and is used to reduce or counteract the threats with coordination between parties, for example by making the distribution network of cassava products.

Fourth, The Weakness-Threat Strategy (W and T or *mini-mini*), namely **'Technical guidelines on cassava cultivation technology as well as food processing technology for farmers and industries considering market preferences (product diversification)'**. In the situation where we have to face weaknesses and threats, we can implement the right strategy by taking policies that are well-targeted and steady, in other words, information on the user demand or cassava markets must be known for certain.

3.6 Implementation of strategies for development of cassava-based local food

Table 6. Action plans for implementing cassava-based local food development strategies.

No	Strategies	Activities	Targets	Target performance indicators
1	Intensify cassava planting by using technological innovations in the form of the application of improved cassava varieties, for example Adira 1 and improving cropping pattern and fertilization to increase quantity and quality of production	1. Technical guidelines on new technology cassava cultivation 2. Cultivation of improved cassava variety according to the need for food processing 3. The use of fertilization techniques according to the recommended type and dosage 4. The setting of cropping patterns for production continuity as a supply of raw materials 5. Application of GAP to obtain good quality yield	Farmers, extension workers, local government	- Obtain the expected quantity of harvest yield according to the output of recommended technology - Quality of cassava harvest according to market demand
2	Capital assistance for cassava farming with easy scheme for the optimal use of production inputs on the application of innovative cassava technology in order to achieve maximum yields in meeting supply of raw material demand for food industries	1. Providing farming assistance in form of direct cash and bank loan for production input 2. Guidelines according to recommended cultivation technology 3. The formation of cassava yield partnerships 4. Local government facilitation o process and post-production of cassava (physical, information, etc)	Farmers, financial institutions, stakeholders (industries) and local government	- Farmers apply recommended cassava technology - Feasibility of selling cassava products
3	Guidelines on cassava technology and education to users (stakeholders) about the utilization of various characteristics of improved cassava varieties and the strengthening of partnerships that are open, mutually beneficial and sustainable	1. Technical guidelines on cassava cultivation 2. Socialization on the latest cassava products 3. The formation of networks and partnerships with off-takers or buyers	Farmers, traders, stakeholders, community group and local government	- Planting improved cassava varieties - The setting of sustainable partnerships between producer and off-taker
4	Technical guidelines on cassava cultivation technology as well as food processing technology for farmers and industries considering market preferences (product diversification)	1. Technical guidelines on cassava cultivation 2. Technical guidelines on cassava processing 3. Information network on the latest cassava-based products	Farmers and stakeholders	- Cultivation of new cassava technology - New processing techniques for cassava products - Product diversification

The strategy is translated into action plan according to the objectives to be achieved. Concrete activities and targets are arranged in Table 6. Target performance indicators aim to detect whether the development of cassava-based local food has been achieved or not. From the implementation of strategy arranged, it is reflected that food culture system covers the activities of production, distribution, and consumption of food in which to improve their welfare as well as their families in the communities.

Socialization and education are the focus of this action plan and aim to increase public understanding and awareness on the importance of developing local food to meet community needs. The targets are actors who are involved in food production, distribution, and consumption activities. The understanding in form of technical guidelines for farmers and industries as well as education to community are also closely related to the efforts to ensure food supply in food diversification. This understanding of community is important because the communities are already very dependent on rice as a source of carbohydrate. Meanwhile, there are many local food resources such as cassava which can be developed as an alternative source of carbohydrates (other than rice).

4 Conclusion

The option of cassava cultivation innovation technology are applying the combination of improved variety of Adira 1 and the recommended doses of fertilizer and ameliorant i.e. 250 kg Phonska, 200 kg Urea, 50 kg KCl, and 750 kg dolomite that can increase the cassava yield. The increase of cassava productivity has an opportunity to meet the raw material demands of food industries in Sukabumi Regency.

There are four important strategies carried out in the development of cassava-based local food, i.e. : (1) *maxi-maxi strategy* by exploiting strength and opportunity factors in cassava development, (2) *mini-maxi strategy* by overcoming the weaknesses of cassava resources owned to take advantage of existing opportunities, (3) *maxi-mini strategy* by trying to find the strengths of the cassava farming and used to ward off the threats with coordination between parties, and (4) *mini-mini strategy* where the threats and weaknesses of cassava farming can be faced by well-targeted and steady policies.

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