The development opportunity of cassava farming under perennial crops to support food security in forest community

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Abstract. The increased demand of cassava (*Manihot esculenta* Crantz.) in Indonesia is not supported by production because cassava cultivated in marginal land has low productivity. The study aimed to determine the potential, opportunities, and constraints of developing cassava in intercropping pattern with the early-aged perennial crops as the main crops. The research was conducted during the 2016 planting season. Areas representing the potential of cassava farming under the stands of perennial crops were Blora, Central Java Province (under the stands of teak or *Tectona grandis*), North Lampung, Lampung Province (under the stands of rubber or *Hevea brasiliensis*) and Barito Koala, South Kalimantan Province (under the stands of oil palm or *Elaeis guineensis* Jacq). The number of respondents were 30 farmers for each location. The survey was conducted using the Participatory Rural Appraisal (PRA) method. The study showed that cassava farming was technically feasible to be intercropped with perennial crops (teak, rubber, and oil palm). Cassava farming under the stands of perennial crops was also financially feasible as indicated by the benefit cost ratio of more than 1. The prospect of cassava development is in an aggressive growth phase located in the business map area (quadrant I).

1 Introduction

The increasing demand for cassava (*Manihot esculenta* Crantz.) in Indonesia contrasts with its production. Generally, cassava is cultivated in dry land or marginal land. Cassava is cultivated as a reserve crop when the main food crops (rice, maize, or other legumes) cannot be produced properly as expected by farmers. In that position, the cassava becomes a secondary crop which is less intensively cultivated. Farmers have not applied cassava production technology optimally. Traditionally, farmers use local varieties for their cassava farming. Farmers never apply fertilizers according to the recommendation of local agriculture office and even do not use fertilizers at all. As a result, competition for land use for cassava farming requires alternative land that can be used to increase production to meet the high demand. One of the alternative lands is production forest area [1]. However, this expansion

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requires many supports to manage the farming, from facilities, as well as farmer institutions [2,3].

According to the data of the Indonesian Statistics or BPS (2019), the national cassava production for the last five years (2014-2018) tends to decline. The production of 23.44 million tons of cassava in 2014 declined about 17% to 19.34 million tons in 2018. The decline in production was due to the decreasing of cassava planting area during that period as an impact of the land use competition with other food crops. During the 2014-2018 period, the productivity of cassava increased from 23.35 t/ha to 24.39 t/ha, however it was still much below the potential yield of several improved varieties of cassava released by the Indonesian Ministry of Agriculture which reached 40-50 t/ha [4]. The four largest cassava producers in Indonesia are Lampung, East Java, Central Java, and West Java Provinces, which account for around 70.45% of the total cassava production in Indonesia [5].

The major constraints of cassava farming in Indonesia and some other countries were low productivity and conventional cultivation which still depend on existing agro-climatic condition [6–8]. Farmers, especially those who live in marginal areas such as dry land and forest edge had not applied yet the recommended technology of cassava. The problem affected the sustainability of cassava supply to various industries. The constraints might be overcome by the application of available recommended technology, both in terms of the use of improved varieties (breeding) as well as cultivation technology and cropping pattern [9,10].

The potential forest managed by the National Company of Forestry (Perum Perhutani) covering an area of 2.4 million ha available in four provinces namely Central Java, East Java, West Java, and Banten, consisting of 0.69 million ha of protected forests and more than 1.72 million ha (75.8%) of production forests [1]. The forests area managed by Perum Perhutani does not include reserve forests and tourism forests managed by the Ministry of Forestry cq. Directorate General of Nature Conservation Forest Protection (PHPA). Therefore, those around 1.72 million ha of production forests was potential for cassava farming. The research aimed to determine the potential, as well as the opportunities and constraints of developing cassava farming under perennial industrial main crops.

2 Methodology

The research was conducted during the 2019 planting season in the areas that have potential for the development of cassava farming under the stands of teak *(Tectona grandis*), rubber (*Hevea brasiliensis*), and oil palm (*Elaeis guineensis* Jacq) as main perennial crops. The representing regencies of cassava farming development namely Blora Regency in Central Java Province for under the stands of teak, North Lampung Regency in Lampung Province for under the stands of rubber, and Barito Koala Regency of South Kalimantan Province for under the stands of oil palm. Data were collected through survey or interview method. The number of respondents were 30 farmers each location. The survey and field trials were conducted in this research. Survey through a rapid rural understanding approach and community participation, or often known as Participatory Rural Appraisal (PRA). PRA implementation used a focus group discussion (FGD) and involved all key persons related to the topic of the potential, as well as the opportunities and constraints of developing cassava farming under perennial crops. Meanwhile, for the field experiment by trying several components of cassava technology on the three types of annual plants.

2.1 Analysis methods

2.1.1 SWOT analysis

SWOT analysis is a systematic identification of internal and external factors to formulate a strategy in management process [11]. The analysis is based on a logic to maximize the strengths (S) and opportunities (O), and at the same time can minimize the weaknesses (W) and threats (T). Strategies are needed to solve the problems related to the development of cassava crops under the stands of perennial crops. The strategy resulting from SWOT analysis is a tool to achieve the objectives related to the follow-up programs and resource allocation priorities. An effective strategy can be achieved through environmental analysis so that the strengths and weaknesses as well as the opportunities and threats can be identified [12–14].

SWOT matrix can clearly describe how the strengths and weaknesses are used to deal with external opportunities and threats from cassava intercropping under the stands of perennial crops. From the result of this analysis, four alternative strategies can be formulated, namely SO, WO, ST, and WT strategies. SO strategy is a strategy that utilize the strengths of the cassava intercropping to seize the existing opportunities. WO strategy is a strategy to overcome the weaknesses of cassava intercropping with the existing opportunities. ST strategy uses the strength of cassava intercropping to deal with the external threats. While, WT strategy is more based on defensive activities to minimize existing weaknesses and avoid threats [15].

2.1.2 Farming analysis

The economic feasibility analysis of cassava farming under the stands of perennial crops employs the benefit cost ratio (B/C ratio) approach. B/C ratio compares total income with total production cost using the following formula [16]:

$$B/C\ ratio = Total\ income / Total\ production\ cost \quad (1)$$

Where:
If the B/C ratio > 1, it means that the farming financially has potential to be develop,
If the B/C ratio = 1, it means that the farming is at break-even point (BEP),
If the B/C ratio < 1, it means that the farming financially has no potential to be develop.

3 Results and Discussion

3.1 Synergism of cassava with perennial crops in intercropping system

Intercropping system requires a deep understanding because not all types of crops can be cultivated as intercrops. Therefore, the aspects related to the concepts of synergism and mutual benefit in intercropping need to be known. The previous studies on intercropping with coconut or rubber as main crops which have been carried out in India, Thailand, Sri Lanka, the Philippines and Indonesia concluded several significant advantages of intercropping pattern, including: (1) the more efficient and productive of farm land use, (2) the increase of farming productivity, (3) the increase of farming income, (4) the more efficient of farm inputs usage, and (5) the more secure of farmers' income [17–21].

In the cultivation of perennial crops such as teak, rubber, and oil palm, cassava as an intercropping crop can perform complementary function so that it can interact synergistically with perennial crops instead of competing each other. Indonesian Legumes and Tuber Crops

Research Institute (Iletri) has proven the synergism by producing cassava farming technology under teak stands [22].

The synergism will improve plant growth and maintain the land resources, so that in the end it can increase crop yields sustainably. In addition, the intercropping system can produce more diverse products which can be an alternative solution to the problem related to the risk of price fluctuation in one commodity and provide more profit opportunities for farmers. Furthermore, intercropping of perennial crops and cassava will better ensure the availability of feed (both in quantity and quality) for the integration of livestock with perennial crops, especially in the period of immature perennial crops therefore the source of raw material for feed are not yet available. Food crops, especially cassava, in a typical cropping system for areas with a long growing season (wet climate) can be intercropped with oil palm plantation. The intercrops depend on the oil palms spacing due to it determines the canopy coverage which the intercrops are no longer possible to be cultivated.

3.2 Potentials and constraints of cassava as an intercrop

The identification results of the potentials and constraints for cassava as an intercrop show that the internal factors have a lot of influence on cassava at the farming level. In SWOT analysis, internal factors consist of strengths identified as potentials and weaknesses identified as constraints [23]. External factors in the form of opportunities and threats are identified depending on the influence of the environment. The internal and external factors that influence cassava farming are identified in Table 1.

Table 1. Potentials and constraints for cassava as an intercrop.

Internal factors		**External factors**	
Strengths (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
Cassava has long been cultivated	Farmer has not mastered the cassava technology	Great demands	Pests and diseases (mealy bug and root rots)
Technologies and varieties are available	The image of cassava as inferior commodity	Secure and conducive price	Presumption wasteful crop nutrients
The existence of institutions (farmer groups)	Production land under the stands of main crops age < 3 years	Wide utilization of cassava-based products	

By looking at the significance of each potential and constraint in cassava farming analyzed with the SWOT matrix, the strengths (S) supporting cassava farming are more superior than the weaknesses (W) (Table 2). So that, in the development of cassava farming, the existing constraints will be easy to deal with. Meanwhile, when looking at the environmental influence on cassava farming, the opportunities (O) to develop cassava are more easily achieved. The threats (T) to develop cassava can be easily overcome by seizing the opportunities (O) as good as possible and supported by utilizing the strengths (S) that are already owned.

To arrange a strategy for developing cassava farming, the identified potentials and constraints are mapped onto a four quadrant map [24]. Mapping result indicates that the position of intercropping cassava under the perennial crops is in quadrant I (Figure 1). This condition is favorable because it means that the cassava farming is in a growing period.

Because the slope (direction) of the cassava development map tends toward the opportunities (O), the next stage of development can be carried out is by optimally managing the strengths (S) owned in order to seize the opportunities (O). The components of the strengths (S) that can be maximally utilized are the quite long experience of farmers in cassava cultivation and the availability of new technology on cassava. Thus, the formulation of strategy that can be applied in this condition is to support an aggressive growth policy (quadrant 1) by applying intensive cassava cultivation through utilizing new technologies in the production and post-production aspects.

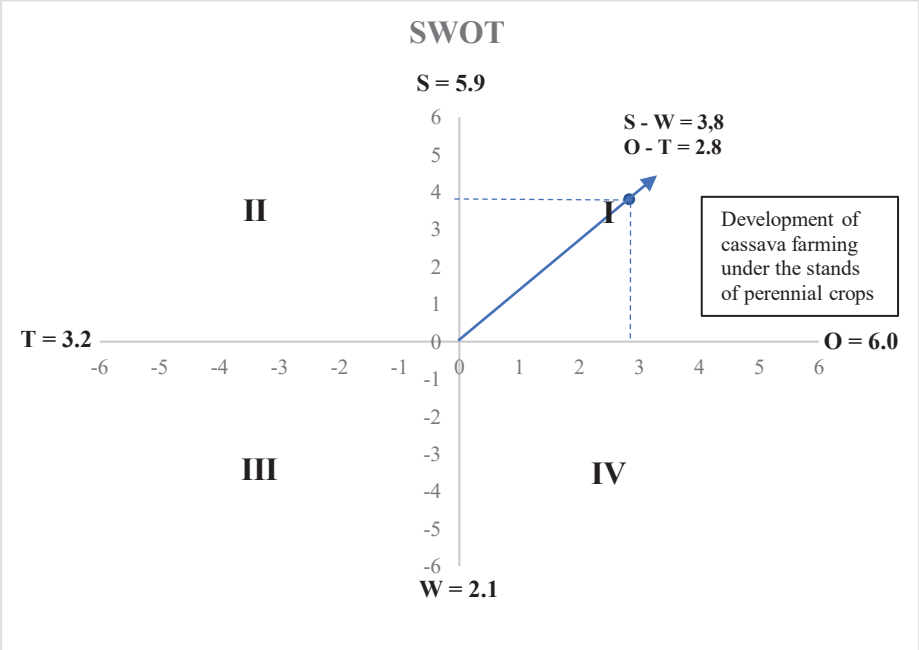

Fig. 1. Position of cassava farming development under the stands of perennial crops.

By looking at the map of cassava farming development (Figure 1), it can be concluded that the use of land under the stands of perennial crops for cassava intercropping has a great opportunity. This is because of the fact that there is less opportunity for developing cassava in lands that are intensively managed for agriculture. The land use competition with other crops which cannot be denied economically will defeat or remove the cassava is a reason.

The operational strategy required based on the SWOT analysis is to develop the strengths and opportunities (SO) factors, namely: (1) Intensive cultivation with the use of new technology in the production and post-production phases; (2) Increasing business scale by increasing producer capacity and product development (diversification); and (3) Dissemination of technology for feed using cassava biomass. The long-term strategy is to regulate the cassava commodity production system from upstream to downstream.

Table 2. The correlation matrix of cassava as an intercrop.

No	Factors	WF (%)	BV	WBV	Correlation																	ACV	WCV	WVT	∑ WVT
	Strengths (S)				**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**				***5.9***
1	The existence of institutions	33.3	5	1,67	**X**	5	5	5	5	5	5	5	1	3	4	2	4	4	5	4	4	3.6	1.2	2.9	
2	Cassava has long been cultivated	25.0	5	1,25	5	**X**	5	5	5	5	5	5	1	4	5	1	5	5	5	3	3	3.5	0.9	2.1	
3	Technologies and varieties availability	12.5	5	0,63	5	5	**X**	4	4	2	2	2	4	2	3	2	4	4	1	1	1	2.4	0.3	0.9	
	Weaknesses (W)																								***2.1***
1	The image of cassava as inferior commodity	12.5	5	0,63	5	5	4	5	**X**	1	2	1	1	2	4	3	5	4	5	2	5	2.6	0.3	0.9	
2	Farmer has not mastered the cassava technology	8.3	5	0,42	5	5	2	2	1	**X**	3	2	1	1	3	2	3	2	4	1	3	1.9	0.2	0.6	
3	Production land under main crops stands (age <3 years)	8.3	5	0,42	5	5	2	3	2	3	**X**	1	1	2	5	3	5	4	3	2	4	2.4	0.2	0.6	
	Opportunities (O)																								***6.0***
1	Secure and conducive price	23.1	4	0,92	3	4	2	2	2	1	2	1	1	**X**	3	2	4	3	3	1	1	1.8	0.4	1.3	
2	Utilization of cassava products	26.6	4	1,06	4	5	3	4	4	3	5	2	1	3	**X**	3	3	4	4	3	2	2.8	0.7	3.2	
3	Great demands	30.8	3	0,92	2	1	2	1	3	2	3	1	2	2	3	**X**	2	4	3	2	2	1.8	0.6	1.5	
	Threats (T)																								***3.2***
1	Presumption wasteful crop nutrients	30.8	5	1,54	5	5	1	5	5	4	3	2	1	3	4	3	3	4	**X**	1	4	2.6	0.8	2.3	
2	Pests and diseases	15.4	4	0,62	4	3	1	1	2	1	2	2	1	1	3	2	3	2	1	**X**	1	1.5	0.2	0.8	

Notes:
Score 5 = very related; 4 = related; 3 = quite related; 2 = less related; 1= unrelated
WF = Weight factor; BV = Base value; WBV = Weighted Base Value = (WF/100) x BV
ACV = Average Correlation Value = Associated Value/n
WCV = Weight Correlation Value = (WF/100) x ACV
WVT =Weight Value Total = WBV+WCV

3.3 Recommended technology of cassava intercropped with perennial crops

Cassava can be cultivated intercropped with perennial crops such as oil palm, rubber and teak before the canopy covers each other [25]. On land managed by *Perum Perhutani* in Java and Madura Islands, cassava is cultivated under the stands of teak with the age under 4 years old. Cassava is planted with a spacing of 100x80 cm and a distance of at least 100 cm between cassava and the main crops. If managed properly, the yield of cassava reaches 15-30 t/ha of the effective area. The cassava cultivation does not interfere with the growth of the main crops and even grow better than that which is not intercropped. From the survey results to farmers who cultivate cassava under the stands of perennial crops in Blora Regency (Central Java), North Lampung Regency (Lampung), and Barito Koala Regency (South Kalimantan), it is found that the use of technology components in the existing cassava cultivation are as listed in Table 3.

Table 3. Components of cassava farming technology under three stands of perennial crops.

Components of cultivation technology	Cassava intercrops with		
	Teak (Blora, Central Java)	**Rubber (North Lampung, Lampung)**	**Oil palm (Barito Koala, South Kalimantan)**
Cassava varieties	Malang 4, Adira-4, local (Cecek hijau)	UJ-5, UK-2	Adira-4, UJ-5, local (Krantil)
Chemical fertilizers:			
Urea	80 kg	-	-
Phonska (N:P:K:S = 15:10:12:12)	360 kg	350 kg	400 kg
KCl (K_2O 60%)	80 kg	-	-
Herbicides	4 l	-	-
Limes:			
Dolomit	-	-	400 kg
Kaptan	-	500 kg	-

The existing technology used by farmers in cultivating cassava under the stands of perennial crops is as follows: (1) The land used is forest area under the stands of perennial crops aged < 4 years old; (2) The spacing for teak trees is 3m x 3m; (3) The soil is processed and two ridges are made in the same direction between stands with a distance of 1m, so that the distance between the ridges and the stands is also 1m; (4) The spacing of cassava in ridges is 80 cm; (5) Planting time is the beginning of rainy season (October to November); (6) Selection of good and healthy cuttings for seedlings, with appropriate age and at least 2 cm in diameter of cuttings; (7) Spraying before planting, with pre-planting herbicide at a dosage of 23 l/ha; (8) The dosage of fertilizer is given according to the effective area for planting cassava that is 60% of the normal population as in Table 3; (9) All fertilizers are given once at the age of 2 weeks after planting, except for Urea which is also given at the age of 3 months with a dosage of 2/3 of the total; (10) Weeding and filling performed at the age of 3 months before the second Urea fertilization.

3.4 Economic benefits of cassava intercropping

The cassava intercropped under the stands of perennial crops such as teak, oil palm and rubber resulted in the number of tuber yield per ha which are almost similar. However, the three of them provide different profits based on farmer behavior patterns or intercropping management under each standing crop and cassava price in each location. The difference in intercropping management is from farming inputs, involving the amount of labor allocation and wages as well as the allocation and price of production input (fertilizers).

In North Lampung, there are many tapioca factories that accommodated cassava harvest. Therefore, the cassava price in Lampung is relatively more conducive and secure because the market has been established. Likewise, the condition in Barito Koala where there are cassava processing factories. Meanwhile, in Blora, the tapioca factory is located at Pati Regency, approximately 70 km from Blora. From the cassava farming location to Pati still requires transportation costs, so that the cassava price in farmer level in Blora is lower than the other two locations. By looking at the feasibility of cassava farming, the three intercrops have R/C ratio > 1 (Table 4) which indicate that cassava farming under the stands of perennial crops is profitable and can increase farmers' income during the first to fourth year period when the perennial crops are not yet productive.

Table 4. The economic feasibility indicator of cassava farming under three stands of perennial crops.

Description	Cassava intercrops with					
	Teak (Blora, Central Java)		Rubber (North Lampung, Lampung)		Oil palm (Barito Koala, South Kalimantan)	
	Number (unit)	IDR 000	Number (unit)	IDR 000	Number (unit)	IDR 000
Production inputs:						
Cuttings	16,000	900	16,000	800	16,000	800
Fertilizers:						
Urea	80	152				
Phonska (N:P:K:S = 15:10:12:12)	360	900	350	875	400	1,000
KCl (K_2O 60%)	80	560				
Limes:						
Dolomite					400	320
Kaptan			500	450		
Herbicides	4	280				
Total production input cost		2,792		2,125		2,120
Total labor cost		3,900		1,750		4,100
Total production cost		6,742		3,875		6,220
Tuber yield (t/ha)	26		27.5		25	
Price per kg		0.90-0.96		0.90-1.00		0.90-1.00
Revenue		25,072.2		27,500		25,000
Profit		18,285.2		23,625		18,780
R/C ratio		3.71		7.10		4.02
B/C ratio		2.71		6.10		3.02

The rate of return from investment in cassava farming under the stands of perennial crops is indicated by the value of benefit cost ratio (B/C ratio). The B/C ratio of the three cassava farms intercropped with perennial crops are more than 1, namely ranging from 2.71 to 6.10, meaning that each unit of investment will provide a profit of at least 2.7 times even up to a maximum of 6.1 times (Table 4).

4 Conclusion

The existing competition for agricultural land use with other food crops requires that cassava be cultivated on forest or plantation areas that are technically feasible for intercropping system under the stands of with perennial crops such as teak, rubber, and oil palm. The position of cassava farming in the growth phase, which is supported by the strengths of the resource and the availability of market opportunities is the basis for this consideration. The development of cassava cultivated under the stands of perennial crops also provides economic benefits to forest community in form of return on investment and profit. This is indicated by the economic indicator which is valued at more than one and quite great during the early age period of perennial crops before they are productive.

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