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Sustainable production technology of sweet potato in response to ecological and economical demands

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A B S T R A C T

Ecological catastrophe in the form of climate change is not only an issue, but now it is a real problem faced by and threatening human civilization, especially in producing food based on cereals and grains. Fortunately, sweet potato has many advantages from its biological potential to withstand climate change; however, it is ignored by policymakers. Consequently, the advantages of biological potential are often not followed by economic benefits for the farmers who grow sweet potato. So far, there has not been a clear regulation provided by policymakers to arrange sweet potato in food security or its agribusiness. Demand for fulfilling food domestically and to meet foreign markets, especially from Singapore, Hong Kong, Korea and Japan, stimulates farmers to increase production. Therefore, farmers have to be encouraged to undertake the sustainable sweet potato production technology leads to high productivity for current demand as well as for future prospective. The greener future technology is oriented to organic with low external input, by utilizing waste integrated with animal husbandry, as well as other sectors. Greener technology, ecologically sound and suitable for future civilization, is required to avoid climate change with low CO_2 emissions.

Keywords: Sustainable production, Sweet potato, Greener technology, Climate change

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Introduction

A greener future ecology in the form of low-emission CO_2 is required to reduce the adverse effects of global warming, corresponding with climate change. The food pattern of Indonesians is based on rice, which is around 115 kg/cap/year. Under population of Indonesia is approximately 272 million people, with a growth rate is 1.07%, resulting in the demand for rice always increasing yearly. On the other hand, producing rice is not ecologically friendly due to in the lowlands the production of methane, which is more dangerous 25-fold than CO_2, while in the upland, rice is sun sun-loving crop; therefore, the conversion of trees into open fields cannot be avoided, and consequently sequestration of CO_2 is low. Thus, exploring food crops besides rice is strongly recommended. Sweet potato (*Ipomoea batatas* L Lam) in nature is a perennial plant; due to human domestication, it is cultivated to be an

annual crop. The high adaptability to grow in a wide range of environments; relatively less in its pest and disease; requires a low input but responds to the additional inputs; can be harvested from 3 to 24 months; and produces an edible portion with nutritious and excellent taste at a high rate of productivity from its root (Antarlina *et al.*, 1993 Bradbury and Holloway, 1988; Braun and Priatna, 1994; COPR, 1986; Takagi *et al.*, 1996) those are the advantage point of sweet potato. Aside from the roots, young leaves could be used as a vegetable, and stems and foliage, as well as small roots, could be used as animal feed (Hoa and Ho, 1996; Winarno, 1982). This biological potential is suitable for developing sweet potato into a beautifully holistic, integrative, and sustainable farming system. From various facts in Pacific islands and Papua New Guinea, sweet potato is used as a staple food (Bradbury and Holloway, 1988; Simatupang and Syafaat, 2000), also in various countries of Africa and Latin America (CIP, 2001).

In China, sweet potato is mainly used for the starch industry, which is further processed into various final products such as noodles, snacks and modified starch. In Japan, the utilization of sweet potato is more diversified, and it is consumed and drunk in the form of various food and beverages. There is an increase in demand for sweet potato as animal feed in Japan; therefore, Toyota Bio Indonesia (TBI) developed large-scale plantations in cooperation with farmers for growing sweet potato in South, Central and Eastern Lampung Sumatra (CIP, 2000). In the highland of Papua or Irian Jaya, sweet potato is a very important crop for staple food. All parts of the crop, from young leaves, were used as vegetables, stems and foliage were used as pig feed and fish, while the root was directly consumed for daily meals. For subsistence farmers such as in Irian Jaya, the advantage of biological potential belongs to the sweet potato really able to feed the people in the struggle against the severity of the diverse risk-prone environment. This paper is to analyze the economic and ecological aspects in order to situate sweet potato as a recommendable food and cash income in response to the environmental and economic sense of balance.

Materials and Methods

The empirical experiences as a sweet potato researcher, 38 years of the first author, then 26 years of the second author and four years of the third author dealing with this commodity are combined and discussed with supported by the current facts and field notes collected by all authors. Data from the Indonesian Statistical Agency or Badan Pusat Statistik (BPS) with the common acronym BPS during the recent three years are descriptively analyzed. Secondary data, particularly from BPS, represents the macro or national contribution in relation to the institutional mandate of ILETRI as a centre of excellence to accomplish sweet potato research completely from A to Z aspects. On the other hand, in attempts to describe the real facts of sweet potato microeconomic responsibility, recent field notes from the planting period of 2012 to 2013 are analyzed. The cultivation of sweet potato in the lowland after rice during the dry season at Tengger Pasuruan, as well as in the upland under the rainy season at Mount Kawi on the border of Malang and Blitar is noted and analyzed for representing output-input cash flow of microeconomic experienced by farmers.

Results and Discussion

Contribution of sweet potato to the national economy

In Indonesia, almost 55% of sweet potatoes are harvested from Java. Despite the area of Java accounts for only 7% of the total population of Indonesia, but population of Java is 70% of Indonesia. Therefore, the total production of food crops, including sweet potato are consumed by the population in Java. Suparlan (1992), based on the previous fact, during the longer drought disaster of 1991, there was a serious crisis in food availability, particularly for the poor people in urban and suburban areas, including Jakarta and around. From the multiple surveys, Suparlan (1992) revealed that sweet potato and cassava were used as a substitution food for rice. For cassava, the utilization as food, especially during famine calamity periods (from mid mid-dry season till early rainy season), is commonly done by poor people in rural areas. Whereas cassava is processed in the form of dried peel (gaplek), and then prepared by cooking into a final product (tiwul). Unlike cassava, sweet potato has the advantage of longer storability. Therefore,

people mostly prefer to prepare it in a fresh form by steaming, boiling, roasting, frying or baking. Recently, although sweet potato has been used for industrial purposes, especially for food-related products such as chili or tomato sauces and noodle snacks, the major demand is not going to factories, but it goes mostly into the traditional market for supplemental food. There was an interesting phenomenon as the impact of multi-crisis swept Indonesia since 1997, from the food consumption data indicated that consumption of rice decreased and was followed by an increase in consumption of root crops, including sweet potato (Table 1). Although the program of food diversification is strongly promoted to attain food security (Satjanata and Partohardjono, 1985; Budianto, 2002; Saragih, 2002), however, due to most people consume a lot of rice, therefore government policy is trying to provide rice. The three principles behind food security consist of availability, vulnerability, and sustainability, were simplified and reduced to merely rice articulation. This is the background of the policy on RASKIN (beras untuk masyarakat miskin). Raskin is a government program in order to provide rice for poor people at a low price (accessible).

Table 1. Food consumption patterns of the citizens of Indonesia during 2020-2022.

Food group	Energy (Kcal/capita/day)		
	2020	2021	2022
Rice	1256	1235	1258
Root crops	58	69	72
Animal meat	127	89	117
Fat and cooking oil	61	171	205
Oily seed	76	41	52
Beans	45	53	62
Sugar	222	92	96
Vegetables	124	71	78
Others	50	26	53
Total	2020	1897	1993

Source: Calculated from data from BPS (2022).

Thus, the government should provide a subsidy for rice in the Raskin Program. Sawit (2002) reported that to provide rice, for Raskin government subsidies Rp 4,800 billions. Consequently import of rice tends to increase up to almost 4 billion ton. This policy conflicts with the mission of the food diversification program, especially sweet potato and other root crops. Among the food crops, sweet potato contributes the lowest gross domestic product (Table 2). Indeed, based on President Decree No 22 of 2009, local food, including sweet potato is recommendable to be consumed in order to realize the expected food pattern (Pola Pangan Harapan). The various flesh colors indicated the variability of nutritive value contained in sweet potato (Table 3). The less comprehensive, non-holistic, non-integrated and inconsistent program has a further impact ultimately on farmers who grow sweet potato. The main reason is that the market opportunity of sweet potato as a substitute and supplemental food was fulfilled by the government rice in the Raskin program, which is still a concerned recently. If farmers could not sell sweet potato as a cash crop, the shadow of poverty would nearly hit farmers because they would lose their income. Therefore, in an attempt to arrange the development of sweet potato should be oriented to market outlets, except if the government pays more attention to alleviating poverty regarding with sweet potato farmers in several areas by adding investment to trigger agro-industrial enterprises.

Table 2. Average consumption of calories and protein per capita/day from various food sources from 1999 to 2009.

No.	Commodities	Calories			Protein		
		1999	2005	2009	1999	2005	2009
1	Cereals	1,066.50	1,009.13	939.99	25.04	23.69	22.06
2	Root and tuber crops	60.73	56.01	39.97	0.43	0.45	0.33
3	Fish	36.04	47.59	43.52	6.07	8.02	7.28
4	Meat	20.07	41.45	35.72	1.33	2.61	2.22
5	Eggs and milk	24.39	47.17	51.59	1.43	2.71	2.96
6	Vegetables	32.28	38.72	38.95	2.23	2.52	2.58
7	Grain legumes /beans	52.40	69.97	55.94	4.81	6.31	5.19
8	Fruits	32.71	39.85	39.04	0.33	0.43	0.41
9	Oil and fat	205.90	241.87	228.35	0.42	0.48	0.34
10	Beverages	103.35	110.73	101.73	0.79	1.08	0.98
11	Spices	15.42	19.25	15.61	0.66	0.82	0.68
12	Miscellaneous	28.76	52.84	58.75	0.53	1.03	1.21
13	Fast food	170.78	233.08	278.46	4.62	6.44	8.10
14	Alcoholic beverages	0.04	-	-	0	-	-
15	Tobacco and pepper	0	0	0	0	0	0
Total		1,849.36	2,007.65	1,927.63	48.67	55.27	54.35

Source: Data selected and calculated from BPS (2009).

Table 3. The main food crops produced in Java and Indonesia in 2019.

Food crops	Java			Indonesia		
	Harvest area (ha)	Productivity (t/ha)	Production (t)	Harvest area (ha)	Productivity (t/ha)	Production (t)
Rice	6,280,933	5.73	35,995,608	13,118,120	5.030	65,980,670
Maize	2,157,424	4.43	9,563,832	4,133,785	4.317	17,844,676
Soybean	440,871	1.38	611,417	672,242	1.346	905,015
Peanut	430,973	1.26	544,216	626,264	1.245	779,677
Mung bean	165,500	1.16	192,902	284,564	1.137	323,518
Cassava	570,387	17.82	10,165,726	1,203,143	19.194	23,093,522
Sweet potato	56,978	13.26	755,700	181,234	11.368	2,060,272

Source: Data selected from BPS (2022).

From existing to sustainable production system

Sweet potato can be planted in upland and lowland. In upland, sweet potato is cultivated at the onset of the rainy season, thus only facilitated by water from rainfall. Harvesting sweet potato in upland is done at the end of the rainy season till the early to mid-dry season. While in the lowland, sweet potato is grown in the early dry season after rice is harvested, especially in the area where irrigation is in shortage. If rice can be planted twice due to water being adequately available, then planting sweet potato is undertaken at the mid or the end of the dry season. Harvesting of sweet potato in the lowland is done at the end of the dry season till mid-wet of the wet season before the rice is planted. This fact indicates that sweet potato is available year-round, and there is no serious problem with seasonality.

As the raw material for industry, the availability of sweet potato year-round is profitable, especially during the peak harvest in the lowland at the end of the dry season, and the price of fresh root is very low. While the price of the final product is relatively stable, therefore processor can get more benefits. This situation could be worse when a lot of farmers are growing sweet potatoes. Under such conditions, the price of sweet potato is not profitable. Heriyanto (1995) reported that the price of sweet potato dropped to Rp 22.50 (US $ 1 = Rp 1,400), so farmers suffered greatly from the loss. Losses due to market uncertainty and price drops are more serious compared to the losses due to natural enemies. When the price is so low, farmers hesitate to harvest and delay the sweet potato in the field. Under the worst situation, since harvesting also needs labor and consequently costs, farmers let sweet potato and plow the field for planting another crop.

As a consequence, the price in the following season or years will be better because many farmers hesitate to grow sweet potato. The better the price is, the more interesting the incentive for the farmers to grow sweet potato. So many farmers are growing sweet potato again, and the price then goes down again. These circumstances, according to farmers, are called a "puzzle circle" because they do not know what the price of sweet potato will be when they harvest. They assumed it was a natural law. So, there is nobody wrong. According to Bird (2000), this honest and simple way of thinking of farmers (people) needs a fundamental education. Could the simplicity of their thinking be enlightened? Who will give enlightenment to them? Or let the sweet potato farmers struggle alone with their traditional minds. Thus, a research institute they are reflecting on an interesting topic to be studied across time (endless) to get more funds without any clear outcome? So, what is next, the follow-up needed that can really help farmers to struggle against poverty? Bogdan and Taylor (1992) revealed that the implementation of social science is able to alleviate such a problem appropriately.

Van de Fliert *et al.* (1996; 2003), from work started in 1994 till 2000, reported that sweet potato yield could be easily increased by applying Farmers Field School (FFS) on Integrated Crop Management (ICM). Furthermore, Van de Fliert *et al.* (2003) revealed that from the study areas in the first stage in two districts of East Java (Mojokerto and Magetan), and two districts in Central Java (Karanganyar and Magelang), then developed into Yogyakarta and West Java provinces (in Kuningan), there was an increase of knowledge which resulted into better crop management and subsequently increase yield. In Mojokerto at the farmers' level, yields up to almost 70 t/ha could be obtained. Due to the growing sweet potato was not a difficult matter. Therefore, dissemination of this advantage was easily spread among the farmers. Despite the mission of the team (CIP-RILET) having been described previously to the farmers about FFS-ICM, however, in the partial discussion, farmers sometimes asked about the price and market of sweet potato and how to alleviate this constraint. The answer was back to the basic ontological aspect that research institutes did not have a mandate to arrange the price and market. The question and the answer are completely right, but there is no context with the real problem faced by farmers. The obvious answer further was to train farmers about post-harvest handling and knowledge about cooperative work in order to handle the market. First-generation problems in the green revolution, namely increasing yield and third-generation problems minimizing pollution, were the major activities in the curriculum of FFS-ICM; therefore, an endeavor to sustain sweet potato production system through participatory technology development (PTD) is recommended.

Unfortunately, when post-program monitoring of sweet potato FFS-ICM was held during 2002-2003, several farmers complained about the repeatable problems, which were the market difficulty and price drop again, as did in the previous periods (Widodo and Rahayuningsih, 2003). The used of the newly improved cultivars, better crop and soil management, proper pest and disease management with ecologically friendly, which led to the increase of sweet potato productivity then after harvest, because the market was not understood, affected the dream of farmers was loose.

Unlike cassava, the utilization of sweet potato is limited. Although the FFS-ICM the flour and starch processing of sweet potato, farmers hesitate to do so. The basic justification of farmers is labor and cost for processing, and ultimately, where the intermediate products could be sold. When the products generated are not marketable, what kind of additional treatment that able to convert them into a cash income? A study done by Rozi and Rachmat (2001) indicated that there was an integration market for sweet potato in the whole of Java, and the price of sweet potato in West Java was better compared to Central and East Java. However, in fact, if sweet potato is transported from Central or East Java to Central Market (Pasar Induk) Kramatjati of Jakarta, retailers and buyers still choose sweet potato roots from Bogor or Kuningan (West Java). Because sweet potato transported from East and Central Java was not as fresh as that from West Java. Therefore, marketing sweet potato from East and Central Java to West Java or Jakarta is not competitive due to transportation costs. Traders' strategies in order to cover costs and to avoid risk are by buying sweet

potatoes from farmers at low prices. This fact can be understood because the risk faced by the trader is not small. Widodo and Rahayuningsih (2003) elucidated that from around 6 tons of sweet potato (1 truck), if it is not finished within 4 weeks, 40% of the roots deteriorate. Root deterioration is mainly due to physiological, microbial or physical factors. Physiological sweet potato can be sweeter if it is stored. However, if storage conditions are not good enough, root rot can easily develop. Fungus, bacterial or other microbial factors affecting the damage to the root by rotten are due mainly to the worse of storage conditions. After harvest, sweet potatoes are cleaned and filled into sacks (similar to fertilizer or sugar sacks). The information from several traders in East Java revealed that if sweet potato is washed with water to remove the soil from the skin, this practice could promote early deterioration. In the market, in big traders, sweet potato sacks are mounted and then distributed to small traders. The easy deteriorate is also caused by the cultivars. The cultivar with the high water content is more deteriorated than the cultivar with the high dry matter content. Cultivars with high dry matter content is more preferred than the cultivars with high water content, especially if it is used for supplemental food and prepared by frying. Cultivar with high water content is not suitable to be fried, but it can be steamed or roasted or baked. Fortunately, in sauce factories, there is no rigid prerequisite for character. High or low water content, white or yellow flesh colors, except for purple flesh color are not accepted, because the color of the sauce will be dark and it will be rejected by consumers. Demand for sweet potato for traditional markets and sauce industries is the determinant factor in the price fluctuation. The demand for fulfilling industries tends to be stable, but the demand for the traditional market fluctuates. During the wet or rainy season, according to traders and retailers, demand for sweet potato tends to increase. This increase is mainly due to the food scarcity, because during that period, the harvesting of food crops was still extraordinary.

Thus, the role of sweet potato as a supplemental food is significant. During the dry season, from the early rice is harvested, then cassava, maize, legumes and sweet potato. So, there are many competitors of food crops other than sweet potato under surplus supply. Therefore, the price of sweet potato during the dry season is mostly low, and the market is more difficult. Thus, from the food system, food availability from the early till mid of rainy season is crucial for people experiencing poverty in rural areas. Since in the rainy season sweet potato demand increases, therefore better prices can be enjoyed by farmers. Unfortunately, commonly farmers have already sold the crop to the village traders by tebasan (transaction with crop standing in the field) during the price drop in peak harvest. So, a better price in the late dry season or during the wet season does not belong to the farmers. The real circumstances reveal that insufficient cash income and unmet basic human needs, lead farmers to sell their cropeven if the price so low.

From sustainably oriented for poverty alleviation

Although the production system under the huge frame of agribusiness is only one of the sub-systems, among the three others, however, in the long run, sustainability is very important. Because sustainability is not merely accomplished through the increase of productivity over time, but it is also to be able to compromise the conflict needs of future generations. It means that sustainability in the broad sense should be able to conserve the natural resources from exploitation, degradation, and the loss of biodiversity. Sustainability of sweet potato production is not limited to cultivation on pre-harvest aspects. But, it is related to the broad mission in holistic, integrative, and comprehensive approaches. Thus, it could not be simplified, reduced to partial action.

Therefore, post-harvest handling of sweet potato fresh root and its market are also important agendas to be solved in the frame of sustainability. Moreover, if action research should be started from the end, to trigger the whole system of sweet potato to be more benefiting and profitable for farmers and consumers, so product and market development are urgently to be handled. Product and market development is a continuum it alike of coin-side, if it is separated, the tangible value is subsequently degraded. Market or product development is the logical articulation, because these two words cannot be

articulated together. Thus, the priority for sweet potato development in Indonesia is mainly laid on market and product development. Delaying to handle of this problem is similar to postponing the poverty alleviation. Even more, due to farmers are not able to sell their sweet potato fresh root, and product development is not managed by farmers, so farmers will suffer more and be trapped in poverty. Poverty alleviation, according to the declaration of Vienna in the 16th paragraph, elucidated that this program was not only an economic policy, but it was also related to social justice and welfare. Poverty is interrelated to many aspects, including less or no income, which further affects dehumanization. This is the controversial feature with the spirit of the United Nation Organization which is strongly promoting human rights (Williams, 2013). Therefore, poverty alleviation in line with a sustainable sweet potato production system is urgently tackled.

To sustain sweet potato farmers need a premium. Despite farmers never being bothered with their own labor, fertilizer in the form of organic and/or inorganic need cash. The use of external low inputs to sustain the sweet potato production system is more recommended. It means that generating and activating the internal or in situ sweet potato production system under sustainable circumstances is low cost. If own farmer labor is calculated, starting from producing green forage for animal to produce dunks as organic fertilizer then harvesting fresh root and returning the waste into the fields in attempts to balance the nutrient removed by sweet potato, the farm gate price of Rp 1,500/kg (1 US$ = Rp 8,500) is really inexpensive. But, again, the natural mandate of farmers is not only to produce the food and simultaneously conserve the natural resources; farmers should provide adequate food at an accessible price to the other poor people, of course, at a low price (Widodo, 2011; Widodo, 2012a; Widodo, 2012b). Farmers should also provide the margin of price between retail and wholesale, thus there is an opportunity for their sweet potato fresh root to be transported and marketed by village traders. Both in upland and lowland after rice, the benefit of farmers' income is determined mainly by the price unit as well as the production obtained (Table 4).

Table 4. Difference in cost and benefit of farmers from sweet potato cultivated at the lowland after rice and upland during 2021-2022.

Item	Financial statement (Rp/ha)	
	Lowland after rice in Pasuruan, dry season 2012	Upland rainy season in Mount Kawi, the border of Malang and Blitar
Land preparation from plowing, harrowing and ridging	2,000,000	2,250,000
Cutting material supplies	800,000	800,000
Planting	750,000	750,000
Weeding	500,000	750,000
Fertilizer application with 200 kg Phonska NPKS 15:15:15:10% + manure 5 t/ha	1,400,000	1,400.000
Hilling up and vine-lifting	1,000,000	1,000,000
Irrigation	750,000	-
Total cost	7,200,000	6,950,000
Harvest yield	22500 kg	17800 kg
Price (Rp/kg)	800	1200
Revenue	18,000,000	21,360,000
Land rent 6 months	4,000,000	3,000,000
Profit	6,800,000	11,410,000

Note: Cutting material is mostly not considered in the financial consequence due to farmers' share from their previous crop and paying cost for taking and selecting good cuttings. Cost for harvest was paid by the trader as follows the rule in crop standing transaction (tebasan). USD 1 = Rp 14,985 July 20, 2022.

Table 5. Food, feed and fuel generated from agro-forestry in various sites of Java.

Food crops	Main forest and space (m)	Shade intensity (%)	Yield (t/ha)	Forage for feed or firewood	Bio-ethanol conversion	Site and year measurement
Upland rice Teak	6x1	25-40	2.25	4.30	Not allow	Cianjur, 2009
Maize Mahogoni	3x2	30-42	3.38	7.12	2.5:1	Blitar, 2008
Sweet sorghum Melaleuca	4x1	10-15	4.17	8.55	2.5:1	Mojokerto, 2008
Soybean Teak	6x1	20-30	1.36	2.49	-	Nganjuk, 2009
Mungbean Teak	6x1	20-30	1.18	1.95	-	Saradan, 2009
Cowpea Mindi	3x2	25-40	1.29	2.90	-	Subang, 2009
Pigeon pea Mindi	3x2	25-40	1.20	2.66	-	Subang, 2009
Cassava Teak	6x1	15-25	37.52	26.23	6:1	Indramayu and Pati, 2009
Sweet potato Mahogoni	6x1	10-20	26.40	12.15	8:1	Blitar, 2008
Arrow root Albizia	2x2	30-50	12.27	2.78	7:1	Blitar, 2008
Cana root Teak	3x2	25-40	16.45	3.17	7:1	Blitar, 2008
Yam Albizia	2x2	30-50	27.59	7.42	6:1	Tuban, 2009
Cocoyam Albizia	2x2	30-60	29.16	4.23	6:1	Banyuwangi, 2008
Taro Mahoni	3x2	30-40	21.05	2.34	6:1	Pasuruan, 2009
Elephant food yam Teak	3x2	40-65	19.24	2.27	6:1	Madiun, 2010

Note: Food crops associated with agro-forestry are conducted by communities around forest areas. In dense areas, each household only manages 0.25 ha under forest.

Table 6. Sweet potato white, yellow and purple, as well as nutritions.

White/yellow/purple	Sweet potato white	Sweet potato yellow	Sweet potato purple
Calory	23 kkal	136 kkal	123 kkal
Carbohydrate	28,79%	24,47%	12,64%
Sugar reduction	0,32%	0,11%	0,30%
Fat	0,77%	0,68%	0,94%
Protein	0,89%	0,49%	0,77%
Moisture	62,24%	68,78%	70,46%
Ash	0,93%	0,9%	0,84%
-Fiber	2,5%	2,79%	3%
Betacaroten	260 mkg (869 SI)	2900 mkg (9675 SI)	9900 mkg (32967 SI)
Vitamin C	28,68 mg/ 100 gr	29,22 mg/ 100 gr	21,43 mg/ 100 gr
Antosianine	0,06 mg/ 100 gr	4,56 mg/ 100 gr	110,51 mg/ 100 gr
Vitamin A	-	-	7.700 mg

Source: Sweet potato white, yellow and purple are very good.

Amazingly, when the farm gate price of sweet potato is so low such as now, many traders are not encouraged to buy because the traditional market is difficult. This fact is a serious problem for the farmers, because they cannot get a cash income. Indeed, the government can help farmers by buying sweet potato fresh and distributing it to the area that suffers from hunger due to drought calamities. There is no strong government for the food diversification program. Unlike rice, the government was able to determine the floor price, and when the price fluctuated and tended to increase, market operations were subsequently implemented to control the cost. For sweet potato, there is no policy implied as the action of Act No. 7 of 1996 revised with Act No. 18 of 2012 or its regulation. Therefore, food security is still dominated by only rice; food diversification is merely stopped in discourses or master plans without any implication.

In fact, the wise policy could be made possible by considering the contribution of food crops to the Gross Domestic Product. Cross-subsidy, reallocation of budget to enhance farmers who grow crops other than rice, should be given. Enhancing a sustainable sweet potato production system is a government task. Product and market development of sweet potato is an appropriate way to be tackled in an attempt to help farmers from the puzzle circle and depart from poverty conditions into better welfare. Product development is mainly

processed sweet potato fresh into intermediate or final goods in the agroindustrial enterprises. Product development is expected to broaden the utilization of sweet potato than it did previously. Market development could be generated by linking the farmers and consumers and facilitating the transportation, fund, and in-line regulation, for example, by rethinking and rechecking about Raskin Program and import of wheat and other food crops. Maintaining traditional markets and requesting supermarkets to sell sweet potato fresh, intermediate and final products in rural, suburban and urban areas, supporting industrial enterprises with sweet potato used as the raw material seems like a breakthrough to broaden the domestic market of sweet potato, aside from developing export for foreign earnings.

Conclusion

Based on the discussion explained, the following conclusion can be presented as:

1. Sustainable sweet potato production system is not a difficult matter for understanding and subsequently implementing this concept into existing practices. Farmer Field School on Integrated Crop Management was able to illuminate farmers about sustainable production systems and has significant contribution to the increase in productivity and efficiency as well.
2. Increasing sweet potato productivity without any clear market outlet will lead to farmers into an unbeneficial condition. Low price and market difficulty are more serious problems than the technical problem. Product and market development is considered an appropriate way out for farmers to safe their fresh roots of sweet potato, and ultimately to attain their cash income.
3. Product and market development is beyond farmers' ability; therefore, government, NGOs, and stakeholders should work hand in hand to help farmers sustain the sweet potato production system. Thus, farmers are not trapped in a poverty situation. As a continuum between economic and ecological demand, product and market development could not be fragmented, simplified, or reduced into partial actions. These should be approached by integrated, comprehensive, and holistic endeavors.

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