A New Future for Cassava in Asia:

Its Use as Food, Feed and Fuel to benefit the Poor

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TRADITIONAL AND NEW USES OF CASSAVA ROOTS IN INDONESIA

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ABSTRACT

In general, cassava roots in Indonesia are being used for food, feed and industrial purposes, which includes products such as chips/gaplek, flour, starch, and sweeteners such as high-fructose syrup, dextrose, maltose and sorbitol, while the new utilization of cassava roots focuses on the new demand for fuel-ethanol.

Factors causing the increased utilization of cassava roots for food are: (1) rice production can not satisfy the increasing demand, (2) cassava is more nutritious than rice due to its higher micro-nutrient content, (3) it is a staple food in remote areas, (4) it has functional properties that are highly suitable for certain foods. About 70% of the national cassava production is still used for food and this has been increasing at a rate of 1.8% per year.

During the last ten years the domestic demand for chips, flour, starch, and sweeteners has increased by 50%, 34%, 25% and 15%, respectively, while production of chips, flour and starch decreased at 34%, 22%, and 25% during the same period. This indicates that demand far outstrips supply and that cassava production needs to be increased.

Utilization of fuel-ethanol as an alternative source of energy is one way to solve the energy crisis and slow down the decrease in national fossil fuel supply of 5.74% per year during the last ten years. Annual demand for fuel-ethanol, to be mixed at 10% with gasoline for transportation, based on Presidential decree No. 5/2006, is estimated to be 1.4 million kl (1.12 million tonnes) which will require 8 million tonnes of fresh cassava roots. It means that cassava production has to be further increased to meet this additional demand for fuel ethanol.

Cassava production can be increased through both increases in yield by intensification and through increases in planted area. In Indonesia the target is to achieve a 5% annual increase in production through intensification and another 15% through increases in area. Sumatra and Kalimantan islands are suitable locations for increasing production through area expansion due to their wet climate and the availability of 5.7 million ha of under-utilized land. By 2025, it is projected that 18.7 million tonnes of fresh cassava roots will be needed for food, 6.1 million tonnes for dry chips, 2.6 million tonnes for starch, 7.9 million tonnes for sweeteners and 23.4 million tonnes for fuel-ethanol, for a total requirement of 67.2 million tonnes, which is over three times the current level of production.

INTRODUCTION

In Indonesia, the annual rate of growth of the utilization of rice, maize and cassava as staple foods during the last ten years were 1.37, 3.02% and 3.39%, respectively. Rice and maize production satisfies only about 90% and 70% of their respective demands, while cassava production exceeds its demand as food. This means that cassava is potentially a staple food alternative to substitute for rice and maize. Its demand for food will increase since the production of both rice and maize is insufficient to meet current demand.

Traditionally, cassava roots are also used for animal feed and for industrial purposes such as the production of dry chips, flour and cassava starch. Starch is an intermediate product to be used as raw material of downstream industries, such as fructose syrup, sorbitol, MSG, etc.

Since the growth of cassava production is below that of cassava usage for food, and this demand accounts for about 70% of national production, the availability of cassava as

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an industrial raw material can, therefore, not keep up with increasing demand. The decreasing availability of cassava fresh roots for industries due to the increasing demand for food, has affected the export of products like chips, flour and starch. On the other hand, the domestic demand of these products increased (FAO, 2005). To solve this problem we need to increase cassava production in order to meet the increasing demand for both industrial purposes and food.

An entirely new utilization of cassava roots is its use as a raw material in the fuel-grade ethanol (FGE) industry. The demand for FGE for mixing with gasoline at 10% (E10), based on Presidential Decree No.5/2006, was estimated at 1.4 million kiloliters in 2007 and will increase at a rate of 7.07% per year. Assuming a factory-gate price of Rp 350/kg fresh cassava roots and Rp 4,500/l FGE, the development of FGE industries is financially feasible based on NPV>0, R/C>1, and the internal rate of return being higher than the commercial bank interest rate (Wargiono, 2008). FGE industries are expected to be developed due to their various internal and external supporting factors. Investors are therefore committed to develop FGE industries. It means that both traditional and new uses of cassava have the potential to be further developed, and cassava production could be increased significantly in line with the increasing demand.

To meet the demand, both as raw material for the traditional and FGE industries as well as for food, national cassava production will need to increase at least 40% during the coming years.

Traditional Utilization of Cassava Roots

Traditionally, cassava roots in Indonesia are used for food, animal feed and for industrial processing into food and non-food products.

1. Cassava roots for food

Cassava is the third main staple food, after rice and maize, for most low- to medium-income people in Indonesia. As production of rice and maize satisfies only about 90% and 70%, of food demand, respectively, the demand of cassava for food is likely to increase. Besides, cassava used as food is nutritionally better than rice due to its higher content of both macro- (except protein) and micro-nutrients, as well as food fiber, while its glycemic index is considerably lower than that of rice, making it a very functional food (**Table 1**). For that reason, about 70% of cassava production in Indonesia is used as food and this demand will increase by 3.63% per year (Statistic Indonesia, 2006).

Based on its superior quality (except in protein content) cassava is used as the main staple food for many communities in remote areas, as well as for low- to medium-income groups. Traditionally, the preparation of *tiwul* as a staple food was relatively simple: put 1 kg of cassava flour in a bamboo winnowing basket, add one liter of water, make small balls by kneading → make many small balls homogeneous in size (similar to rice grains) by turning around on the basket, steam for about 30 minutes and the *tiwul* is ready to eat.

Malnutrition and anemia resulting from inadequate levels of energy and micronutrients in the diet are serious public health problems in Indonesia. **Table 1** shows that the rice in the diet could not supply sufficient vitamin A and C, while only 4.2% of calcium and iron and 33.6% of the micro-nutrient requirement could be supplied. On the other hand, cassava eaten as staple food is able to supply both vitamin A and C, and more than 60% of calcium and iron required in the diet. It means that malnutrition resulting in anemia and vitamin A deficiencies, which is affecting one million and nine million people in Indonesia, respectively (WNPG, 2004), could be reduced by eating cassava as a staple food.

Dietary fiber, which consists of soluble fiber and non-soluble fiber, takes longer to transit the digestive tract, where some is fermented by intestinal microbes into fatty acids. The function of soluble fibers is to slow down starch digestion, thus decreasing the blood glucose level, and the need for insulin, which is involved in the transfer of glucose into body cells to produce energy. Non-soluble fiber also helps to reduce colon cancer, diverticulosis as well as vizier. It means that introducing cassava in the diet is not only suitable for diabetic consumers, but also increases the health of various digestive tract organs.

Since the utilization of cassava for food is of first priority, and the growth rate of food demand is higher than that of production, cassava production has to be increased to meet the demand for both food and industrial purposes.

Table 1. Nutrient characteristics of staple food crops in terms of calories, vitamins and minerals.

Food crops/ recommendation[1)]	Amount (g)	Protein (g)	Vit.A (si)	Vit.C (mg)	Ca (mg)	P (mg)	Fe (mg)	DF[2)]	DS[2)]	GI[2)]
Recommended	1,269 (cal)	36	356	53	474	356	7.71	-	-	-
Rice	326	22	0	0	20	456	2.59	5.4	70.0	56.0
Cassava[3)]	748	6	2,881	225	247	299	5.2	7.0	62.1	37.0
Maize	352	32	14	1,795	35	901	9	-	-	-

[1)] Nutrition recommended in the diet
[2)] DF = digestible fiber; DS= digestible starch; GI= Glycemic index
[3)] Fresh roots
***Source**: WNPG, 2004.*

2. Cassava used for traditional industrial purposes

For traditional industries, such as dry cassava chips, flour, starch and sweeteners, their raw material supply depends on the total national cassava production, and on the demand for food, which has been increasing annually at a rate that is 45% higher than that of production. Consequently, the processing of these traditional cassava products has decreased annually by 19% due to insufficient availability of the raw materials (Statistik Indonesia, 2006). The products of these traditional industries, such as cassava chips, flour, and starch, are either exported to international markets or used as the raw material for downstream industries, such as maltodextrin, glucose syrup, fructose syrup, sorbitol, monosodium glutamate, textiles, paper, cosmetics, drugs, etc.

The impact of decreasing production by these traditional industries due to the insufficient supply of cassava roots has decreased the export of these products and increased the importation of these product to meet the domestic demand. This problem could be solved by increasing cassava root production to satisfy the demand of these traditional industries. To meet the demand for food, feed, and these traditional industries, as well as the expected future use of fuel-grade ethanol (FGE), it is estimated that fresh cassava root production by 2025 will need to increase to 67.17 million tonnes (**Table 2**).

Table 2. Projection of cassava fresh root production in Indonesia to meet the demand for food, feed and various industries from 2010 to 2025.

	Fresh root equivalent ('000 t)				Growth (%/year)		
Indicators	2010	2015	2020	2025	2010-2015	2015-2020	2020-2025
National production	24,512	38,289	53,424	67,165	8.26	7.00	5.00
Uses:							
-Food	14,521	15,883	17,373	19,004	1.81	1.81	1.81
-Feed	344	348	351	355	0.02	0.02	0.02
-Industrial purposes							
-Chips	937	1,702	3,793	6,109	15	12.5	10
-Flour	343	553	890	1,433	13	13	13
-Starch	1,847	3,015	4,922	7,969	10	10	7.5
-Sweeteners	1,255	2,021	2,902	4,166	10	9.5	9.5
-FGE	2,970	11,838	19,455	23,359	32	10.4	3.7
-Others + waste	2,295	2,929	3,738	4,770	4.9	4.0	4.0

***Source**: Wargiono, 2008.*

Increasing cassava root production can be achieved through both intensification in production and by increasing the growing areas. To guarantee fresh root availability as raw material for industries, cassava has to be planted continuously during the wet season (at least six months) and harvested throughout the year. The cassava can be harvested from 7 to 12 months to meet the demand for a continuous supply of raw materials. Areas which have more than six wet months during the wet season are suitable to increase production through both intensification and extensification. Besides, currently unused land is needed for increasing the planted area from the current 1.2 million ha to about 2.2 million ha by 2025, while also increasing yields from 16 t/ha to 30.5 t/ha by 2025. **Table 3** shows that Kalimantan and Sumatra are suitable areas for developing industries, especially for cassava starch and downstream industries such as sweeteners, sorbitol, MSG, etc. While production of dry chips and cassava flour could be developed in dryer areas such as Java, Sulawesi and East Nusa Tenggara islands. Increasing cassava production successfully through both intensification and extensification depends on the contribution to the income of both farmers and government.

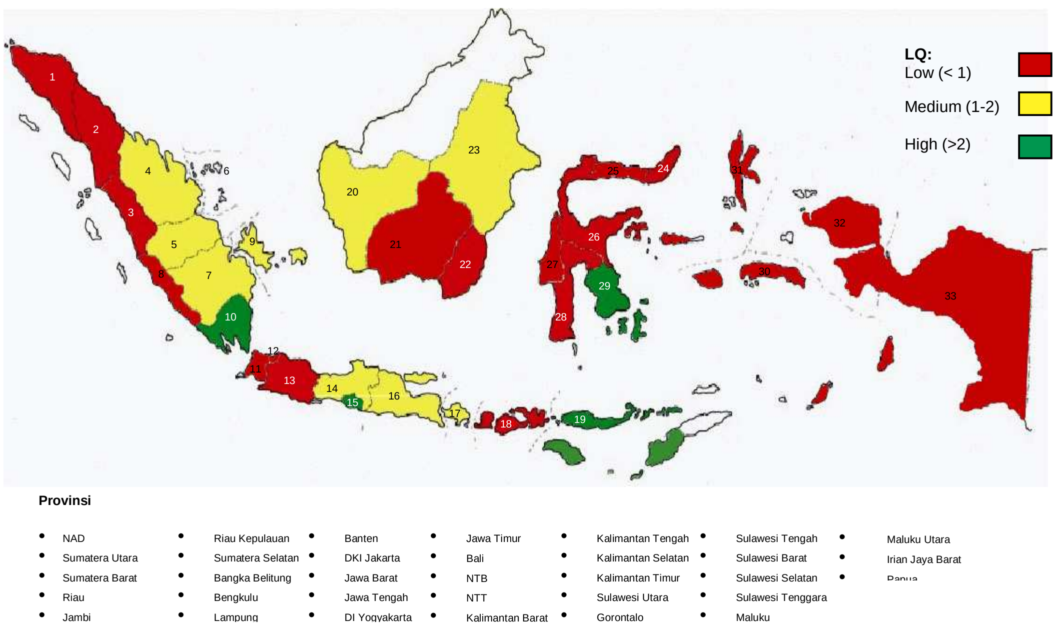
Table 3. Suitable regions based on land and climate to develop cassava as raw material for industries.

Region	Soil type ('000 ha)			TNUL land[1)] ('000 ha)	Dominant climate
	Inceptisol	Alfisol	Ultisol		
Sumatra	10,598	-	8,008	2,156	wet
Java	4,231	1,053	4,463	111	dry
Kalimantan	11,025	-	20,400	3,633	wet
Others	5,803	976	2,336	1,163	dry

[1)]TNUL= temporarily not used land.

***Source**: Adimihardja and Mappaona (Eds.), 2004.*

A location quotient (LQ) could be used to describe the contribution of cassava farming to the regional economy. The LQ of cassava-based provinces could be divided into three categories: low (<1), medium (1-2), and high (>2). Provinces with medium to high LQ are characterized by the dominating presence of commercial cassava farming (Wargiono, 2008). Commercial farming systems are characterized by farmers who are responsive to yield and price change and adopt recommended technologies in order to obtain high profits. The benefit-cost (B/C) ratio of commercial cassava farming systems is generally >1. The B/C ratio of >1 is an indication that cassava farming is financially feasible and can be developed to contribute more than 40% of farmers' income (Ditkabi, 2008). Therefore, increasing production through both intensification and extensification in areas with medium to high LQ, i.e. where there is temporarily not used land and with a suitable climate, will be the first priority. Based on this criteria 39 districts in seven provinces of Sumatra island and 35 districts in four provinces of Kalimantan island have potential for further development of cassava to be used as raw material for both traditional and FGE industries (Wargiono, 2008) (**Figure 1**).



Gambar 6. Sebaran Location Quotient (LQ) ubikayu per provinsi.

Figure 1. Suitability of provinces for the development of FGE industries, based on their LQ status.

Traditional industries which use fresh cassava roots and derived product as raw material include those producing chips, flour, starch, sweeteners, sorbitol, MSG, cracker/crisp etc. The traditional industries are mostly concentrated on Java and Sumatra islands (**Table 4**). The decrease in the export of cassava chips, flour and starch and the increasing deficit to meet domestic demand for these products indicate that these industries were not able to produce sufficient products due to the inadequate supply of the raw material to meet demand.

Table 4. Currently existing traditional cassava-based industries.

Industries	Number of factories
Dry chips	13
Pellets	11
Cassava flour	1
Cassava starch	54
Sweeteners	8
Sorbitol	1
MSG	1
Crackers/crisps[1)]	27

[1)] Such as krupuk and kripik
***Source**: Hafzah, 2003.*

(a) Dry chips and flour industries

During the last ten years, cassava chip production decreased while domestic demand for chips increased 33.9%; the export of dry chips and cassava flour decreased 21.64% and 25.37%, respectively, while the import of cassava flour to meet domestic demand increased 33.9% (Statistik Indonesia, 1996-2005). This indicates that chip production needs to be increased both through a greater supply of raw material to the existing 24 chips and pellets factories and to develop new chipping and drying industries.

Since fresh roots have to be processed within three days after being harvested, the simple processing of fresh roots to dried roots (*gaplek*) by each farmer (home-scale industries) is a popular alternative for most farmers that are located in areas that are far from markets or industries. However, most chips produced by these home industries are of low quality. On the other hand, high quality chips are needed for both exported chips and for use as raw material in downstream industries. Therefore, the development of medium- to large-scale chip industries will not only enable an improvement in chip quality, but will also provide a local market for fresh roots. The existence of these medium- to large-scale chip industries would eliminate the need for processing fresh roots by home-scale industries that produce low-quality chipping and drying due to the alternative of selling fresh roots directly to these chipping and drying industries.

The capital that need to be invested for a chips industry with a capacity to process 100 t fresh roots/day, will be Rp 1.344 million (about US$ 150,000) both for building and for operational costs, including raw material at Rp 400/kg (about $45/t) fresh roots. Financial analyses shows that Rp 1,281/kg (about $140/t) dry chips could be produced; this is feasible as its NPV is positive, B/C ratio is higher than one and the IRR is higher than the commercial bank interest (**Table 5**). Because chips can be processed into cassava flour, the chips industry could be combined with the cassava flour industry. By combining these industries transportation cost of chips as raw material for the flour industry is eliminated resulting in a lower price of the flour produced, making the product more competitive in domestic and international markets.

Chips can be stored for more than six months (Wargiono, 2008), which means that the chips are available for the cassava flour industries during the whole year even though these industries should be developed mainly in areas with dry climates, such as Java, East Nusa Tenggara (NT) and Sulawesi islands (**Table 6).**

Table 5. Financial analyses of various cassava-based industries*.

Indicators	Chips	Starch
Total costs (Rp'000,000)	11,794	14,160
Yield (kg/100 kg fresh roots)	35	25
Price of product (Rp/kg)	1,123	1,890
Net income (Rp'000,000)	13,650	18,500
Net benefit (Rp'000,000)	1,856	3,840

* Raw material 100 t/day fresh roots at Rp 400/kg; 1 US$ = Rp 9,000.

Table 6. Projected priority areas for the development of cassava-based industries in Indonesia.

Industries	Java	Sumatra	Kalimantan	Sulawesi	East NT
Chips	***	*	*	**	***
Flour	***	*	*	*	***
Pellets	**	**	**	*	**
Starch	*	***	***	*	-
Sweeteners	*	***	***	*	-
Sorbitol	**	**	*	*	*
MSG	*	**	*	*	*
Crackers/Crisps	**	**	**	**	*
Ethanol	*	***	***	*	-

*** = high priority; * = low priority.

(b) Cassava starch industry

During the last ten years, cassava starch production decreased 9.5%, while domestic demand for cassava starch increased 10.2% (Statistic Indonesia, 1996-2005). To meet the demand, cassava starch needs to be imported. Cassava starch imports have increased from 35 tonnes to 2,136 tonnes. This indicates that increasing cassava starch production, both through increasing production at the existing 54 starch factories and by developing new starch factories, is needed. The factors causing the decrease in starch production are: (1) raw material availability is less than demand; (2) low agro-ecological support; and (3) the starch price in the world market fluctuates widely. Cassava starch is used for various food and non-food industries, so the starch factories should be built in areas that are environmentally most suitable, such as Sumatra and Kalimantan.

The capital that need to be invested for a cassava starch factory with a capacity to process 100 t fresh roots per day will be Rp 14,100 million (about US$ 1.5 million) for the buildings, machinery and operational costs, including raw materials at Rp 400/kg fresh roots. The factory will be able to produce dry starch at Rp 1,890/kg (about $ 210/t) and is economically viable to be developed in Sumatra and Kalimantan because of a positive NPV, the B/C ratio is more than one, and the IRR is higher than the commercial bank interest (**Table 5**). Traditionally, cassava starch is a raw material of both non-food and food industries such as sweeteners, noodles, cakes, biscuits and other downstream industries. These downstream industries could make cheaper products by combining the starch and downstream industries in one area due to lower transportation costs.

Instant noodle industry

Consumption of instant noodles in Indonesia is increasing at a rate of 12.38% per year. PT Indofood Sukses Makmur is the biggest instant noodle company in the country, followed by PT Asia Inti Selera, PT Nissinmas, PT ABC President Food Enterprises, PT Mie Barokah, followed by another 25 smaller instant noodle companies (Richana, 2003). These companies produce about 9.2 million packs/year of instant noodle. The cassava starch demand of these industries is about 0.045 million tonnes, corresponding to about 0.20 million tonnes of fresh roots. In order to obtain a monthly supply of starch, the instant noodle industries should cooperate with small-scale cassava starch factories such as ITTARA by providing credit to farmers for the purchase of fertilizers and for land preparation costs.

Cake and biscuit industries

In the cake and biscuit industries cassava starch is mixed with wheat flour, at about 10-20% for cakes and at 30-40% for biscuits. The annual demand for wheat flour is about 4 million tonnes, which is totally imported; therefore, mixing wheat flour with cassava starch is a way to reduce the production cost of cakes and biscuits. The demand for cassava starch in these industries is about 90,000 tonnes/year. Demand for these products increased at an annual rate of 14.9% (Richana, 2003). This means that the cake and biscuit industries have good future prospects, and demand for cassava starch could be increased as well. Household-scale cake and biscuit industries could be developed in the villages. For that reason, cassava starch should be just as available as wheat flour in local markets.

Sweetener industries

The industries, that produce products such as glucose, fructose, sorbitol, and organic acids like MSG, citric acid and enzymes, can use both fresh and dry cassava roots as the raw material. As most of these products are currently imported, domestic production should be increased to meet the demand.

The demand for cassava starch as raw material of the sweetener industry that produce glucose, fructose and sorbitol is about 0.17 million tonnes and is increasing annually at a rate of 9.17% (Statistik Indonesia, 2000; Capricorns, 1998). But most of these products are still being imported. The demand for glucose syrup is 40% higher than current domestic production; this is similar for glucose, fructose, maltose, mannitol and sorbitol. Demand for glucose as the raw material for the production of candy, soft drinks, traditional medicines and the biscuit industries also tends to increase (Statistik Indonesia, 2000). Domestic production of these products should be increased urgently to meet the domestic demand.

Glucose syrup can be produced by hydrolyzing starch with either acid or α-amylase enzyme. Cutting the starch chain using acid will produce a mixture of dextrin, maltose and glucose (Richana, 2003).

Imported gluco-amylose and α-amylase enzymes for producing glucose and fructose syrups could well be substituted by other enzymes produced domestically (Richana *et al.,* 1999; Lestari *et al.,* 2000). **Table 7** shows that the amylose content of cassava starch is lower than that of arrowroot or maize starch, but the yield of cassava roots is much higher than those of maize and arrowroot. **Table 7** shows that the amylose content of cassava starch is similar to that of maize but its glucose syrup yield is slightly lower than that of maize starch. However, the availability of maize can not meet the domestic demand (Statistic Indonesia, 2005). Moreover, cassava starch will probably be the main raw material for the domestic production of glucose and fructose syrup due to its greater domestic availability.

Table 7. The yield of glucose syrup from different starches.

Starch type	Amylose content (%)	Glucose syrup yield (%)
Maize	29.84	89.1
Arrow root	34.80	83.5
Cassava	29.86	86.0
Sago	33.28	83.3

***Source**: Richana, 2000.*

(c) Home and small-scale industries

Various home- and small-scale industries use cassava roots and derived products as raw material for making fermented roots, crisps, crackers, *rengginang* and other traditional foods. Traditional crackers and crisps are produced by about 27 small-scale industries and are consumed domestically and exported. These industries, mostly located in both urban and remote areas, are the only local markets for the sale of fresh roots since other fresh root-based industries have not developed yet.

New Utilization of Cassava Roots

The utilization of bio-energy as a renewable alternative energy source is a way to solve the problem of decreasing fossil energy supply. The supply of fossil energy in Indonesia is decreasing at about 6% per year, while domestic consumption of gasoline for transportation is 18.37 million kl which could be mixed with fuel grade ethanol (FGE). By implementing the E10 policy of gasoline mixed with 10% ethanol for transportation, the demand for FGE will increase annually by 7.1%. In 2007 the demand for FGE was estimated at 1.84 million kl, which is equivalent to 11.0 million tonnes of fresh cassava roots. To satisfy the FGE industry demand for raw material, cassava root production has to be increased by about 56% during the next five years in order to satisfy the demand for food, feed and all other cassava-based industries (**Table 2**).

An adequate supply of raw materials could be realized if the FGE industries are located in areas with a wet climate that have sufficient availability of unused land. By 2025, the amount of fresh cassava roots needed as raw material for the FGE industries is projected to be 23.36 million tonnes (**Table 2**). Sumatra and Kalimantan islands are environmentally the most suitable areas for development of FGE industries because of the availability of land and their rather wet climates (**Figure 1**).

In principle it should be possible to plant cassava during the six months of the wet season and to harvest during the whole year, in order to supply the feedstock for the FGE industry on a continuous basis (**Figure 2**).

The capital that need to be invested for an FGE factory with a capacity to process 100 t fresh cassava roots per day, will be Rp 15,284 million (about US$ 1.7 million) for the buildings, machinery and operation costs including raw material at Rp 400/kg fresh roots. The factory will be able to produce FGE at Rp 3,057/l (about US$ 0.34/l), and produce a net income of Rp 22,499 million and net benefit of Rp 5,686 million. A financial analysis indicates that it is economically viable because of a positive NPV, a B/C ratio higher than one, and IRR higher than the commercial bank interest (**Table 8**).

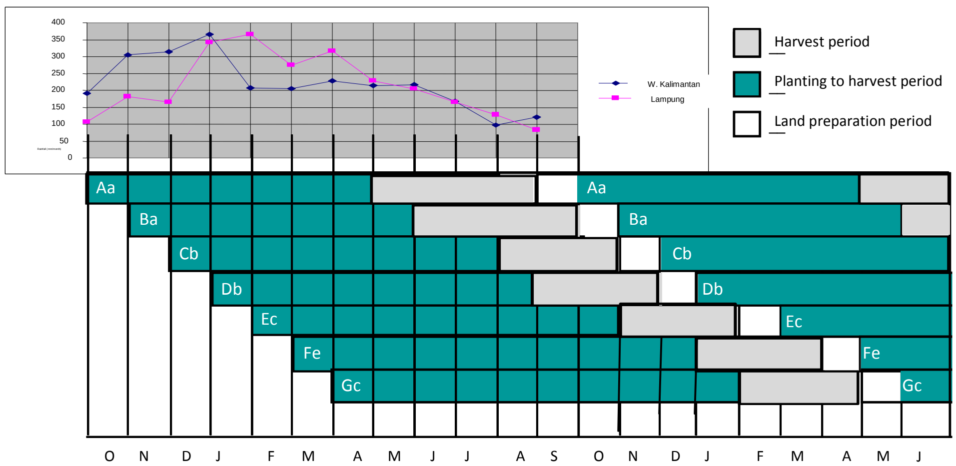


Figure 2. Time schedule for planting and harvesting of cassava based on the rainfall patterns in West Kalimantan and Lampung provinces of Indonesia to produce feedstock for FGE industries during the whole year.

Table 8. Financial analysis of the FGE industry.

Indicators	Input-Output
- Total costs (Rp'000,000)	15,284
- Ethanol yield(l/100 kg fresh roots)	20
- Price of product (Rp/l)	3,057
- Net income (Rp'000,000)	22,449
- Net benefit (Rp'000,000)	5,686

A SWOT analysis indicate that the FGE industries in Indonesia can be developed with good prospects due to their high potential from the production and economic stand point, and for marketing aspects as well.

To be economically and environmentally most viable, the FGE industries should be located in areas which are environmentally most suitable, such as Sumatra and Kalimantan. Based on land availability for cassava farming to supply the 23.4 million tonnes of fresh roots to the FGE industry (**Table 2**), at least 10,000 ha per district in about 38 districts of Sumatra and 35 districts in Kalimantan are potential areas for the development of FGE industries in Indonesia (Sensus Pertanian, 2005).

REFERENCES

Adimihardja and A. Mappaona. (Eds.). 2004. Teknologi pengelolaan lahan kering menuju pertanian produktif dan ramah lingkungan (upland technology management to achieve productive and sustainable agriculture). Puslitbangtanak, Bogor. 246 p.

Ditkabi. 2008. Studi pengembangan ubikayu untuk produk baru pertanian (Study of cassava for new agriculture products). BP Ditjentan, Jakarta.

FAO. 2005. Harvested area, yield, production, exported and imported cassava products during the last ten years. FAOSTAT.

Hafzah, M.J. 2003. Bisnis ubikayu Indonesia (Cassava agribusinesses in Indonesia). Pustaka Sinar Harapan, Jakarta. 263 p.

Lestari, P., N. Richana and U. Murdiyatmo. 2000. Pemurnian α-amylase dari *B.stearothermophilus* dengan membram ultrafiltrasi (Purification of α-amylase from *B. stearothermophilus* by ultra filtration). Indonesian J. Microbiology 5(1):10-14.

Presiden R.I. 2006. Peraturan Presiden No.5/2006, tentang kebijakan energi nasional (Presidential decree for national energy policy). Sekneg. Jakarta.

Richana, N., H.Y. Makagiansar, A. Suryani and T.T. Irawadi. 2000. Pengaruh cara hidrolisis pati untuk media pertumbuhan *Bacillus sp. BMN14* penghasil biosurfaktan lipopeptida (Hydrolysis methods of starch for culture media of *Bacillus sp. BMN14* producing biosurfactant lipopeptide). Indonesian J. Microbiology 4(2): 35-39.

Sensus Pertanian. 2005. Jenis lahan dan penggunaannya (Land types and its utilization). BPS. Jakarta.

Statistik Indonesia. 1999-2006. Luas panen, hasil, produksi ubikayu dan neraca bahan makanan penduduk Indonesia (Harvested area, yield, production of cassava and its utilization in food balances). BPS, Jakarta.

Richana, N., J. Wargiono and Nasir Saleh. 2003. Recent developments in cassava starch and derived products used in food processing in Indonesia. *In*: R.H. Howeler (Ed.). Cassava Research and Development in Asia. Exploring New Opportunities for an Ancient Crop. Proc. 7^{th} Regional Workshop, held in Bangkok, Thailand. Oct 28-Nov 1, 2002. pp. 590-598.

Wargiono. J. 2008. Wilayah potensial untuk pengembangan ubikayu sebagai bahan baku industri bioethanol (Potential and suitable regions for cassava development as raw material for the bioethanol industries). Seminar Puslitbangtan. Bogor, Indonesia.

WNPG. 2004. Ketahanan pangan dan gizi di era otonomi daerah dan globalisasi. Widyakarya Nasional Pangan dan Gizi ke-8. BPS. Jakarta: 60 p.