

# Sustainable Agricultural Bioindustry Development: Integration of Cassava Cultivation with Beef Cattle Husbandry in North Sulawesi Province

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**Abstract**— This paper reviews the potential sustainable agricultural bioindustry development based on animal feed and organic fertilizer through an integration between crops cultivation with livestock production. This bio-industrial development could be carried out successfully in Indonesia, including in the region of North Sulawesi Province. Cattle feed bioindustry could be developed from biomass of cassava plantation, such as the cassava leaves, tubers and cassava peelers. Whereas, the solid and liquid organic fertilizers bioindustry could be developed from cattle feces and urine. Agricultural bioindustry can be carried out in all areas of North Sulawesi Province, because almost in every district has beef cattle and cassava plants. The largest cassava production in North Sulawesi Province are in the regencies of Bolaang Mongondow, Sangihe Island and Talaud Island. Whereas the highest population of beef cattle are in the regencies of Bolaang Mongondow, North Bolaang Mongondow, Minahasa, North Minahasa and South Minahasa. Therefore, this type of bioindustry will be well implemented in the three regencies of Bolaang Mongondow, Minahasa and North Minahasa, as there are large cassava plants and with a high livestock population in these three areas. Although numbers of beef cattle population are also higher in some other regencies, but the production of cassava in those areas are still very small.

**Keywords**—Animal feed, Beef cattle, Bioindustry, Cassava, Organic fertilizer.

## I. INTRODUCTION

Cassava is one of the staple foods in addition to rice and maize in Indonesia and is also a staple food for most of the population residing in tropical climates. Cassava is also a source of food that plays an important role for food security in developing countries, especially in addressing

the impacts of climate change (Koswara, 2013; Krisdiana, 2015). According to ISB (2016) in 2015 Indonesia produced more than 24 million tons of cassava per year and later in 2016, the national production reached 27 million tons. Indonesia is among the world's three largest cassava producers after Nigeria and Thailand. Indonesia also could become the world's largest cassava producer country if the cassava cultivation diversification is done intensively and continuously and the opportunity to export cassava is still to be done to other countries including China, Korea and Europe.

Cassava is widely consumed wherever the plant is cultivated either regionally, nationally, or ethnically, such as for staple foods, snacks, dessert and so on. Around 200 million people or nearly a third of the sub-Saharan African population also make cassava an important regional food. In Nigeria for example, cassava tubers and leaves not only serve as an important source of calories but also as a major source of income for rural households. Cassava is also food and income sources for over 30 million farmers and many craftsmen and traders in Nigeria (Abdoulaye *et al.*, 2014). Also, in Ghana about 46% of the country's GDP is contributed by cassava trade. Almost every farming family in the country grows cassava that contributes daily caloric intake of at least 30% of the population in the country.

At present time, cassava has been commercially processed into various types of food in the form of fried or other types of chips made from cassava flour with some additional flavorings (Koswara, 2013; Ahza *et al.*, 2015). The tender taste can replace the potatoes. Cassava is used in cholent in some households, can be processed into cassava starch flour used in bread, noodles, cakes and cookies. However, cassava can not last long in a fresh state, so it must be processed first into other more durable

forms, such as cassava chips, cassava flour, fermented cassava, and others.

In 2015 the Government of Indonesia has launched a concept for developing bioindustry farming system in the Agricultural Development Master Plan of the year 2015-2040 (MOA, 2014). To accelerate the improvement of quality, added value and competitiveness of agricultural products (including plantation and livestock), sustainable agricultural bioindustry development based on animal feed and organic fertilizer through an integration between crops cultivation with livestock is expected to become one of the bioindustrial development that will be successful in Indonesia, including in the region of North Sulawesi Province. Integration system of cassava cultivation and beef cattle production has a great potential for the bioindustry development, which is in the form of bioindustry of animal feeds and organic fertilizer. Cattle feed bioindustry could be developed from biomass of cassava plantation including the cassava leaves and cassava peelers. Whereas, organic fertilizer bioindustry could be developed from cattle feces and urine. In the concept of agricultural bioindustry it is not only to produce processed food products but also production of non-food products and energy. The implementation of this concept aimed at optimizing the potential of land resources that are formed in the agricultural area scale.

## II. POTENTIAL OF CASSAVA CULTIVATION IN NORTH SULAWESI PROVINCE

In North Sulawesi Province, corn and tuber crops are alternative food after rice. Cassava is one of the staple food of the people in the archipelago region of North Sulawesi including Talaud and Sangihe Islands. Cassava tubers that are often planted and consumed are the white and yellow/ivory tubers. Cassava planted in this area is more prevalent in dry land areas with sufficient water availability and rainfed water. As reported that cassava plants are tolerant of soils that have low fertility and drought as well resistant to pests and diseases (Aboki *et al.*, 2013). Cassava plants in North Sulawesi are also planted among the coconut plants with a wide spacing of the coconut.

Based on data from ISB of North Sulawesi Province (2016), the average cassava productivity in this area is still quite low, which is only 12.280 tons/ha. In addition, there is also a decline in the harvested area and the cassava production in the period of 2010-2015. Cassava production in 2010 was 84,083 tons but it was decreased in 2015 to only 44,134 tons. This is mainly due to the decreasing in harvested area which was 6,424 ha in 2010 and it was decreasing steadily within 5 years period to

3,594 ha in 2015 (Table 1). This decrease in harvested area is due in part to changes in the use of agricultural land (land conversion) that turns into land for housing, factories/industries and so on.

The largest cassava production in North Sulawesi Province in 2015 are in the regencies of Bolaang Mongondow (7,998 tons), Sangihe Island (6,851 tons) and Talaud Island (6,212 tons). In addition, in the Minahasa regency and the surrounding areas also have a quite large cassava production which are between 2,417 and 4,506 tons. The production of cassava in these areas exceeds the need for consumption of local communities. So that some of them are exported to other areas in need. While in some other areas cassava is only grown by farmers for their own consumption purposes.

## III. INNOVATIONS OF CASSAVA CULTIVATION TECHNOLOGIES

The principal objective of rural agricultural development is to improve the welfare of peasant communities as measured by the level of real income or average consumer spending per capita. Technological improvements, such as improved varieties, are the most important factors in improving agricultural productivity and poverty reduction in the long term. The use of cassava superior varieties accompanied by integrated crop management can produce as much as 30-35 ton/ha, and even when using higher input, it can reach up to 80-100 ton/ha (ICFCRD, 2012). Now, there are also some types of superior and fast harvested cassava available, such as Malang-1 variety, with a production between 45-59 tons/ha or an average of 37 tons/ha, and Malang-2 variety, with an average production between 34-35 tons/ha. Up to 2014, the Indonesian Agency for Agricultural Research and Development (IAARD) has released as many as 11 varieties of cassava, including: Adira-1, Adira-2, Adira-4, Malang-1, Malang-2, Darulhidayah, UJ-3, UJ-5, Malang-4, Malang -6, and UK-2 (ILTCRI, 2016).

To improve cassava productivity, technology should be adopted in the production process and the adoption rate of new technology is highly correlated with the profitability, level of risk associated with it, capital requirements, agricultural policy and socio-economic characteristics of farmers. The adoption of innovation is the final step in the decision-making process to make full use of innovations will have a positive impact on the farmers or user's welfare level. Increased adoption of agricultural technology provides an opportunity to increase production, substantial income and to reduce food insecurity (Nata *et al.*, 2014). The adoption of agricultural technology depends on the personal, social, cultural and economic factors as well as on the

Table.1: Harvested area, Yield and Production of Cassava in North Sulawesi Province, in 2015.

No.	City/Regency	Harvested Area (Ha)	Yield (Ton/Ha)	Production (Ton)
1.	Bitung City	179	12.100	2,165.90
2.	Bolaang Mongondow	654	12.230	7,998.42
3.	Bolaang Mongondow East	134	12.260	1,642.84
4.	Bolaang Mongondow North	60	12.250	735.00
5.	Bolaang Mongondow South	103	12.270	1,263.81
6.	Kotamobagu City	28	12.070	337.96
7.	Manado City	82	12.060	988.92
8.	Minahasa	356	12.240	4,357.44
9.	Minahasa North	367	12.280	4,506.76
10.	Minahasa South	275	12.280	3,377.00
11.	Minahasa South-East	197	12.270	2,417.19
12.	Sangihe Island	553	12.390	6,851.67
13.	Sitaro Island	-	-	-
14.	Talaud Island	501	12.400	6,212.40
15.	Tomohon City	105	12.050	1,265.25
<b>North Sulawesi Province</b>		<b>3,594</b>	<b>12.280</b>	<b>44,134.32</b>

Source: ISB of North Sulawesi Province (2016).

characteristics of the innovation itself. Increased adoption of agricultural technology also has a positive impact on poverty reduction and improving human welfare (Challa and Tilahun, 2014).

Ojo and Ogunyemi (2014) have analyzed factors influencing the adoption of improved cassava production technology at the Ekiti State, Nigeria. The results of socio-economic analysis revealed that approximately 73.3 percent of respondents adopted improved cassava production technology. The cost and return analyses showed that cassava production benefits the adopters of improved cassava production technology and has a higher and significant net return rate compared to the non-users. Furthermore Adetule *et al.* (2017) has also undertook research at the Ekiti State, Nigeria, on factors influencing the adoption of improved crop varieties by cassava farmers. The study showed that the majority (55.8%) of farmers finally adopted, 19.3% were in the trial phase, 7.2% were still evaluating, 13.8% had shown interest to know more about improved varieties while only 3.9% said that they newly realize better cassava cultivars are available in the city.

A study aimed to assess the impact of adoption of improved cassava varieties on the welfare of cassava-producing households was carried out by Afolami *et al.* (2015) in two states in Southwestern Nigeria. TME 419 is the most widely adopted varieties among cassava varieties introduced in the state with 60.2% of farmers adopting this varieties. The results also showed that adoption of improved cassava varieties in the study area increases the annual income and annual consumption expenditure by cassava farm households thus improving their welfare. The adoption of improved cassava varieties is therefore

pro-poor community with the adopters having lower poverty rates than the non-adopters. Significant relationships were found between marital status of farmers, agriculture as main occupations, farming experience, access to cassava cutting in villages, radio use and adoption of improved cassava varieties.

Pingmuanglek *et al.* (2017) has compared the conventional system of cassava starch production by incorporating an increase of one change in the practice of crop production, transportation and starch production. In an improved scenario of crop production, some nutritional management practices are applied together with optimization of fertilization. Flour mills have been modified to improve water recycling and reduce losses to reduce input of cassava. Reduction of starch loss was achieved in fiber and pulp separation processes in which the largest starch loss occurs. The results showed that technological and management improvement scenarios can reduce consumption of all resources and emissions including cassava (4%), fertilizer (50%), water (30%), wastewater (40%) and energy (8%). All dregs of cassava can be used to produce ethanol as well as for animal feed. All waste water can be reused for irrigation in the cassava plantation areas.

According to Qurrahman *et al.* (2014), the use dry land for intensive cassava production without applying sustainable cultivation techniques has the potential to cause soil damage, so it is necessary to use the organic fertilizer. Otherwise, agricultural activities will be high investment with low yields due to the uncontrolled use of synthetic chemicals that become dangerous for the ecosystem. To protect the ecosystem, organic farming needs to be practiced properly without the use of

hazardous chemicals and replace them with organic fertilizers, bio-pesticides, and others. The results of Mathias and Kabambe (2015) study stated that the use of organic fertilizer can improve soil structure to facilitate root penetration and cassava tubers formation. Similarly, nutrients contained in organic fertilizers are released more slowly and stored longer in the soil allowing longer residual effects. Although manure and dolomite can be replaced by adding urea fertilizer to 500 kg/ha, but manure is superior in terms of soil treatment (Radjit *et al.*, 2014). One effort to increase the availability of organic fertilizer is to conduct a system of cassava crop farming with beef cattle production.

Perfect soil treatment is considered the most important to improve cassava productivity. This is because the dry lands cultivated for cassava plants by farmers generally have relatively hard soil layers so that the good soil processing that could make the land become looser is needed, which makes the cassava plants can grow optimally (Ariningsih, 2016). Deliyana *et al.* (2016) showed that minimum tillage and herbicides application caused the highest increased in growth of cassava compared to the complete soil preparation + herbicide, minimum soil preparation and complete soil preparation only. The complete soil preparation system + herbicide produced highest cassava production and the amount of nutrient transported crops (i.e. N, P and K and C-plant) compared to the minimum soil preparation + herbicide, minimum soil preparation and complete soil preparation. The complete soil preparation and herbicides are more advantageous than complete soil preparation, minimum soil preparation and minimum soil preparation + herbicide in the second growing season.

In the irrigation method, the most important technological component is the volume of water supply as needed in the cassava plantation on dry land and frequent drought that causes the decreasing of crop yield and causing the dry cassava crop and non-optimal production, cassava tubers become small, or even cause the crop failure (Ariningsih, 2016). To anticipate the occurrence of drought, the drought tolerant superior varieties such as Malang-6, Malang-4 and Adira-4 varieties should be used. All these three varieties are suitable as raw materials for starch industry because they have high yield potential and have high starch levels as well, although the flavor of the tubers is rather bitter (Wahyuni, 2015).

#### IV. BEEF CATTLE FARMING CONDITION IN NORTH SULAWESI PROVINCE

North Sulawesi province has big potential or opportunity for cattle raising. This is due to the support of natural resources (lands, feeds), human resources and has good market prospects and potential. In addition, cattle

business is also a source of regional revenue through the inter-provincial and inter-island trades.

At present, about 60% of the meat requirement is fulfilled by pork, however the Government of North Sulawesi Province will develop an artificial insemination program to increase beef production to meet the national needs. North Sulawesi Province has a large area with a total land area of 1,527,219 hectares that can be used for crops, horticulture and plantation areas. In North Sulawesi Province, cattle are maintained in an integrated manner with plants known as plant integration systems with livestock. Integration of cattle business with crops can gain a positive influence on the cultivation, social and economic community.

Cattle business in North Sulawesi Province is generally extensive or livestock still traditionally maintained. Cattle rearing is done with a binder and moved system with feeding in the form of green grass and corn straw. Cattle is brought to the grazing area in the morning with the distance from the house about 1-3 km, then in the afternoon the cow was taken back to its shade accompanied by additional feed grass and corn straw. The allocation of daily cattle management can take about 2-4 hours/day depending on the distance of the grazing areas and the number of cows owned by farmers.

The Agriculture and Livestock Service Office of North Sulawesi Province has undertaken various measures to develop livestock farms in the province. One of these policies was to provide cattle to several farmer groups. To increase the livestock productivity, it is necessary to increase the calf birth, shortening the calving interval, extend the production period. Successful cattle raising is strongly influenced by various interrelated factors, such as education, input use, marketing, planning and others. The success of cattle business depends on three elements: breeds, feed and management. The North Sulawesi province has the potential to be a cattle center in the eastern part of Indonesia.

Based on the Agricultural Census data of 2013 (ISB, 2014) it was reported that the highest population of livestock breed in the North Sulawesi Province is Pigs (123,943 heads), while the number of beef cattle is only 96,628 heads and goats are 10,776 heads (Table 2). In addition, there are also few numbers of horses and dairy cattle kept farmers in this province. In general, beef cattle are found throughout most of the North Sulawesi province, with the highest number are in the following regencies: Bolaang Mongondow (19,993), Minahasa (16,089), as well as in regencies of North Bolaang Mongondow, North Minahasa and South Minahasa with an average amount of 12,197 heads.



## V. CASSAVA AS FEED INGREDIENTS FOR ANIMALS

One way in anticipating the problem of limited sources of feed for livestock and as an effort for feed cost efficiency, is to find the new feed materials in the form of agricultural wastes which have not been generally used by farmers or known as unconventional feed materials. In some areas there are several types of agricultural crops

and plantations wastes that have not been used as feed materials by farmers other than rice straw and corn leaves. These include: corn beard, soybean shell, cassava peelers, cocoa husk, cocoa shell and coffee shell; but in some other areas there are already using the material as animal feed.

Table.2: Population (heads) of Beef cattle, Goats and Pigs raised by farmers in North Sulawesi Province, in 2015.

No.	City/Regency	Beef Cattle	Goats	Pigs
1.	Bitung City	2,145	681	4,519
2.	Bolaang Mongondow	19,993	1,642	14,839
3.	Bolaang Mongondow East	2,372	1,384	571
4.	Bolaang Mongondow North	12,287	1,769	361
5.	Bolaang Mongondow South	3,255	691	39
6.	Kotamobagu City	1,678	239	1,005
7.	Manado City	2,290	315	3,755
8.	Minahasa	16,089	542	32,987
9.	Minahasa North	12,651	1,185	13,434
10.	Minahasa South	11,654	440	14,589
11.	Minahasa South-East	3,126	851	6,862
12.	Sangihe Island	1,595	644	7,584
13.	Sitaro Island	71	112	9,536
14.	Talaud Island	748	128	7,625
15.	Tomohon City	2,674	153	6,237
<b>North Sulawesi Province</b>		<b>92,628</b>	<b>10,776</b>	<b>123,943</b>

Source: Agricultural Census data of 2013 (ISB, 2014).

All parts of the cassava plant in general, can be used as animal feed. Leaf parts can be used as a source of protein that can be given in dry or silage form. Stems can be mixed with leaves as ingredients in concentrate feeds. Tubers can be converted into pellets. There are also cassava peelers which are the main cassava plant wastes in developing countries. Cassava peelers can be given to cattle directly or after fermented.

Feed ingredients derived from postharvest cassava wastes include cassava tubers, cassava stems, cassava leaves, dried cassava and cassava pomade, are classified as feeds with an easily digestible carbohydrate source. Cassava pomade can be dried prior to use or can be used as a substrate to produce single cell proteins. Some research results in the use of cassava as ruminants feed has been done for both small and large ruminants. The utilization of cassava in the form of dried cassava or cassava pomades is the most commonly used as a best concentrate for beef or dairy cattle.

The use of cassava pomade as an energy source in a concentrate mixture of up to 45% to replace corns did not affect the milk production of dairy cow (Suksombat and Lounglawan, 2004). This will greatly benefit small farmers because the price of the cassava pomade is cheaper than the price of corn. The effects of feed

containing cassava (tubers and leaves) were investigated for feed intake, weight gain, feed conversion ratio, egg production performance and egg quality for 5 weeks of experimental feeding in laying hens in Myanmar. The results showed that, up to 40% of corn can be replaced with cassava to increase egg production and egg quality. Moreover, the substitution of cassava leaves with cassava tubers was more efficient in reducing cholesterol content in egg yolks (Kyawt *et al.*, 2015).

## VI. ALTERNATIVE ENERGY SOURCE FROM ANIMAL WASTES

Wastes in the form of feces and cow urine are commonly used as organic fertilizer by most of farmers. However, most of these types of wastes are immediately taken to the field without being previously composting. Though the feces are still hot and can disrupt the growth of plants. Therefore, to overcome this problem, biogas installation can be provided, and farmers will get gas as fuel, solid organic fertilizer, and liquid organic fertilizer from the remaining fermentation of organic materials in the biogas digester. It also can reduce the pollutions caused by stacks of feces.

Hasiholan *et al.* (2016) examined the production, productivity, hydraulic retention time, and quality of

biogas made from cassava tubers and leaves with cow dung as the starter. It was concluded that the substrates compositions significantly affected the total biogas production, but it did not have significantly effect on biogas productivity. The highest biogas production (6,995 ml) was obtained from the composition of 25% of cassava tubers and 75% of cattle manure. The farmers' perception and their willingness to adopt the biogas technology in Indonesia is very good. Cattle manure will not only produce biogas that can be used by the local people for cooking, but it is also needed to overcome air pollution and disease hazard arising from untreated cow dung (Asmara *et al.*, 2013).

The process of biogas making begins by inputting the livestock wastes in the form of dirt, feed residues, urine and wastewater into the biogas reactor. The stages of the biogas manufacturing process are as follows: a) The biogas input materials (in the form of fresh livestock organic wastes) mixed with water, with a ratio of 1 part of wastes and 1 part of water. b) The mixture is stirred, then flowed into the biogas reactor to the maximum extent of the discharge hole. c) Fermented for 2-3 weeks period, with the position of the gas control valve and the gas valve expenditure to the stove are in a closed state. d) The result of the fermentation process can be seen at the end of the second week, the mild biogas will be accumulated at the top of the reactor dome. e) The first gas formed is removed until a typical biogas smell comes out. f) If the use of biogas is used every day, then the filling of biogas input materials is also carried out every day. g) Biogas production will take place continuously, depending on the filling and maintenance of the installation. h) The entry of pesticides, disinfectants, detergent/soap/shampoo solutions into the biogas reactors, should be avoided (Widodo and Asari, 2011). The raw biogas cannot be used directly as fuel because it still contains CO<sub>2</sub> and H<sub>2</sub>S which will decrease the heating value and could cause corrosion in the biogas storage vessels. Enrichment of biogas could be done by removing the CO<sub>2</sub> and H<sub>2</sub>S contents which will significantly improve the quality of the biogas (Akila *et al.*, 2017).

## VII. BIOSLURRY FROM BIOGAS DIGESTER AS ORGANIC FERTILIZER

The sludge comes out of a biogas installation is called the bio-slurry and this can be used as an organic fertilizer in the solid or liquid form (Amir, 2016). The solid in the wet or dry form can be used directly as crops fertilizer as it has been decomposed during the fermentation process in the biogas digester/reactor. This solid contains very small quantities of pathogenic microorganisms so that it is very good to be used a media for planting mushrooms or plant nurseries. Oktavia and Firmansyah (2016) introduced a biogas technology to reduce the economic costs of

households in Tanjung Bulan Village in Prabumulih City, South Sumatra. It was concluded from the study that the biogas program was very beneficial for the community in the Village. There were three main benefits perceived by the community, including a) Biogas could be used as a substitute for the liquid petroleum gas (LPG) which has been used previously by the community. b) The biogas byproducts have been widely used as organic fertilizers. (3) From the social point of view, the program has also educated the community to utilize the livestock manure that has been considered by the community as waste can provide an economic and environmental benefits.

The by-products of the biogas technology which are processed into organic fertilizers could increase soil nutrients, save costs for fertilizer purchases and increase public incomes (Rajendran *et al.*, 2012). The process of making organic liquid fertilizer is as follows: The sludge output from the biogas reactor is filtered by a fine sieve and the water is collected in a plastic drum. To improve the quality of the fertilizer, it is necessary to add such other ingredients as bone meal, egg shell flour and blood meal. All these ingredients are thoroughly mixed and fermented for a 7 days period. The fluid is then filtered again by using a cloth then the cloth is squeezed. The liquid is then collected in plastic drums and allowed to stand for 3-4 days and frequently stirred or aerated to remove the residual gases. Furthermore, the liquid is left without stirring for 2 days to settle the particles and the liquid becomes clearer. The liquid is then packed in plastic bottles and ready to be used or sale.

## VIII. INTEGRATION OF CASSAVA CULTIVATION WITH BEEF CATTLE HUSBANDRY

The model of integration between crops and livestock or often called integrated agriculture, is to combine the livestock production and farming activities. This model is often called as zero-waste farming or bio-industrial farming, because the livestock wastes are used as fertilizer, and the agricultural wastes as animal feeds.

The agricultural bioindustry is an agricultural system which in principle manages and/or utilizes optimally all biological resources including agricultural biomass and/or organic wastes, for the welfare of society in an ecosystem in harmony. The key word of this bioindustry farming system lies in all biological resources, biomass, and agricultural wastes (including livestock), science and technology, bioprocess, utilization and genetic engineering. Therefore, this farming system will produce high value food products and bioproducts, zero waste, biorefinery and sustainable.

The interaction between crops and livestock should be complementary, supportive and mutually beneficial, to encourage increased production efficiency and increased

profitability of its farm operations. Some references state that the integration model is directed to the concept of food products, feed sources, renewable energy and soil fertility (Anugrah *et al.*, 2014; Amir, 2016).

The concept of cassava crops and cow production integration is presented in Fig. 1 (Amir, 2016). This zero-waste model is directed to a net production as an effort to extend the production cycle by optimizing the by-products. As it has been explained previously that the main products of beef cattle production are meat/carcass and manure as its by-products. Livestock manure is then processed into the biogas and fertilizer for cassava plant. Cassava has the main product of tubers with tubers peelers and leaves as the by-products which could be processed into cow feed in the form of silages and concentrates. By applying this integration model, the concept of bio-industrial agriculture is expected to be formed by itself.

The activities of agricultural bioindustry in the form of integration of beef cattle production with cassava plants can be carried out in almost all areas of North Sulawesi Province. This is because almost in every district has beef cattle and cassava plants, except in the Sitaro Island that does not have cassava plantation. The implementation of this agricultural bioindustry in North Sulawesi Province will be able to be implemented well in three regencies, namely Bolaang Mongondow, Minahasa and North Minahasa. In relation to these three areas, there are large cassava plants (Table 1) and with a high livestock population (Table 2). Cassava plants are also present in a

quite large amount in the regency islands of Sangihe (553 ha) and Talaud (501 ha), but the beef cattle exists in these regions are only in a few number. Therefore, beef cattle population in both areas should be increased through various government programs.

The number of beef cattle population is also high in the regencies of North Bolaang Mongondow (12,287 heads) and South Minahasa (11,654 heads). However, the production of cassava in these regions are still very small. Therefore, it is necessary to increase the amount of existing cassava productions by increasing the planted areas or using superior cassava varieties, so that it can support the integration activities between beef cattle production with the cassava plants.

## IX. CONCLUSION

Agricultural bioindustry can be carried out in all areas of North Sulawesi Province, because almost in every district has beef cattle and cassava plants. This bioindustry will be well implemented in three regencies including Bolaang Mongondow, Minahasa and North Minahasa, as there are large cassava plants and with a high livestock population in these three areas. Although numbers of beef cattle population are also higher in the regencies of North Bolaang Mongondow and South Minahasa, but the production of cassava in these regions are still very small. So that, to support the agricultural bioindustry, it is necessary to increase the amount of existing cassava productions in these areas by increasing the planted areas or using the superior cassava varieties.

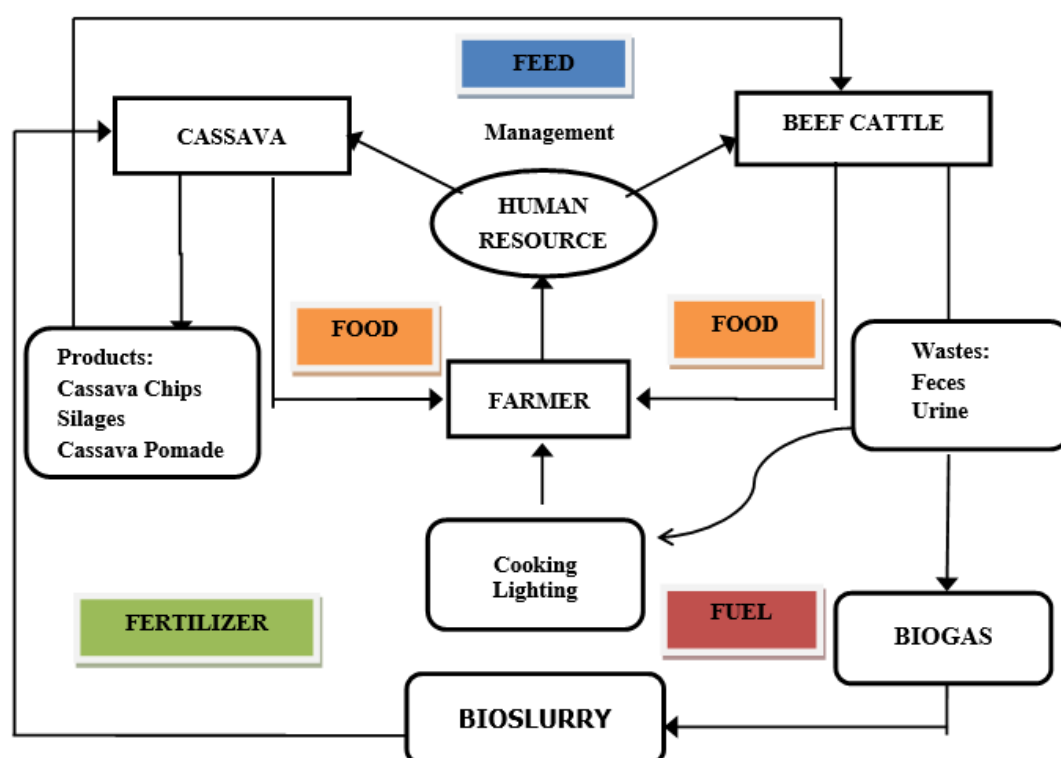


Fig. 1: The Diagram Concept of Integration between Cassava Cultivation and Beef Cattle Husbandry (Adopted from Amir, 2016).

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