



## **Brown Cane Sugar–cattle Production Integration for Rural Economic Development Prospects in South Sulawesi, Indonesia**

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. Authors RD and AMAZ designed the study; produced data gathering instruments and coordinated the data collection. Authors RD and ANT conducted data gathering and analysis, while authors RD and AMAZ wrote the draft. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Sugar plays an important role in Indonesian economy; the commodity is one of the major import commodities in recent years. Integration of brown cane sugar (BCS) with cattle production is a potential business opportunity that can be developed for rural economic development. This integration can optimize the use of marginal lands, and facilitate the development of environment friendly organic farming. The research objective was to identify the potential for the development of BCS-cattle production integration based on land resources, technology, culture, labor force, and markets. Data were collected through focus group discussions and interviews of 75 randomly selected farms from three districts (Barru, Wajo, and Bone), all of them in South west Sulawesi, Indonesia. The results showed that there is a huge potential of 302,771 ha's cultivated farm land, comprising of 10,355 ha's rice fields, 86,753 ha's dry land and 205.663 ha's paddock grazing. Cattle

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raising is part of the farming culture in Sulawesi and a major source of income for most rural households. BCS-cattle production integration can generate employment opportunities, promote sugar and meat import substitution, produce biogas as an alternative energy source, increase the use of organic fertilizer, and promote organic-based farming system. For this system to be successful, government support is needed in establishing pilot projects at various locations which are expected to encourage farmers to adapt and develop the integrated farming system for rural economic development.

*Keywords: Integrated farm; appropriate technology; organic farm; rural employment; small scale enterprises.*

## 1. RATIONALE

Indonesia is a tropical agricultural country where most agricultural products can be grown, but it imports almost all foods. Currently a lot of agricultural land is not utilized in the form of concession or controlled individually; there are many landless farmers. These conditions make the countryside less attractive and encourage high urbanization. The unemployment rate in Indonesia has increased drastically from 3.2 percent in 2000 to 8.9 percent in 2009 where the unemployment rate in urban areas is higher than in the country side. In 2009, the urban unemployment rate was 11.4 percent, substantially higher than in the country side with *about* 7.6 percent in the rural sector. The same thing happened to women unemployment compared to that of men; amounting to 10.7 and 7.8 percent respectively [1]. Potential areas for sugar cane development in South Sulawesi are approximately 91,108 ha's which consist of 10,355 ha's paddy fields and 86,753 ha's dry land. Pasture land can partly be converted into cane fields for the small scale cane sugar industry development and at the same time be integrated with cattle breeding.

Sugar is a strategic commodity in Indonesia's economy as it belongs to the group of nine-basic needs for daily consumption. In 2010, total national sugar consumption both industrial and household consumption amounted to 4.55 million tons, while domestic production was only 2.44 million tons of sugar, so the shortage was met by imports [2]. Production cannot keep pace with consumption of sugar for several reasons, namely the decline in sugar cane plantations because the land is converted into residential and industrial areas, the decline in yield, continuously declining price of sugar, and decrease in plant efficiency [3].

Cane sugar industry on a household scale is suitable for rural development as it adds several work opportunities for poor farmers including the women. The development of brown cane sugar (BCS) can be integrated with cattle breeding; the shoots and leaves of the sugarcane can be used as feed materials for cattle. Cattle feces and urine waste can be processed to produce organic fertilizer and biogas. Manure as fertilizer is a substitution of chemical fertilizers supporting organic farming. The research objective was to identify potential land resources, technology, farming culture and the market for the development and BCS-cattle production.

Increasing production of BCS serves as import substitution and/or yields an export commodity, which drives regional economic development. It supports an increase in the cattle population by providing feeds for cattle which in turn leads to an increase in animal protein production and meat import substitution. This concept promotes organic fertilizer to substitute chemical fertilizer, encourages organic agriculture and reduces green gas emission. Development of integrated sugar cane with cattle breeding is an appropriate concept for rural economic development because it will generate huge employment opportunities for the rural population, especially for poor households through the use of less productive agricultural land.

## 2. CONCEPTUAL FRAMEWORK

### 2.1 Integrated BCS-cattle Development

Markets, natural resources, appropriate technology, and farming culture offer a great potential for the development of BCS and beef cattle production integration. Sugarcane can be developed easily on marginal or unutilized lands. Sugarcane is commonly planted on asphalt sidewalk in both rural and urban areas where it can grow without any further maintenance.

Cultivation of sugar cane has long been known by the Indonesian farmers in rural areas, including the processing into brown sugar or palm sugar substitute such as used as *Saka*, raw vinegar, and sweetener in Japan [4].

The processing of sugar cane into BCS could be regarded as part of the culture of farmers in many rural communities in Indonesia. Brown sugar is widely used for household consumption as a sweetener, flavor and color enhancer. Brown sugar can change the soft food texture other than crystal sugar and it is used as a raw material for small food and beverage industries such as soy and *Tauco* industries using brown sugar as a sweetener [5]. In addition, BCS is one of the alternatives to meet the needs of sugar in Indonesia [6].

Growing cane and cattle simultaneously to produce BCS and beef integrates farming and organic agriculture. Integrated BCS-Cattle farming is an innovation to the farmers which will increase their knowledge and skill for organic farming and sustainable agriculture. The importance of organic farming for the perspective of sustainable agriculture development can be found in several studies [7-10]. A set of agricultural technologies or innovations which are simple, effective and need based are selected and implemented to improve the knowledge, skills and abilities of farmers [11]. The integration of cultivated crops and livestock maintains productivity, protects the environment and the health of farmers and their families and at the same time adopts sustainable agricultural systems [12]. Integration of farming will also provide higher revenues due to reducing the use of external inputs. Integrated farming is a pattern of land use on a regular basis, taking place naturally and not using the external input [13]. The integration of farming also encourages farmers to develop organic farming. Organic agriculture is an integrated farm that aims to reflect the strong linkage between farm biota, production and the environment as a whole [14]. Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony [15].

BCS-cattle production integration is a combination of two effective technologies that can be easily developed by farmers. Appropriate

technology (AT) is an alternative method to overcome the problems encountered in agriculture, whether in relation to the development, production, development opportunities, or the creation of employment opportunities. AT is a technology appropriate to the needs of the community, to address the problem of society, and to preserve environment that can easily be utilized by the community to generate additional value from the economic and environmental aspects (President Act No. 3/2001). BCS processing technology as an AT is cheap and easy and has huge potential to convert natural resources, reduce unemployment, encourage domestic industry and increase incomes, especially for rural economy.

## 2.2 Rural Employment Development

Rural workers have low skills and are flexible in entering the employment opportunities available in rural areas, especially in agriculture and in the informal sectors. Therefore, it is necessary to develop a relatively inexpensive technology that can be easily developed locally so that rural unemployment and urbanization can be resolved. The skill level of work needed for the BCS-cattle production integration is generally low matching that of most rural workers. Low human capital, education and experience are dominant characteristics for rural labors [16-18].

The problem of unemployment is not only economic issues but more related to social issues. Types of jobs created in the economy must be in accordance with the capabilities and expectations of the work force [19]. Human resources investment can boost growth through creating agricultural economic activities for which there is a market, for which local resources are available and which are supported by innovations and appropriate technology. In the current era of global trade liberalization specific products that have been produced naturally and environmentally friendly will have a strong bargaining position; besides they can be labeled as super labor intensive involving many members of rural communities [20]. Small scale integrated BCS-Cattle production is a new technology that can easily be adopted by rural people with low level of education and skill; it can absorb large numbers of family labor, especially female labor. It could also be considered as a training process for local people towards sustainable development.

The BCS development is the reverse of trends towards more capital-intensive processes or to commercial commodities. The small scale industrial development based on BCS-cattle production integration is a concept of labor transformation from urban to rural area. It goes contrary to the concept described by Feridhanusetyawan and Stahlin which the transformation of labor in the global competition is drastically changing from rural to urban areas, from low-technology-based industry to modern technologies, or from low-tech and labor-intensive industries to capital-intensive modern industry [21].

Employment in agriculture and the urban informal sector can be expanded; the labor market and the social structure of the sector are sufficiently flexible to absorb the workers who are not absorbed in the formal sector [22]. At the same time, capacity building is needed through intensive labor investment with appropriate technology as a potential way to improve rural employment and the quality of human resources [23]. So the development of BSC-cattle production integration is an economic development concept for rural economic development. The rural labor development is a key strategy for rural development of agricultural countries [24,25].

### 2.3 Research Method

The study was conducted in three districts in the center of cattle development South Sulawesi, Indonesia. Barru district is the center of Bali cattle germ plasm development, Wajo district is an area that generated BCS in the 1960s, and Bone district is part of the largest sugar cane planting area in South Sulawesi.

Primary data was collected by method of focus group discussions and interviews with randomly selected samples of 30 farmers in Barru district, 25 farmers in Wajo district, and 20 farmers in Bone district. The data collected include methods of animal husbandry, sugar cane plantation and cultivation of BCS. Secondary data including area of unutilized agricultural land, grazing area, sugar cane planting area, and the BCS development site were taken from South Sulawesi Statistical Bureau. Qualitative analysis was used to describe the development prospects of BCS-cattle integration based on the potential of natural resources, appropriate technology, culture, labor force, and market.

## 3. RESULTS AND DISCUSSION

### 3.1 Land Resources Potential

The development of cane and cattle in South Sulawesi has a huge potential. Sugar cane can be developed in the area of non cultivated agricultural land and grazing land, while cattle can be developed by utilizing an abundant unutilized agricultural waste. Farmers can extend their businesses thanks to sufficient labor, paddocks and grazing land that can be converted into cane growing land and be integrated with cattle farming.

Table 1 showed that in 2010 there were about 205.663 ha's of uncultivated agricultural land or 8.44 per cent of the total agricultural land in South Sulawesi which could be classified as potential for cane development. The total area of agricultural land of 2,434,968 ha's in 2010 consisted of 582,444 ha's of rice fields and 852,524 ha's of dry land (not for paddy). Approximately 10,355 ha of rice fields or 1.78 percent of the total paddy fields and 86,753 ha's or 4.68 percent of the total area of dry land are not cultivated.

Table 1. illustrates the decrease in agricultural land at around 13.41 per cent over three years from 237.518 ha in 2007 to 205.663 ha in 2010. Land is widely used to plant corn, cocoa, sugarcane in accordance with the activities of the agricultural development program. There is around 97,108 ha consisting of 10,355 ha of rice fields and 86,753 ha of dry land which has potential for cane development. Pasture land could be converted into sugar cane for the development of household scale sugar cane industry and cattle development in an integrated manner without significant changing the function of pasture land. If 25 percent of that land (205,663 ha) would be used for sugar cane development then there would be about 51.4 thousand hectares with an average productivity of s 70 tons of sugar cane per ha. The conversion factor of sugar cane is 10 percent. The BCS produced could be about 367.5 thousand tons or about 13 percent of the national sugar production or about 20 percent of sugar imports that could be substituted. On top of that an additional 500 thousand heads of cattle can be bred or about 50 percent of the cattle population in the South Sulawesi.

### 3.2 Human Resource Potential

BSC is a business model that can be developed on a small and medium scale making it very suitable to encourage the rural economy in Indonesia. BSC provides employment opportunities and income throughout the year and reduces the risk of food shortages for poor families. Integration of low cost BSC production and cattle breeding can be a development strategy through which farming can provide higher revenues [26].

Population growth and less optimal use of agricultural resources generate an increase in unemployment in the agricultural sector. In contrast, the unemployment rate in the non-agricultural sector is decreasing. The population of South Sulawesi in 2010 was 8,034,776 of which approximately 3,272,365 people were employed and 298,952 unemployed, including open unemployment about 0.14% of total the population. There were an increase in employment and a decrease in unemployment of 4.12 percent and -21.30 percent respectively during the period of 2010-2012 [27,28]. In contrast, the number of people employed in the agricultural sector reduced with about 123 thousand workers, i.e. from 1,592,299 workers in 2011 to 1,469,325 workers in 2012. At the same time other sectors increased: by about 2.2 thousand in the processing industry and around 60 thousand in trade, restaurant, accommodation, and services. GDRP (Gross Domestic Regional Product) for the processing

sector increased by about 6.10 percent and for the trade sector, hotels and restaurants by 10.07 percent per year during the period 2005-2010.

Employment opportunities in the agricultural sector (including farming, forestry, and fisheries) increased by 50.9 thousand workers from 1,569,316 workers in 2009 to 1,620,177 workers in 2010. BPS also reported that the total female workforce in South Sulawesi 1,07 million people or 88 percent of the total population in 2009 which was increased from 71.10 percent in 2005. The proportion of the female workforce was 47.9 percent in agriculture, 29.9 percent in the commercial sector, restaurants and accommodation services, and 12.3 percent in the service sector, community, social and personal [29]. The idle female workforce is a potential for the development of BCS-cattle production integration because many types of jobs are matched by female labor. This potential can be seen from the great absorption of female labor in the agricultural sector (45.21%).

In urban areas, the majority of women workers are employed in the large commercial, retail, restaurants and hotels (47.33%) and social service sector (30.06%). Of particular interest is that the proportion of female workers absorbed in the processing industry tends to be higher than that of male employees, respectively 7.69 percent and 6.05 percent in both urban and rural areas. Based on these data, there is a potential workforce to develop the BCS-cattle integration. Temporary employment opportunities that can be

**Table 1. The potential land cultivated and non-cultivated for cane development (ha)**

No.	Kinds of Land	2007(ha)	2010(ha)	Changes (ha)	Percentage (%)
1.	Unutilized rainfed	7,527	7,368	-159	-2.11
2.	Temporary Unutilized rainfed	4,194	2,987	-1,207	-28.78
3.	Uncultivated Dry Land	114,297	86,753	-27,544	-24.10
4.	Paddock Grazing	111,500	108,555	-2,945	-2.64
	Total	237,518	205,663	-31,855	-13.41

Source: South Sulawesi provincial office of food and horticulture; 2011

**Table 2. Production, import, and domestic consumption of sugar (in million ton)**

Year	Production	Import	Total Supply	Household consumption	Industrial consumption	Total demand
2005	2.24	2.37	4.61	2.78	1.21	3.99
2006	2.31	1.71	4.02	3.08	1.22	4.30
2007	2.95	2.84	5.79	3.39	1.31	4.70
2008	2.57	2.04	4.61	3.83	1.51	5.34
2009	2.30	2.75	5.05	2.97	1.57	4.54
2010	2.24	2.91	5.15	2.86	1.69	4.55

Source: National symposium of sugar, Surabaya, Indonesia; 2012

created with the expansion model are at least 150 thousand. Cane growing-cattle breeding integration is an excellent economic activity because it can optimally utilize the unproductive agricultural land, develop livestock population, support the development of organic agriculture, create employment opportunities of around 2-3 people per hectare, reduce the level of poverty in rural, and empower women workers [30].

### 3.3 Market Potential of BCS and Beef

Sugar is a strategic commodity in Indonesia's economy as it belongs to the group of nine basic needs for daily consumption. In 2010, total national sugar consumption both industrial and domestic amounted to 4.55 million tons, while production was only 2.44 million tons of sugar [31]. Shortage of sugar supply is met by importing sugar. In Table 2, it appears that national production is unable to meet the needs of overall consumption and so the government had to import sugar. Sugar consumption cannot be matched by domestic sugar production due to several reasons, such as the decrease in sugar cane plantations because of land being converted to residential and industrial areas, the decline in yield, continuous decline in sugar prices and decreased sugar plant efficiency [32].

Sugar supply shortage will be met from brown sugar as one of the alternatives that can meet the needs of sugar in Indonesia [33]. The BCS market potential is magnified by the food industry such as in East Java with a need of 30-40 thousand tons per year, while the BCS industries can only produce about 5 thousand tons per year [34]. BCS has also export potential with the greatest demand from Canada, USA, Belgium, Australia, and Europe as the amount can reach 500 tones per month while the current BCS supply is only 30 to 50 tons per month [35]. East Java province has a sugar manufactory, owned by Ahmad Rubai, who has become the sole producer and exporter of raw sugar to Japan since 1995. Rubai exports BCS as much as 300 tons per year with a turnover of Rp 15 Billion per year. Japan uses BCS as raw material for industrial syrup, ketchup, and cake [36].

Annual beef consumption per capita of Indonesia has reached 1.87 kg. This figure is low when compared to other countries in Southeast Asia. Low consumption even then, Indonesia needs at least 448,000 tons of beef equivalent to 4.48 million cows weighing 100 Kgs on average. Of these, only about 85 percent can be met by

domestic beef production and the remaining, approximately 15 percent, was derived from imports. Based on these data, the number of additional cattle needed is about 672 thousand cows which can be met from the increase of cattle population in South Sulawesi and import. Cattle population in South Sulawesi can be increased with about 500 thousand heads through the development of BCS-cattle integration of production equaling approximately 74.4 percent of the total shortage of meat in Indonesia.

### 3.4 Development of Brown Cane Sugar

Processing of cane into BCS can be considered as a new economic activity for farmers, especially in the area of cane sugar factories in South Sulawesi. Farmers are presently interested in planting sugar cane not only for selling it to sugar cane factories but also for processing it to BSC integrated with cattle farming. There is renewed interest in reintegrating crops and livestock because of concerns about natural resource degradation, the profitability and stability of farm income, long-term sustainability, and fostering diversified cropping systems [37-39].

In general, cane plantation is developed in South Sulawesi on marginal land with limited water availability. BSC-cattle production integration is one form of farm management than can utilize marginal lands with limited water resources. Improving the effectiveness of land resources with limited water resources requires knowledge of good water management practices [40]. Sugar cane in South Sulawesi has huge potential to develop based on the availability of land, suitable climate and sugar cane cultivation techniques that are well known by the farmers. Sugar cane has long been cultivated in the cane planting areas of three factories in South Sulawesi. Over the last two years, the total cane area of these three sugar cane mills have increased by about 5 percent. The increase occurred mainly in *PG-Takalar* (Takalar Sugar Factory while both *PG-Bone* (Bone Sugar Factory) and *PG-Camming* (Camming Sugar Factory) decreased respectively 0.60 and 5.43 percent. This is because the three sugar mills suffered losses.

The small-holder planting area of sugar cane at the three plants showed a significant increase of around 17.84% from 2010 to 2011 due to government programs to increase the domestic production of sugar and reduce sugar imports.

Table 3. shows that the total area of cane for the three plants in South Sulawesi increased from 10,196.42 ha's in 2010 to 12,900 ha's in 2011; 28.43 percent and 17.84 percent of the sugar cane factories concessions and the farmers' concessions respectively. The development of sugarcane area owned by farmers is financed by National Development Budget (*APBN-Anggaran dan Pendapatan Belanja Negara*), the credits of food security and energy (*KKPE-Kredit Ketahanan Pangan dan Energy*) from BRI Bank and the Partnership Program for Environmental Development (*PKBL-Program Kemitraan Bina Lingkungan*) from (state owned) PTPN-X company. Although there was an increase in sugarcane acreage, the milling period of the three sugarcane factories was brief due to limited availability of cane as raw materials. Sugarcane acreage is around 13 thousand hectares with an average productivity of 60 tonnes of cane per hectare and milling capacity per factory of 2,500 TCD (tonnes cane per day), so that the production processing period of the three plants is only about 70-90 days per year, which should normally be around 150-180 days per year.

Development of BCS could encourage farmers to grow sugar cane and then produce BCS themselves or sell the cane to sugar factories.

### 3.5 Cattle Breeding Potential

Raising cattle is a way of life for most the farmers in South Sulawesi and serves as a main or as an additional sources of income. Various innovations are being made by farmers, such as the development of collective cages to reduce labor requirements improve the security of livestock, and simultaneously collects the waste that can be converted into organic fertilizer and biogas [41]. Integrated BCS-cattle production is one of the important farm models, generating benefits, creating employment opportunities in rural areas, attracting the rural labor force to work in the agricultural sector where urban-oriented job seeking is predominant. Some forms of employment in the non-agricultural sector are becoming less attractive, while agriculture and other rural businesses have turned into a promising business [42-44].

**Table 3. The cane area on the region of three sugar cane factories in South Sulawesi, 2010-2011 (in ha basis)**

No.	Factories /Acquisition land	2010	2011	Change	%
I.	<b>PG-takalar</b>	<b>3,276.68</b>	<b>4,186.03</b>	<b>909.35</b>	27.75
	- Cane of Factory	2,376.68	3,118.49	741.81	31.21
	- Cane of Farmer	900.00	1,067.54	167.54	18.62
II.	<b>PG-bone</b>	<b>3,822.30</b>	<b>3,799.19</b>	<b>-23.11</b>	-0.60
	- Cane of Factory	3,822.30	3,743.49	-78.81	-2.06
	- Cane of Farmer	0.00	55.7	55.70	100.00
III.	<b>PG-camming</b>	<b>5,197.44</b>	<b>4,914.99</b>	<b>-282.45</b>	-5.43
	- Cane of Factory	4,253.22	3,864.99	-388.23	-9.13
	- Cane of Farmer	944.22	1,050.00	105.78	11.20
IV.	<b>Total</b>	<b>10,196.42</b>	<b>12,900.21</b>	<b>2,703.79</b>	26.52
	- Cane of Factory	8,352.20	10,726.97	2,374.77	28.43
	- Cane of Farmer	1,844.22	2,173.24	329.02	17.84

Sources: South Sulawesi Provincial Office of Plantation; 2012

**Table 4. Cow population development in South Sulawesi (2007-2010)**

No.	Year	Beef cattle	Dairy cows	Total
1.	2007	666,662	1,867	668,529
2.	2008	703,303	1,919	705,222
3.	2009	769,066	1,826	770,892
4.	2010	848,916	2,198	851,114
5.	2011	1,021,110	1,894	1,023,004
	Growth (%)	11.38	1.12	11.35

Source: South Sulawesi statistical livestock; 2011

**Table 5. Number of respondents (advanced farmers) in three districts based on rice farming and livestock cultivated**

No.	Farm Classifications	District of barru (n=30)	District of wajo (n=25)	District of bone (n=20)
I	<b>Commodity</b>			
	Paddy	76.6 %	60.0 %	90.0 %
	Crops	20.0 %	60.0 %	75.0 %
	Bulrush	36.6 %	-	62.5 %
	Cane	-	30.0%	82.5 %
	Cattle	86.3%	25.0%	62.5%
II	<b>Cattle Farming</b>			
	Range of Ownership (head)	2-14	2-25	5-25
	Average of Ownership (head)	6.5	8.8	7.0
	Farmers as Agricultural Waste Users	80.0%	15.0%	62.5%
	Intensive Cage	3.3%	5.0%	37.5%
	Seller of Manure	10.0%	25.0%	-

Cattle breeding have the potential and opportunities to develop as a competitive advantage in South Sulawesi. It is supported by the labor input cost components which are relatively cheap, plenty non cultivated agricultural land, and a culture of cattle breeding. The capacity of the dry matter crop waste suitable for animal feed amounted to 25.8 million heads of livestock in South Sulawesi on 2006 [45].

Table 4 showed that over the last five years (2007-2011), the beef population growth in South Sulawesi increased about 11.35 percent per year. This happened because the cow is a commodity and cow breeding is one of the development priorities of the provincial government of South Sulawesi. Various forms of financial assistance were provided by the government, such as the financing for the purchase of cattle which shall be returned to the participating banks for revolving to other farmers. Revolving fund financing is given to sugarcane farmers through Cane Farmer Group (*KPT-Kelompok Petani Tebu Rakyat*) distributed by BRI bank.

BPS reported that the population of cattle in South Sulawesi has reached one million head in 2011 which is a fantastic figure, as it is faster than planned, with a target of reaching one million in 2013 [46]. The districts of Bone, Wajo, and Barru are cattle development centers in South Sulawesi. The proportion of the cattle population of these three districts by about 40 percent of the total population of cattle in South Sulawesi, while 60 percent of the cattle population is spread in other 19 districts in South Sulawesi. Table 5 illustrates that The population density in the two districts of Bone and Barru is

very high, respectively 20.73 and 22.68 heads per hectare, while the average cattle density for South Sulawesi was 5.23 heads per hectare and in other areas only 3.74 heads per hectare. This figure shows that the development of an integrated BCS-cattle production in the two districts should be promoted, because the cattle is a main business for most of the farmer community in both regions.

Cattle breeding, with the utilization of agricultural waste, and the intensive stall system, are a form of farming activity that can support the development of integrated sugar cane-cattle farming system. Cattle breeding in South Sulawesi has grown from the traditional grazing system to the system supported by intensive stalls with specific grass being grown as fudder. Some farmers use agricultural waste from grain and fodder crops as forage source, but in small quantities.

On all three locations of the research the farmers cultivated paddy and other crops and kept cattle, but forage and sugar cane cultivation was not done in all areas. Cattle management systems differ among the three areas. Cultivation of animal feed and agricultural waste utilization were correlated with cattle management development in the districts of Bone and Barru.

There is great potential area for the development of an integrated BCS-cattle system in the three study sites, Barru, Wajo, and Bone districts. Communities in Wajo district were the first to know or to process cane into brown sugar, but this business was not growing because it was not supported by processing technology. Cattle business is also done by some farmers, but more



in the form of grazing system. Semi-intensive or intensive systems have been introduced by the government, but were not well responded by the community. The farmers do not use specific fodder or agricultural waste, so that the cattle business is still a secondary enterprise, even though Wajo district is one of the Bali cattle development centers in South Sulawesi.

Cattle breeding, especially Bali cows is the traditional business or culture for most farmers and growers as well as the main business. Barru district is one of Bali cattle development centers in South Sulawesi as well as the center for germplasm preservation of Bali cattle in Indonesia. Cows are bred by semi-intensive and intensive systems. Semi-intensive is done by using natural sources of feed in the form of forage that grows wild and agricultural waste such as straw, corn stalks, and other crops, while intensive culture is practiced by using a source of food from the cultivation of elephant grass (*orchard grass*) or hay, and by manure and urine processing for organic fertilizers. Farmers in Barru district are not familiar with the cane plant that can be processed into sugar and be used as a forage source for cattle. The average farmer in Barru is raising between 5-10 heads of cattle. It can be said that every 5 cows can provide employment opportunity for around 1 person. Cow manure and biogas are utilized in this area. Feces as manure is sold at Rp 500 /kg, while the urine is processed to liquid fertilizer product, but the concentration and effectiveness of urine use is not known yet by farmers.

Cultivation of sugar cane for crystal sugar has been well known by farmers in the district of Bone since the 1960s, when *PG. Bone* was built. However, the BCS processing technique has not been widely known by sugar cane growers in this area. The top of the cane has not been used extensively as a feed source for livestock. This happens because the sugar harvest is conducted once a year during the milling period of the sugar factory causing the availability of sugar cane tops as cattle feed source to be very short, so it was not a concern to the farmers.

The district of Bone is also a center for cattle development in South Sulawesi with the largest cattle population among districts in South Sulawesi. Cattle, especially Bali cows, is a traditional livestock bred by most farmers and growers as the main business; the cows are bred in semi-intensive and intensive systems. Semi-intensive is done by using natural sources

of food in the form of forage that grows wild and agricultural waste such as straw, corn stalks, and other crops, while intensive culture is conducted by using food sources of grass farming (orchard grass) and hay.

### 3.6 APPROPRIATE TECHNOLOGY FOR BCS-CATTLE INTEGRATION

Cattle, agricultural waste utilization, and intensive stall system is a form of agricultural activity that can support the integration of sugarcane farm and livestock. BCS could be produced easily by routinely harvesting sugarcane after which new shoots will grow that can be harvested after nine months. Sugarcane can be harvested every day during 7-8 months per year outside the rainy season. Household farmers can harvest 0.5 to 1 ton per day depending on the cultivated sugar cane area. Taking in account the nature of this crop, sugar cane shoot leaves can be used as fodder. In addition, there is molasses as a by-product in the process of cooking cane juice into BCS. Molasses is considered as an excellent mixture of cow's feed.

The processing of BCS is an appropriate technology (AT), using a sugar cane juice press that can be manufactured locally, powered by an engine of 8-12 HP (Horse Power), and complemented with a cooking stove using 4-6 pans in line for each stove. The processing capacity is about 2 tons of cane per day. AT-BCS is fuelled efficiently because the bagasses produced from sugar cane juices are enough to cook the sap of sugar cane into BCS. BCS-cattle breeding integration can be developed locally with a small amount of investment. It supports the development of intensive stall integrated with bio digester which is an AT that has been well known to the rural community, but which has not been developed because it is not supported by the availability of adequate forage to grow cows. Economies of scale of integration of both ATs can be reached easily and provide enormous impacts to the economic, social, and environmental aspects. BCS increases employment opportunities in the agricultural sector and farmers' income and simultaneously boosts employment opportunities outside the agricultural sector. The development of employment opportunities outside the agricultural sector associated with BCS will encourage rural and regional economic development. The creation of new rural agricultural employment has a positive influence on the growing of non-agricultural sector [47]. This contrasts with other

regions, where the business linkages of agriculture and non-agricultural sectors lowers farm incomes, especially for small-scale farmers who, because of lack of land or capital, are engaging in non-farm employment to supplement farm incomes [48].

BCS-cattle breeding integration will encourage the development of the cattle population growth both in grassland-based and in fattening system breeding. The Bali cow's body weight increases around 0.25 percent by feeding 10 percent body weight of forage or 3 percent of dry matter/concentrate of body weight. The average potential of Bali cattle weight gain is thus 0.25 kg per day based on 100 kg cow weight. This weight gain is lower than the 0.2-0.3 kg /day with a traditional culture, 0.35 kg/day by supplementing forage, and 0.42 kg/day with forage and concentrate as shown in other research [49]. Intuitively, the farmer could produce best feed from the mixture of the old leaves, shoot leaves, molasses, and sugarcane juice foam. If the price of beef is Rp 80,000 /kg or equivalent to Rp 48,000/kg of price live-weight (60% of the price of meat), it means that farmers can earn Rp 12,000/day of additional cow weight (0.25 kg x Rp 48,000/kg live weight).

Integrated BCS-cattle farming is a system that is highly efficient and environmentally friendly. This system can reduce nutrient leaching in the soil because tillage activities are not carried out, while older leaves of sugarcane can be used as mulch to reduce nutrient leaching during the rainy season. Leaching of N in sugarcane is difficult to avoid given the absence of cover crops, especially during the rainy season [50]. Potential cane shoots are 30 percent of the production of sugarcane and old leaves make up 10 percent totalling to about 40 percent of the biomass. The production of 80-90 tonnes of sugarcane equals to a biomass production of 125-140 tonnes/ha/year consisting of sugar cane, shoots leaves, and old leaves. Potential old and shoots leaves are available for harvesting (200 days) at around 150-200 kgs per day meeting the needs of 8-10 cows heads per hectare during harvest period. BCS and cattle breeding integration could provide employment for about 3 people per hectare. However, behind this promising potential there is the need to provide at least 20% additional feed and the additional labor needed for bagasse fermentation to overcome lignin content.

It is recommended that the use of sugarcane shoots and leaves should not exceed 8 per cent of the live weight of a cow and a high content of lignin must be fermented [51]. Another problem also occurs because the BCS-cattle production integration requires investments to build processing capacity and sugar cane plantations; these investments are relatively large for most farmers, not only in South Sulawesi, but also in Indonesia in general. This concept is difficult to develop quickly if there is no serious support from the government.

#### 4. CONCLUSION AND RECOMMENDATIONS

When BCS-cattle integration scenarios are developed the scale of household BCS industries have potential for further growth with prospects such as 1) brown sugar can be marketed in the form of brown crystal sugar (*palm suiker*) which is often found in hotels and as raw materials for food industries; 2) BCS can also be developed as an export commodity for which there is a great demand abroad because it is perceived to have less or no chemical content; 3) The BCS-cattle production integration will promote the utilization of agricultural wastes as alternative sources of income; and 4) it is expected in future there will be a processing technology that converts BCS to white crystal sugar, so that the BCS produced in big amounts by cane farmers becomes the raw material for white crystal sugar factories. Thus the white crystal sugar factories could be operated all year long as they will not be depending on the cane harvesting season like conventional crystal sugar factories. BCS-cattle production integration is an alternative concept for rural development and sustainable agriculture in South Sulawesi. There is a great potential for cultivated farm land of around 302,771 ha that can be used for the development and BCS-cattle integration. This occurs because cow breeding is part of the farmer culture and a major source of income for most residents in rural areas which can be improved through the integration of processing BCS. Meanwhile, the development of BCS-cattle integration creates employment opportunities for 3 people per hectare, allows for sugar and meat import substitution, enables biogas as an alternative household energy source, as well as organic fertilizers that encourage environmentally friendly farming. The government support is expected to make pilots in each area involving skilled farmers considered as early adaptors to develop BCS-cattle production

integration which will encourage other farmers to be followers.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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