Potential Utilization of Oil Palm Plantation Waste Supports Beef Cattle Development in West Sulawesi

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Abstract. West Sulawesi Province has oil palm plantation areas that have the potential to be integrated with beef cattle. This study aims to collect data on feed availability from oil palm plantation waste and the carrying capacity of beef cattle development in West Sulawesi Province. The research method used is the desk study method that uses secondary data from Statistics Indonesia in 2022 related to oil palm plantations, palm oil production, and beef cattle populations, as well as research data relevant to this study. The data collected were analyzed descriptively. The results showed that West Sulawesi Province has oil palm plantation areas in 4 districts (Polewali Mandar, Mamuju, Central Mamuju, and Pasangkayu). The availability of dry matter from the plantation and palm oil processing waste is 479,554.04 Tons DM/year with a capacity of 210,330.72 LU/Year and can meet the needs of 317.61% of the beef cattle population from four districts. The index of feed availability from palm oil waste was highest in Pasangkayu Regency, with dry matter production of 11,298.8 tons DM/year. West Sulawesi Province has the potential to support the development of beef cattle with an integrated system of palm oil and cattle.

1 Introduction

The main drivers of livestock productivity performance in Asia are the availability and efficiency of feed resources. The increasing population and income of the Indonesian people

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encourage the growth of the livestock industry in Indonesia, as seen by the growing consumption of livestock products (meat, milk, and eggs) [1]. Most developing countries have utilized agricultural by-products as a source of feed, which can help reduce feed costs. There has been a shift in the development of ruminants (cattle, goats, buffaloes, and sheep) in the agro-ecological zone by utilizing.

Biomass was available as a feed source for agricultural and agro-industrial waste and other unconventional feed sources [2]. Using local feed (e.g., agrarian by-products) is one strategy for reducing animal feed imports and is one way to overcome environmental pollution [3].

In the last few decades, the palm oil industry has experienced an increasing development along with the growing demand for food, cleaning, and cosmetics. In addition to producing oil, the palm oil industry produces waste (wet and dry) [4]. Oil palm plantations have 10% oil and 90% biomass. Some of the waste produced by oil palm plants is oil palm midrib (OPM), empty fruit bunch (EFB), and oil palm trunk (OPT). Meanwhile, palm oil mills are in the process of converting fresh fruit into crude palm oil (CPO), namely palm kernel cake (PKC), palm kernel shells (PKS), oil palm fiber (OPF), and palm oil mills effluent (POME) [5–7].

Palm oil is a plantation commodity with a role in the Indonesian economy and is spread over several islands, namely Sumatra, Kalimantan, Java, Sulawesi, Maluku, and Papua [8]. West Sulawesi province has 14 palm oil plantation companies that are privately owned companies [9]. In 2021 the area of oil palm plantations in West Sulawesi is 104,845 Ha spread across 4 districts, namely Polewali Mandar, Mamuju, Pasangkayu Regencies 59,933 Ha and Central Mamuju [10].

Integrating various separate sectors by utilizing the linkages with each other (water, food, and energy relations) is one of the sustainable development strategies that is considered capable of preventing future resource insecurity [11]. The integration system of oil palm cattle is a symbiotic mutualism. This system can save 94% of wedding costs and 15% of labor costs and saves total production costs of 8.6%, which is the effect of cattle grazing [12]. In Indonesia, the integration system of oil palm and cattle has been carried out with intensive, semi-intensive, and extensive patterns [13]. Livestock rearing in plantation areas using an intensive system (cut and carry) does not hurt oil palm. An extensive system with livestock released in oil palm plantations can damage the main crop [14]. The presence of cattle in palm oil plantations is expected to control weeds on plantation land [15].

Based on this, this study aims to see the potential of palm oil waste in West Sulawesi Province as beef cattle feed to support livestock development with an integrated system of palm oil and cattle.

2 Methodology

The research uses a desk study method in secondary data tracing activities derived from government documents, namely Statistics Indonesia and relevant previous research results. This study determined the carrying capacity of oil palm plantation waste (OPM, EFB, PKC, and POME) for developing beef cattle in West Sulawesi Province. Some of the data analyzed are:

2.1 Analysis of agricultural waste production as feed resources

Analysis of waste products from oil palm plantations is calculated based on the production of fresh matter and dry matter (BK) with the following calculations [16]:

$$Total\ Dry\ Production = Dry\ Production\ (Tons/Ha) \times Plantation\ Area\ (Ha) \quad (1)$$

$$Total\ Production\ DM = Total\ production\ of\ DM\ (Tons/Ha)\ x\ harvested\ area \quad (2)$$

The average production of OPM is 5,872 kg/Ha/year [17]. Production of empty fruit bunches is 25%-26% of fresh fruit production or as much as 250 kg of EFB per 1 tons of oil palm production [18]. Meanwhile, 4-6% of waste is obtained from POME and 45% PKC from fresh fruit bunches in palm oil processing[19].

2.2 Feed production concentration Index (FPCI) of oil palm plantation waste

The Feed Production Concentration Index (FPCI) by-products of oil palm plantations show the amount of production of each waste from oil palm plantations based on BK in each District. FPCI is the amount of by-product production in a certain area compared to the average production of by-products in the province. FPCI is the ratio between the amount of production in a particular sub-district and the average amount of production in the district. The FPCI category > 1.0 is high, FPCI = 0.5-1 is medium, and FPCI < 0.5 is low. FPCI is calculated using the formula [16].

$$FPCI = \frac{Palm\ waste\ production\ per\ District}{Province's\ average\ palm\ waste\ production} \quad (3)$$

2.3 Carrying capacity of oil palm plantation waste as animal feed

Plantation Waste Carrying Capacity (PWCC) is the capacity of an area to provide feed from plantation by-products to accommodate several cattle populations without going through feed processing technology. The calculation of PWCC through several assumptions is that one unit of cattle (1 LU) of beef cattle has an average need for a dry matter of 6.25 kg/day or 2.28 tons/year [20]. The formula can calculate PWCC [16]:

$$PWCC = \frac{DM\ Production\ (tons/year)}{DM\ requirement\ 1\ LU\ (ton/year)} \quad (4)$$

2.4 Population distribution and beef cattle concentration index

The calculation of the total beef cattle population based on the age of the livestock is used the conversion value (percentage) of the livestock of the Weaning off (16.99%), young (26.68%), and adults (56.33%) to the population (head). While calculating the number of ruminant livestock units (LU) for each type of livestock, the livestock population is estimated based on the population structure (head) multiplied by the common value of livestock units, namely children (0.25 LU), young (0.6 LU) and adults (1 LU) [16].

Livestock concentration index (LCI) is calculated based on the ratio of the district livestock population (Pd) to the average district population in the entire Province (Pp) with the category Pd/Pp > High or dominant population, Pd/Pp = 0.5 - 1 medium or average population and Pd/Pp < 0.5 population low/minimum [21].

3 Results and discussion

3.1 Overview of oil palm plantations and oil palm waste production in West Sulawesi Province

In 2021, the administrative area of West Sulawesi Province consisted of six regencies; based on the Regulation of the Minister of Home Affairs Number 72/2019, the land area of each

regency, namely: Majene Regency (947.84 Km^2), Polewali Mandar Regency (1,775.65 Km^2), Mamasa Regency (3,005.88 Km^2), Mamuju Regency (4,999.69 Km^2), Pasangkayu Regency (3,043.75 Km^2), and Central Mamuju Regency (3,014.37 Km^2) [10].

The production of plantation commodities continues to increase with domestic consumption and export needs. Plantation commodities in west Sulawesi include cocoa, oil palm, coffee, coconut, and other commodities [22]. Oil palm plantations in West Sulawesi are spread across four regencies, namely Polewali Mandar, Mamuju, Pasangkayu, and Central Mamuju Regencies. Table 1 shows the area of oil palm plantations and palm oil production in 2021 in West Sulawesi Province [10]:

Table 1. Area and palm oil production in West Sulawesi

No.	Regency	2020		2021	
		Acreage (Ha)	Production (Tons)	Acreage (Ha)	Production (Tons)
1.	Mejene	-	-	-	-
2.	Polewali Mandar	-	-	1,951.10	907.32
3.	Mamasa	-	-	-	-
4.	Mamuju	10,791.00	12,351.29	10,079.68	12,351.29
5.	Pasangkayu	59,933.00	138,564.00	59,93300	138,564.00
6.	Mamuju Central	34,121.00	90,910.24	36,159.15	90,910.24
West Sulawesi Province		**104,845.00**	**242,732.85**	**104,845.00**	**242,732.85**

Along with the development of the palm oil industry, with the increase in plantation areas and the production of crude oil that continues to increase, it will undoubtedly produce waste that can cause environmental pollution if not appropriately managed. Waste generated from the palm oil industry includes palm fronds, palm fruit fiber, palm trunks, empty fruit bunch, oil palm meal, palm sludge, and palm kernel shells. Palm fronds are available in palm plantations, while oil palm trunks are available for replanting season [4].

Palm oil waste as animal feed has long been developed through the oil palm and livestock integration systems. The oil palm-livestock integration system promotes the sustainability of palm oil production with various benefits, including socioeconomic improvements, national food security, and the environment [23].

Palm oil waste production is calculated based on the area, and palm oil production is based on the dry matter content of palm oil waste. Table 2 shows the production of palm oil waste in West Sulawesi in dry matter production.

Table 2. Palm oil waste dry matter production.

No.	Regency	Production of OPM (DM Ton/year)	Production of EFB (DM Ton/year)	Production of PKC (DM Ton/year)	Production of POME (DM Ton/year)
1.	Majene	-	-	-	-
2.	Polewali Mandar	5,672.29	208.91	367.46	41.19
3.	Mamasa	-	-	-	-
4.	Mamuju	29,303.92	2,843.88	5,002.27	560.75
5.	Pasangkayu	174,238.85	31,904.36	56,118.42	6,290.81
6.	Mamuju Central	105,122.86	20,932.08	36,818.65	4,127.32
West Sulawesi Province		314,337.92	55,889.24	98,306.80	11,020.07

OPM production is 314.337.92 Tons DM/Year, PKC 98. 306.80 Tons DM/Year, EFB 55. 889.24 Tons of DM/Year, and POME 11. 020.07 Tons DM/Year. As palm oil production increases, the biomass produced will be comparable, so fast and precise handling is needed [24]. One solution to reducing environmental impact is integrating oil palm and beef cattle. This is expected to reduce the need for grazing land and deforestation and reduce herbicide use in plantations with cattle-eating weeds [25].

Low nutritional value and high lignocellulosic content are limiting factors for using OPM as feed [26]. OPM can be processed using silage technology to meet the needs of animal feed, while cow dung can be used as biogas so that people can get economic benefits [27]. Palm kernel cake fermented with yeast has nutritional content, namely DM 88.61%, CP 41.67%, NDF 47.98%, ADF 32.50%, OM 96.12% [28]. Meanwhile, palm kernel cake fermented using a combination of two cellulolytic and hemicellulolytic bacterial cultures reduced the cellulose, hemicellulose, ADF, and NDF to increase digestibility and suitable for use as feed ingredients in monogastric without disturbing growth. The nutritional content of PKC with these treatments were DM 93.03%, CP 16.60%, NDF 72.92%, ADF 46.88%, Hemiculose 26.03%, Cellulose 31.52% [29].

3.2 Concentration of feed production from palm oil waste and the carrying capacity of waste as animal feed

The feed concentration index (FCI) of palm oil waste origin is calculated based on the area that has an oil palm plantation area in West Sulawesi. Table 3 shows the feed concentration index per District, which is calculated based on estimates of total palm waste production consisting of OPM, EFB, PKC, and POME:

Table 3. Feed concentration index of oil palm waste origin in West Sulawesi Province.

No.	Regency	Total DM production of palm oil waste (tons/year)	FCI Per District	Category	Carrying capacity DM (LU)
1.	Majene	-	-	-	-
2.	Polewali Mandar	6,289.86	0.05	Low	2,758.71
3.	Mamasa	-	-	-	-
4.	Mamuju	37,710.83	0.31	Low	16,539.84
5.	Pasangkayu	268,552.43	2.24	High	117,786.16
6.	Mamuju Central	167,000.92	1.39	High	73,246.02
West Sulawesi Province		**479,554.04**			**210,330.72**

Table 3 describes the highest feed concentration index in Pasangkayu Regency, 2.24, with a livestock carrying capacity of 117,786.16 LU / Year, then in Central Mamuju Regency with an FCI of 1.39 with a carrying capacity of 73,246.02 LU / Year. Based on palm oil waste's production and carrying capacity, palm oil waste can provide feed for cattle. Palm oil waste can be used as a feed source of fiber and a source of protein at a generally relatively low waste price [30].

3.3 Population distribution and beef cattle concentration index

Beef cattle are large ruminants that the people of West Sulawesi mostly cultivate. Table 4 shows the distribution of the beef cattle population throughout the Province of West Sulawesi.

Table 4. Beef cattle population and LCI in West Sulawesi Province in 2017-2021

No.	Regency	2017	LCI	2018	LCI	2019	LCI	2020	LCI	2021	LCI
1	Majene	13,303.67	1.11	13,596.22	1.12	13,895.67	1.13	14,174.44	0.98	14457.81	0.98
2	Polewali Mandar	26,983.37	2.25	26,193.01	2.15	26,454.93	2.14	27,114.33	1.87	27656.56	1.88
3	Mamasa	4,510.89	0.38	4,479.49	0.37	4,523.91	0.37	7,186.02	0.50	7545.20	0.51
4	Mamuju	13,957.71	1.16	14,097.09	1.16	14,407.26	1.17	14,503.00	1.00	14571.16	0.99
5	Pasangkayu	7,261.07	0.61	7,699.91	0.63	7,777.26	0.63	12,081.36	0.83	12201.60	0.83
6	Mamuju Central	5,985.16	0.50	6,910.31	0.57	6,952.43	0.56	11,773.49	0.81	11793.40	0.80
West Sulawesi Province		**72,001.86**		**72,976.03**		**74,011.46**		**86,832.64**		**88,225.73**	

In 2021 the population of beef cattle in the Province of West Sulawesi was 88,225.73 LU, with an estimated feed requirement of 100,577.33 LU. Meanwhile, LCI is high in Polewali

Mandar and Majene regencies. The lowest LCI is in Mamasa District. The beef cattle population continues to increase from year to year, with the increasing population requiring adequate feed support by utilizing existing resources. The livestock business depends on three things: seeds, feed, and management [31].

Based on data on the availability of feed resources from palm oil wiped waste and the current capacity and beef cattle population, West Sulawesi has the potential to increase the beef cattle population with an oil palm integration system, especially in Pasangkayu regency and Central Mamuju Regency. The integration of oil palm cattle also can increase the beef cattle population. The wider the development area of oil palm plantations, the greater the potential to increase livestock populations [32].

4 Conclusion

The development of beef cattle with an integration system for palm oil and cattle has the potential to be developed in West Sulawesi, especially the Pasangkayu and Mamuju Tengah Regencies. This can be seen from the high feed production from palm oil by-products, which supports feed availability in the region. In addition, the population of beef cattle is relatively lower than in other districts.

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