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CARRYING CAPACITY OF BEEF CATTLE FODDER FORAGE FROM AGRICULTURAL WASTE IN THE TROPICAL ENVIRONMENT OF WEST JAVA PROVINCE USED GIS PROCEDURES

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ABSTRACT

The application of Geographic Information System (GIS) in animal husbandry incorporates data on grazing variation and excretion behavior in ruminant species, information on various forms of land use, grasslands, and grazing management with agropastoral systems. This study aimed to 1) identify, inventory, and map land parameters from geographical conditions; 2) determine potential base areas for beef cattle development businesses in West Java Province; and 3) calculate the potential availability of forage feed from agricultural waste. This research was conducted from July 2020 to August 2021 in four districts in West Java Province, namely Cirebon, Majalengka, Indramayu, and Ciamis. Secondary data from 2016 until 2020, were taken by the Central Bureau of Statistics of each region. Data analysis includes 1) land cover mapping supported by (GIS), 2) air temperature and air humidity index (THI) suitable for beef cattle, and 3) agricultural waste carrying capacity (CC) and carrying capacity index (IK) for beef cattle. The results of land cover mapping show that shrubs, forests, and fallow land in the four districts can be used for fodder grass cultivation. In contrast, paddy fields, rainfed rice fields, and drylands produce agricultural waste as a source of fodder forage. THI values of 79.69 - 83.08 are suitable for beef cattle development. Based on the results of inventory and mapping conducted by CCI, it can be concluded that 30 sub-districts from four districts in West Java Province are potential areas for beef cattle development. CC agricultural waste can increase the availability of forage feed for cattle.

Keywords: *beef cattle, forage, environmental, Geographic Information Systems*

BACKGROUND

The problem of limited land for forage production is one of the obstacles to animal feed production on Java Island. Therefore, it is necessary to utilize food crop waste for animal feed, especially ruminants. Most agricultural waste is suitable for animal feed when processed into feed, ingredients with high nutritional value (Devendra & Leng, 2011). The livestock industry must

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consider feeding input factors for livestock companies, particularly beef cattle (Bell & Moore, 2012). If feed inputs can be supplied locally in quantity and quality, it may support livestock development. In that case, the region can potentially support cattle farming businesses optimally and sustainably. Waste from food crops can replace forage feed to overcome the forage scarcity. Some circumstances that slow the provision of forage from agricultural waste are converting land into non-agricultural lands, such as residential and industrial buildings making cow production a challenging business to develop (Ali et al., 2019).

To illustrate, from 2016 to 2020, West Java imported 22.01 percent of beef cattle while DKI Jakarta imported 3.94 percent (Animal Husbandry and Animal Health Statistics, 2020). The shortage of beef supply country forces the government to implement a beef cattle import policy to fulfill the demand (Sunyigono et al., 2021). The concentration of consumption in West Java Province is in Bogor Regency, Sukabumi Regency, Purwakarta Regency, Karawang Regency, Bogor City, Sukabumi City, Bandung City, Depok City, and Tasikmalaya City. These strategic locations in West Java Province will produce the characteristics that farmers need to run their livestock business. In comparison, some areas known as beef cattle centers in West Java are Tasikmalaya, Majalengka, Sumedang, Subang, Indramayu, and Ciamis sub-districts (Firman et al., 2018).

A geographic information system is a computer-based information system that focuses on the geography of an area. It is designed and used to compile, store, transform, process, display, and analyze data containing spatial information (Khusnawati & Kusuma, 2020). GIS is an information management tool related to mapping systems and spatial analysis that accurately represents the earth's surface phenomena through maps. The geographical conditions of agricultural locations vary greatly, so GIS is significant for obtaining spatial data and geographically representing the results of multicriteria analysis. The use of GIS in the field of animal husbandry has been developed by academics and scientists both abroad and domestically, including information on grazing variations and excretory behavior in ruminant species, types of land use, grass gardening, and grazing management with agropastoral systems (Kunang & Sulaiman, 2016; Gallego et al., 2019; Santoso et al., 2018). Compared to manual methods with tile methods that take a long time, GIS technology makes it easier to make projections of food crop area. The livestock industry must consider forage input factors for livestock companies, especially beef cattle, which are large ruminants (Bell & Moore, 2012). Most agricultural components are suitable for animal feed and then processed into feed ingredients with high nutritional value(Devendra & Leng, 2011). The livestock industry must consider feeding input factors for livestock companies, especially beef cattle, which are large ruminants (Bell & Moore, 2012). If feed inputs are locally accessible in quantity and quality, and their quality supports livestock development, the region is said to have potential. The livestock business, especially the beef cattle business, shows optimal performance over the long term.

The potential carrying capacity of regional livestock can be focused on the area's capacity to accommodate various livestock and produce animal feed so that livestock can breed and produce following the specific agroecosystem of each region (Suhaema, 2014). The potential carrying capacity can be used to develop, cultivate, and process animal feed using current feed technology. Regional capacity as a source of animal feed is also an important component that must be linked to the carrying capacity of regions for beef cattle development in Indonesia(Ali et al., 2019). This study combines geographic information systems with area mapping and inventory of the food crop waste availability as forage for animal feed to determine the development potential of beef cattle. This

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research aims to: 1. identify, create inventory, and map land parameters from geographical conditions. 2. determine land parameter values to calculate feed production from agricultural waste by analyzing carrying capacity and carrying capacity index. 3. calculate the potential availability of forage feed from agricultural waste.

RESEARCH METHODS

Study Area

This research was conducted from July 2020–August 2021 in four regencies of eastern West Java Province, namely Cirebon, Majalengka, Indramayu, and Ciamis Regencies (Figure 1) based on considerations of 1) geographical location where population density per agricultural land area is still low compared to other districts, and 2) the four regencies have access to toll roads, which means they have potential assess to markets in cities big Indonesia (Jakarta, Bogor, Depok, Tangerang, and Bekasi).

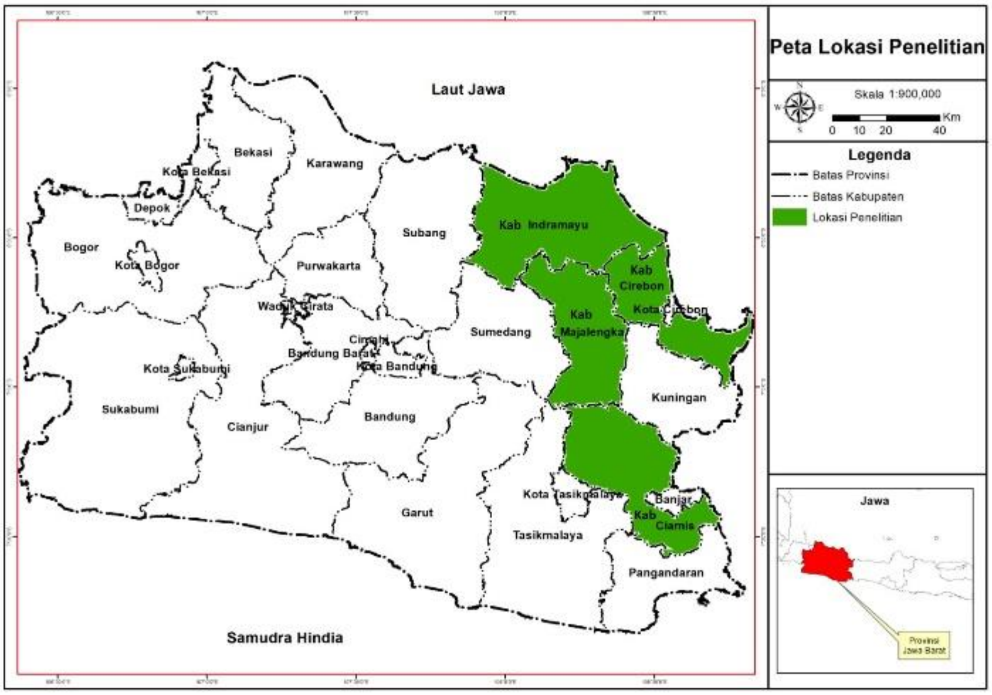

Figure 1. Research Location in West Java Province

Data Source and Data Collection

This study uses secondary data during the five years from 2016–2020, taken from the Indonesian Central Bureau of Statistics from four regencies where the study is located, consisting of 1) geographical conditions (temperature, humidity, and regional boundaries), 2) ruminant livestock populations (cattle, dairy cattle, buffalo, sheep, and goats) converted in livestock units, 3) agricultural production (rice, corn, beans, peanuts, soybeans, cassava, and sweet potato) are calculated and converted with the availability of agricultural waste based on the dry matter and calculated according to the needs of adult cattle. Secondary data as a comparison in the form of land cover data obtained from the Geospatial Information Agency (BIG) to transform into land information data requires

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Geographic Information System (GIS) technology (Burrough, 1988). Geographic Information Systems can provide land cover information to map land following the availability of forage feed, various agricultural products, and agricultural waste that can be used as potential cattle breeding sites. This study also used remote sensing technology to create the mapping of the potential land using Landsat 7 ETM+ imagery in 2017.

Image interpretation is carried out visually using a 1:400,000 scale map of Rupabumi Indonesia (Ciamis and Majalengka regencies), 1:350,000 (Cirebon Regency), and 1:450,000 (Indramayu Regency) as a reference and combined with field surveys. Landsat and GIS analysis were interpreted in the remote sensing and cartography laboratory of the Faculty of Geography, Universitas Gadjah Mada. Temperature Humidity Index (THI) uses the formula THI=T(in F)-0.55*(100-RH)/100*(T-58) to see the effect of heat stress on beef cattle (Armstrong, 1994). If the THI value is 70≤THI≤74, beef cattle are in the comfort zone. THI values range from 75 to ≤THI≤78, and cattle experience mild stress. THI value 79≤THI≤83, livestock will experience moderate stress. THI value 84≤THI≤91, livestock will experience severe stress (Hoppe et al., 2022).

The carrying capacity of forage availability analysis consists of several variables: 1. Support for ruminant livestock farms is analyzed by calculating agricultural waste production in dry form. 2. Calculate the need for animal feed for adult cows, assuming a body weight of 400 kg for one year. 3. Comparing the production of forage for animal feed converted in dry form divided by the adult animal feed needs for one year. 4. Comparing forage production that has been converted in dry form divided by adult animal feed needs for one year, and the number of ruminant livestock populations in livestock units (AU) forage dry matter production was estimated using the amount of potential agricultural waste (Suhaema, 2014; Yuniar et al., 2015). The numbers in the formula are based on assumptions about the potential waste produced from each type of plant food.

Dry mater Agricultural waste potential (ton) = {(wr x 0.4) + (fr x 3 x 0.4) + (cn x 3 x 0.5) + (sb x 3 x 0.55) + (pt x 2 x 0.55) + (sp x 0.25/6) + (cs x 0.25/4)} x 0.65.

Information:
wr : Wetland rice
fr : Field rice
cn : Corn
sb : Soybean
pt : Peanuts
sp : Sweet potatoes
cs : Cassava.

Minimum cattle feed requirements (R) / adult animal feed (AAF) = 2.5% x 50% x 365 x 400 kg = 1.83-ton DDM/year/AU, where R is the minimum cattle feed requirements (1 AU) in tons of digestible dry matter for a year, 2.5 % is the minimum requirement for the number of forage rations (dry matter) on livestock weight, 50% is the average value digestibility power of various types of plants, 365 is the number of days in a year, or 400 kg is the live weight of 1 AU of beef cattle in (Cirebon, Ciamis, Indramayu and Majalengka sub-district) were used in the equations. The following equations, the result assessment of forage dry matter production were utilized to compute the carrying

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capacity of beef cattle farms (Suhaema, 2014). The carrying capacity of forage feed aims to determine the carrying capacity of livestock using the following equation:

Carrying capacity of forage feed (AU) = (Production of natural forage dry matter (TON))/(Minimum Feed Needs DM adult cow (Ton/AU))

This forage carrying capacity index has the aim of determining the level of animal feed safety in an area, namely with the following equations:

CCI = (Production of natural forage dry matter (TON)/(Number of livestock populations (AU) x Minimum Feed Needs DM adult cow (Ton/AU))

Data Analysis

The Carrying Capacity and Carrying Capacity Index, the ability of the region to produce feed that can accommodate and meet the needs of several ruminant populations, indicates the region's ability for livestock development. Fresh forage (grass, legumes) and dry forage are the two studied forage (hay) types. Forage carrying index assessment is carried out to assess the availability of animal feed in an area, whether it is classified as safe, vulnerable, critical, or very critical. The four possible values of the ratio are:

1. CCI > 2 "SAFE" means that the availability of feed resources functionally meets environmental needs efficiently.
2. CCI > 1.5 – 2 "Cartilage" means developing organic matter into mediocre.
3. CCI > 1 – 1.5 "Critical" means that farms already have options to utilize resources but conservation aspects have not been met.
4. CCI ≤ 1 means you cannot utilize the available resources.

There is a depletion of resources in the agroecosystem. There are no forages and natural waste that recycled.

RESULT AND DISCUSSION

Land Cover Map

Identification, inventory, and mapping of land parameters from geographical conditions aspects using Arch GIS's help to determine land cover maps in four regencies. Geographical maps of land use in Cirebon, Majalengka, Indramayu, and Ciamis regencies can be seen more clearly in Figures 1 and 2. The results come from a GIS that can provide information on land use map conditions following the potential availability of forage from agriculture can be used to develop a ruminant livestock business.

The GIS analysis results of land cover in Cirebon Regency illustrate the availability of forage feed comes from agricultural waste because most of the land in the district is used as rice fields, rainfed rice fields, dry land, forests, and shrubs, which are generally planted with crops that produce agricultural waste. There is a brackish water land in Pangenan, Suranenggala, and Kapetakan sub-districts because it is close to the sea, so the land is only used to make salt by the surrounding community. Five sub-districts (Palimanan, Sumber, Kedawung, Weru, and Plumbon) have a

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population density of 61,642 people to 83,387 people, classified as dense (BPS 2020), so it cannot be used to develop cattle populations. The high population will affect the land's carrying capacity to support the development of beef cattle populations (Arifin et al., 2017).

GIS results of land cover in Ciamis Regency are divided into rice fields, rainfed rice fields, dry land, plantations/gardens, forests, settlements, shrubs, and grazing pastures. Rainfed rice fields in Ciamis Regency are more dominant, as shown in Figure 2. Mixed dry land in the Banjasari sub-district has a broader mix of dry land and more legume production than other regions. Lakbok sub-district has the highest rice fields and production area compared to other sub-districts. The forest area includes Cihaurbeti, Panumbangan, Cikoneng, Sadanaya, Panjalu, Cipaku, Kawali, Lumbung, and Sukamantri sub-districts.

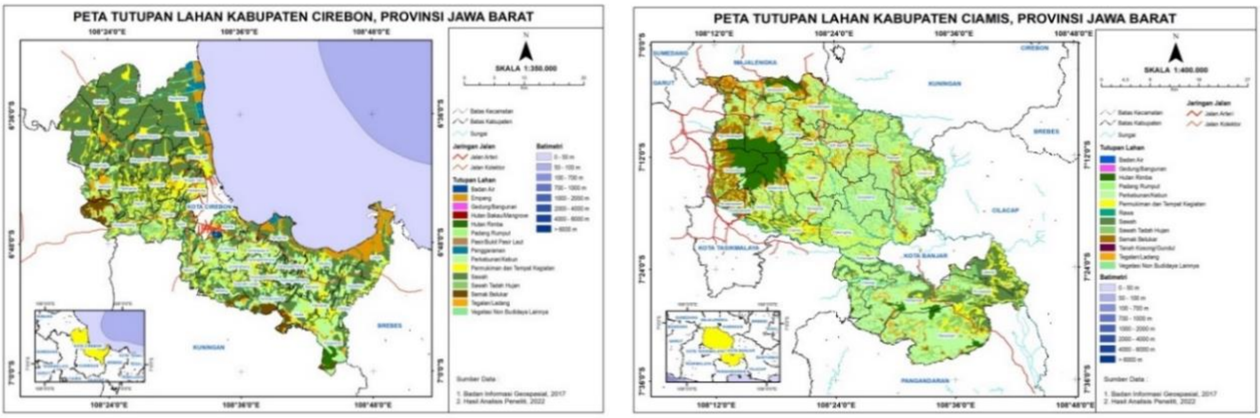

Figure 2. Land cover map in Cirebon Regency and Ciamis Regency
Source: Laboratory of Remote Sensing and Cartography, Faculty of Geography Universitas Gadjah Mada

The results of GIS analysis, land cover in the Majalengka Regency consists of rice fields, rainfed rice fields, forests, settlements, vacant land, dry land, shrubs, and grasslands spread throughout (Figure 2). The results of the GIS analysis of land cover in Indramayu Regency consist of rice fields, rainfed rice fields, mangrove forests, settlements, vacant land, dry land, plantations/gardens, shrubs and swamps spread throughout the sub-district in Indramayu Regency. Pasekan, Cantingi, and Lohsarang sub-districts are dominant for swampland use. Planting brachia brizantha grass in forest ecosystems is suggested. Silvopasture can produce brachia brizantha grass production as much as 4.5 tons/ha, nutrients in the soil, especially nitrate content, air temperature, wind speed, and annual pruning (Suryanto et al., 2020; Susilo, 2012).

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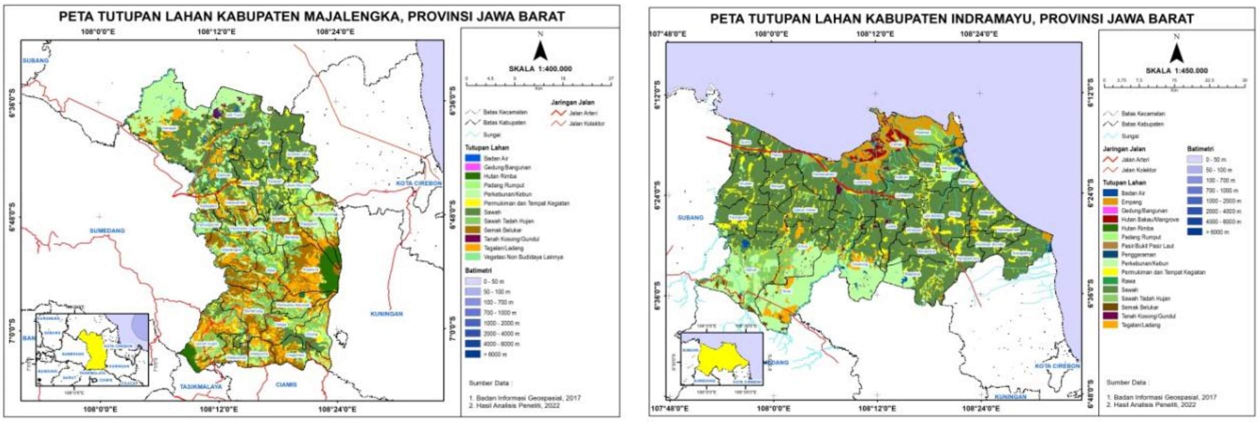

Figure 3. Land cover map in Majalengka Regency and Indramayu Regency
Source: Laboratory of Remote Sensing and Cartography, Faculty of Geography Universitas Gadjah Mada

The results of the statement above indicated that each sub-district in the study location has different areas and land uses in terms of geographical conditions, land use, and agricultural crop production. Irrigated rice fields, rainfed land, and settlements became the dominant land used. Forests, vacant land, and shrubs at the study site can be used as beef cattle breeding areas but still require efforts with land clearing to cultivate forage by selecting superior grass. Each sub-district has a different area and proportion of land use (Susilo, 2012). Efforts to develop livestock areas need to optimize potential lands such as wetlands, drylands, forests, shrubs, secondary dry lands, and plantation forests for forage production by planting superior grasses such as king grass, elephant grass, odot grass, or Indigofera (Delima et al., 2015).

Ecological Environment of Beef Cattle

Assessment of the suitability of the ecological environment for beef cattle production in four districts is constrained because temperature, humidity, surface height, Temperature Humidity Index (THI), and annual rainfall can be seen more clearly in Table 1.

Table 1. Observations of Environmental Elements that Affect Beef Cattle's Growth in the West Java Province

Regency	Temperature C	Temperature F	Moisture	Surface Height	THI
Cirebon	28.38	83.08	72.35	36.25	83.08
Ciamis	27.97	82.34	74.75	203	82.34
Indramayu	26.50	79.70	73.00	30	79.69
Majalengka	27.95	82.31	74.75	141	82.30

Source: BPS Data (2016-2020)

The ambient temperature at the study site ranged from 26.50 ^{0}C – 28.38 ^{0}C, which is still tolerable or suitable for beef cattle like Limousine cattle and Limousin cross-breeds cattle. Tropical cattle in Indonesia can still adapt to temperatures of 22℃ to 30℃ (Gantner et al., 2011). Livestock environment is the external environment of livestock that can affect development, growth response,

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and progression (Patriani et al., 2019). Temperature and humidity are the most influential factors in production. Since many sweat glands generate significant body heat loss, lowering the high body temperature in tropical livestock is an excellent thermoregulatory characteristic. Low metabolic heat activity is an advantage for livestock in increasing their productivity (Yetmaneli et al., 2020). Most of the beef cattle in West Java Province are Simmental and Limousin breeds, resulting from the mating with local cattle. Simmental and Limousine cross-breed cattle are cross-genotypes with various genotypes. Referring to the interaction of genotype and the environment, on various performance measures, especially for the performance of physiological response productivity will be better and more profitable (Pribadi et al., 2021). Crossing local Indonesian cattle with cattle from Europe aims to produce offspring with larger body sizes that will attain heavier body weights at higher selling prices (Widyas et al., 2022).

The Temperature Humidity Index (THI) measures the relationship between temperature and humidity and can be used to determine how stressed the animal. The THI calculation results in the four study location districts were between 76.48 and 79.27, value THI 72 – 79 the environment is in heat stress or under moderate stress (Nuriyasa et al., 2015). This study's results differ from those of (Suhaema 2014), who said that THI values between 68 and 73 follow the conditions of beef cattle. When THI is more than 73, it is necessary to improve housing management. Air circulation is assisted by providing shade. Furthermore, rainfall in the four study locations ranges from 100 mm/month to 163 mm/month in moderate criteria. One of the research locations, Indramayu Regency, is 944 mm/month, which is included in the very high criteria. The amount of rainfall, in an area will affect the availability of forage both in the amount and type of forage in the area.

Food Crop Production and Potential Food Waste

Agricultural crop production at the study site ranged from 14,774 to 54,705 tons (Table 2). Almost 90% of agricultural waste comes from rice (Table 2), so the potential for rice straw is abundant. The study's results of Suwignyo et al. (2021) confirm that the potential source of animal feed in Gunungkidul is 82.42% derived from crops by-products. In general, agricultural crop waste used as feed for beef cattle is rice straw. The parts of rice straw that are widely used are stems and leaves, as well as processed rice husks that are ground into bran.

Table 2. Average Production of Agricultural Waste for 5 Years in Fresh

Regency	Production (Ton)						Result
	Rice Field	Corn	Soybean	Peanuts	Cassava	Sweet Potato	
Cirebon	13,632	881	12	55	24	169	14,774
Ciamis	18,058	1,238	74	112	2,039	146	21,668
Indramayu	52,410	1,041	1,105	26	115	9	54,705
Majalengka	30,310	5,345	171	110	277	560	36,773

Source: BPS Data (2016-2020)

The most corn production in Majalengka Regency is compared to other districts because almost all districts in Majalengka Regency produce corn, as confirmed by (Widiati et al. 2021). Corn straw is widely used by beef cattle farmers, especially in sub-districts in the Majalengka Regency. Corn straw that farmers commonly use as beef cattle feed is the stem and leaves part. The results of

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the study by Yuniarsih and Nappu (2013) showed that mostly corn straw consisting of leaves (92.5%), stems (5%), and cornhusks (2.5%) are used for ruminants, especially beef cattle feed. The extensive use of corn leaves is because it has high palatability and contain low water content of DM 20%, and DP 7%. The parts of the corn crops that are often used consist of everything above the ground except corn kernels. Corn kernels are usually used for poultry feed and food (Yanuartono et al., 2020). Compared to other regencies, the most soybean production is in the Indramayu Regency. Despite using soybean leaves for human consumption, the utilization of soybean leaves for animal feed is not widely used. Soybeans are processed for tempeh, tofu, soy sauce, oncom, and tauco. By-products from soybean raw materials used as tofu produce pulp, which is used for animal feed. Soybean straw also has excellent potential for animal feed, especially ruminants, considering its production and nutritional content are still relatively high (Fuskhah and Darmawati, 2018).

Compared to other districts, the most significant production of cassava is in Ciamis Regency. Most Ciamis Regency farmers use it for concentrate feed due to its abundant availability. Cassava's tubers and skins are washed before being used as feed. Farmers do not use soybean and peanut leaves for beef cattle feed as usually people consume them. However, cassava's skin can be used as additional feed ingredients for ruminants as a high source of carbohydrates (Rahayu, 2019). Cassava's leaves, stems, and tubers contain cyanide acid (HCN) which can lead to poisoning. The HCN content in young cassava leaves ranged from 427 – 542 mg/kg; in old leaves, the content was lower, around 343 – 379 mg/kg. It is suggested not to give fresh cassava leaves but shall be withered first. This withering process will reduce the levels of cyanide acid (Sirait and Simanhuruk 2010). High cyanide in cassava can be removed physically, biologically, and chemically. It can be done physically by washing, cutting, soaking, steaming, and drying. Biologically and chemically, among others, by the fermentation process, hydrolysis using acid or a combination of fermentation followed by acid hydrolysis (Antari & Umiyasih, 2009). Sweet potatoes are known to feed sheep and goats. Sweet potato waste is sometimes given only to beef cattle in the research location. All parts of the sweet potato plant (leaves, stalks, and stems) are a source of forage for sheep and goats (Sirait and Simanihuruk, 2010).

Food crop production produces staples and by-products or food waste that can be used as animal feed. The production of food crops in Table 2 yields food waste by conversion to dry matter according to Formula 1 which can be seen in Table 3. From this version, each district produces waste in the calculation of dry matter (DM) as follows: The potential of rice straw production at 40% of the rice product. The production of corn, corn waste, soybeans, and beans during three times of harvests in a year is promising so its agricultural waste potential is 50% more than the corn, soybeans, and beans production. The potential of cassava and sweet potato waste is 10% of cassava and sweet potato production.

Table 3. Average Potential of Agricultural Waste for 5 Years in the Form of Dry Matter

Regency	Food Waste Potential (BK/TON)						Total
	Rice	Corn	Soy Bean	Beans	Cassava	Sweet Potato	
Cirebon	5,452.71	1,322.05	18.95	60.51	1.61	7.05	6,862.87
Ciamis	7,223.40	3,356.84	170.13	182.35	196.52	9.98	11,139.22
Indramayu	20,963.97	1,560.27	1,108.95	26.04	7.19	0.38	23,666.80
Majalengka	11,962.19	8,016.93	159.40	100.90	17.31	23.32	20,280.07

Source: BPS Data (2016-2020)

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The most potential forage source is rice straw (in Table 3). According to the opinion of Perwitasari et al. (2021) and Saputra (2016), rice straw is better accessible for animal feed. Farmers choose rice straw for the following reasons: 1) it is easy to access, 2) cheap, and 3) it is available in large quantities, which can be stored for later use. Rice straw has the highest carrying capacity compared to other food crop wastes. Rice straw is available annually and can be used as a substitute for grass forage. Rice straw is high in fiber but has low nutritional value. Therefore, a production processing system is still needed (Adinata et al., 2012; Salendua et al., 2018; Suhaema, 2014).

Table 4. Potential Forage Availability and Carrying Capacity Index for Beef Cattle Development

No	Sub-district	Total Availability of Forage Agricultural Waste (DM)	CC	Ruminant Livestock Population (AU)	CCI	CA	LSC
	Cirebon Regency						
1	Ciledug	4,680.25	2,557.51	1,027.28	2.49	2,557.51	1,530.23
2	Pabedilan	9,403.76	5,138.67	1,043.47	4.92	5,138.67	4,095.20
3	Babakan	11,625.26	6,352.60	1,480.38	4.29	6,352.60	4,872.23
4	Sedong	4,371.29	2,388.68	889.82	2.68	2,388.68	1,498.86
5	Palimanan	3,976.45	2,172.93	640.35	3.39	2,172.93	1,532.58
6	Gunung Jati	2,097.19	1,146.00	518.71	2.21	1,146.00	627.29
7	Kaliwedi	6,760.99	3,694.53	615.94	6.00	3,694.53	3,078.60
	Ciamis Regency						
8	Banjarsari	10,434.54	5,701.94	1,060.68	5.38	5,701.94	4,641.25
9	Lakbok	11,556.70	6,315.14	701.86	9.00	6,315.14	5,613.28
10	Cijeungjing	4,070.35	2,224.24	758.91	2.93	2,224.24	1,465.33
11	Cisaga	5,556.23	3,036.19	812.70	3.74	3,036.19	2,223.49
12	Tambaksari	12,873.42	7,034.65	2,831.70	2.48	7,034.65	4,202.96
13	Rajadesa	6,494.09	3,548.68	1,169.74	3.03	3,548.68	2,378.94
14	Cikoneng	3,833.99	2,095.08	857.03	2.44	2,095.08	1,238.05
15	Sadananya	3,481.26	1,902.33	335.14	5.68	1,902.33	1,567.19
16	Baregbeg	3,508.74	1,917.34	433.56	4.42	1,917.34	1,483.79
17	Sukamantri	4,875.28	2,664.08	1,124.27	2.37	2,664.08	1,539.81
	Majalengka Regency						
18	Majalengka	32,913.50	17,985.52	8,408.79	2.14	13,037.42	4,628.63
	Indramayu Regency						
19	Haurgeulis	16,219.99	8,863.38	260.15	34.07	9,965.09	9,704.94
20	Gantar	42,142.82	23,028.87	5,243.29	4.39	28,308.96	23,065.67
21	Gabuswetan	20,312.60	11,099.78	555.19	19.99	12,501.16	11,945.97
22	Cikedung	23,710.01	12,956.29	5,594.00	2.32	21,450.75	15,856.74
23	Terisi	38,051.01	20,792.90	2,404.42	8.65	25,921.06	23,516.64
24	Bangodua	12,637.88	6,905.94	401.47	17.20	7,155.80	6,754.33
25	Kertasemaya	11,480.03	6,273.24	423.91	14.80	6,799.72	6,375.81
26	Kedokanbunder	7,688.53	4,201.38	433.59	9.69	4,990.82	4,557.23
27	Juntinyuat	14,639.76	7,999.87	366.96	21.80	8,211.84	7,844.88
28	Suyeg	15,886.04	8,680.90	1,920.10	4.52	9,407.82	7,487.72
29	Sindang	6,757.27	3,692.50	210.34	17.55	5,439.90	5,229.56
30	Patroli	10,241.00	5,596.17	400.87	13.96	5,711.79	5,310.92

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Source: BPS Data (2016 - 2020)
Information:
DM : Potential agricultural waste of critical materials
AAF : Adult animal feed (1,83 ton/AU)
CC : Carrying capacity = DM divided by adult animal feed (AAF = 1,83 ton/AU)
CCI : Carrying capacity index = DM divided by adult animal feed multiplied by the population
CA : Livestock capacity
LSC : Increased capacity

Farmers in Indonesia, especially smallholder farms, generally use agricultural waste as the primary feed component because of its availability throughout the year. However, meeting the needs of ruminants from crop waste alone has not met the needs of livestock bodies. Therefore, it is necessary to use agricultural waste processing technology through physical, chemical, and biological treatment with the help of microbes (Agus, 2015). As rice straw has a low nutritional content, it is necessary to apply technology, such as silage technology to increase its nutritional content. Many beef cattle farmers in West Java province have not been familiar with this technology.

Table 4 shows that the potential for forage production derived from agricultural waste, especially in the "basis" area of beef cattle found in Cirebon Regency is in Ciledug, Pabedilan, Babakan, Sedong, Palimanan, Gunung Jati, and Kaliwedi sub-districts. Forage production potential ranges from 2,097.19 – 11,625.26 BK tons/year, and livestock capacity (CC) of 1,146 – 6,352 AU. The potential forage production capacity, when compared to the average livestock population forecasting (2021-2025) ranges from 518.71 – 1480.38 AU, can increase the livestock population (LSC) by 627.29 – 4,872.23 AU or range from 17.31 – 79.99% (Table 4).

Forage production potential ranges from 3,481.26 – 12,873.42 BK tons/year and can accommodate livestock capacity (CC) of 1,146 – 6,352 AU. Comparing the average livestock population forecasting, the potential forage production capacity is (2021-2025) ranging from 288.26 – 3006.35 AU. It can still increase the livestock population, which is (LSC) ranging from 1,238.05 – 5,613.28 AU or ranging from 34.56 – 88.53% (Table 4). The potential region for forage production derived from agricultural waste, especially in the basis area of beef cattle is found at the Majalengka Regency, which is in the Majalengka sub-district. Forage production potential is 32,905.50 DM tons/year, with livestock capacity (CC) of 17,981.15 AU. The potential forage production capacity, compared to the forecast of the average livestock population (2021-2025) ranging from 8,450.18 AU, can still increase the livestock population (LSC) by 9,576: 73 AU or about 11.76 % (Table 4).

Indramayu Regency produces the most rice and soybean production. The highest corn and sweet potato production is in Majalengka Regency, and the type of corn produced is hybrid corn. In contrast, sweet corn is produced in Cirebon Regency in the eastern region. The most production of cassava is in Ciamis Regency. Potential forage assessment is not only based on the production and area of natural and cultivated grassland, but also on rice, corn, beans, and sweet potatoes in farmland, fields, and mixed gardens (Widiati et al., 2017). Agricultural waste, especially in crop-based areas can support the development of beef cattle farming businesses. It can overcome feed shortages and integrate livestock and agricultural production supported by the use of available and user-friendly technology. Areas that show the potential of forage availability for beef cattle, especially from

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agricultural waste, by using technology, will turn the waste into high-quality animal feed at a reasonably affordable production cost (Parmawati et al., 2018).

The potential availability of agricultural waste production for beef cattle feed can be calculated based on dry matter. Furthermore, the forage needs of adult beef cattle feed are also converted into dry matter so that the potential carrying capacity for developing beef cattle farming can be calculated (Santoso and Prasetiyono, 2020). Forage feed is essential for ruminants' growth, especially beef cattle because these cattle are herbivorous animals or forage consumers. Forage from field grass, rice straw, and corn straw are used as sources of fiber, while legumes are a cheap source of protein for livestock (Salendua et al., 2018). Smallholder farmers in Java generally own two to four cows and integrate complementary crop and livestock production where livestock produce fertilizer to fertilize agricultural land, and agriculture produces waste that cannot be used by humans but can be used as animal feed (Priyanti et al., 2012; Widiati and Widi, 2016).

The carrying capacity of forage from agricultural waste measures the availability of forage to provide sufficient feed supply according to ruminant feed requirements. However, it has several obstacles, namely: 1) low nutritional value and high crude fiber, 2) agricultural waste production is highly dependent on harvest time and is not sustainable throughout the year, 3) where to store feed (Sari et al., 2016; Rauf and Rasbawati, 2015). Because the CCI value is > 2, it means that there are 30 sub-districts (Table 4) in the study location in the safe category. The area can provide the availability of forage feed from agricultural waste products for the needs of adult livestock. This area is very suitable for developing a ruminant livestock business. The advantage received by areas with this safe category is that the availability of forage from agricultural waste for farmers can reduce the cost of producing ruminant animal feed (Santoso and Prasetiyono, 2020). However, in reality, not all farmers are willing to use agricultural waste for animal feed due to time constraints, storage, and different harvest seasons, so farmers have to look for the waste in other areas (Suwignyo et al., 2021).

Based on land cover maps, utilizing forest land, shrubs, and vacant land for planting forage for animal feed (superior grass) in the region is suggested. Forage management and selection of certain types of forage and strategies to increase forage production require innovative facilitation and training for stockbreeders and farmers to increase their knowledge. This effort should be supported by the government and private companies that develop programs on the importance of forage in increasing ruminant production (Muhakka et al., 2019). Land use and crop integration in Java Island are needed to develop beef cattle adopt appropriate technology with fermentation processes and produce legume plants that have high protein feed as additional sources of protein feed (Agus and Widi, 2018). To increase the growth rate of the beef cattle population through artificial insemination (IB) programs, it is necessary to adopt animal feed manufacturing technology, protect and utilize productive agricultural lands (Arifin et al., 2017).

CONCLUSION AND SUGGESTION

The calculated THI in the four study districts was between 76.48 and 79.27, indicating that the environment was under heat or the livestock were moderately stressed. This requires improvements in housing management and the selection of animals resistant to tropical temperatures. Geographical conditions that allow land use for agricultural crop production can utilize agricultural waste for animal feed, meaning that the waste must be pre-treated. In the study sites, forests, vacant

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land, and shrubs can be used as beef cattle farming sites; however, legume efforts are needed to clear the land to cultivate fodder forages by selecting superior grasses. The availability of forage feed from agricultural waste can increase the adult beef cattle population from 627.29 heads to 18,381.74 heads or 11.36% - 88.53%. The potential for development and sustainability of the beef cattle business can be identified and mapped spatially quickly and accurately through the calculation and determination of the carrying capacity of an area with the help of Geographic Information System (GIS) technology in 30 sub-districts in four districts in West Java Province.

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