

# Vegetation diversity based on peat hydrological units for supporting cattle production in West Kalimantan, Indonesia

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**Abstract.** *Setiawan D, Jayanegara A, Nahrowi, Kumalasari NR. 2024. Vegetation diversity based on peat hydrological units for supporting cattle production in West Kalimantan, Indonesia. Biodiversitas 25: 2011-2019.* This study determined the characteristics of forage supply, composition, and diversity in various West Kalimantan Peat Hydrological Units (PHU) and the capacity for livestock development. The methods used were a combination of surveys, direct observations, and measurements of samples of peat hydrological units commonly used as pasture by farmers. The results showed that the pattern of providing forage for livestock is that the majority of farmers are in the productive age category (41-60 years), the education level was only elementary school, livestock farming was only a side business (78.33-81.67%), and the mowing capacity was still above livestock feed requirements. Important Value Index (IVI) in Mempawah *Ageratum conyzoides* (32.34%), Pontianak IVI *Digitaria sanguinalis* (27.17%), Kubu Raya IVI *Cyperus brevifolius* (22.43%). The forage species diversity index (H) of the three districts in West Kalimantan was classified as moderate or high. The species Richness Indices (R) for Mempawah, Pontianak, and Kubu Raya were 5.01, 6.22, and 6.41, respectively. The carrying capacity index in Kubu Raya (2.01) and Mempawah (5.19) was included in the safety criteria because it has a CCI above 2. In conclusion, The West Kalimantan livestock population can be increased by utilizing land in rice fields, dry fields, community forests, and plantations as a source of diverse forage vegetation.

**Keywords:** Carrying capacity, forage diversity, livestock, vegetation biodiversity, West Kalimantan

## INTRODUCTION

West Kalimantan, comprising an approximate 7.53% of Indonesia's total area or 147,305 km<sup>2</sup>, ranks as the second most expansive province in the country. Peatlands in the province support various ecosystem services, including the regulation of the water cycle, provision of habitats and commodities for exploitation, and regulation of biodiversity (Rahajoe et al. 2016). Tropical peatlands are receiving growing attention due to their increasingly recognized role in the global greenhouse gas exchange, carbon cycle, paleoecology, hydrological interactions and maintenance of biological diversity (Householder et al. 2012). Peatlands are rich in biodiversity due to the favorable conditions for plant and animal life. Additionally, a wide array of species of biodiversity thrives there due to the year-round presence of sunlight. West Kalimantan is situated in the western region of Borneo, which is subdivided into numerous Peat Hydrological Units (PHU). These PHUs possess considerable vegetation diversity potential due to the fact that residential land use constitutes a mere 1.53% of the total area (BPS-Statistics of Kalimantan Barat Province 2022). This potential can be utilized to support the cultivation of ruminant livestock. West Kalimantan had a cattle population of 158,938 in 2022, producing 5,404 tons of beef per year, contributing 6.7% of West Kalimantan's total meat

consumption of 80,075 tons (BPS-Statistics of Kalimantan Barat Province 2022). This condition has yet to achieve beef self-sufficiency in West Kalimantan, even though the new meat consumption is 8.84 kg-1capita-1 year-1. The ruminant livestock population in West Kalimantan has a low productivity. Still, it needs to meet the consumption needs of West Kalimantan's population of 5.5 million people, which continues to increase yearly. One of the causes of the low livestock productivity in West Kalimantan is the unsatisfactory demand for green fodder. The success of the ruminant livestock development business must be distinct from the availability of forage in terms of quality, quantity, and continuity because forage is the primary livestock feed source and affects livestock productivity (Suharlina et al. 2016). However, in reality, the availability of forage for ruminants must be increased in terms of quantity, quality, and continuity. Many interrelated factors, including recurrent droughts, restrictions on livestock mobility, rangeland degradation, overgrazing, land ownership, land use changes, resource use conflicts, land encroachments, invasive plant species, and plant production constrain forage and feed availability systems. The chemical composition of the forage consumed also affects livestock productivity (Niderkorn and Jayanegara 2021; Yanza et al. 2021). So far, farmers only obtain forage from the sides of the road where grass and legumes grow naturally; this

resulted in competition in obtaining forage among farmers.

In recent decades, researchers have attempted to determine the effect of land use changes on the diversity and composition of plants in the Peat Hydrological Unit (PHU) Batanghari River, Mendahara, Jambi Province. The findings demonstrated that changes in land usage led to a decline in plant species. Out of the total 58 species of plants, 51-53 were found in second-growth forest areas and were absent from coffee and oil palm plantation areas. Variations in composition were also noted in the low community similarity scores (less than 50%) (Dwisutono et al. 2019). Exploration of the diversity of forage vegetation under integrated and non-integrated oil palm plantations has been carried out in South Kalimantan. The findings demonstrated that higher yields were produced by fodder forage vegetation in the oil palm integration (Rostini et al. 2020).

Previous research on vegetation diversity only focused on one location, such as the Peat Hydrology Unit (PHU) (Dwisutono et al. 2019); areas with a specific shade (Rostini et al. 2020); peat swamp forest (Susilawati et al. 2021), had not taken a more holistic approach to vegetation diversity in several areas in various Peat Hydrology Units (PHU), and the role of forage in increasing livestock production. Therefore, studies on the potential and the level of diversity of forage vegetation in various Peat Hydrological Units (PHU) in the province of West Kalimantan need to be improved. Differences in types of forage and productivity affect the region's carrying capacity in developing ruminants, hence it is necessary to study the analysis of the potential diversity of forages and their use as animal feed in supporting livestock development in West Kalimantan.

## MATERIALS AND METHODS

### Study location

This research was carried out in Anjongan, East Mempawah, Jongkat, Mempawah Sub-district, West Pontianak, East Pontianak, North Pontianak, Pontianak City, and Rasau Jaya, Kakap, Ambawang, and Kubu Raya Sub-district at West Kalimantan province from August to December 2022. The methods used were a combination of direct observations, survey and measurements on samples of peat hydrological units commonly used as pasture by farmers. Data on livestock populations were collected from relevant institutions and organizations i.e., BPS-Statistics of Kalimantan Barat Province, Department of Plantation and Livestock Security Province West Kalimantan, Department of Agriculture and Food Security Kubu Raya District, Department of Food, Agriculture and Fisheries Pontianak City, Department of Agriculture, Food Security and Fisheries Mempawah District.

### Data collection

Data from field interviews with farmers, including age, education, farming experience, livestock ownership, and livestock business status, were analyzed descriptively. Vegetation data collection techniques were used for lower-level plants (seedlings) with 20 m × 20 m observation plots and five sub-plots measuring 2 × 2 m<sup>2</sup> in the observation plots.

Identification was carried out on all types of forage in each observation plot. Forage identification was performed by placing the quadrats and vegetation in the photos' quadrants. Collections were labeled and photographs were taken of each forage type. Forage species are identified using the "Picture This" application by entering a photo of the plant into this application. Those not identified in the field were made into a herbarium and then identified in the ecology laboratory at Tanjungpura University and consulted with taxonomists.

The composition of forage species was evaluated based on the diversity index, important value index, dominance index, evenness index, and species richness index.

### Important Value Index (IVI)

Important Value Index (IVI) was used to determine the species composition and dominance in a community. IVI refers to calculations quoted from Soerianegara and Indrawan (2016): Importance Value Index (IVI) = RD + RF (for seedlings, saplings, and non-tree plants).

### Diversity Index (H')

The Shannon-Wiener's diversity index is a method to quantify diversity within ecological communities, including forage diversity. This index incorporates the richness and evenness of forage species and is a useful parameter for determining species diversity.

$$H' = \sum_{i=1}^n \left[ \frac{n_i}{N} \ln \frac{n_i}{N} \right]$$

Where:

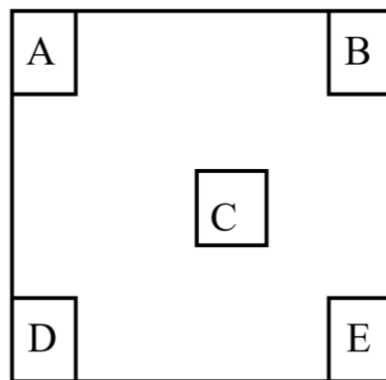
H' : Shannon-Wiener Diversity Index

s : Number of types

n<sub>i</sub> : Density of the i-th kind

N : Total density

There are three criteria for index analysis diversity of species, namely if the value of H' < 2, included in the low category, the value of 2 < H' in the medium group; if H' > 3, high category (Magurran 1998).



**Figure 1.** Design an observation plot measuring 20 x 20 m<sup>2</sup> with 5 observation sub plots 2 x 2 m<sup>2</sup>

### Dominance Index

The dominance index is a metric used in ecology to quantify the degree to which a particular species dominates within a community or ecosystem. It measures the relative abundance or contribution of a dominant species compared to others. The dominance index is used to determine species dominance in the community by using the following equation:

$$C = \sum \left( \frac{N_i}{N} \right)^2$$

Where:

- C : Dominance Index  
 N<sub>i</sub> : IVI of each type  
 N : Total IVI of all types

### Evenness Index (E)

The evenness index is a measure used in ecology to assess the relative distribution of individuals among different species within a community. It quantifies how evenly the abundance or presence of species is distributed in an ecosystem, whether the species in a community are represented fairly equally or if one or a few species dominate the community. A high evenness index indicates a more balanced distribution of individuals among species. In contrast, a low evenness index suggests that one or a few species are much more abundant than others.

$$R = \frac{H'}{\ln(S)}$$

Where:

- E : Evenness Index of species  
 H' : Species diversity index  
 S : Number of types

Based on Magurran (1998), the magnitude of  $E < 0.3$  showed a low evenness of species,  $0.3 < E < 0.6$  shows the level of evenness of species is classified as moderate, and  $E > 0.6$  indicates the evenness of species relatively high.

### Margalef Species Richness Index (R)

The Margalef Index was used to determine species richness (Magurran 1998).

$$R = \frac{S - 1}{\ln(N)}$$

Where:

- R : Margalef Species Richness Index  
 S : Number of types  
 N : Total Number of individuals

Based on Magurran (1998), the magnitude of  $R < 3.5$  indicates low species richness,  $3.5 < R < 5.0$  indicates moderate species richness, and  $R > 5.0$  indicates high species richness.

### Carrying capacity

Carrying capacity was analyzed by comparing forage production to available livestock, resulting in a ratio indicating the number of livestock that could be developed in the study area. There are three potential ratios:  $AUp/AUt < 1$  indicates that there are more animals than

there is feed available;  $AUp/AUt = 1$  indicates that there is a balance between the quantity of forage and the number of animals; and  $AUp/AUt > 1$  indicates that there are fewer animals than there is feed in the pasture. The animal units  $AUt$  and  $AU$ , which stand for animal units for feed and livestock, respectively, are the equivalent of an animal unit  $AUp$  (Kleden et al. 2015).

## RESULTS AND DISCUSSION

### General condition of livestock population in West Kalimantan Province, Indonesia

West Kalimantan is the area traversed by the equator; geographically, it is situated between latitudes  $2^{\circ}08' N$ - $3^{\circ}05' S$  and longitude  $108^{\circ}0' E$ - $114^{\circ}10' W$ . West Kalimantan is bordered north by Sarawak Malaysia, east by East Kalimantan and Central Kalimantan, west by the Karimata Strait and Natuna Sea, and south by the Java Sea. The area of West Kalimantan is  $147,305 \text{ km}^2$ , located at an altitude of 0-600 m above sea level, with a population of 5,541,376 people. West Kalimantan is a lowland, slightly hilly area stretching west to east along the Kapuas River Valley, the Natuna Sea, and Karimata Strait, along swampy plains mixed with peat (BPS-Statistics of Kalimantan Barat Province 2022).

The West Kalimantan region has diverse environmental conditions regarding temperature, humidity and rainfall (Table 1). Environmental factors such as temperature, humidity, and rainfall can affect forage productivity. The research area, situated in various districts within peat hydrological divisions, has the potential to foster the growth of the livestock sector, particularly ruminant livestock, which could serve as an economic driver for the community. Forage land that possesses the capacity to yield forage consists of community forests, paddy fields, plantations, and fields.

The types of livestock maintained at the research location were beef cattle, dairy cattle, goats, and sheep. The ruminant livestock mostly kept in the Kubu Raya District are beef cattle and goats, with 14,057 and 31,088 heads, respectively. The number of livestock populations at the research location is shown in Table 2.

**Table 1.** Environmental condition of the research area in West Kalimantan Province, Indonesia

Region	Temperature	Humidity	Rainfall
Mempawah District	25-32	46-93	151-304
Pontianak City	22-34	46-95	161-309
Kubu Raya District	22-34	45-97	140-473

**Table 2.** Livestock population by region in West Kalimantan Province, Indonesia

Region	Beef cattle	Dairy cattle	Goat	Sheep
Pontianak	2,416	-	1,843	67
Mempawah	10,947	-	16,822	-
Kubu Raya	14,057	168	31,088	84

### Socioeconomic characteristics of respondents

As presented in Table 3, in the three research areas, around 41.67-63.33% of respondents were in the productive age category (41-60 years), followed by the age group of 25-40 years. This result agrees with the above 40 years reported in Ogun State of Nigeria mean age farming community (Ettu et al. 2016). According to Widiati and Widi (2016) the age characteristics of cattle farms in Yogyakarta are 45-52 years. The farmer's age is synonymous with the level of productivity, especially in the development of livestock businesses. Farmers over 60 have entered an unproductive age, so their mowing capacity has decreased. The productive age of farming ranges from 15-54 years old, and farmers over 60 have difficulty accepting technology transfers for business development (Birhan and Adugna 2014).

The education level of the majority of farmers is only at the elementary school level in Kubu Raya District at 60% and Pontianak City at 46.67%. The level of education in this study is better than that of farmers in the Oromiya and Amhara regions who do not go to school 30.81% (Adnew et al. 2018). Mempawah District has a junior high school education level of 40%, better than Kubu Raya District and Pontianak City. In this study, the education of farmers was classified as low, resulting in limited knowledge, skills, and information in managing their livestock. The low education level of farmers hurts their ability to adopt technology and the mindset of the community in development. Based on livestock ownership, 90.00-91.67% of farmers in Kubu Raya District, Pontianak City, and Mempawah District

place the farmers as owners, while only 8.33-10.00% are farm workers.

This study has a high percentage of livestock ownership because livestock is a saving used to meet family needs and fill spare time. Meanwhile, based on farming experience, 40.00-60% of farmers in Kubu Raya District, Pontianak City, and Mempawah District dominantly have farming experience for 3-10 years, and 5.00-16.67% say they have been raising livestock for less than two years. This study is similar to Adnew et al. (2018) based on the length of farming; 39.5% of farmers have farming experience for 6-10 years, and 37.2% said they have been farming for 11-20 years. This is possible because farmers prefer raising livestock that can be sold anytime.

### Vegetation analysis of forage

The relative frequency of forage vegetation in Mempawah District showed that *Ageratum conyzoides* (12.61%) in East Mempawah and *Cyperus rotundus* (10.83%) in Jongkat and *Paspalum conjugatum* (8.97%) in Anjongan produced a high relative frequency (Table 4). The Pontianak City area produces forage vegetation with a high relative frequency of *Digitaria sanguinalis* (12.43%) in West Pontianak, *Asystasia gangetica* (8.63%) in East Pontianak and *Micania cordifolia* (9.25%) in North Pontianak (Table 5). Furthermore, the Kubu Raya District area produces forage vegetation with a high relative frequency of *Spermatocoe alata* (8.75%) in Kakap, *Cyperus brevifolius* (9.24%) in Ambawang and *Micania micrantha* (8.62%) in Rasau Jaya (Table 6).

**Table 3.** Socioeconomic characteristics of farmers by region and Peat Hydrological Units (PHU) in West Kalimantan Province, Indonesia

Variables	Kubu Raya District				Pontianak City				Mempawah District			
	RJ	K	A	Average	WP	EP	NP	Average	A	J	EM	Average
Percentages (%)												
Ages of respondents (years old)												
25-40	20	10	25	18.33	20	30	20	23.33	10	30	65	35.00
41-60	65	65	40	56.67	80	60	50	63.33	55	45	25	41.67
>61	15	25	35	25.00	0	10	30	13.33	35	25	10	23.33
Education level of the respondents												
No school	5	5	10	6.67	15	0	0	15.00	0	15	5	6.67
Elementary school	60	75	45	60.00	70	25	45	46.67	35	30	30	31.67
Junior high school	25	10	20	18.33	5	45	30	26.67	45	30	45	40.00
Senior high school	15	10	25	16.67	10	30	10	16.67	20	15	20	18.33
Collage	20	0	0	20.00	0	0	15	15.00	0	10	0	10.00
Ownership status												
Owner	90	90	90	90.00	95	90	90	91.67	90	85	95	90.00
Farm worker	10	10	10	10.00	5	10	10	8.33	10	15	5	10.00
Farming experience												
<2	5	35	10	16.67	0	10	5	5.00	15	5	15	11.67
3-10	25	45	50	40.00	70	55	55	60.00	45	40	40	41.67
11-20	35	10	15	20.00	10	25	30	21.67	30	30	30	30.00
>20	35	10	25	23.33	20	10	15	15.00	10	25	15	16.67
Livestock business status												
Side business	70	90	75	80.00	90	85	60	78.33	80	75	90	81.67
Main business	25	10	25	20.00	10	15	40	21.67	20	25	10	18.33

Note: RJ: Rasau Jaya; K: Kakap; A: Ambawang; WP: West Pontianak; EP: East Pontianak; NP: North Pontianak; A: Anjongan; J: Jongkat; EM: East Mempawah

The highest relative frequency was observed in *Ageratum conyzoides* (12.61%); when the research was carried out, *Ageratum conyzoides* was evenly distributed in each plot and was found in large numbers, so it had a relatively high frequency in the Mempawah area. *Ageratum conyzoides* is a fast-growing forage species that dominates other plants and can live on agricultural land, plantations, and open areas. Likewise, *Digitaria sanguinalis* (12.43%) in Pontianak City has a relatively high frequency because it is a commonly found type of weed. This grass inhabits various habitats, including agricultural lands, gardens, fields, and roadsides.

The relative density in Mempawah District showed that *Ageratum conyzoides* (19.73%) in East Mempawah, *Paspalum conjugatum* (17.26%) in Anjongan and *Cyperus rotundus* (16.47%) in Jongkat produced a high relative density. The Pontianak City area produces forage vegetation with a high relative density of *Paspalum conjugatum* (15.08%) in East Pontianak, *Digitaria sanguinalis* (14.74%) in West Pontianak, *Panicum maximum* (10.75%) in North Pontianak. Furthermore, the Kubu Raya District area produces forage vegetation with a high relative density of *Digitaria sanguinalis* (20.62%) in Ambawang, *Spermatocoe alata* (9.70%) in Kakap and *Brachiaria mutica* (9.06%) in Rasau Jaya. According to field research's result, *Digitaria sanguinalis* is a grass species widespread in almost all research plots, although its occurrence in each plot is only sometimes high. *Digitaria sanguinalis* is a grass variety that cattle rarely like if other grass is available.

Table 4 shows the Important Value Index (IVI) in Mempawah District, IVI values in East Mempawah sub-district *Ageratum conyzoides* (32.34%), Jongkat sub-district *Cyperus rotundus* (27.30%), Anjongan sub-district *Paspalum conjugatum* (26.23%). Pontianak City IVI values in West Pontianak Sub-district *Digitaria sanguinalis* (27.17%), East Pontianak Sub-district *Paspalum conjugatum* (27.17%), North Pontianak Sub-district *Panicum maximum* (17.11%) (Table 4). Kubu Raya District IVI values in Kakap Sub-district *Spermatocoe alata* (18.45%), Ambawang Sub-district *Digitaria sanguinalis* (29.32%), Rasau Jaya *Cyperus brevifolius* (13.20%) (Table 4). Rostini et al. (2020) reported that the highest value index for forage vegetation in South Kalimantan was IVI *Paspalum conjugatum* (60.80%), followed by *Axonopus compressus* (7.55%), *Ageratum conyzoides* (4.49%); this study revealed the order was different after *Ageratum conyzoides* (32.34%) which had the highest IVI followed by *Paspalum conjugatum* (26.23%) *Digitaria sanguinalis* (27.17%), and others. Based on IVI, grasslands in West Timor were dominated by *Euphorbia hirta*, *Eleusine indica* and *Cyperus rotundus* (Gaol 2023). Different results from research on the diversity of tropical dry forest vegetation in Tenabo, Campeche, Mexico, found that the highest IVI scores were *Neomillspaughia emarginata*, *Gymnopodium floribundum*, *Harvardia albicans*, *Caesalpinia gaumeri*, and *Lysiloma latisiliquum* (Albores-Moreno et al. 2020). Based on the results of the analysis of forage vegetation found in various peat hydrological unit locations, research has shown that the highest IVI was found in the East Mempawah Sub-district, Mempawah District (*Ageratum conyzoides* 32.34%). A high IVI value indicates that the species has good adaptability, competition, and reproduction compared with

other species in the same area. Differences in the IVI between research locations are related to different climatic conditions and environmental biophysical factors (Benítez-Malvido et al. 2020). The high IVI value in East Mempawah Sub-district shows that the vegetation is dominant and can adapt to the local area. Natural factors and human intervention can cause the diversity of forage vegetation types on peatlands in West Kalimantan. Diversity can be created by introducing species of grass and legumes that are able to adapt to the peatlands at the research location e.g: *Panicum* sp., *Setaria* sp., *Brachiaria* sp., *Leersia hexandra*, *Paspalum* sp., *Leucaena leucocephala*, *Centrosema pubescens*, *Indigofera zollingeriana*, *Clitoria ternatea*. Competition between forage species is also one of the factors that cause differences in the number and variety of species found (Nampanzira et al. 2015).

According to the relative frequency of forage vegetation in Mempawah District, the following species produced a high relative frequency: *Ageratum conyzoides* (12.61%) in East Mempawah, *Cyperus rotundus* (10.83%) in Jongkat, and *Paspalum conjugatum* (8.97%) in Anjongan. The forage vegetation in the Pontianak City area is characterized by the presence of specific species: *Micania cordifolia* (9.25%) in North Pontianak, *Digitaria sanguinalis* (12.43%) in West Pontianak, and *Asystasia gangetica* (8.63%) in East Pontianak. In addition, the Kubu Raya District exhibits a notable abundance of forage vegetation, including *Cyperus brevifolius* (9.24 percent) in Ambawang, *Spermatocoe alata* (8.75 percent) in Kakap, *Micania micrantha* (8.62 percent) in Rasau Jaya.

#### Forage diversity analysis

Analysis of forage species diversity in three regions of West Kalimantan revealed the differences in the structure of forage vegetation in these communities (Table 7). The forage species Diversity Index (H) of the three districts in West Kalimantan was classified as moderate to high. Mempawah District has a moderate diversity value ranging from 2.40-2.96, and Pontianak City has a high diversity value ranging from 3.27-3.66.

Kubu Raya District has a high diversity value ranging from 3.02-3.37. The diversity value  $H' < 2.0$  is low, the diversity value  $2.0 < H' < 3.0$  is classified as medium, and the diversity is high if  $H' > 3.0$  (Magurran 1988). This study's diversity index was higher than Yoshihara et al. (2014) in the improved semi-natural pasture, it was 2.23 on average, in the partially improved semi-natural pasture, 2.14 in that one, and 1.07 in the semi-natural pasture. The  $H'$  value describes the number of species composition in a community with similar characteristics and adaptability.

The species Evenness Index (E) of Mempawah District, Pontianak City, and Kubu Raya District are 0.77, 0.82, and 0.82, which means that the forage species in the three locations are high with  $E > 0.6$ ; therefore, in Mempawah District, Pontianak City and Kubu Raya District is dominated by a type of forage that grows in that area. Magurran stated that the value of evenness of species is low if  $E < 0.3$ , moderate if  $0.3 < E < 0.6$ , and high if  $E > 0.6$ . This study's high species evenness index indicates the dominance of forage growing in an ecosystem.

**Table 4.** Dominance of diversity of forage types in Mempawah District, Pontianak City, and Kubu Raya District of West Kalimantan Province, Indonesia

Location & Scientific name	No. of individuals	RF	RD	IVI
<b>Mempawah District</b>				
<b>East Mempawah</b>				
<i>Ageratum conyzoides</i>	357	12.61	19.73	32.34
<i>Spermatocoe alata</i>	235	10.92	12.99	23.91
<i>Aleta</i>	224	8.40	12.38	20.79
<i>Desmodium triflorum</i>	178	7.56	9.84	17.40
<i>Phyllanthus urinaria</i>	37	5.04	2.05	7.09
<i>Salvia plebeia</i>	45	4.20	2.49	6.69
<i>Panicum repens</i>	59	3.36	3.26	6.62
<i>Commelina diffusa</i>	63	2.52	3.48	6.00
<i>Asystasia gangetica</i>	39	3.36	2.16	5.52
<i>Wedelia trilobata</i>	60	1.68	3.32	5.00
<b>Jongkat</b>				
<i>Cyperus rotundus</i>	328	10.83	16.47	27.30
<i>Digitaria sanguinalis</i>	248	10.00	12.45	22.45
<i>Paspalum scrobiculatum</i>	222	10.00	11.14	21.14
<i>Ischaemum aristatum</i>	160	12.50	8.03	20.53
<i>Setaria verticillata</i>	193	10.83	9.69	20.52
<i>Cyperus brevifolius</i>	67	5.00	3.36	8.36
<i>Echinacea purpurea</i>	73	2.50	3.66	6.16
<i>Carex pendula</i>	20	2.50	1.00	6.04
<i>Microstegium vimineum</i>	57	1.67	2.86	4.53
<i>Spermacoe alata</i>	20	2.50	1.00	3.50
<b>Anjongan</b>				
<i>Paspalum conjugatum</i>	469	8.97	17.26	26.23
<i>Ischaemum aristatum</i>	429	10.34	15.79	26.13
<i>Asystasia gangetica</i>	273	11.72	10.05	21.77
<i>Spermatocoe alata</i>	255	8.28	9.39	17.66
<i>Cyperus brevifolius</i>	195	6.21	7.18	13.38
<i>Panicum repens</i>	173	4.83	6.37	11.19
<i>Ottlochloa nodosa</i>	168	3.45	6.18	9.63
<i>Desmodium triflorum</i>	58	5.52	2.13	7.65
<i>Dicranopteris linearis</i>	50	3.45	1.84	5.29
<i>Desmodium triflorum</i>	81	1.38	2.98	4.36
<b>Pontianak City</b>				
<b>West Pontianak</b>				
<i>Setaria verticillata</i>	109	2.82	4.93	7.75
<i>Digitaria sanguinalis</i>	326	12.43	14.74	27.17
<i>Asystasia gangetica</i>	171	10.73	7.73	18.47
<i>Spermatocoe alata</i>	107	4.52	4.84	9.36
<i>Cyperus brevifolius</i>	105	3.95	4.75	8.70
<i>Paspalum conjugatum</i>	225	3.95	10.18	14.13
<i>Torenia crustacea</i>	94	1.13	4.25	5.38
<i>Brachypodium sylvaticum</i>	90	1.13	4.07	5.20
<i>Oxalis barrelieri</i>	88	1.69	3.98	5.68
<i>Phyllanthus niruri</i>	79	5.08	3.57	8.66
<b>East Pontianak</b>				
<i>Imperata cylindrica</i>	107	3.55	4.52	8.07
<i>Mikania micrantha</i>	82	5.58	3.46	9.05
<i>Asystasia gangetica</i>	128	8.63	5.41	14.03
<i>Paspalum conjugatum</i>	357	6.09	15.08	21.17
<i>Torenia crustacea</i>	97	2.54	4.10	6.63
<i>Cayratia trifolia</i>	74	2.03	3.13	5.16
<i>Setaria verticillata</i>	109	2.54	4.60	7.14
<i>Cyperus brevifolius</i>	175	5.08	7.39	12.47
<i>Paspalum dilatatum</i>	81	1.52	3.42	4.94
<i>Digitaria sanguinalis</i>	145	3.05	6.12	9.17

<b>North Pontianak</b>				
<i>Asystasia gangetica</i>	96	6.36	4.41	10.77
<i>Spermatocoe alata</i>	95	4.05	4.36	8.41
<i>Panicum repens</i>	178	5.20	8.18	13.38
<i>Micania cordifolia</i>	106	9.25	4.87	14.12
<i>Panicum maximum</i>	234	6.36	10.75	17.11
<i>Paspalum conjugatum</i>	170	5.20	7.81	13.01
<i>Digitaria sanguinalis</i>	106	2.31	4.87	7.18
<i>Centrocema pubescent</i>	82	1.16	3.77	4.92
<i>Phyllanthus niruri</i>	66	3.47	3.03	6.50
<i>Axonopus compressus</i>	56	1.16	2.57	3.73
<b>Kubu Raya District</b>				
<b>Kakap</b>				
<i>Asystasia gangetica</i>	111	3.75	5.05	8.80
<i>Microstegium vimineum</i>	77	1.88	3.50	5.38
<i>Spermatocoe alata</i>	213	8.75	9.70	18.45
<i>Paspalum conjugatum</i>	213	5.63	9.70	15.32
<i>Cyperus esculentus</i>	109	3.75	4.96	8.71
<i>Phyllanthus niruri</i>	179	8.13	8.15	16.27
<i>Cavex sylvatica</i>	115	3.75	5.23	8.98
<i>Echinochloa colona</i>	137	3.13	6.24	9.36
<i>Mimosa pudica</i>	70	2.50	3.19	5.69
<i>Axonopus compressus</i>	66	1.88	3.00	4.88
<b>Ambawang</b>				
<i>Paspalum conjugatum</i>	140	3.26	5.72	8.98
<i>Cyperus brevifolius</i>	323	9.24	13.19	22.43
<i>Spermatocoe alata</i>	137	4.35	5.59	9.94
<i>Mimosa pudica</i>	101	4.35	4.12	8.47
<i>Digitaria sanguinalis</i>	505	8.70	20.62	29.32
<i>Vandellia anagallis</i>	62	1.63	2.53	4.16
<i>Cyperus brevifolius</i>	91	1.63	3.72	5.35
<i>Paspalum dilatatum</i>	59	2.72	2.41	5.13
<i>Axonopus compressus</i>	52	1.09	2.12	3.21
<i>Fimbristylis dichotoma</i>	51	1.63	2.08	3.71
<b>Rasau Jaya</b>				
<i>Vandellia anagallis</i>	143	1.72	5.47	7.19
<i>Cyperus esculentus</i>	164	4.60	6.27	10.87
<i>Asystasia gangetica</i>	101	3.45	3.86	7.31
<i>Mikania micrantha</i>	103	8.62	3.94	12.56
<i>Imperata cylindrica</i>	109	2.30	4.17	6.47
<i>Axonopus compressus</i>	96	2.87	3.67	6.54
<i>Cyperus brevifolius</i>	210	5.17	8.03	13.20
<i>Setaria verticillata</i>	128	2.30	4.89	7.19
<i>Brachiaria mutica</i>	237	2.30	9.06	11.36
<i>Digitaria sanguinalis</i>	95	1.15	3.63	4.78

**Table 7.** Forage diversity analysis in of West Kalimantan Province, Indonesia

Regions	H'	E	C	R
<b>Mempawah District</b>				
Anjongan	2.40	0.67	0.06	4.43
Jongkat	2.96	0.83	0.08	5.13
Mempawah Timur	2.93	0.82	0.09	5.47
Average	2.76	0.77	0.08	5.01
<b>Pontianak City</b>				
Pontianak Barat	3.27	0.82	0.06	5.84
Pontianak Timur	3.50	0.81	0.04	6.31
Pontianak Utara	3.66	0.84	0.04	6.51
Average	3.48	0.82	0.05	6.22
<b>Kubu Raya District</b>				
Rasau Jaya	3.02	0.84	0.06	5.33
Kakap	3.37	0.86	0.05	6.99
Ambawang	3.32	0.77	0.08	6.93
Average	3.24	0.82	0.06	6.41

The species Richness Indices (R') for Mempawah District, Pontianak City, and Kubu Raya District were 5.01, 6.22, and 6.41, respectively. The three regions' species Richness Index (R) was classified as high; a high R' value indicates many types of forage growing. Apart from being influenced by physical and chemical factors, the diversity of forage types also influences the existence of animals and humans (Pepeta et al. 2022). Human activities in managing peatlands in West Kalimantan are innovative species that must be protected to avoid causing environmental damage. Stable biodiversity can occur due to the balance of habitat in the West Kalimantan peat hydrological unit, even though the area of green land continues to shrink.

**Mowing capacity of farmers**

An increasing livestock population will increase the amount of grass cut; this influence was modeled as a linear equation. Based on the linear model, it can be explained that the capacity of mowing grass every day in 3 locations in Mempawah District, namely Anjongan 39.29 Kg with R<sup>2</sup> of 97.76%, East Mempawah 40.77 Kg with R<sup>2</sup> of 96.67%, and Jongkat 37.12 Kg with R<sup>2</sup> of 94.01%. Grass mowing capacity in 3 locations in Pontianak City, namely West Pontianak 31.95% with R<sup>2</sup> of 96.73%, East Pontianak 29.82 Kg with R<sup>2</sup> of 96.15%, North Pontianak 32.29 Kg with R<sup>2</sup> of 97.62%. The grass mowing capacity in 3 locations in Kubu Raya District, namely Rasau Jaya 44.85 Kg with an R<sup>2</sup> of 95.15%, Snapper 35.26 Kg with an R<sup>2</sup> of 97.47%, and Ambawang 39.04 Kg with an R<sup>2</sup> of 95.15% (Figure 2). The study's mowing capacity in Pontianak City was lower than that in Mempawah District and Kubu Raya District because of the large number of residential areas, offices, and less forage land. According to Da Cunha et al. (2022), the capacity to forage grass is related to various factors, including forage availability, foraging experience, and age.

The mowing capacity of farmers in West Kalimantan is classified as above the standard forage requirement of 28.59 kg fresh AU<sup>-1</sup> day<sup>-1</sup> or 6.29 kg dry weight AU<sup>-1</sup> day<sup>-1</sup> (Nell and Rollinson 1974). Based on the ownership level, the herding capacity of livestock farmers increases along with the number of livestock (AU). Farmers in West Kalimantan raise livestock

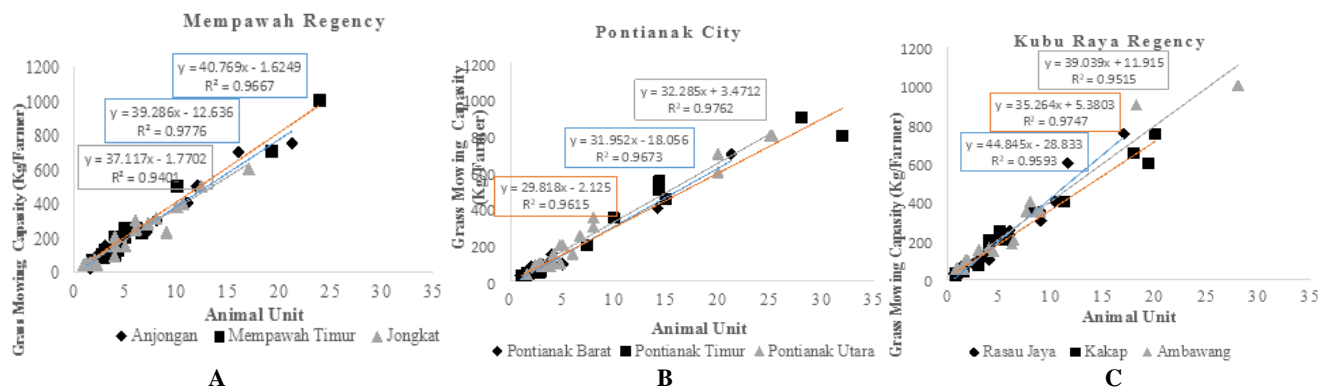
as a side business using limited time and traditional equipment. The traditional mowing system is a limiting factor in meeting livestock feed requirements (Parolo et al. 2011).

**Carrying capacity index**

The livestock carrying capacity in Mempawah District, Pontianak City, and Kubu Raya District was calculated with the approach of land potential for forage presented in Table 8. The livestock carrying capacity is calculated based on land conversion to permanent grassland, assuming that forage was obtained from paddy fields, dry fields, forest people, and plantations. The availability of forage for animal feed greatly influences the carrying capacity of ruminant livestock in West Kalimantan. Table 8 showed that Mempawah District has adequate forage production from various land sources such as paddy fields, dry fields, forest people, and plantations of 65,105.55 Ton DW/Ha/Year. Kubu Raya District can produce forage production of 22,5264.46 tons DW/ha/year. Pontianak City produces forage production of 340.91 tons/year. The Pontianak City produces lower arable land conversion value than other areas because it is an urban area, most of which is residential, and forage is obtained from paddy fields and dry fields. Thus, the potential for forage production from various arable lands will help provide cattle feed when there is a supply shortage during the dry season.

The results of the calculation of the carrying capacity of livestock are presented in Table 9. The data is obtained assuming that the forage comes from paddy fields, dry fields, Forest people, and plantations.

The forage potential in the peat hydrological unit area in Kubu Raya District and Mempawah District was included in the safe criteria because it has a carrying capacity index above 2. The results of this study are similar to those of Salendu et al. (2018) on cattle cultivation with the development of forage in coconut plantations, which produced a CCI of 2.04. The carrying capacity of land in Mempawah and Kubu Raya is still relatively high compared with the animal feed needed. Based on the land potential in these two areas, the actual population can be increased by 2.10 and 5.19 times.



**Figure 2.** Grass mowing capacity in West Kalimantan Province, Indonesia: A. Mempawah District, B. Pontianak City, and C. Kubu Raya District

**Table 8.** Conversion of arable land in Mempawah District, Pontianak City, and Kubu Raya District of West Kalimantan Province, Indonesia to permanent grasslands

Regions	Land	Land area (Ha)	Equality to permanent grasslands (Ton DW/Ha/Year)	Total (Ton DW/Ha/Year)
Mempawah District	Paddy fields	15,610.97	4,683.29	65,105.55
	Dry fields	7,255.09	1,088.26	
	Forest people	17,242	19,397.25	
	Plantation	53,249	39,936.75	
Pontianak City	Paddy fields	198.40	59.52	340.91
	Dry fields	1,875.94	281.39	
	Forest people	0	0	
	Plantation	0	0	
Kubu Raya District	Paddy fields	30,796.15	9,238.85	22,5264.46
	Dry fields	68,133.25	10,219.99	
	Forest people	66,633	74,962.13	
	Plantation	174,458	130,843.50	

**Table 9.** Carrying Capacity Index (CCI) and potential population in West Kalimantan Province, Indonesia

Regions	Mempawah	Pontianak	Kubu Raya
Carrying Capacity (AU)	28357.93	148.49	98118.11
Real Population AU)	13515.72	2695.52	18899.08
Development Potential	14842.21	-2547.03	79219.03
Population (AU)			
Carrying Capacity Index	2.1	0.06	5.19

The forage potential in the peat hydrological unit area in Pontianak City is included in the critical criteria; therefore, the ruminants have no choice but to utilize feed resources and conservation aspects must be fulfilled. In addition, Pontianak City is a densely populated area; therefore, more forage must be needed. Table 9 on the CCI showed that the two District areas in West Kalimantan could be the basis for developing livestock in these regions, but Pontianak City had insufficient foraging.

Based on our analysis, it can be inferred that the majority of farmers fall within the productive age range (41-60 years), possess a minimum education of elementary school, operate livestock farming as a supplementary enterprise, and utilize a cut-and-carry system to ensure that forage production remains sufficient to meet livestock feed requirements, with the exception of Pontianak City. The classification of the forage species Diversity Index (H) for the three districts in West Kalimantan as moderate to high was applied. The species Richness Indices (R') for Kubu Raya District, Mempawah District, and Pontianak City were, respectively, 5.01, 6.22, and 6.41. Due to their CCI values exceeding 2, the carrying capacity indexes for Kubu Raya (2.01) and Mempawah (5.19) were incorporated into the safe criteria. In summary, the livestock population in West Kalimantan may be enhanced through the utilization of land encompassing rice fields, arid fields, community forests, and plantations, which serve as valuable sources of varied forage vegetation.

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