

Ruminant Livestock Development in Kutai Kartanegara Regency Based on Feed Potential

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ABSTRACT

Feed availability is a key factor determining the development of ruminant livestock. This study aimed to quantify the potential production of forage from paddy fields, plantations, and agricultural crop residues (HHSP), determine the potential carrying capacity for increasing the ruminant livestock population (KPPTTR), and identify ruminant livestock-based areas in Kutai Kartanegara Regency. This descriptive study used secondary data from 2021 obtained from the Central Statistics Agency and the Agriculture and Livestock Office of Kutai Kartanegara Regency across 18 districts. Forage production was estimated using the Nell and Rollinson method, while carrying capacity and KPPTTR were calculated based on a dry matter requirement of 6.25 kg ST⁻¹ day⁻¹. Livestock-based areas were identified using Location Quotient (LQ) analysis. The potential forage production reached 268,113.51 Mg DM year⁻¹, consisting of 126,891.32 Mg DM year⁻¹ from agricultural crop residues, 100,349.70 Mg DM year⁻¹ from paddy fields and fallow land, and 40,872.50 Mg DM year⁻¹ from plantations. This forage resource had the capacity to support 117,529.21 animal units (AU), while the actual livestock population was 35,034.46 AU, resulting in a KPPTTR of 82,494.75 AU. Sixteen districts had positive KPPTTR values, with Tenggarong Seberang, Loa Kulu, and Muara Kaman ranking highest, whereas Samboja and Muara Wis had negative values. Eight districts were identified as ruminant livestock-based areas (LQ > 1), namely Muara Wis, Samboja, Loa Kulu, Kenohan, Tenggarong Seberang, Marang Kayu, Kota Bangun, and Muara Muntai. Kutai Kartanegara Regency still has considerable potential to increase its ruminant livestock population based on locally available feed resources.

Keywords: *Forage, KPPTTR, Kutai Kartanegara, Location Quotient, Ruminants*

INTRODUCTION

Forage is the basal feed and primary feed resource for ruminant livestock; therefore, increasing ruminant livestock production must be accompanied by an adequate supply of forage in terms of both quantity and quality (Afrizal et al. 2014). The provision of forage is constrained by land-use conversion, whereby areas previously used for forage growth are converted into settlements, food-crop fields, and industrial crops. One approach to addressing this limitation is to utilize agricultural residues and forage growing in plantation areas as feed resources for ruminant livestock (Pangestu et al. 2019).

Smallholder farmers generally continue to rely on natural grazing areas around settlements to obtain fresh forage. Under this production system, low forage productivity limits the number of livestock that can be maintained. Therefore, additional forage resources from plantation areas and food-crop fields, including agricultural crop residues, are required. Forage resources from plantations include those derived from coconut, oil palm, cocoa, and rubber plantations, while paddy fields may provide forage from fallow areas. Agricultural crop residues include rice straw, corn stover, and cassava leaves. Ruminant livestock can utilize substantial quantities of agricultural and plantation residues and can also contribute to employment opportunities when managed under more intensive production systems (Fariani and Susantina 2014).

Kutai Kartanegara Regency covers an area of 27,263.10 km² and is administratively divided into 18 districts (BPS Kutai Kartanegara Regency 2021). The region has natural resources that support the development of ruminant livestock, particularly beef cattle, buffaloes, and goats (Daru et al. 2013). Forage growing in oil palm plantations in the region has also been reported to have potential as a feed resource for beef cattle (Daru et al. 2014). At the national level, however, the growth of the ruminant livestock population has not kept pace with the number of animals slaughtered, potentially contributing to the slaughter of productive females and increasing livestock prices (Tiwow et al. 2016). Adequate forage availability in terms of both quality and quantity, together with land suitable for forage production, is an important factor supporting livestock population development programs (Delima et al. 2015).

The potential of an area for ruminant livestock development can be assessed using the potential capacity for increasing the ruminant livestock population (KPPTR), which represents the number of additional livestock that can still be supported in a given area based on the availability of forage resources. This capacity is influenced by agricultural land area, harvested area, and the existing ruminant livestock population (Prasetyo et al. 2015), while the carrying capacity of an area varies according to its specific agroecosystem (Suhaema et al. 2014). The KPPTR approach can be complemented by Location Quotient (LQ) analysis to identify livestock-based areas with development potential (Edi 2020b), as applied previously in Berau and North Penajam Paser Regencies (Nurhidayati et al. 2023; Daru et al. 2024). However, information on these aspects at the district level in Kutai Kartanegara Regency remains limited.

This study aimed to (1) quantify the potential production of forage resources derived from paddy fields, plantations, and agricultural crop residues; (2) determine the carrying capacity and potential capacity for increasing the ruminant livestock population; and (3) identify ruminant livestock-based areas for development in Kutai Kartanegara Regency.

MATERIALS AND METHODS

Study Location and Period

The study was conducted from August to November 2022 in Kutai Kartanegara Regency, East Kalimantan Province, Indonesia. The study area is located between 115°26'–117°36' E and 1°28' N–1°08' S, covering an area of 27,263.10 km² and comprising 18 districts and 225 villages/urban villages (Figure 1). The topography is predominantly undulating and hilly, with slopes ranging from gentle to steep. Flat to gently sloping areas are mainly found along the coastal zone and the Mahakam River watershed, whereas the inland and border areas are characterized by mountainous terrain with elevations ranging from 500 to 2,000 m above sea level.

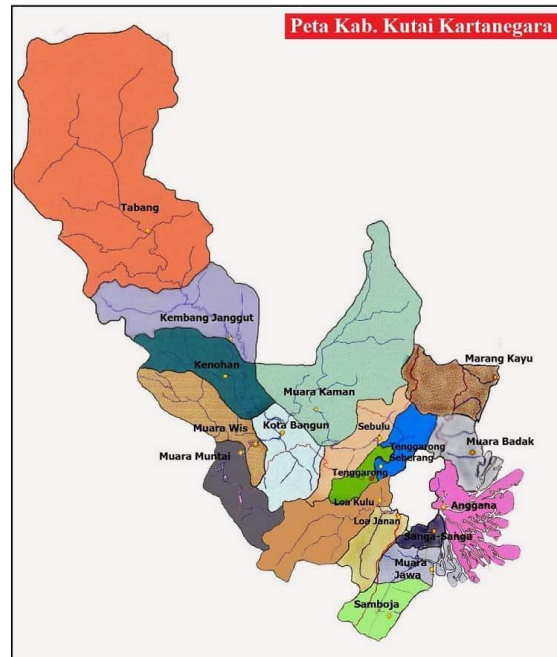


Figure 1. Peta wilayah Kabupaten Kutai Kartanegara

Types and Sources of Data

This descriptive study used secondary data for 2021 obtained from the Central Statistics Agency (Badan Pusat Statistik, BPS) of Kutai Kartanegara Regency and the Agriculture and Livestock Office of Kutai Kartanegara Regency. The data included human population, ruminant livestock population (cattle, buffaloes, and goats), harvested area of lowland and upland rice, harvested area of food crops (maize, soybean, peanut, cassava, and sweet potato), and plantation crop area (coconut, rubber, coffee, cocoa, and oil palm) for each district.

Procedures

Estimation of Forage Production Potential

The potential production of forage resources was estimated using the method of Nell and Rollinson (1974), with permanent pasture as the reference forage source and an assumed production of 15 Mg dry matter (DM) ha⁻¹ year⁻¹. The production of agricultural crop residues (HHSP) was estimated based on production and DM-content assumptions reported by the Directorate General of Livestock Services and the Faculty of Animal Science, Universitas Gadjah Mada (1982). The assumptions used are presented in Table 1. Dry matter production from each forage source was calculated as follows:

1. Lowland rice straw (Mg DM year⁻¹) = lowland rice harvested area (ha) × 3.86 Mg ha⁻¹ × 92.5%
2. Upland rice straw (Mg DM year⁻¹) = upland rice harvested area (ha) × 2.76 Mg ha⁻¹ × 92.5%
3. Fallow paddy fields and upland fields (Mg DM year⁻¹) = total rice harvested area (ha) × 20% × 15 Mg ha⁻¹
4. Plantation areas (Mg DM year⁻¹) = plantation crop area (ha) × 5% × 15 Mg ha⁻¹
5. Food-crop residues (Mg DM year⁻¹) = harvested area (ha) × assumed residue production (Mg ha⁻¹) × DM content (%)

Rice straw and food-crop residues were subsequently grouped as agricultural crop residues (HHSP), whereas fallow paddy and upland fields and plantation areas were classified as forage resource areas (SDH).

Table 1. Assumptions of forage production and conversion factors used in the study

Forage source	Assumed production (Mg ha ⁻¹ year ⁻¹)	DM content/conversion factor	Reference
Lowland rice straw	3,86	DM 92.5%	Directorate General of Livestock Services and Faculty of Animal Science, UGM (1982)
Upland rice straw	2,76	DM 92.5%	Directorate General of Livestock Services and Faculty of Animal Science, UGM (1982)
Maize straw	10,00	DM 80.3%	Directorate General of Livestock Services and Faculty of Animal Science, UGM (1982)
Cassava leaves	5,00	DM 26.0%	Directorate General of Livestock Services and Faculty of Animal Science, UGM (1982)
Sweet potato leaves	15,00	DM 20.0%	Directorate General of Livestock Services and Faculty of Animal Science, UGM (1982)
Soybean straw	3,00	DM 88.9%	Directorate General of Livestock Services and Faculty of Animal Science, UGM (1982)
Peanut leaves	4,00	DM 90.0%	Directorate General of Livestock Services and Faculty of Animal Science, UGM (1982)
Fallow paddy and upland fields	15,00	20% of rice harvested area	Nell and Rollinson (1974)
Plantation areas	15,00	5% of plantation area	Nell and Rollinson (1974)

Note: DM = dry matter; UGM = Universitas Gadjah Mada.

Carrying Capacity and Potential Capacity for Increasing the Ruminant Livestock Population

The ruminant livestock population was converted into animal units (AU) based on the Directorate General of Livestock Services (1998), using conversion factors of 1 AU for cattle and buffaloes and 0.14 AU for goats. Because age-structure data were unavailable, all livestock were considered equivalent to adult animals. The DM requirement was set at 6.25 kg AU⁻¹ day⁻¹, equivalent to 2,281.25 kg AU⁻¹ year⁻¹ (NRC 1984). Carrying capacity (CC) was calculated by comparing the total forage DM production with livestock DM requirements (Edi 2020a), while the potential capacity for increasing the ruminant livestock population (KPPTR) was calculated as the difference between carrying capacity and the existing livestock population:

$$CC \text{ (AU)} = \text{Total forage DM production (kg year}^{-1}\text{)} \div 2,281.25 \text{ (kg AU}^{-1} \text{ year}^{-1}\text{)}$$

$$KPPTR \text{ (AU)} = CC \text{ (AU)} - \text{Existing livestock population (AU)}$$

A positive KPPTR value indicates that a district still has the capacity to support additional ruminant livestock, whereas a negative value indicates that the existing livestock population exceeds the available forage resources. The districts were subsequently ranked according to their KPPTR values, from the highest to the lowest.

Data Analysis

Ruminant livestock-based areas were identified using Location Quotient (LQ) analysis (Edi 2020b; Nurhidayati et al. 2023) according to the following equation:

$$LQ = (Si/S) \div (Ni/N)$$

Where S_i = ruminant livestock population (head) in district i ; S = total human population in district i ; N_i = ruminant livestock population (head) at the regency level; and N = total human population at the regency level. An $LQ > 1$ indicates that a district is a livestock-based area whose production potential exceeds the requirements of the local population and may contribute to meeting demand in surrounding areas. An $LQ = 1$ indicates a non-base area whose livestock potential is proportionate to local requirements, whereas an $LQ < 1$ indicates a non-base area with relatively lower potential for livestock development. All data were analyzed descriptively and presented in tabular form.

RESULTS AND DISCUSSION

Ruminant Livestock Population

The ruminant livestock population in Kutai Kartanegara Regency in 2021 consisted of 30,555 cattle, 2,738 buffaloes, and 12,439 goats, equivalent to 35,034.46 animal units (AU) (Table 3). The largest cattle population was recorded in Samboja District (8,330 head), the largest buffalo population in Muara Wis District (931 head), and the largest goat population in Tenggarong Seberang District (3,619 head). The distribution of livestock populations varied considerably among districts. In terms of animal units, the largest populations were recorded in Samboja (8,865.58 AU), Loa Kulu (4,602.80 AU), and Tenggarong Seberang (3,451.66 AU).

Potential Forage Production

The total harvested rice area in Kutai Kartanegara Regency was 33,449.9 ha, consisting of 28,947.1 ha of lowland rice and 4,502.8 ha of upland rice. The total plantation area was 54,496.66 ha, dominated by oil palm (28,691.65 ha), rubber (17,686.74 ha), and coconut (7,977.02 ha). The harvested areas of food crops included maize (1,051.2 ha), cassava (801.5 ha), sweet potato (449.7 ha), peanut (312.7 ha), and soybean (30.8 ha).

The total potential forage production in Kutai Kartanegara Regency reached 268,113.51 Mg DM year⁻¹ (Table 2). The largest contribution came from rice straw, amounting to 114,851.27 Mg DM year⁻¹ (42.8%), followed by fallow paddy and upland fields at 100,349.70 Mg DM year⁻¹ (37.4%), plantations at 40,872.50 Mg DM year⁻¹ (15.2%), and food-crop residues at 12,040.05 Mg DM year⁻¹ (4.5%). Thus, agricultural crop residues (HHSP) contributed 126,891.32 Mg DM year⁻¹, equivalent to 47.3% of the total forage potential. Among the food-crop residues, maize straw contributed the largest amount (8,441.14 Mg DM year⁻¹), whereas soybean straw contributed the smallest amount (82.14 Mg DM year⁻¹).

Tenggarong Seberang had the highest forage potential (57,353.26 Mg DM year⁻¹), associated with its large harvested rice area of 8,723.9 ha, followed by Loa Kulu (35,909.02 Mg DM year⁻¹) and Muara Kaman (25,776.88 Mg DM year⁻¹). The lowest forage potentials were recorded in Sanga-Sanga (2,350.69 Mg DM year⁻¹) and Kenohan (2,498.05 Mg DM year⁻¹). The largest contribution from plantation areas was recorded in Marang Kayu (6,178.72 Mg DM year⁻¹), corresponding to its largest plantation area of 8,238.30 ha.

The dominance of rice straw as a feed resource should be accompanied by efforts to improve its nutritional quality. Rice straw is generally classified as a low-quality roughage, with crude protein content of approximately 2–6% and low digestibility associated with its relatively high lignin content (Afrizal et al. 2014). Processing methods such as fermentation can improve the utilization value of rice straw, whereas cassava leaves can serve as a protein-rich feed resource (Suwanda 2014). Plantation-derived feed resources, such as cocoa pod husks, which contain approximately 10% crude protein, may require prior processing because of their theobromine content, which can cause toxicity when they are provided as the sole feed (Afrizal et al. 2014). In addition, agricultural residue production depends on harvesting periods, resulting in seasonal availability. Drying and preserving residues during periods of high production are therefore necessary to maintain feed supplies during the dry season (Suwanda 2014).

Table 2. Potential dry matter production of forage resources by district in Kutai Kartanegara Regency (Mg DM year⁻¹)

District	Rice straw	Fallow paddy and upland fields	Plantations	Food-crop residues	Total
Samboja	5,066.18	4,256.70	4,703.25	2,422.90	16,449.03
Muara Jawa	1,730.44	1,940.40	2,925.00	56.56	6,652.40
Sanga-Sanga	1,029.49	1,100.10	168.00	53.10	2,350.69
Loa Janan	2,081.51	1,849.80	2,732.66	82.50	6,746.46
Loa Kulu	18,359.45	15,521.70	1,872.00	155.87	35,909.02
Muara Muntai	235.78	240.00	953.26	1,482.83	2,911.88
Muara Wis	1,600.31	1,413.00	433.88	-	3,447.18
Kota Bangun	6,171.12	5,274.00	2,412.38	629.86	14,487.35
Tenggarong	11,279.61	9,491.70	992.25	1,192.57	22,956.13
Sebulu	10,736.30	9,074.70	1,711.50	1,035.09	22,557.59
Tenggarong Seberang	30,080.31	26,171.70	652.12	449.13	57,353.26
Anggana	6,033.79	5,121.00	1,405.50	369.00	12,929.29
Muara Badak	858.64	817.20	5,562.00	911.63	8,149.47
Marang Kayu	859.42	722.10	6,178.72	2,146.18	9,906.42
Muara Kaman	12,834.29	10,791.30	1,471.12	680.17	25,776.88
Kenohan	847.28	711.90	743.10	195.77	2,498.05
Kembang Janggut	249.26	272.70	4,693.50	65.09	5,280.55
Tabang	4,798.08	5,579.70	1,262.25	111.80	11,751.83
Total	114,851.27	100,349.70	40,872.50	12,040.05	268,113.51

Note: Rice straw and food-crop residues constitute agricultural crop residues (HHSP). Food-crop residues include maize straw, cassava leaves, sweet potato leaves, soybean straw, and peanut leaves. Source: BPS Kutai Kartanegara Regency (2021), processed.

Carrying Capacity and Potential Capacity for Increasing the Ruminant Livestock Population

The forage potential of 268,113.51 Mg DM year⁻¹ was estimated to support 117,529.21 AU, whereas the existing livestock population was only 35,034.46 AU, equivalent to 29.8% of the estimated carrying capacity. Consequently, the KPPTR for Kutai Kartanegara Regency was 82,494.75 AU (Table 3). Sixteen districts had positive KPPTR values. The highest values were recorded in Tenggarong Seberang (21,689.50 AU), Loa Kulu (11,138.14 AU), and Muara Kaman (8,936.04 AU), followed by Sebulu (8,874.28 AU) and Tenggarong (8,740.80 AU). In contrast, negative KPPTR values were recorded in Samboja (-1,655.05 AU) and Muara Wis (-77.87 AU).

The relatively low utilization of the estimated carrying capacity indicates that forage availability was not the primary limiting factor in most districts. Livestock development is influenced by several major components, including livestock, human resources as managers, land resources as the basis for livestock production and forage supply, and supporting technologies (Fariani and Susantina 2014). Livestock development may also progress slowly when livestock production remains a secondary or supplementary livelihood activity. A similar condition was reported in North Penajam Paser Regency, where all districts were identified as having potential for ruminant livestock development based on forage carrying capacity and KPPTR (Daru et al. 2024).

The negative KPPTR values observed in Samboja and Muara Wis may be associated either with existing livestock populations exceeding the estimated forage potential or with potential forage resources that were not fully captured in the dataset. The latter possibility is plausible because the calculation did not include forage from natural grasslands, rice-field bunds, forests, dryland agricultural areas, and roadsides, which have also been identified as potential forage resources by Nell and Rollinson (1974). These two districts may therefore require additional forage supplies from surrounding districts or more intensive utilization of agricultural residues, for example through drying and storage to extend their period of use.

Table 3. Ruminant livestock population, carrying capacity, and KPPTTR by district in Kutai Kartanegara Regency

District	Cattle	Buffaloes	Goats	Existing population (AU)	CC (AU)	KPPTTR (AU)	Rank
Samboja	8,330	319	1,547	8,865.58	7,210.53	-1,655.05	18
Muara Jawa	840	15	251	890.14	2,916.12	2,025.98	11
Sanga-Sanga	341	-	130	359.20	1,030.44	671.24	14
Loa Janan	1,771	24	882	1,918.48	2,957.35	1,038.87	13
Loa Kulu	4,390	21	1,370	4,602.80	15,740.94	11,138.14	2
Muara Muntai	544	693	81	1,248.34	1,276.44	28.10	16
Muara Wis	649	931	64	1,588.96	1,511.09	-77.87	17
Kota Bangun	1,495	14	1,097	1,662.58	6,350.62	4,688.04	8
Tenggarong	1,198	20	744	1,322.16	10,062.96	8,740.80	5
Sebulu	921	36	407	1,013.98	9,888.26	8,874.28	4
Tenggarong Seberang	2,869	76	3,619	3,451.66	25,141.16	21,689.50	1
Anggana	595	37	457	695.98	5,667.64	4,971.66	6
Muara Badak	959	41	512	1,071.68	3,572.37	2,500.69	9
Marang Kayu	1,793	144	421	1,995.94	4,342.54	2,346.60	10
Muara Kaman	2,031	255	553	2,363.42	11,299.46	8,936.04	3
Kenohan	869	112	241	1,014.74	1,095.04	80.30	15
Kembang Janggut	523	-	21	525.94	2,314.76	1,788.82	12
Tabang	437	-	42	442.88	5,151.49	4,708.61	7
Total	30,555	2,738	12,439	35,034.46	117,529.21	82,494.75	

Note: AU = animal unit; CC = carrying capacity; KPPTTR = potential capacity for increasing the ruminant livestock population; ranks are based on KPPTTR values from highest to lowest. Source: Agriculture and Livestock Office of Kutai Kartanegara Regency (2021 data, unpublished) and BPS Kutai Kartanegara Regency (2021), processed.

Ruminant Livestock-Based Areas

The LQ analysis indicated that eight of the 18 districts were ruminant livestock-based areas ($LQ > 1$), namely Muara Wis (2.81), Samboja (2.43), Loa Kulu (1.77), Kenohan (1.68), Tenggarong Seberang (1.55), Marang Kayu (1.40), Kota Bangun (1.13), and Muara Muntai (1.09) (Table 4). The remaining ten districts were classified as non-base areas, with LQ values ranging from 0.30 to 0.97. The lowest value was recorded in Tenggarong (0.30), which also had the largest human population (106,553 inhabitants). Higher LQ values indicate a relatively greater concentration of a commodity within a district compared with the corresponding regional level (Edi 2020b). In livestock-based areas, ruminant livestock may contribute to household income and local economic activity; therefore, efforts to improve livestock production, productivity, and value addition can be considered in accordance with local resource conditions.

The integration of KPPTTR and LQ results provides a differentiated picture of livestock development conditions among districts. Tenggarong Seberang and Loa Kulu had both positive KPPTTR values and LQ values greater than 1, indicating the simultaneous presence of substantial forage-based capacity and a relatively high concentration of ruminant livestock. Muara Kaman, Sebulu, and Tenggarong had relatively high KPPTTR values but LQ values below 1. This combination indicates substantial estimated forage capacity relative to the existing livestock population, although these areas were not classified as livestock-based areas according to the LQ criterion. In contrast, Samboja and Muara Wis were classified as livestock-based areas but had negative KPPTTR values. In these districts, attention may therefore be directed toward increasing forage supply and improving livestock productivity rather than relying solely on population expansion. Kenohan and Muara Muntai were also classified as livestock-based areas, but their KPPTTR values were relatively small (80.30 and 28.10 AU, respectively); therefore, any increase in livestock population would need to be accompanied by additional forage resources.

The findings should be interpreted in light of several limitations. The calculations were based on secondary data from a single year and standardized production assumptions; therefore, they did not account for seasonal fluctuations in forage production, livestock age structure, or forage nutrient quality. Forage availability in Kutai Kartanegara Regency may vary annually with changes between wet and dry seasons. Periodic reassessment is therefore necessary to support more accurate livestock development planning.

Overall, Kutai Kartanegara Regency had an estimated forage potential of 268,113.51 Mg DM year⁻¹, with an estimated carrying capacity of 117,529.21 AU and an additional potential capacity of 82,494.75 AU. Eight districts were classified as ruminant livestock-based areas, while several districts—including Tenggarong Seberang, Loa Kulu, Muara Kaman, Sebulu, and Tenggarong—showed relatively high KPPTTR values and therefore represent areas with substantial estimated forage-based capacity for further ruminant livestock development.

Table 4. Location Quotient (LQ) values for ruminant livestock by district in Kutai Kartanegara Regency

District	Human population	Ruminant livestock	LQ	Category
Samboja	67,306	10,196	2.43	Base
Muara Jawa	42,001	1,106	0.42	Non-base
Sanga-Sanga	19,767	471	0.38	Non-base
Loa Janan	68,067	2,677	0.63	Non-base
Loa Kulu	52,459	5,781	1.77	Base
Muara Muntai	19,432	1,318	1.09	Base
Muara Wis	9,398	1,644	2.81	Base
Kota Bangun	36,883	2,606	1.13	Base
Tenggarong	106,553	1,962	0.30	Non-base
Sebulu	41,014	1,364	0.53	Non-base
Tenggarong Seberang	67,912	6,564	1.55	Base
Anggana	33,183	1,089	0.53	Non-base
Muara Badak	46,945	1,512	0.52	Non-base
Marang Kayu	26,934	2,358	1.40	Base
Muara Kaman	46,819	2,839	0.97	Non-base
Kenohan	11,664	1,222	1.68	Base
Kembang Janggut	25,775	544	0.34	Non-base
Tabang	11,514	479	0.67	Non-base
Kabupaten	733,626	45,732		

Note: LQ > 1 = base area; LQ ≤ 1 = non-base area. Source: BPS Kutai Kartanegara Regency (2021), processed.

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