



Geographic Analysis of Distribution and Development of Goat Farms

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ABSTRACT. This study investigates the distribution and development of goat farms in Limapuluh Kota District with two main objectives: (a) to map the spatial distribution and development areas of goat farms, and (b) to enhance the capacity of the goat population within the district. Spatial analysis was conducted using ArcGIS 10.9, Location Quotient, and Shift Share Analysis to identify key areas for goat farm distribution and development. The capacity of livestock populations was evaluated through the CIRP method using Microsoft Excel, based on potential land resources. Secondary data from 2017 to 2021 on goat farm production was sourced from the Livestock and Animal Health Service Office and Central Bureau of Statistics of Limapuluh Kota. Results indicated that goat farms are primarily concentrated in the Harau, Suliki, and Bukit Barisan Districts, while the Mungka, Payakumbuh, Guguak, Lareh Sago Halaban, and Kapur Sembilan Districts are identified as development areas. The Situjuh Limo Nagari, Luak, Akabiluru, and Pangkalan Koto Baru Districts are classified as consolidation areas, and the Gunuang Omeh District serves as a supporting area. The analysis highlights that 13 districts have potential for boosting the goat population, whereas Situjuh Limo Nagari and Guguak are categorized in the low group due to their goat population being below the threshold of 200 LU.

Keywords: animal protein, goat farms, livestock development, spatial analysis, zero hunger

INTRODUCTION

Spatial planning in regional development categorizes areas into protected and cultivated zones, with livestock areas falling under cultivated regions. Effective spatial planning is essential for determining the direction of livestock distribution and development, considering the potential of available resources. Spatial dimensions—air, land, and water—play critical roles in supporting various activities, necessitating location-specific decisions to optimize space utilization (Rustiadi, 2018).

Goats (*Capra hircus*) are among the earliest domesticated livestock, valued for both food and clothing. Biologically, goats are productive and adaptable to diverse environmental conditions in Indonesia, making them relatively easy to manage and develop (Yoyo *et al.*, 2013). They are a significant source of animal protein, contributing to improved nutrition, increased income for farmers, market opportunities, and national food security. Additionally, sheep and goats are commonly raised by small farmers in rural areas (Wibowo *et al.*, 2016). Effective goat farming development requires an integrated regional planning approach that considers natural resources, human resources, and agroecosystems.

Enhancing goat production involves three key elements: land availability, feed, and livestock. These interrelated factors are crucial for improving goat farming quality and farmer prosperity

(Rusdiana *et al.*, 2016). A comprehensive evaluation of these elements in the Limapuluh Kota District is essential for supporting sustainable goat farming practices.

Previous studies have explored goat distribution and development in Indonesia. Azizah *et al.* (2020) employed SWOT and AHP (Analytic Hierarchy Process) analyses to determine development strategies based on farmers' social capital. Cyrilla *et al.* (2016) examined dairy goat development strategies in Bogor using Internal Factor Evaluation, External Factor Evaluation, SPACE Matrix, and Grand Strategy Matrix. Habsari *et al.* (2021) analyzed ruminant livestock development potential in Central Lampung using descriptive-analytical methods. However, these studies did not integrate analyses such as Location Quotient (LQ) and Shift Share Analysis (SSA) with spatial analysis to produce a comprehensive map, particularly in West Sumatra.

According to the 2012 Regional Spatial Plan for Limapuluh Kota District, goat farming is designated across 11 sub-districts, as outlined in Regional Regulation No. 7 of 2012, which covers the plan for 2012-2032. However, this regulation does not specify which sub-districts hold the greatest potential for goat livestock development. Therefore, this study aims to: (a) map the distribution and development areas for goat farming, and (b) assess the development potential and capacity for increasing the goat population within Limapuluh Kota District. As Rustiadi (2018) notes, spatial analysis can provide valuable geographical insights through statistical tabulations and mapping. This study utilizes ArcGIS software

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version 10.9 for spatial analysis, offering a detailed mapping approach to guide future livestock development, particularly for goats, within the district.

Research Methodology

This study was conducted in Limapuluh Kota District, encompassing 13 sub-districts and 79 Kenagarians. This district was chosen due to its status as a center of livestock production and its Regional Spatial Plan, which outlines potential areas for ruminant livestock but does not specifically address goats. The research relied on secondary data sources, including data from "Limapuluh Kota District in Figures 2015-2021," published by the Central Bureau of Statistics of Limapuluh Kota District, as well as data from the Livestock, Agriculture, Food Crops, Plantation, and Forestry Services of Limapuluh Kota District. The analysis was conducted in stages. The first stage involved assessing regional development potential based on criteria for dispersal areas as outlined by Rohaeni (2014). This included calculating population density and livestock density. The formula for population density is as follows:

$$\text{Population density} = \frac{\text{total population}}{\text{area}}$$

Table 2. Livestock density

No	Description	Formula	Criteria
1	Economic density	$\frac{\sum \text{Goats population (LU)} \times 1000}{\sum \text{population}}$	<ul style="list-style-type: none"> • Very dense (>300) • Dense (100-300) • Medium (50-100) • Rare (<50)
2	Farm density	$\frac{\sum \text{Goats population (LU)}}{\sum \text{Area of cultivated land}}$	<ul style="list-style-type: none"> • Very dense (>2) • Dense (1-2) • Medium (0.25-1) • Rare <0.25
3	Area density	$\frac{\sum \text{Goats population (LU)}}{\sum \text{Area}}$	<ul style="list-style-type: none"> • Very dense (>100) • Dense (50-100) • Medium (20-50) • Rare (<20)

Info: LU = Livestock Unit (Rohaeni, 2014)

Spatial Analysis: Spatial analysis was conducted to visualize the distribution and development areas of goat farming using a Geographic Information System (GIS) approach. ArcGIS software was utilized for this purpose, employing features such as the joint table function to integrate data from population density, livestock density, LQ, and SSA results. The query feature in ArcGIS facilitated data identification and analysis. The tabulated data were combined into a map, which was then overlaid with

The classification of population density based on BNPB (2013) regarding the procedures for planning residential neighborhoods is presented in the following table.

Table 1. Population density classification

No.	Population Density	Classification
1	>400 population/km ²	Very dense
2	201-400 population/km ²	Dense
3	150-200 population/km ²	Medium
4	<150 population/km ²	Rare

Source: BNPB (2013)

Shift Share Analysis (SSA): SSA was employed to evaluate shifts in the activity structure of goat farming within specific sub-districts relative to the district at two distinct time points. The formula used for SSA calculation is as follows:

$$SSA = \underbrace{\left[\frac{X_{..}(t_1)}{X_{..}(t_0)} - 1 \right]}_a + \underbrace{\left[\frac{X_{.i}(t_1)}{X_{.i}(t_0)} - \frac{X_{..}(t_1)}{X_{..}(t_0)} \right]}_b + \underbrace{\left[\frac{X_{ij}(t_1)}{X_{ij}(t_0)} - \frac{X_{.i}(t_1)}{X_{.i}(t_0)} \right]}_c$$

Location Quotient (LQ) Analysis: The Location Quotient (LQ) was calculated to assess the relative concentration of goat farming in different sub-districts. The formula for LQ is:

$$LQ_{ij} = \frac{X_{ij}/X_i}{X_{.j}/X_{..}}$$

the administrative map of Limapuluh Kota District to identify goat livestock distribution and development areas. Sub-districts not included in the distribution and development areas were categorized as development areas, stabilization areas, or supporting areas based on specified criteria.

The tabulated data were integrated into a map and overlaid onto the administrative map of Kabupaten Limapuluh Kota. This overlay allowed

for the creation of a map depicting the distribution of goat livestock and the development areas within specific sub-districts. Sub-districts not included in the primary distribution and development areas were categorized as development areas, stabilization areas, or supporting areas. The criteria for designating livestock distribution and development areas are outlined in the table below. The second objective was to calculate the increase in the goat population based on land resources. This was analyzed using Microsoft Excel with the Maximum Potential of Land Resources (MPLR) formula.

Table 3. Livestock development area criteria

Economic Density of Livestock (LU/1000 population)	Population Density (population/km ²)			
	Rare	Medium	Dense	Very Dense
Rare	DDA	DDA	DA	CA
Medium	DDA	DA	CA	CA
Dense	DA	DA	SA	SA
Very Dense	DA	CA	SA	SA

Source: Rohaeni (2014)

Info: DDA (deployment and development areas), DA (development areas), CA (consolidation areas), SA (supporting areas)

RESULT AND DISCUSSION

The study of the suitability of goat livestock distribution and development areas involved analyzing various factors, including population density, livestock density, Location Quotient (LQ), Shift Share Analysis (SSA), and spatial distribution. The findings for each aspect are detailed below:

Potential Development Areas

The potential for development areas was assessed based on population density, livestock density, Location Quotient (LQ), and Shift Share Analysis (SSA). High population density may limit opportunities for utilizing these areas due to increased competition among residents. The results of the population density calculations are presented in Table 4.

Based on Table 4, Kapur Sembilan and Pangkalan Koto Baru sub-districts exhibit lower population densities and larger land areas. However, these areas have low land suitability for forage planting and limited land area suitable for forage cultivation. In contrast, the sub-districts of Luak, Situjuh Limo Nagari, Akabiluru, and Payakumbuh, despite their smaller land areas, are densely populated. This high population density can intensify competition for land use (Handayani,

2017). Nonetheless, this challenge can be mitigated as most goat farmers engage in intensive farming practices. The primary land requirement for these farmers is to cultivate forage to ensure a consistent feed supply. Livestock density is categorized into three types: farm density, regional density, and overall density. The results of the livestock density calculations for Limapuluh Kota Regency are presented in Table 5.

Table 4. Population Density

Sub-district	Population Density (population/km ²)	Classification
Kapur Sembilan	39	R
Situjuh Limo Nagari	317	D
Luak	459	VD
Lareh Sago Halaban	98	R
Akabiluru	305	D
Payakumbuh	379	D
Gunuang Omeh	90	R
Suliki	109	R
Bukit Barisan	78	R
Guguak	338	D
Mungka	324	D
Harau	135	R
Pangkalan Koto Baru	41	R

Source: Data processing results (2022)

Info: R= rare, M= medium, D= dense, VD= very dense

Based on Table 5, the area density in Kecamatan Kapur Sembilan and Kecamatan Pangkalan Koto Baru is classified as sparse, with densities below 100 ST/km². Kapur Sembilan has only 1 hectare of land suitable for forage cultivation, while Pangkalan Koto Baru has 6 hectares (BPS Limapuluh Kota, 2022). This limited availability of suitable land contributes to the sparse density classification for these sub-districts. In contrast, other sub-districts fall into the moderate to very dense categories. This variation in density reflects both the land's capacity for forage planting and the community's predominant occupation as livestock farmers, which influences the area's overall density.

In conjunction with the area density results, farming density is assessed based on the land's capacity to produce forage for livestock. Kapur Sembilan and Pangkalan Koto Baru sub-districts are classified as rare due to a lower number of farmers and limited land available for forage cultivation compared to other sub-districts. Conversely, the overall economic density is categorized as dense to very dense. To address this issue, there is an opportunity for the community to develop goat farming businesses. The results of the Location Quotient (LQ) and Shift Share Analysis

(SSA) for each sub-district in Kabupaten Lima Puluh Kota are presented in Table 6.

Table 5. Criterion value of livestock density characteristics

Sub-district	Area Density (LU/ km ²)	Classification	Farm Business Density (LU/Ha)	Classification	Economic Density (LU/ km ²)	Classification
Kapur Sembilan	10.61	R	0.09	R	272.53	D
Situjuh Limo Nagari	282.42	VD	2.73	VD	891.83	VD
Luak	269.25	VD	3.65	VD	586.91	VD
Lareh Sago Halaban	80.45	M	1.47	D	819.60	VD
Akabiluru	126.85	D	1.09	D	415.63	VD
Payakumbuh	206.31	VD	2.98	VD	544.61	VD
Gunuang Omeh	44.90	M	0.48	M	497.81	VD
Suliki	58.42	M	0.66	M	537.06	VD
Bukit Barisan	98.38	M	0.87	M	1,265.32	VD
Guguak	91.67	M	1.03	D	270.99	D
Mungka	258.82	VD	1.50	D	799.39	VD
Harau	47.18	M	0.65	M	350.15	VD
Pangkalan Koto Baru	14.82	R	0.14	R	358.87	VD

Source: Data processing results (2022)

Info: R= rare, M= medium, D= dense, VD= very dense

Table 6. Location quotient (LQ) and shift share analysis (SSA) result

Sub-district	Location Quotient (LQ)	Shift Share Analysis (SSA)
Kapur Sembilan	1.06	3.21
Situjuh Limo Nagari	1.05	0.17
Luak	1.06	1.38
Lareh Sago Halaban	0.99	0.41
Akabiluru	1.03	0.42
Payakumbuh	1.05	0.22
Gunuang Omeh	0.90	4.83
Suliki	1.00	5.07
Bukit Barisan	1.02	3.4
Guguak	0.90	3.87
Mungka	1.07	3.82
Harau	1.05	3.12
Pangkalan Koto Baru	1.06	11.71
Average	1.02	3.20

Source: Data processing results (2022)

The results of the Location Quotient (LQ) and Shift Share Analysis (SSA) presented in Table 6 indicate that goat farming is a basic sector in nine sub-districts: Kapur Sembilan, Luak, Akabiluru, Payakumbuh, Suliki, Bukit Barisan, Mungka, Harau, and Pangkalan Koto Baru (LQ>1). This LQ value is derived from comparing the area of cultivated land with the number of farmers in these sub-districts. The availability of facilities and infrastructure in several sub-districts influences the development of goat farming in Kabupaten Limapuluh Kota. The SSA calculation reveals an aggregate growth rate of 0.77 for goat farming in the region, with an average SSA of 3.20. These results suggest that goat farming is competitive and holds promising prospects for future development.

Following the analysis of regional development potential, Location Quotient (LQ), and Shift Share Analysis (SSA), spatial analysis was performed to assess goat livestock distribution and development areas. This spatial analysis integrated the results from population density, livestock density, LQ, and SSA to establish regional criteria. The criteria for distribution and development areas are summarized in Table 7.

Livestock placement should consider land suitability, forage availability, and potential human resources (Suhaema *et al.*, 2014). According to the criteria for livestock development areas, the sub-districts identified for goat livestock distribution and development fall within the rare to moderate levels. This assessment is further supported by the values obtained from the Location Quotient (LQ) and Shift Share Analysis (SSA). As shown in Table 7, Harau, Suliki, and Bukit Barisan sub-districts are designated as areas for goat farming distribution and development (DDA). The livestock and population densities in these three sub-districts align with the criteria, as they are classified in the rare to moderate category. Harau, Suliki, and Bukit Barisan are identified as base sectors for goat farming and hold significant potential for future development.

Based on Table 7, Lareh Sago Halaban meets the Shift Share Analysis (SSA) criteria but is not classified as a basic sector due to its Location Quotient (LQ) value being less than 1. However, this sub-district shows potential for future development. In contrast, Mungka sub-district, with an SSA value of 3.82, is classified as a basic

sector because its LQ value exceeds 1. Both Lareh Sago Halaban and Mungka sub-districts are designated as development areas (DA) and have the potential to be utilized as goat livestock deployment and development areas (DDA) in the future.

The sub-districts of Akabiluru, Luak, Situjuh Limo Nagari, and Pangkalan Koto Baru are classified as basic sectors due to their Location Quotient (LQ) values exceeding 1. Akabiluru, Luak, and Situjuh Limo Nagari possess substantial

human and natural resources, classified as dense and very dense. These sub-districts have reached a point where further improvement in livestock population and forage cultivation is limited. Conversely, Pangkalan Koto Baru, despite having a significant amount of land, faces challenges with land suitability for forage planting. As a result, these sub-districts are categorized as consolidation areas (CA). Stabilization areas are those where livestock development cannot be expanded and can only be maintained at current levels (Edi, 2020).

Table 7. Criteria for deployment and development areas

Sub-district	I	II	III	IV	LQ	SSA	Criteria	Priority
Kapur Sembilan	R	R	R	D	√	√	DA	
Situjuh Limo Nagari	D	VD	VD	VD	√	√	CA	
Luak	VD	VD	VD	VD	√	√	CA	
Lareh Sago Halaban	R	D	M	VD		√	DA	
Akabiluru	D	D	D	VD	√		CA	
Payakumbuh	D	VD	VD	VD	√		DA	
Gunuang Omeh	R	M	M	VD			SA	
Suliki	R	M	M	VD	√	√	DDA	2
Bukit Barisan	R	M	M	VD	√	√	DDA	3
Guguak	D	D	M	D		√	DA	
Mungka	D	D	VD	VD	√	√	DA	
Harau	R	M	M	VD	√	√	DDA	1
Pangkalan Koto Baru	R	R	R	VD	√	√	CA	

Source: Data processing results (2022)

Information: I = population density, II = farm business density, III = area density, IV = economic density, LQ = Location Quotient, SSA = Shift Share Analysis, DDA (deployment and development areas), DA (development areas), CA (consolidation areas), SA (supporting areas)

Gunuang Omeh sub-district is not classified as a goat farming base sector. Table 7 indicates that the livestock and population densities in Gunuang Omeh are still at the rare to moderate level. Additionally, the institutional and human resources in this sub-district do not meet the required criteria, resulting in its classification as a supporting area (SA). Supporting areas are characterized by regional potential but lack prospects for future development (Edi, 2020). The areas designated for goat livestock distribution and development in Kabupaten Limapuluh Kota, based on the Location Quotient (LQ) and Shift Share Analysis (SSA), are mapped in Figure 1 below.

Figure 1 illustrates that the development area (DA) is adjacent to the goat deployment and development area (DDA). The sub-districts identified for livestock distribution and development include Harau, Suliki, and Bukit Barisan. In contrast, the consolidation area (CA) comprises Luak, Akabiluru, and Situjuh Limo Nagari, which have smaller areas compared to others. The productivity of goats in these consolidation areas must be maintained to satisfy the region's internal needs. Pangkalan Koto Baru

sub-district, despite its large land area, faces challenges due to inadequate land potential to support sustainable goat farming.

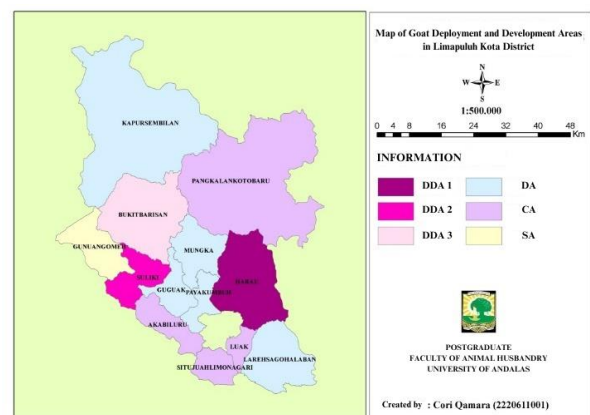


Figure 1. Map of Goat Deployment and Development Areas in Limapuluh Kota District

Capacity to Increase Goat Population in Limapuluh Kota Regency

The Capacity for Ruminant Population Increase (CRPI) is regarded as a closed system, wherein the potential is limited to meeting the needs of livestock within the area itself. The CRPI

for goats in Limapuluh Kota Regency is detailed in Table 8.

From Table 8, the maximum potential land in Limapuluh Kota District is 54,435.64 Livestock Units (LU), while the Capacity for Ruminant Population Increase (CRPI) results reach 3,716.26 LU. This land can serve as a potential feed source if utilized for forage cultivation. The primary function of land in animal husbandry, including goat farming, is forage cultivation, which can enhance goat growth and development (Rusdiana *et al.*, 2014). The study reveals that 13 sub-districts have a positive CRPI value, indicating that the goat population can continue to grow and has significant potential for future expansion. For instance, Harau sub-district has a CRPI value of 485.22 LU, suggesting that its capacity can be increased by an additional 485 LU. Similarly, Kecamatan Suliki and Kecamatan Bukit Barisan have capacities that can be increased by 212 LU and 222 LU, respectively.

Table 8. Capacity to increase goat population in Limapuluh Kota District

Sub-district	MPLR (LU)	CRPI (LU)
Kapur Sembilan	7,362.69	576.57
Situjuh Limo Nagari	2,372.41	133.09
Luak	6,625.82	441.62
Lareh Sago Halaban	7,078.93	451.48
Akabiluru	3,248.31	217.65
Payakumbuh	2,642.12	155.98
Gunuang Omeh	2,909.17	212.41
Suliki	2,906.36	211.51
Bukit Barisan	3,801.65	221.57
Guguak	1,840.12	117.64
Mungka	2,788.59	161.62
Harau	6,601.53	485.22
Pangkalan Koto Baru	4,259.45	329.92
Jumlah	54,435.64	3,716.26

Source: Data processing results (2022)

Information:

MPLR (LU): Maximum potential based on land resources in a livestock unit

CRPI (LU): Capacity to increase ruminant population in one livestock unit

CONCLUSION

The distribution and development areas (DDA) for goats are identified in Harau, Suliki, and Bukit Barisan. The development areas (DA) include Kapur Sembilan, Lareh Sago Halaban, Payakumbuh, Guguak, and Mungka. The consolidation areas (CA) are Situjuh Limo Nagari, Akabiluru, Badger, and Pangkalan Koto Baru. Gunuang Omeh is categorized as a supporting area (SA). The capacity to increase the goat population

is positive in 13 sub-districts, with only Situjuh Limo Nagari and Guguak classified in the low category, as their capacities are below 200 LU.

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