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MAPPING LAND POTENTIAL AND CARRYING CAPACITY FOR CATTLE BREEDING AREA DEVELOPMENT

Audi Cindra Arini[1*], Isti Farin Oktafia Safitri[2], Maulidya Nur Aini[3]

[123]Master's of Geography Education, State University of Malang, Indonesia

Email: audicindraarini@gmail.com[1*], isti.farin.2307218@students.um.ac.id[2], maulidya.nur.2307218@students.um.ac.id[3]

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ABSTRACT

Resources have a crucial role in maintaining the sustainability of human life and the surrounding ecosystem. Malang Regency, one of the regions with the largest number of beef cattle in Indonesia, has great potential to support the growth of the livestock sector with 234,481 beef cattle and is ranked fifth nationally. Optimal support, especially land carrying capacity, is the key to maximizing the potential of the livestock sector. The establishment of a livestock area in Tumpang District is a strategic step to increase production capacity and availability of animal feed. This research uses a Mixed Methods method with a spatial approach, involving data analysis such as unsupervised classification, evaluation of natural forage potential, and calculation of the Forage Carrying Capacity Index (IDD). The findings show that all villages in Tumpang District have an IDD above 2 so they are categorized as safe. With several potential villages such as Pulungdowo, Duwet Krajan, and Bejor. With these findings, strategic steps can be taken to utilize this potential sustainably to increase the contribution of the livestock sector in Malang Regency.

Keywords*: Area development, Cattle farm, Mapping, Land carrying capacity.*

INTRODUCTION

Resources are an important component in the survival of humans and the lives of living things around them. The higher the population of living things, the more resources are utilized for sustainability, giving rise to increased utilization of activity space. Indonesia, with a very large population, is a potential market for livestock products. The increase in the Indonesian economy is in line with the increasing public awareness of consuming fish and meat (Febriarta & Oktama, 2020; Octarini, Hellyward, & Madarisa, 2022). The livestock sub-sector has a main role as a provider of animal food, especially protein, (Rusdiana & Adawiyah, 2013). Based on BPS data for 2022 regarding beef production in all provinces in Indonesia amounting to 498,923.14 from the previous amount of only 487,802.21 in 2021, this states that there is an increase from 2021 to 2022 of 11%. This shows that there is a high level of public consumption of animal needs, as well as showing that there is great enthusiasm in society to develop cattle cultivation businesses.

Beef cattle farming is a very potential and strategic livestock sub-sector commodity, where the fulfillment of protein needs,

especially animal protein, is one of the standard factors for nutritional adequacy for children and this is following the standard nutritional adequacy figures that have been set based on the regulations of the Ministry of Health.. Beef cattle farming is a livestock sub-sector commodity with great potential and strategic importance (Dzanja, Kapondamgaga, & Tchale, 2013; Triyanto, Rahayu, & Purnomo, 2018). Increasing beef consumption in Indonesia is a business opportunity for those involved in beef cattle farming. Based on the 2014 National Socio-economic Survey (SUSENAS), developments in the level of per capita beef consumption by Indonesian people from 2000 to 2014 fluctuated and tended to increase. The increase in per capita beef consumption per year in Indonesia can be caused by Indonesian people's awareness of nutritional needs in food, especially animal protein. To be able to support beef cattle, it is necessary to have the land-carrying capacity to be able to develop the livestock sector (Marzuki, 2019).

Fulfillment of nutritional protein, especially animal protein, is certainly an urgency for the local government to develop the livestock sector to support the free nutritious food program initiated by the government. with the latest program currently being run by the Indonesian government, namely the free nutritious food program (MBG) for students based on the nutritional adequacy standard based on Permenkes number 28 of 2019, the nutritional adequacy figure for the contents of the plates of elementary school children must be met between 500-700 calories and contain elements of carbohydrates, vegetable and animal protein, fat and fruit in one meal (Peraturan Kementrian Kesehatan RI, 2019).

East Java is the province with the highest population of beef cattle in Indonesia, namely 4,4,657,457 heads or 27.32% of the national population (Badan Pusat Statistik, 2022). Malang Regency as one of the regions in East Java has quite large potential for developing the beef cattle population. Apart from suitable agro-climatic, market and community culture factors, Malang Regency also has a fairly large beef cattle population compared to other districts. Based on BPS data, Malang Regency is in fifth place with the largest population of beef cattle, namely 234,481 heads. This potential needs to be supported by various aspects, one of which is adequate land carrying capacity (Peters et al., 2016). One way to optimize the carrying capacity of land is by establishing livestock areas.

Livestock areas are defined as areas that are specifically used for integrated livestock activities as components of farming businesses based on plantations, food crops, or fisheries and integrated as components of certain ecosystems (protected forest areas, nature reserves). In developing livestock areas, it is necessary to optimize local resources and appropriate development policy strategies following the regional spatial allocation (Primasworo & Widyastuti, 2018). One of the sub-districts in East Java that has the potential to be developed into a livestock area is Tumpang Sub-district.

Tumpang District is one of the 33 sub-districts in Malang Regency. Astronomically, Tumpang District is located between 112.4254 to 112.4846 east longitude and 7.5954 to 8.0170 south latitude. The territorial boundaries of Tumpang District are as follows. To the north it borders Jabung and Pakis Districts, to the east it borders Poncokusumo District, to the South it borders Tajinan and Poncokusumo Districts, to the West it borders Malang City. Tumpang District consists of 15 villages.

The large livestock population in Tumpang District, Malang Regency in 2021 is 531 dairy cattle, and 4,204 beef cattle, 11 buffalo and 17 horses (BPS Kabupaten Malang, 2022). Even though the livestock population in Tumpang District is not as large as in other sub-districts in Malang Regency, Tumpang District still has quite large potential to develop into a livestock production center area. To turn an area into an independent livestock area, a structured and sustainable planning concept is needed with the initial step of mapping potential locations that will be developed into livestock areas as well as mapping existing livestock locations. Presenting the geographic distribution of livestock populations can describe the patterns of appearance on the earth's surface through the presentation of thematic maps that show qualitative and quantitative data on specific elements (Adinata, Sumadi, & Adiarto, 2009).

In carrying out the production process, production factors are needed, in the form of capital, land and labor. In the production process of a good/service, including the dairy cow production process, profits will be influenced by the costs of resource use and

business management (Astuti, Widiati, & Suranindyah, 2010). Some of the problems in the livestock sector are that productivity is still low, lack of availability of calves, high feed costs, small scale of ownership and the quality of human resources is still low, cultivation techniques and land availability for feed production is decreasing, conversion of agricultural land to non-agricultural, business capital is low. banking is still low and cross-sectoral cooperation is not yet integrated, product sales prices are still low, livestock sales prices are unstable (Santosa, Setiadi, & Wulandari, 2013), and the market structure approach is less efficient with breeders not selling directly to the market (Ningsih, Hartono, & Nugroho, 2017).

Environmental factors that support livestock businesses are the existence of green land for animal feed. Natural forage in the form of field grass or wild grass that is not cultivated intensively. This grass naturally grows around agricultural land (rice fields and fields), forests and around house yards. Natural forage can not only be found in natural pastures but in various areas of empty land that intentionally or unintentionally have the potential to provide natural forage (Sonbait, Santosa, & (Panjono), 2012), so appropriate and accurate land resource information services are needed (Ikanubun et al., 2021).

Three factors influence consumer purchasing decisions, namely location, product completeness, and price (Firdaus, Firman, & Fitriani, 2022). So in efforts to develop livestock areas, it is important to establish a regional development center. Considering that not all areas in Tumpang District have close access to animal markets, determining villages that have the highest potential is strategic for designing livestock area development centers in Tumpang District. This step is expected to help cattle breeders in marketing their livestock to consumers, both in Tumpang District and outside the area. Through this mapping, it is hoped that there will be interaction between actors/breeders with traders and private institutions in livestock business management (Sol'uf, Krova, & Nalle, 2021) as a form of promotion and effort to overcome the lack of marketing personnel (Putritamara, Febrianto, & Ndaru, 2018). Based on this background, this research was carried out to determine the potential of the area and the carrying capacity of the land in supporting the availability of animal feed for the development of cattle farming in Tumpang District.

RESEARCH METHODS

This research uses Mixed Methods research with a spatial approach. Mixed Methods research type, as stated by Creswell and Plano Clark in Dawadi et al, (2021), mixed methods research is a research design that has its own philosophical assumptions and investigative methods. The mixed methods design establishes a relationship between qualitative and quantitative data in such a way that the research problem is explained meaningfully. It also offers a logical foundation and methodological flexibility and deep understanding (Maxwell, 2016).

In this research, the spatial approach is aimed at assessing the potential carrying capacity of land for developing cattle farming areas. The spatial approach is an attempt to examine a series of similarities between various geosphere phenomena in space (Made, Antara, Putu, Suryana, & Paramartha, 2022). To get a faster and more efficient picture of spatial data, geographic information technology is needed to manage spatial data, which we call a geographic information system. A geographic information system is a computer system used to manage spatial data, including storing, processing, analyzing and managing data to present spatial information (Prahasta, 2022).

This research was conducted in Tumpang District, Malang Regency, East Java. Astronomically, it is in the middle of Malang Regency, located at 112.06° - 112.07° E and 7.06° - 8.02° S with the northern border of Singosari District and Karangploso District, east of Pakis District. and Tumpang District, south of Tajinan District and Pakisaji District, west of Wagir District and Dau District.

The data used in this research includes primary data and secondary data. Primary data is in the form of observations and interviews to obtain census data on cattle breeders in Tumpang District, which includes breeder biodata, farm address, number and type of cattle, as well as the coordinates of the farm location. Secondary data is in the form of Landsat 8 satellite image data which is then analyzed to determine the classification of land cover in Tumpang District, Malang Regency. This research uses research instruments in the

form of documentation sheets, observation sheets, interview guides.

In this research, the stages that will be carried out are the first stage of data collection. The data collected is in the form of primary and secondary data. Primary data is in the form of observations and interviews to obtain census data on cattle breeders in Tumpang District, which includes breeder biodata, farm address, number and type of cattle, as well as the coordinates of the farm location. Secondary data is in the form of Landsat 8 satellite image data which is then analyzed to determine the classification of land cover in Tumpang District and also data from BPS, journals and related references.

The data analysis techniques used are the unsupervised classification method, natural forage potential, and the Forage Carrying Capacity Index (IDD). The unsupervised classification method uses pixel values to be grouped first by a computer into spectral classes using a clustering algorithm (Richards, 2022). The data needed to apply the unsupervised classification method in mapping the carrying capacity of land for cattle farming includes: land use data, land area, and cattle population data. Next, the data is processed with ArcGis with image pre-processing activities, selecting the best band combination, visual image interpretation, creating class identifiers, separability analysis, image classification, and accuracy testing.

The final stage is analysis of the mapping data that has been created to understand the patterns identified in the data regarding regional potential and land carrying capacity for cattle farming. In this research, natural forage potential mapping will be carried out using the formula according to Tiwow et al., (2016) as follows:

Natural Forage Potential = {((Yard x 0.53 x 2) + ((Moor + Fld + Gar + Fallnd) x 2.875) + (Grz x 0.75)+ (CT x 0.6)+ (Etc x 0.75) + (Lkld x 10)+ (Lckh x 5))}x 0.5

Infromation:
Yard : yard
Moor : moor
Fld : field
Gar : garden
Fallnd : fallow land
Grz : grazing land
CT : community forest
Etc : other
Lkld : area of coconut plantations
Lckh : area of clove plants

The Carrying Capacity Index (IDD) value of forage is the quotient of the potential for providing forage with the amount needed by livestock Atmiyati in Rahasia et al., (2021). The formula used to measure the forage carrying capacity index is as follows:

IDD = (Total Potential Available Feed (BKC))/(Total Feed Requirement (BKC))

Animal feed requirements can be calculated using the minimum feed requirement figures. The minimum feed requirements for ruminant livestock for 1ST are calculated according to Thahar et al in Rahasia et al., (2021) with the equation:

K = 2.5% x 50% x 365 x 250 Kg => 1.14 Tons BKC

Information:
K: The minimum feed requirement is 1 ST in tons of digestible dry matter or also known as DDM (Digestible Dry Matter) for one year.
2.5%: Minimum required amount of forage ration (dry matter) for body weight
50%: Average value digestibility of various types of plants
365: Number of days in a year
250 Kg: The amount of biomass for one livestock unit

Based on the carrying capacity index value, the criteria for forage carrying capacity status are obtained. The carrying capacity index reflects the level of food security in an area, to support the lives of livestock located above it. The following are the criteria for the carrying capacity index value:

Table 1. Forage Carrying Capacity Index Criteria

Criteria	IDD value
Safe	characterized by a carrying capacity index (IDD) > 2
Prone	characterized by a carrying capacity index (IDD) < 1.5-2
Critical	characterized by a carrying capacity index (IDD) < 1-1.5
Very Critical	characterized by a carrying capacity index (IDD) < 1

Source: Saputra in Mashudi et al., 2022

To provide a clear picture of the stages of this research, a Research Flow Diagram is prepared that explains the research process systematically. This research flow includes the main steps, starting from collecting primary and secondary data, processing spatial data using GIS technology, to analyzing natural forage potential and calculating the Carrying Capacity Index (IDD). The preparation of this flow aims to ensure that each stage of the research is carried out in a structured manner, so that the results obtained can support the development of livestock areas efficiently and based on data.

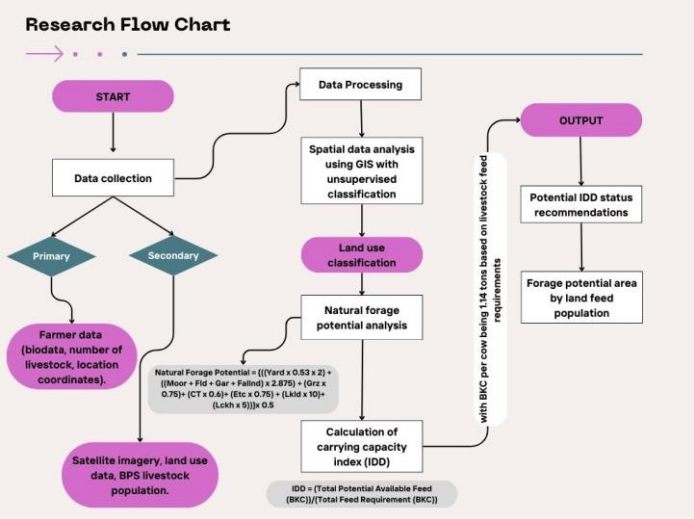

Figure 1. Research Flow Chart, 2025

RESEARCH RESULTS

Results of a livestock population distribution of 379 heads from 13 villages in the Tumpang sub-district, where the total distribution of cattle consists of local or dairy cattle, private farms, and also Brahma. Based on this data, it shows that the largest number of villages distributed is in the areas of Wringinsongo, Kidal, Tulus Besar, Bokor, Jeru, which for these five areas is the area that has the highest distribution level in five out of a total of 13 villages in the Tumpang sub-district. This cattle farming business is generally carried out using a drum system because adequate grazing land is not available.

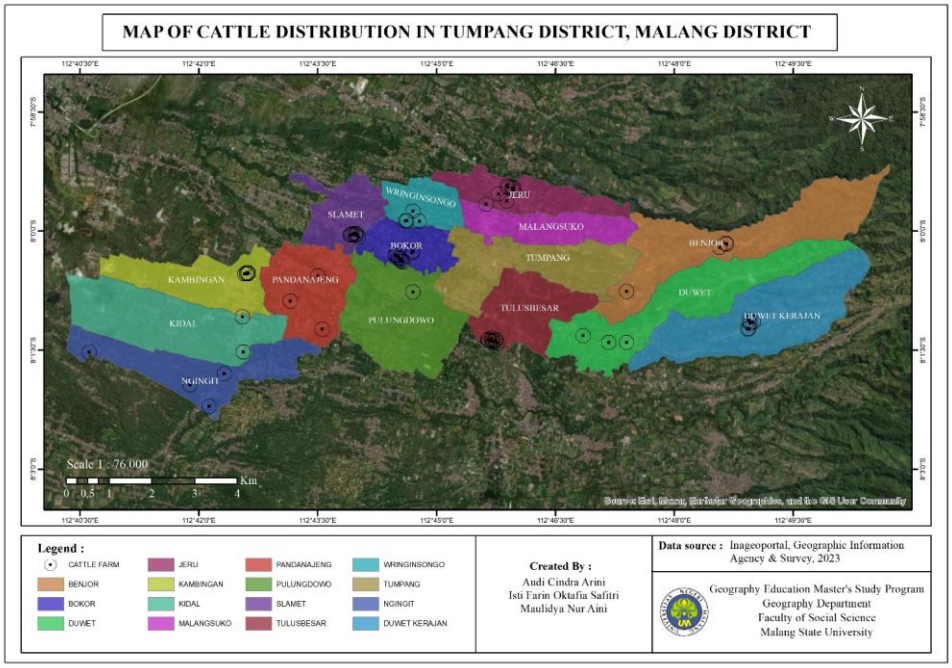

Figure 2. Map of Cattle Distribution, 2025

Forage for livestock in the form of superior grass is generally planted by breeders themselves. Most of it is mixed with crops in their own gardens, fields or moors or rice fields. The cultivation and management techniques for raising cattle have been implemented quite well, as can be seen from the feed provided, the selection of seeds that tend to use an artificial insemination system and knowledge about livestock health. The institution of breeders has also developed with groups of farmer breeders. Some of these groups have developed into cooperatives or institutions that can distribute the needs for livestock production facilities. Apart from that, another aspect that influences cow development is vitamins. The following is a map of land cover in Tumpang District:

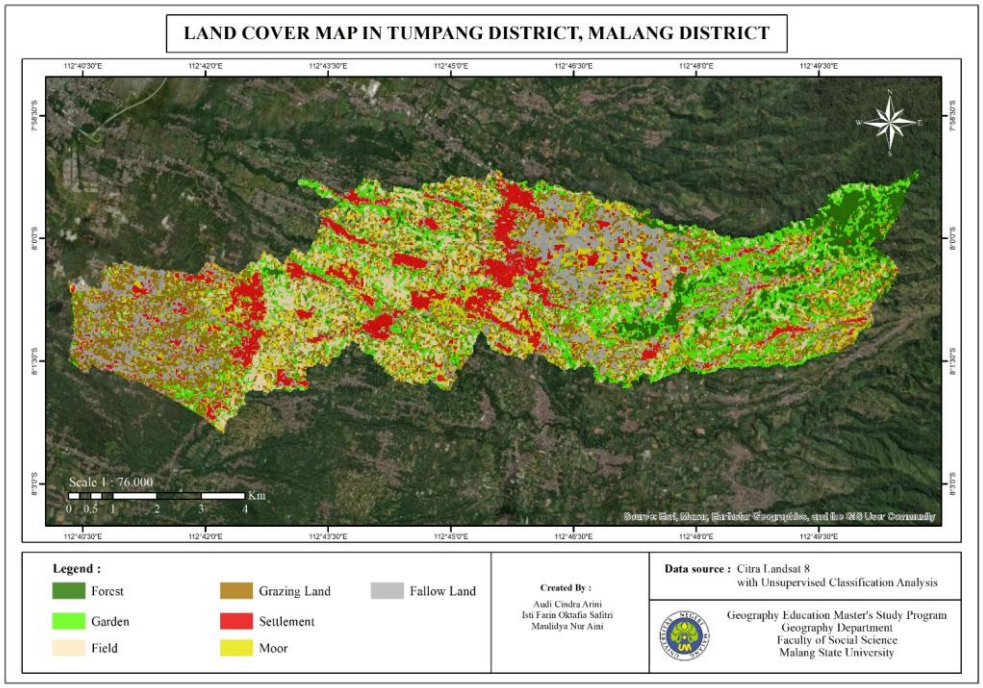

Figure 3. Land Cover Map in Tumpang District, 2025

Based on Figure 2 presented, it shows that, the land cover which is the supporting capacity for the development of cattle farming in Tumpang District, is in first place in the grazing class which is presented in light brown on the map and can support it in terms of feed and location in the eastern part of Tumpang in the village. Duwet and Duwet Krajan Villages as well as in the western part of Tumpang in Ngingit Village, Kambingan Village and Kidal Village. The forest class with dark green color is dominated in the Ds area. Duwet and Ds. Duwet Krajan and is still spread, although not widely, in several other villages. The garden class is shown in neon green, indicating the garden class which is the largest land cover in Tumpang District. The cream colored area shows that the field classes are fairly evenly distributed with the largest number being in the Ds area. Pandanajeng and Ds. Pulungdowo. Fallow land classes shown in gray are widely distributed in Ds. Kidal and Ds. Malangsuko. The residential class shown in red is in the middle and is surrounded by forests and open land. The moorland class is spread throughout the village area in Tumpang District. Further information regarding the IDD value for each village in the Tumpang sub-district can be seen in the following table.

Table 2. Forage Carrying Capacity Index Criteria

No	Village	Land Carrying Capacity	Number of Existing Cows	Minimum Feed Requirements	IDD
1	Pandanajeng	432,97	23	26,22	16,51
2	Pulungsdowo	595,13	8	9,12	65,25
3	Bokor	216,53	44	50,16	4,32
4	Slamet	260,17	25	28,5	9,13

No	Village	Land Carrying Capacity	Number of Existing Cows	Minimum Feed Requirements	IDD
5	Wringinsongo	186,19	33	37,62	4,95
6	Jeru	264,02	45	51,3	5,15
7	Tumpang	488,00	-	-	-
8	Duwet	625,20	29	33,06	18,91
9	Duwet Kerajaan	700,13	15	17,1	40,94
10	Ngingit	420,77	20	22,8	18,45
11	Kidal	558,54	69	78,66	7,10
12	Kambingan	322,77	20	22,8	14,16
13	Malangsuko	282,22	-	-	-
14	Tulusbesar	358,56	33	37,62	9,53
15	Bejor	651,23	15	17,1	38,08

Source: Research Results, 2023

Based on Table 2, analysis of areas with high and low Carrying Capacity Index (IDD) can provide a deeper understanding of the potential for livestock management. For example, Pulungsdowo Village has an IDD of 65.25 which is considered high, with a land capacity of 595.13, a number of cattle of 8, and a minimum feed requirement of 9.12. This village shows great potential in supporting sustainable livestock, which can be optimized by utilizing grazing areas and planting livestock feed crops. In contrast, Bokor Village has a very low IDD, namely 4.32, with a land capacity of 216.53 and a number of cattle reaching 44, which results in high pressure on feed resources.

Pulungdowo Village has a very large potential area for livestock, namely an IDD of 65 compared to other villages. One of the large and good land covers for supporting livestock activities is a field with an area of 128 hectares. Therefore, the use of fields must be optimized by planting plants for animal feed that are suitable for planting on field land. Duwet Kerajan Village has a huge potential area for livestock, namely an IDD of 41 compared to other villages. One of the large and good land covers for supporting livestock activities is a garden with an area of 217 hectares. Therefore, the use of gardens must be optimized by planting plants for animal feed that are suitable for planting in garden soil. Another village that has a very large potential area for livestock is Bejor Village which has an IDD of 38. One of the large and good land covers for supporting livestock activities is a garden with an area of 210 hectares. Therefore, the use of gardens must be optimized by planting plants for animal feed that are suitable for planting in garden soil.

From these results indicate the importance of balance between land capacity, feed requirements, and livestock numbers in supporting sustainable livestock management. In this study, a spatial approach was used to assess the potential carrying capacity of land in developing cattle farming areas.

DISCUSSIONS

Land use as an analysis of land carrying capacity was carried out to determine the prospects for developing the cattle rearing business in Tumpang District. Land use management in the livestock business is very necessary to optimize land and water utilization (Hosu & Mushunje, 2013). The components used to determine the carrying capacity of an area are land and plants as a source of animal feed. Based on the area of Tumpang sub-district, namely 7,209.83 ha, it is used as residential land, fields, grazing, moorland and so on. Based on the results obtained in this research, it show that in the livestock subsector, the most prominent livestock business in the Tumpang sub-district, Malang Regency is cattle farming. Based on the population distribution and livestock density that have been analyzed and obtained by researchers in the field in the Tumpang sub-district, Malang district, the distribution of livestock populations, cattle in the Tumpang sub-district, Malang regency have different levels of distribution.

All villages in Tumpang District have an IDD value above 2 which is included in the safe category. Several villages have great potential for livestock, namely Pulungdowo Village, Duwet Krajan Village, and Bejor Village. There were no cattle breeders found in Tumpang Village. Based on the carrying capacity of the land, the estimated minimum feed requirement available in the village is 150 with a total of 130 cows. In Malangsuko Village there were no cattle breeders found. Based on the carrying capacity of the land, the estimated minimum

feed requirement available in the village is 120 with a total of 100 cows.

Based on primary and secondary data, as well as data analysis carried out by researchers in the form of mapping potential land that supports the development of cattle farming, it can be concluded that there are several villages including Duwet Village, Duwet Krajan Village, Ngingit Village, Kambingan Village, Kidal Village which can indeed be said to have the most potential for development. become a farming area. Other villages that have the potential to be developed for cattle farming are Pandanajeng Village, Tulusbesar Village and Wringinsongo Village. Apart from that, from their geographical location, these areas are quite strategic in terms of marketing cattle products because they are close to animal markets and cattle markets in Bokor Village, Jeru Village, Ngingit Village, Tulus Besar Village, Malang Suko Village, and Tumpang Village.

Based on the data that has been mentioned, Duwet Kerajan Village and Benjor Village are the villages with the latest development, so it is quite difficult to develop livestock further. The distance from Benjor Village to Malang City is 24.9 km, which can be reached in approximately 53 minutes by a 4-wheeled vehicle. The distance from Duwet Krajan Village to Malang City is 27.1 km, which can be reached in approximately 50 minutes by 4-wheeled vehicle. Topography and accessibility is inadequate. Apart from that, human resources are also lacking because they have not focused on sales for products that are traded on a large scale. Pulungdowo Village is a village with great potential to be developed for livestock because the distance is quite close to Malang City, namely only 17.4 km or can be reached in around 36 minutes.

The ability to provide forage is closely related to the land use area of a region. The type of land use that has the potential for developing beef cattle is farming land in general. An area is said to be capable if the animal feed available in the area is greater than the living needs of livestock in the area concerned (Hendaru, 2022). Based on the results obtained in this research, it show that the table of potential natural forage food requirements is 432.96. This yield is obtained from the carrying capacity of the land divided by the minimum annual food requirements, resulting in an IDD for livestock areas in the Overlapping sub-district of 14.14504803. So the maximum limit for the number of cows that can be supported with natural forage potential in Tumpang sub-district is 2700 cows, while the number of cows so far recorded is 379 cows from 13 villages in Tumpang sub-district, Malang Regency.

The balance between livestock population and land area in a district can be one of the considerations in determining livestock development (Robinson et al., 2014). Large areas of land as a production base will provide loose support for livestock life, so livestock populations tend to be high. However, if the threshold for the ratio of the number of livestock to land is exceeded, the limited land will no longer support the lives of livestock in the area.

CONCLUSION

All villages in Tumpang District have a Supporting Capacity Index (IDD) above 2, falling into the safe category. Pulungdowo, Duwet Krajan, and Bejor villages stand out as villages with great potential for livestock farming, with Pulungdowo having an IDD of 65, superior to other villages. The area of fields in Pulungdowo is around 128 hectares, creating great opportunities for livestock farming activities. Duwet Krajan Village has an IDD of 41 and a garden of 217 hectares, providing significant potential for livestock farming. Bejor Village with an IDD of 38 and a garden of 210 hectares also promises great potential. The ability of the region to provide green fodder is related to the area of land use, and agricultural land has the potential for developing beef cattle, efforts to develop this land are one of the supporting forces to facilitate cattle breeders in cultivating, as well as an effort to achieve one of the standard factors for nutritional adequacy for children for animal protein needs in accordance with the standard nutritional adequacy figures that have been set based on the regulations of the Ministry of Health. Based on the IDD potential, Tumpang District is able to support up to 2700 cattle, currently only 379 cattle have been recorded from 13 villages in Tumpang District, Malang Regency.

The findings of this study reinforce the concept of land carrying capacity, which emphasizes that the availability of green fodder is a crucial factor in supporting the sustainability of livestock development in an area. With an IDD value above 2 for all villages

in Tumpang District, the results indicate that land with planned and optimized use can effectively support the livestock population. Moreover, the application of the concept of utilizing agricultural land is highly relevant in the context of developing livestock based on local resources. This approach maximizes the contribution of the livestock sector to food security and regional economic improvement, which holds significant potential for further optimization in the future.

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