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Author Statement Form

To:
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Herewith we submit a manuscript,

Title : The Regional Analysis of Beef Cattle Farm Development in Semarang Regency

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Dear Authors:

Thank you for submitting manuscript, "The Regional Analysis of Beef Cattle Farm Development in Semarang Regency" to Tropical Animal Science Journal (previously Media Peternakan). I would like to confirm about your approval as a co-author of the attached manuscript. If you disagree with the authorship, please send your confirmation in three days. Otherwise, manuscript will be further processed according to the journal system.

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PAPER EVALUATION

Paper Title: The Regional Analysis of Beef Cattle Farm Development in Semarang Regency

Comments (please use additional paper if more space is needed)

No	Comments	Author's response
A	**Reviewer I**	Thank you for the review. Comments are very worthwhile.
1	There is a basic wrong in this article in regards with writing the numbers, i.e., the land area suitable reaches 5.760,141 Ha (the right number is 5,760.141 Ha). All numbers are wrong written	I have made correction to all the numbers contained in the article.
2	**There is overlapping between results and discussion.** The author puts a lot of discussion in the result section., while the discussion is shorter than the results. Please check the journal's guidelines and other published articles on how to write Results, Discussion.	Okay, I have revised it as recommended. The discussion has shown the relevance of the results and the field of investigation and / or hypothesis
3	The author did not mention, discuss, and conclude the sustainability aspect, while the objectives of the study is to determine the priority areas for developing beef cattle farm in Semarang Regency based on the concept of sustainability.	I have added and clarified the concept of sustainability for beef cattle farm in the method section. The objectives of this study is to determine priority areas for beef cattle development based on sustainability analysis. Sustainability assessed are **economic factors** (determination of leading commodity through LQ and SS) and **environmental factors** (determination of carrying capacity and carrying capacity index of forage, assessment of suitability ecological environment of beef cattle)
4	The author also used un-usual terms for animal, for example cultivation (keeping), cages (housing, barn. Cage is used for poultry)	I have fixed it according to the comments in the text.
5	The author mention that the study also would like to evaluate the economic	Economic sustainability in this study was determined by the assessment of leading

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	sustainability, however, I did not find the economic sustainability aspect either on the result or Discussion	commodity (through LQ and SS analysis). In the research results, precisely in the first section related to leading commodity, an interpretation of LQ and SS values has been explained which can be useful for the regional analysis of beef cattle farm development in Semarang Regency.
6	The author did not explain detailed in Material and methods, how can they categorized the value of suitable indicator into S1;S2, etc (Table 6)	Okay, I have revised it as recommended. In the material and method section, the value of suitability ecological environment of beef cattle farm has been added
7	The Result of the study are mostly in PRESENT TENSE form, it should be PASTE TENSE	Okay, I have revised it as recommended.
8	Inconsistency when writing the references. Sometimes, the author abbreviates the journal names; however, some journal names are not abbreviated.	Okay, I have revised it as recommended.
9	Please check the number of the last 10 year journal publications. It should be more than 80% according to the guidelines.	I have reviewed the journal publication in the last 10 years and it complies with the guidelines (>80%).
10	Please see other comments on the text.	Yes, I check at every comment in the text.
B	**Reviewer II**	Terimakasih untuk reviewnya. Komentar sangat membangun.
1	I will use Bahasa in my comments	Saya menggunakan Bahasa Indonesia untuk Response.
2	Penelitian mengunakan concept of sustainability (baris 8), dengan pendekatan economic dan environmental (baris 89). Indikator yang digunakan LQ dan SS (baris 8; baris 101-105). Namun demikian, hal ini tidak tergambar pada judul.	Judul saya buat seringkas dan sepadat mungkin. Konsep **analisis wilaya**h untuk pengembangan dalam sektor apapun, selalu mempertimbangkan banyak faktor (ekonomi, lingkungan, sosial). Secara eksplisit, kata-kata **analisis wilayah** yang terdapat dalam judul, sudah menggambarkan arah penelitian ini. Bagian abstrak penelitian kemudian lebih memperjelas hal tersebut, dimana keberlanjutan yang dinilai hanya faktor ekonomi dan lingkungan.
3	Baris 37: konsep sustainability dalam	Konsep keberlanjutan dalam perumusan

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	perumusan masalah di pendahuluan, berbeda maksudnya dengan sustainability pada metode penelitian.	masalah di bagian pendahuluan, menurut saya sudah sinkron dengan yang terdapat pada metode penelitian. Hal tersebut dibuktikan pada **paragraph 4 dan 5** dalam pendahuluan, yaitu bahwa **keberlanjutan ekonomi** ditentukan melalui analisis komoditas unggulan (LQ dan SS), sementara itu **keberlanjutan lingkungan** ditentukan melalui analisis potensi wilayah (Daya dukung dan Indeks daya dukung hijauan, Kesesuaian lingkungan ekologi peternakan sapi potong). Bagian metode penelitian sudah saya revisi agar lebih jelas tentang konsep keberlanjutan peternakan sapi potong.
4	Baris 58: rumusan masalahnya "beef cattle continued to decline", namun di baris 61 dijawab dengan "development of sustainable beef cattles farm, dari segi ekonomi, lingkungan dan sosial	Permasalahan peternakan sapi potong di Kabupaten Semarang yaitu penurunan populasi ternak selama kurun waktu 2014-2016. Permasalahan tersebut disebabkan oleh faktor teknis maupun non teknis (misal: kebijakan). Untuk menjawab permasalahan ini, makan diperlukan konsep pembangunan peternakan yang berkelanjutan. Keberlanjutan yang dinilai dalam penelitian ini yaitu keberlanjutan ekonomi dan lingkungan. Konsep keberlanjutan mampu memberikan gambaran tentang: • Wilayah yang menjadi basis ternak sapi potong dan wilayah yang mengalami pertumbuhan ekonomi terkait aktivitas peternakan sapi potong, • Ketersediaan hijauan pakan ternak pada suatu wilayah (**aman, rawan, kritis, sangat kritis**) sehingga pemeliharaan atau pengembangan peternakan sapi potong yang over kapasitas dapat dihindarkan, • Wilayah yang sesuai untuk pengembangan peternakan sapi potong, dilihat dari kesesuaian lingkungan ekologi ternak tersebut.

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5	LQ dan SS keduanya menggunakan data populasi sapi and all type of livestock (baris 102). Tidak dijelaskan apakah di dalamnya tidak memasukkan unggas yang tidak berkompetisi dengan sapi dalam menggunakan pakan rumput.	Analisis LQ dan SS **tidak berhubungan** dengan kompetisi penggunaan pakan (rumput). Analisis ini digunakan untuk mengetahui pola pemusatan ternak (basis atau non-basis) dan trend pertumbuhan ekonomi wilayah (positif atau negative), khususnya untuk peternakan sapi potong. Data yang digunakan merupakan **data seluruh jenis ternak**. Ternak di Kabupaten Semarang meliputi **Ternak besar** (kuda, sapi potong, sapi perah, kerbau), **Ternak kecil** (babi, kambing, domba, kelinci), dan **Unggas** (ayam ras layer, ayam ras broiler, ayam ras buras, itik, burung puyuh, mentok). Interpretasi dari nilai LQ dan SS sudah dijabarkan dalam Results and Discussion.
6	Baris 105-106: equation (2) tidak ada hubungannya dengan penjelasan di baris 106 ada rumus SS: a+b+c	Equation (2) tentang Shift Share (SS). SS terdiri dari 3 komponen, yaitu Regional share (a), Proportional shift (b), dan Differential shift (c). Pernyataan **a+b+c** saya hilangkan saja karena menimbulkan kebingungan.
7	Baris 124 dan 129: 134 rumus tidak ada penjelasan satuan dan tidak ada sumbernya (diambil dari mana?).	Produksi bahan kering hijauan merupakan hasil **potensi limbah pertanian + potensi hijauan alami.** Sumber: (Suhaema, Widiatmaka, & Tjahjono,2014; Yuniar, Fuah, & Widiatmaka, 2016). Satuan dari rumus potensi limbah pertanian dan potensi hijauan alami adalah **ton**. Setiap rumus yang digunakan juga terdapat keterangan lengkap di bagian bawahnya.
8	Tabel 1: satuan Dry month (<100mm rainfall/month?); slope (land slope?)	**Dry month** = jumlah curah hujan <100 mm/bulan. Sesuai (S) untuk ternak sapi potong jika <8 bulan (tergolong agro klimat basah-sedang), sebaliknya menjadi tidak sesuai (NS) jika >8 bulan (agro klimat kering-sangat kering). **Slope** = kemiringan lereng Sesuai (S) untuk ternak sapi potong jika nilai

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		slope <40% (datar sampai berbukit), sebaliknya menjadi tidak sesuai (NS) jika nilai slope >40% (curam sampai sangat terjal).
9	Tabel 2: ruminansia ada goat, sheep, horse, buffalo; namun di table 4 hanya memperhitungkan Bcp=populasi sapi. Seharusnya carrying capacity dihitung dengan memperhitungkan populasi rumanansia selain sapi.	Daya dukung atau Carrying capacity **(CC)** dan Indeks daya dukung atau Carrying capacity Index **(CCI)**. Dalam penelitian ini **hanya difokuskan** untuk pengembangan **peternakan sapi potong,** jadi perhitungan nilai CC dan CCI khusus untuk ternak sapi potong saja.
10	Baris 512-513: e (c x d) seharusnya e = cxd	Saya setuju dan sudah diperbaiki pada Tabel 4.

The Regional Analysis of Beef Cattle Farm Development in Semarang Regency

ABSTRACT

One of the reasons for low production and productivity of beef cattle in Indonesia is that information on the allocation of livestock areas development is not yet clear. This study aims to determine the priority areas for developing beef cattle farm in Semarang Regency based on the concept of sustainability. Sustainability is analyzed through the determination of leading commodities (analysis of Location Quotient/LQ and Shift Share/SS), optimization of regional potential (analysis of carrying capacity and carrying capacity index of forage), and assessment of land suitability. The process of spatial analysis used GIS software. Comprehensive planning for the development of beef cattle farm was directed in 3 sub-districts, namely: Bringin, Bancak, and Banyubiru. The sub-district areas have LQ>1 and SS positive values which means they are beef cattle base area and experiences business growth. The carrying capacity for beef cattle farm in Bringin sub-district is 15.829 AU, Bancak is 8.457 AU, and Banyubiru is 6.315 AU. Forage carrying capacity index values in each of these sub-districts is >2, which is safe category for the availability of forage. The land area suitable for beef cattle farm from the 3 priority sub-districts reaches 5.760,141 Ha. It was concluded that the development of beef cattle farm in Semarang Regency is focused on 3 priority sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of this study can be an input for local governments in determining the direction and pattern of beef cattle farm development to be more sustainable.

Key words: beef cattle, regional analysis, sustainability of livestock sector.

INTRODUCTION

The directed and sustainable development of the livestock sector is believed to be able to contribute positively to regional development. Along with the increase in population, there is an increasing demand for food from animal protein such as beef. Beef consumption in developing countries such as in Indonesia tends to increase every year (Thornton, 2010; Agus & Widi, 2018), however the population of beef cattle in some regions actually decreases due to the complexity of technical and non-technical problems (Paly *et al*., 2013; Ariningsih, 2014; Nuhung, 2015). There is a gap between demand and supply of beef products which are increasingly widening (Prasetiyono *et al*, 2007). Many factors causing this gap, including the domestic production of beef cattle is still low because information on the allocation of livestock development areas is not yet clear.

Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009; Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able to meet the high consumption of people against meat. The consumption of beef in 2020 is estimated to reach 3,36 kg per capita per year, but beef production is still not able to fulfill it, there is a deficit in beef procurement of 198.350 tons (Kementan, 2016; Agus & Widi, 2018). Most of beef production in Indonesia, 78% comes from traditional livestock, 5% from imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al*., 2017). Imports of beef are indeed relatively larger compared to other types of meat imports, contributing 21,44% to the total import value of livestock, while the import value of livestock is 18,29% of the total value of agricultural imports nationally (Rouf *et al*., 2014).

Policy efforts to reduce beef imports must be studied, by strengthening domestic production that is beneficial for farmers (Pasandaran *et al*., 2014). The development of

beef cattle farms in potential areas is an effort to strengthen meat production in the country so that the implementation must be carried out with a comprehensive assessment. Semarang Regency is a region in Central Java Province that has the potential to develop beef cattle farms because it has natural resources in the form of land as a place for livestock cultivation and forage production. Good quality and always available forage can increase production, especially for increasing body weight of cattle (Suhaema *et al.*, 2014). Forage producing areas in Semarang Regency include gardens (25.562,04 Ha), rice fields (23.745,96 Ha), and forests (6.032,77 Ha). The beef cattle population in this region during the 2014-2016 period continued to decline, ranging from 53.135, 49.172, and 46.238 (BPS Kabupaten Semarang, 2018).

The development of beef cattle farms in Semarang Regency needs to adopt the concept of sustainability. The concept of sustainability is the achievement of economic, environmental and social goals simultaneously which is represented by various performance indicators (Darnhofer *et al.*, 2010). Sustainability is also defined as the concept of multidimensional (economic, ecological, social) and multiscale (micro, meso, and macro), although in its application it is often limited to one particular aspect (Santos *et al.*, 2017). Economic sustainability is closely related to the value of comparative and competitive advantages of certain commodities (Broom *et al.*, 2013; Sabaghi *et al.*, 2016), while environmental sustainability includes optimizing the availability of natural resources and efficient use (Atanga *et al.*, 2013).

The sustainability of beef cattle farms can be identified through a regional approach, by considering the existence of leading commodities and the potential of the region concerned (Mulyono & Munibah, 2016; Parmawati *et al.*, 2018). Determination of leading commodities characterized by the existence of comparative and competitive advantages is the first step towards efficient development of the livestock sector (Hendayana, 2003). The potential of the region to support the development of beef cattle farms is determined by optimizing the carrying capacity and carrying capacity index of forage, as well as assessing the suitability of the land where the livestock grows. Land suitability for beef cattle farms with intensive maintenance patterns considers several environmental factors that affect the growth of these cattle.

Mapping activities based on the determination of leading commodities and optimization of regional potential are needed as a basis for planning sustainable development of beef cattle farms. This study aims to determine the priority areas for developing beef cattle farms in Semarang Regency. The results of this study are expected to be one of the considerations in determining the direction and development policy of the beef cattle farms sector in Semarang Regency.

MATERIALS AND METHODS

This research is a type of quantitative research and applies the concept of sustainability. Sustainability assessed is economic and environmental sustainability for beef cattle farm in Semarang Regency. In detail, each step of the analysis is outlined below.

Leading Commodity

Determination of leading livestock commodities in an area uses Locationt Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods is the economic basis theory. LQ analysis is relatively simple, but the benefits are large enough for the initial identification of the ability of a sector in regional development. The shift in the structure of economic activity in beef cattle business, whether experiencing growth or decline is analyzed using Shift Share (SS). SS analysis can be used to see the growth of the economic sectors of a region for two time points (Muta'ali, 2015). LQ and SS analysis uses equations that refer to (Ciptayasa *et al*., 2016; Mulyono & Munibah, 2016).

$LQ_{ij} = \frac{Xij\ /\ Xi.}{X.j\ /\ X..}$ (Equation 1)

(X_{ij} = Beef cattle population in the sub-district A, $X_{i.}$ = Population of all types of livestock in the sub-district A, $X_{.j}$ = Beef cattle population in Semarang Regency, $X_{..}$ = Population of all types of livestock in Semarang Regency).

$SS = \left[\frac{X..(t1)}{X..(t0)} - 1\right] + \left[\frac{X.i(t1)}{X.i((t0)} - \frac{X..(t1)}{X..(t0)}\right] + \left[\frac{Xij(t1)}{Xij(t0)} - \frac{X.i(t1)}{X.i((t0)}\right]$ (Equation 2)

(SS = a + b + c, where a = Regional share, b = Proportional shift, c = Differential shift, X .. = Population of all types of livestock in Semarang Regency, Xi = Beef cattle population in Semarang Regency, Xij = Beef cattle population in sub-district A, t0 = Early 2013 year point, t1 = End of year 2017).

Carrying Capacity and Carrying Capacity Index of Forage

The carrying capacity of the region for livestock development is indicated by the ability of the region to produce forage that can accommodate and meet the needs of a number of beef cattle populations. Forages are divided into two types, namely fresh forage (grass, legume) and dry forage (straw). An assessment of the carrying capacity index of forage is conducted to assess the availability of animal feed in a region, whether classified as safe, vulnerable, critical, or very critical.

The carrying capacity of beef cattle farms is calculated based on the production of forage dry matter against the minimum feed requirements of cattle (1 AU) in one year. The animal unit (AU) is a unit for the ruminant livestock population multiplied by the conversion factor. The conversion factor for cattle is 0,7 which can represent cow parent, cattle parent, and calves with various age levels (Muta'ali, 2015; Saputra *et al*., 2016).

Forage dry matter production is the amount of potential agricultural waste and natural forage potential, using equations that refer to (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

Potential of agricultural waste (ton) = {(wr x 0,4) + (fr x 3 x 0,4) + (cn x 3 x 0,5) + (sb x 3 x 0,55) + (pt x 2 x 0,55) + (sp x 0,25/6) + (cs x 0,25/4)} x 0,65

(wr: wetland rice, fr: field rice, cn: corn, sb: soybean, pt: peanuts, sp: sweet potatoes, cs: cassava. The numbers in the formula are assumptions about the potential waste produced from the production of each type of plant food).

Natural forage potential (ton) = {(Ga x 2,875) + (Fa x 0,6) + (Cpa x 10) + (Cfa x 0,5) + (Cla x 5)} x 0,5

(Ga: garden area, Fa: forest area, Cpa: coconut plant area, Cfa: coffee plant area, Cla: clove plant area. The numbers in the formula are assumed to be natural forage potential produced per hectare of land use area).

Minimum cattle feed requirements.

R= 2,5% x 50% x 365 x 400kg = 1,82 ton DDM/year/AU (Equation 3)

(R = minimum cattle feed requirements (1 AU) in tons of digestible dry matter for 1 year, 2.5% = minimum requirement for the number of forage rations (dry matter) on livestock weight, 50% = average value digestibility power of various types of plants, 365 = Number of days in 1 year, 400 kg = live weight of 1 AU of beef cattle in Semarang Regency).

The results of the calculation of forage dry matter production are then used to determine the carrying capacity of beef cattle farms using the following equations (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

$$\text{CC (AU)} = \frac{\text{Forage Dry Matter Production (tons of DDM / year)}}{\text{Minimum Cattle Feed Requirement (tons of DDM / year / AU)}} \text{ (Equation 4)}$$

The level of animal feed security in a region is measured by forage carrying capacity index. Carrying capacity index values are values that indicate the status of the availability of forage for beef cattle, namely: very critical (≤1), critical (>1-1,5), vulnerable (> 1,5-2), and safe (>2).

Forage carrying capacity index = $\frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}}$ (Equation 5)

Suitability of The Ecological Environment of Beef Cattle

The research sample for the assessment of the suitability ecological environment of beef cattle farms in Semarang Regency is 19 points spread throughout the sub-district area (Table 5). Determination of the sample is using purposive sampling technique. The purposive sampling technique is also called judgment sampling (Tongco, 2007), which is to determine the sample based on research considerations. In each sub-district one village is taken which has the most beef cattle population.

Land available for the development of beef cattle farms is: gardens, grasslands, open land, rice fields, and dry land agriculture. The fields are assumed to be able to be built for cages for beef cattle. The assessment of land suitable for beef cattle farming with intensive maintenance patterns, also takes into account several environmental parameters that influence the growth of livestock.

Land suitability assessment for beef cattle farms begins with making a map of land units. Maps of beef cattle land units refer to research (Rusmana *et al*., 2006) which states that there are four maps needed for overlaying, namely: land type maps, agro-climate maps, regional altitude maps, and slope maps. The final step is to make a "suitability map of the ecological environment of beef cattle". The method used is by overlaying between land unit maps with environmental parameters that affect the growth of beef cattle (Table 1). The entire process was created and analyzed using GIS software.

RESULTS

Leading Commodity

Leading commodity livestock in an area is determined based on comparative advantage (location quotient analysis) and competitive advantage (shift share analysis). Beef cattle commodities that have LQ>1 and SS (+) values are the leading commodities in the region. The interpretation of the value of LQ>1, is a base or leading sector, beef cattle products (meat) are able to meet markets inside and outside the region. LQ<1 value, is a non-base sector, livestock products have not been able to meet markets inside and outside the region. LQ=1 value, meaning that the sector is balanced with the reference region, livestock products are only able to meet markets in the area. The basis for calculating LQ analysis for livestock commodities is livestock population data (Hendayana, 2003). Data bias in calculations can be minimized by using a minimum 5 year data series (Table 2).

Shift share analysis starts from the basic assumption that economic growth or added value of an activity in a particular region is influenced by three main components which are interconnected with each other, namely: regional growth, sectoral growth, and growth in share or regional competitiveness (Ciptayasa *et al*., 2016). Through these three components, it can be seen which elements have encouraged regional economic growth. The value of each component can be positive or negative, but the total number (shift share) will always be positive if the regional economic growth is positive, and vice versa.

The results of the calculation of LQ and SS analysis for beef cattle commodities in Semarang Regency are shown in Table 3. The sub-districts which are the base sectors of beef cattle livestock (LQ>1) are: Bancak (4,93), Banyubiru (3,97), Ambarawa (3,92), Bringin (2,82), and Bawen (2,34). Cultivation of beef cattle is concentrated in these areas or in other words the economic density of beef cattle is higher than in other regions. Beef cattle commodity in the base sub-district is a prominent or dominant livestock business compared to the other livestock businesses, so the effort for future development is easier (Yuniar *et al*., 2016; Mulyono & Munibah, 2016). The concept of comparative advantage is economic feasibility. According to Mulyono (2016), commodities that have a comparative advantage (LQ>1) show that the commodity (beef cattle) is supported by the existence of adequate natural resources so that the population level is higher than in other regions (Mulyono & Munibah, 2016).

Beef cattle commodities that have competitive advantages are seen based on positive shift share (SS) values. Sub-districts with a positive SS value means experiencing growth (competitiveness) related to cultivated beef cattle. On the contrary, sub-districts with negative SS value means that the area is not growing (stagnant) and can even experience setbacks. As seen in Table 3, sub-districts with positive SS values include: Ungaran Barat (1,286), Banyubiru (0,47), Pabelan (0,435), Bandungan (0,203), Bancak (0,077), Bringin (0,039), and Tengaran (0,026). The concept of competitive advantage is financial feasibility. Beef cattle commodities are cultivated in effective and efficient ways, so that they have competitiveness from aspects of quality, quantity, continuity and price (Saptana, 2008; Muta'ali, 2015; Mulyono & Munibah, 2016).

The development of beef cattle farms in Semarang Regency is prioritized in the sub-districts with LQ>1 and SS (+) values. The sub-districts are Bringin, Bancak, and Banyubiru.

Carrying Capacity and Carrying Capacity Index of Forage

Carrying capacity is defined as the maximum population that can be supported by an ecosystem from time to time. The carrying capacity of an area is not static, there is a kind of reciprocal relationship between organism and their environment. The carrying capacity of a region can vary for different species and change over time due to various factors (Taiwo & Feyisara, 2017). Regional carrying capacity for livestock development is the size of the region's ability to support the livelihoods of a number of livestock populations optimally through the role of forage availability (Ardhani, 2008).

Potential availability of feed for beef cattle is seen based on the amount of forage dry matter production (tons of DDM) that can be produced by the region concerned. Dry matter is the total feed ingredients without water content, which can come from forages. The region with the largest forage dry matter production has the highest carrying capacity for the development of beef cattle farms, and vice versa. Forage is one of the production inputs that determines the success of livestock business because it directly affects productivity and efficiency (Yuniar *et al*., 2016). Table 4 shows the calculation of carrying capacity and carrying capacity index of forage for beef cattle farms in Semarang Regency.

Based on the calculation results of Table 4, it is known that there are three sub-districts with the largest production of forage dry matter, namely Bringin (28.808,63 tons DDM), Pringapus (23.509,36 tons DDM), and Suruh (19.522,03 tons DDM). Sub-district area with the smallest forage dry matter production, namely Bandungan (4.327,55 tons DDM). The status of availability of forage in Bandungan sub-district was categorized as very critical (0,82), while in Tengaran sub-district it was categorized as vulnerable (1,69). Thus, these two sub-districts are not recommended for the development of beef cattle farms. Sub-district areas with carrying capacity index value >2 (safe) means that the area can be recommended for the development of beef cattle farms. The advantage obtained by the area with this safe category is that farmers can reduce the amount of production costs for beef cattle feed.

Semarang Regency has carrying capacity for beef cattle farms of 122.725 AU. The population of beef cattle in 2017 is 33.911 AU, so the Semarang Regency area is assumed to still be able to accommodate 88.814 AU beef cattle in 2018.

Suitability of The Ecological Environment of Beef Cattle

The results of measurements in the field and secondary data collection on several environmental factors that influence the growth of beef cattle are shown in Table 5. The factors that limit the assessment of the suitability ecological environment of beef cattle farming in Semarang Regency are the Temperature Humidity Index (THI) and water pH. Annual rainfall (<4000 mm) and dry months (<8) are in the appropriate category.

The relationship between the amount of air temperature and humidity is called the Temperature Humidity Index (THI). If THI exceeds the threshold (>80), it can cause stress or heat stress in beef cattle (Dobson *et al*., 2003; Eirich, 2018). Long-term heat stress has an impact on increasing drinking water consumption, increasing urine volume, and decreasing feed consumption. The direct effect of heat stress on livestock production causes a decrease in the productivity of beef cattle. This is due to the increasing need for livestock maintenance (Jordan, 2003; Berman, 2005). Furthermore, the THI value that exceeds the threshold influences the decrease in daily body weight gain, depletion of the thickness of meat fat, and the increase of potential for disease occurrence especially in male cattle (Nardone *et al*., 2010).

Hydrogen potential (pH) characterizes the balance between acidic and alkaline solvent in water. If the pH of drinking water for beef cattle is below the quality standard or acid (<6,5), the water becomes sour and can cause physiological and digestive disorders in livestock. On the contrary, if the pH of water is too alkaline (>9), the water becomes bitter and causes a decrease in consumption of drinking water which has an impact on decreasing livestock productivity (Pfost & Fulhage, 2001; Sarwanto & Hendarto, 2011).

The suitability ecological environment map for beef cattle farms in Semarang Regency is shown in Figure 1. The white area is an area that is not assessed because it is designated as land for settlements, plantations, tourism, and forests. Based on Figure 1, it is known that the level of suitability of the produced beef cattle ecological environment is: very suitable (S1), quite suitable (S2), and according to marginal (S3). Unsuitable (NS) categories are not raised and not assessed because the area has a slope >40% (steep - very steep).

The symbol "p" indicates that there is a limiting factor in the area assessed. The limiting factors are the Temperature Humidity Index (THI) and the pH of the water for beef cattle consumption (Table 5). Semarang Regency consists of 19 sub-districts. The development of beef cattle farms is prioritized in sub-districts that have LQ>1, SS (+) value, and carrying capacity index of forage (>2), namely Banyubiru, Bringin, and Bancak. Banyubiru sub-district is not constrained by limiting factors, while Bringin and Bancak are constrained by THI values that exceed the comfort zone for growing cattle (>80). The extent suitability of the ecology of beef cattle farms from the three priority sub-districts is shown in Table 6.

Based on Table 6, the sub-districts that have the largest land area for the development of beef cattle farms with intensive maintenance patterns, respectively are Bringin (2.758,86 Ha), Bancak (1.550,08 Ha), and Banyubiru (1.451,2 Ha). The limiting factor in the form of temperature humidity index (THI) or water pH can be minimized through the engineering design of livestock cages and provision of materials or neutralizing water acidity solvent (Yani *et al*., 2007; Sarwanto & Hendarto, 2011). Cattle with intensive maintenance patterns are generally more susceptible to heat stress than extensively maintained cattle. Efforts that can be done to reduce heat stress in beef cattle include: adding shade around the cage location, watering to the livestock body, using fans to help circulate air in the cage, choosing the right cage roof material, etc (Suhaema *et al*., 2014).

DISCUSSION

Semarang Regency is a potential area for the development of beef cattle farming because it has abundant natural resources in the form of land for livestock cultivation and forage production. The maintenance pattern of beef cattle that is often found in Semarang Regency is an intensive maintenance pattern. Beef cattle are able to show optimal physical conditions if they have superior genetic traits, and are supported by the suitability of their ecological environment (Suhaema *et al*., 2014). Animal ecology is the study of the interactions between animals and their environment (Sumarto & Koneri, 2016). Environmental factors tend to affect the production and productivity of livestock more (Gunawan *et al*., 2008). Some environmental factors that influence the growth of beef cattle with intensive maintenance patterns are: soil type, length of dry season, altitude, slope (Kadarsih, 2004; Calderon *et al*., 2005; Rusmana *et al*., 2006), temperature and relative humidity, rainfall, water pH (Chantalakhana & Skunmun, 2002; Dobson *et al*., 2003; Rumetor, 2003; Yani *et al*., 2007; Herbut & Angrecka, 2012; Eirich, 2018).

The mapping activity is based on the determination of leading livestock commodities, and optimization of regional potential can be one of the benchmarks in realizing sustainable development of beef cattle farms. The concept of sustainable development is to meet the needs of the current generation, without sacrificing future generations and this concept has become a reference for welfare in almost all sectors, including the livestock sector (Pezzey, 2004; Wasike *et al*, 2011). The concept of sustainability has been widely debated throughout the world over the past few years (Van Passel *et al*, 2007; De Longe *et al*., 2016; Keesstra *et al*., 2016; Rasmussen *et al*., 2017), not only concerning issues environmental and social issues, but also discussing economic issues to gain certain market or commodity advantages (Broom *et al.*, 2013; Sabaghi *et al*., 2016). Sustainability assessment is achieved by evaluating the relative contribution of each of the economic, environmental and social factors to the overall goal (Astier & García-Barrios, 2012).

The synthesis of the assessment results of leading commodities, calculation of carrying capacity and carrying capacity index of forage, as well as land suitability assessment, shows that there are three sub-districts (Bringin, Bancak, and Banyubiru) which are priorities for the development of beef cattle farms in Semarang Regency. It is expected that livestock development in priority sub-districts can increase production and productivity of beef cattle. Governments, communities (cattleman) and the private sector (investors) must coordinate and cooperate with each other so that the development of sustainable beef cattle farms can be achieved.

CONCLUSION

Planning for the development of beef cattle farming with intensive maintenance patterns in Semarang Regency is recommended in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The assumption of forage production produced from these three sub-districts reaches 55.693,72 tons of DDM. The total carrying capacity for beef cattle farms is 30.601 AU. The total land area suitable for beef cattle farming in the three priority sub-districts is 5.760,141 Ha. The pattern of developing beef cattle farms in the future should be directed to the development of large scale farms (Feedlot) in order to be able to meet the scale of business economics.

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Table 1. Environmental parameters that influence the growth of beef cattle with intensive maintenance patterns

Parameter	**Order of environmental suitability of beef cattle**	
	S (Suitable)	N (Unsuitable)
Temperature Humidity Index (THI)	70-80	<70, >80
Water availability (w)		
Dry month (<100 mm rainfall/month)	<8 months	>8 months
Rainfall / year (mm)	< 4,000	> 4,000
The existence of a water source	Available	Not Available
Water Quality (q)		
pH water	6.5-9.0	<6.5; >9.0
Slope (%)	<40	>40

Source: (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

Table 2. Growth of livestock populations in Semarang Regency

Type of livestock	**Number (head)**				
	2013	**2014**	**2015**	**2016**	**2017**
Pig	32,640	17,300	18,431	15,971	15,850
Goat	197,029	136,999	123,294	117,003	117,373
Sheep	290,764	191,346	172,211	167,374	162,694
Rabbit	20,352	9,375	10,462	11,629	11,916
Horse	1,711	497	515	524	581
Beef cattle	51,901	53,135	49,172	46,238	48,444
Dairy cows	22,308	27,609	25,780	25,690	25,557
Buffalo	2,941	3,168	2,614	2,629	2,589
Laying Chicken	1,821,286	1,813,049	1,452,019	1,331,528	1,572,463
Broiler Chicken	12,046,319	7,501,700	10,144,846	10,754,602	11,812,311
Chicken Breed	819,067	860,408	818,568	861,989	823,226
Duck	206,882	92,963	80,801	127,859	125,261
Quail	122,200	238,930	227,737	176,730	142,856
Muscovy Duck	102,966	72,227	63,889	61,963	54,402

Source: (BPS Kabupaten Semarang, 2018).

508 Table 3. Value of LQ and SS beef cattle in Semarang Regency in 2018

NO	SUB-DISTRICT	BEEF CATTLE				
		LQ	RS	PS	DF	SS
1	Getasan	0.63	-0.052	-0.014	-0.359	-0.425
2	Tengaran	0.55	-0.052	-0.014	0.092	0.026
3	Susukan	1.11	-0.052	-0.014	-0.137	-0.203
4	Kaliwungu	1.22	-0.052	-0.014	0.048	-0.018
5	Suruh	0.88	-0.052	-0.014	-0.213	-0.279
6	Pabelan	1.75	-0.052	-0.014	0.501	0.435
7	Tuntang	0.28	-0.052	-0.014	-0.689	-0.755
8	Banyubiru	3.97	-0.052	-0.014	0.536	0.47
9	Jambu	0.42	-0.052	-0.014	-0.417	-0.483
10	Sumowono	0.95	-0.052	-0.014	-0.234	-0.3
11	Ambarawa	3.92	-0.052	-0.014	0.006	-0.06
12	Bandungan	1.01	-0.052	-0.014	0.269	0.203
13	Bawen	2.34	-0.052	-0.014	0.0009	-0.0651
14	Bringin	2.82	-0.052	-0.014	0.105	0.039
15	Bancak	4.93	-0.052	-0.014	0.143	0.077
16	Pringapus	1.38	-0.052	-0.014	-0.312	-0.378
17	Bergas	0.77	-0.052	-0.014	-0.106	-0.172
18	Ungaran Barat	0.77	-0.052	-0.014	1.352	1.286
19	Ungaran Timur	0.3	-0.052	-0.014	-0.62	-0.686

509 LQ = Location quotient, SS = Shift share, RS = Regional share, PS = Proportional shift, DS = Differential
510 shift.

Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency in 2018

SD	Bcp 2017	Bcp 2017 (AU)	Rm	R Bc	F Dmp	CC	CCI	AV
A	b	c	d	e = c x d	f	g = f/d	h = g/c	
Getasan	2,085	1,459.5	1.82	2,656.29	7,802.45	4,287.1	2.94	S
Tengaran	4,881	3,416.7	1.82	6,218.39	10,526.78	5,783.9	1.69	V
Susukan	2,905	2,033.5	1.82	3,700.97	15,301.29	8,407.3	4.13	S
Kaliwungu	4,650	3,255	1.82	5,924.1	13,231.72	7,270.2	2.23	S
Suruh	3,335	2,334.5	1.82	4,248.79	19,522.03	10,726.4	4.59	S
Pabelan	4,251	2,975.7	1.82	5,415.77	12,690.04	6,972.5	2.34	S
Tuntang	211	147.7	1.82	268.81	9,458.6	5,197.03	35.19	S
Banyubiru	3,840	2,688	1.82	4,892.16	11,493.54	6,315.1	2.35	S
Jambu	741	518.7	1.82	944.03	8,816.47	4,844.2	9.34	S
Sumowono	2,228	1,559.6	1.82	2,838.47	10,921.51	6,000.8	3.85	S
Ambarawa	1,661	1,162.7	1.82	2,116.11	4,935.95	2,712.05	2.33	S
Bandungan	4,140	2,898	1.82	5,274.36	4,327.55	2,377.8	0.82	VC
Bawen	2,717	1,901.9	1.82	3,461.46	7,241.14	3,978.6	2.09	S
Bringin	2,349	1,644.3	1.82	2,992.63	28,808.63	15,828.9	9.63	S
Bancak	2,820	1,974	1.82	3,592.68	15,391.55	8,456.9	4.28	S
Pringapus	1,333	933.1	1.82	1,698.24	23,509.36	12,917.2	13.84	S
Bergas	1,828	1,279.6	1.82	2,328.87	7,593.47	4,172.2	3.26	S
Ungaran Barat	2,105	1,473.5	1.82	2,681.77	5,400.34	2,967.2	2.01	S
Ungaran Timur	364	254.8	1.82	463.74	6,387.01	3,509.3	13.77	S
Jumlah	48,444	33,910.8		61,717.64	223,359.43	122,724.7	120.68	

SD = sub-district, Bcp = beef cattle population, Bcp (AU) = beef cattle population in livestock units, Rm = minimum feed requirements for beef cattle (ton DDM /year /AU), R bc = beef cattle feed requirements (tons /DDM/year), F Dmp = forage dry matter production (ton DDM), CC = carrying capacity (AU), CCI = carrying capacity index of forage, AV = forage availability status; S = safe, V = vurnerable, VC = very critical.

Table 5. Results of measurements of environmental factors that influence the growth of beef cattle in Semarang Regency in 2018

Subdistrict	Sample (Village)	Temperature (°C)	Temperature (°F)	Humidity (%)	THI	Rainfall (mm/year)	Dry months	Water pH
Getasan	Samirono	31	87.8	51	79.77	3,403	3	7
Tengaran	Duren	30	86	65	80.61	2,591	3	5.8
Susukan	Timpik	32	89.6	57	82.13	2,618	3	6.5
Kaliwungu	Mukiran	32	89.6	56	81.95	2,618	0	5.5
Suruh	Dadapayam	32	89.6	65	83.52	2,680	4	6.3
Pabelan	Terban	32	89.6	58	82.3	1,927	4	6.5
Tuntang	Tlumpakan	35	95	46	84.01	2,676	0	7
Banyubiru	Wirogomo	30	86	51	78.45	2,066	3	8
Jambu	Genting	31	87.8	49	79.44	2,489	0	6.2
Sumowono	Candi Garon	28	82.4	58	76.76	1,383	4	6.3
Ambarawa	Pasekan	30	86	51	78.45	1,291	3	6.8
Bandungan	Candi	29	84.2	54	77.57	1,291	0	6.7
Bawen	Polosiri	35	95	49	84.62	2,061	4	6.1
Bringin	Banding	35	95	54	85.64	2,211	3	7.9
Bancak	Pucung	33	91.4	58	83.68	2,091	0	6.5
Pringapus	Penawangan	32	89.6	56	81.95	2,290	3	4
Bergas	Munding	32	89.6	48	80.56	3,802	2	5.9
Ungaran Barat	Gogik	32	89.6	49	80.74	3,316	0	7.7
Ungaran Timur	Kawengen	33	91.4	51	82.4	3,316	0	6.6

THI = T - {0.55 (1-RH / 100) (T-58)}, where T = temperature (°F), RH = relative humidity.

Table 6. Extent of suitability ecological environment map of beef cattle farms in Bancak, Banyubiru, and Bringin sub-districts

NO	SUBDISTRICT	Extent of Land Suitability (Ha)						Total
		S1	S1p	S2	S2p	S3	S3p	
1	Bancak	0	40.26	0.06	1,342.25	0	167.51	1,550.079
2	Banyubiru	17.10	0	1,434.10	0	0	0	1,451.2
3	Bringin	0	36.01	0	2,327.42	0	395.43	2,758.862
	TOTAL	17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

S1 = very suitable, S2 = quite suitable, S3 = according to marginal, P = limiting factor in the form of temperature humidity index (THI).

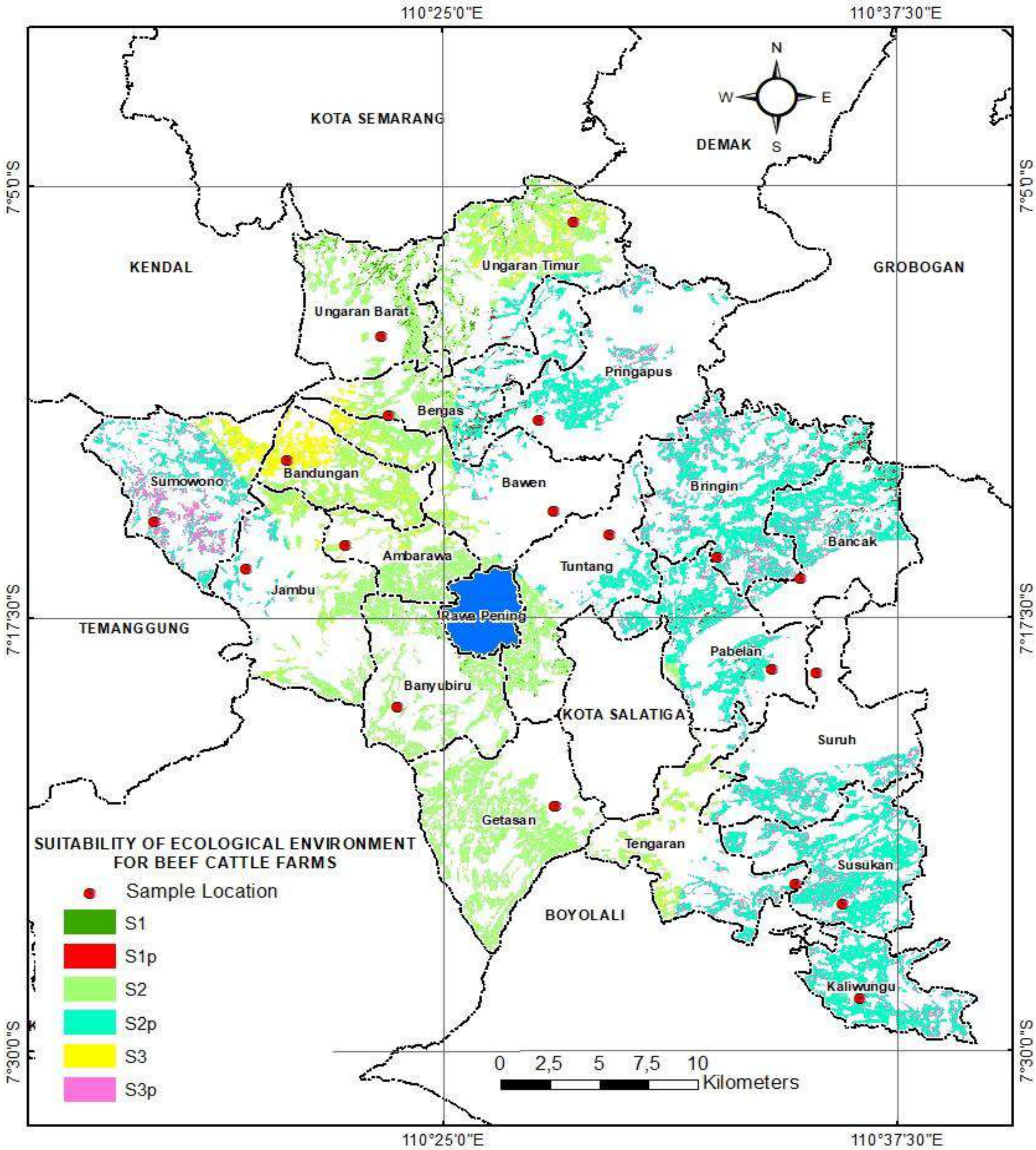

Figure 2. The suitability ecological environment map for beef cattle farms in Semarang Regency

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The Regional Analysis of Beef Cattle Farm Development in Semarang Regency

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ABSTRACT

One of the reasons for low production and productivity of beef cattle in Indonesia is that information on the allocation of livestock areas development is not yet clear. This study aims to determine the priority areas for developing beef cattle farm in Semarang Regency based on the concept of sustainability. Sustainability is analyzed through the determination of leading commodities (analysis of Location Quotient and Shift Share), optimization of regional potential (analysis of carrying capacity and carrying capacity index of forage, and assessment of suitability ecological environment of beef cattle). The process of spatial analysis used GIS software. Comprehensive planning for the development of beef cattle farm was directed in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of the analysis show that the three sub-districts were beef cattle base areas (LQ>1), had business growth (positive SS), and had a safe status for forage availability (>2). Other results show that the carrying capacity for beef cattle farms in Bringin sub-district was 15,829 AU, Bancak was 8,457 AU, and Banyubiru was 6,315 AU. The land area suitable for beef cattle farm from the three priority sub-districts was 5,760.141 Ha. It can be concluded that the development of beef cattle farm in Semarang Regency is focused on three priority sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of this study can be an input for local governments in determining the direction and pattern of beef cattle farm development to be more sustainable.

Key words: beef cattle, regional analysis, sustainability of livestock sector.

INTRODUCTION

The directed and sustainable development of the livestock sector is believed to be able to contribute positively to regional development. Along with the increase in population, there is an increasing demand for food from animal protein such as beef. Beef consumption in developing countries such as in Indonesia tends to increase every year (Thornton, 2010; Agus & Widi, 2018), however the population of beef cattle in some regions actually decreases due to the complexity of technical and non-technical problems (Paly *et al*., 2013; Ariningsih, 2014; Nuhung, 2015). There is a gap between demand and supply of beef products which are increasingly widening. Many factors causing this gap, including the domestic production of beef cattle is still low because information on the allocation of livestock development areas is not yet clear.

Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009; Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able to meet the high consumption of people against meat. The consumption of beef in 2020 is estimated to reach 3.36 kg per capita per year, but beef production is still not able to fulfill it, there is a deficit in beef supply of 198,350 tons (Kementan, 2016; Agus & Widi, 2018). Most of beef production in Indonesia, 78% comes from traditional livestock, 5% from imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al*., 2017). Imports of beef are indeed relatively larger compared to other types of meat imports, contributing 21.44% to the total import value of livestock, while the import value of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al*., 2014).

Policy efforts to reduce beef imports must be studied, by strengthening domestic production that is beneficial for farmers (Pasandaran *et al*., 2014). The development of

beef cattle farms in potential areas is an effort to strengthen meat production in the country so that the implementation must be carried out with a comprehensive assessment. Semarang Regency is a region in Central Java Province that has the potential to develop beef cattle farms because it has natural resources in the form of land as a place for livestock keeping and forage production. Good quality and always available forage can increase production, especially for increasing body weight of cattle (Suhaema *et al*., 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha), rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this region during the 2014-2016 period continued to decline, ranging from 53,135, 49,172, and 46,238 (BPS Kabupaten Semarang, 2018).

The development of beef cattle farms in Semarang Regency needs to adopt the concept of sustainability. The concept of sustainability is the achievement of economic, environmental and social goals simultaneously which is represented by various performance indicators (Darnhofer *et al*., 2010). Sustainability is also defined as the concept of multidimensional (economic, ecological, social) and multiscale (micro, meso, and macro), although in its application it is often limited to one particular aspect (Santos *et al*., 2017). Economic sustainability is closely related to the value of comparative and competitive advantages of certain commodities (Broom *et al*., 2013; Sabaghi *et al*., 2016), while environmental sustainability includes optimizing the availability of natural resources and efficient use (Atanga *et al*., 2013).

The sustainability of beef cattle farms can be identified through a regional approach, by considering the existence of leading commodities and the potential of the region concerned (Mulyono & Munibah, 2016; Parmawati *et al*., 2018). Determination of leading commodities characterized by the existence of comparative and competitive advantages is the first step towards efficient development of the livestock sector. The potential of the region to support the development of beef cattle farms is determined by optimizing the carrying capacity and carrying capacity index of forage, as well as assessing the suitability of the land where the livestock grows. Land suitability for beef cattle farms with intensive production systems considers several environmental factors that affect the growth of these cattle.

Mapping activities based on the determination of leading commodities and optimization of regional potential are needed as a basis for planning sustainable development of beef cattle farms. This study aims to determine the priority areas for developing beef cattle farms in Semarang Regency. The results of this study are expected to be one of the considerations in determining the direction and development policy of the beef cattle farms sector in Semarang Regency.

MATERIALS AND METHODS

This research is a type of quantitative research and applies the concept of sustainability. Sustainability assessed is economic and environmental sustainability for beef cattle farm in Semarang Regency. Economic sustainability is identified through the determination of leading commodity of livestock, while environmental sustainability is identified through the calculation of the carrying capacity and carrying capacity index of forage, and assessment of suitability ecological environment of beef cattle. In detail, each step of the analysis is outlined below.

Leading Commodity

Determination of leading livestock commodities in an area uses Locationt Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods is the economic basis theory. LQ analysis is relatively simple, but the benefits are large enough for the initial identification of the ability of a sector in regional development. The shift in the structure of economic activity in beef cattle business, whether experiencing growth or decline is analyzed using Shift Share (SS). SS analysis can be used to see the growth of the economic sectors of a region for two time points (Muta'ali, 2015). LQ and SS analysis uses equations that refer to (Ciptayasa *et al*., 2016; Mulyono & Munibah, 2016).

$LQ_{ij} = \frac{Xij\ /\ Xi.}{X.j\ /\ X..}$ (Equation 1)

(X_{ij} = Beef cattle population in the sub-district A, $X_{i.}$ = Population of all types of livestock in the sub-district A, $X_{.j}$ = Beef cattle population in Semarang Regency, $X_{..}$ = Population of all types of livestock in Semarang Regency).

$SS = \left[\frac{X..(t1)}{X..(t0)} - 1\right] + \left[\frac{X.i(t1)}{X.i((t0)} - \frac{X..(t1)}{X..(t0)}\right] + \left[\frac{Xij(t1)}{Xij(t0)} - \frac{X.i(t1)}{X.i((t0)}\right]$ (Equation 2)

(Regional share, Proportional shift, Differential shift, X .. = Population of all types of livestock in Semarang Regency, Xi = Beef cattle population in Semarang Regency, Xij = Beef cattle population in sub-district A, t0 = Early 2013 year point, t1 = End of year 2017).

Carrying Capacity and Carrying Capacity Index of Forage

The carrying capacity of the region for livestock development is indicated by the ability of the region to produce forage that can accommodate and meet the needs of a number of beef cattle populations. Forages are divided into two types, namely fresh forage (grass, legume) and dry forage (straw). An assessment of the carrying capacity index of forage is conducted to assess the availability of animal feed in a region, whether classified as safe, vulnerable, critical, or very critical.

The carrying capacity of beef cattle farms is calculated based on the production of forage dry matter against the minimum feed requirements of cattle (1 AU) in one year. The animal unit (AU) is a unit for the ruminant livestock population multiplied by the conversion factor. The conversion factor for beef cattle is 0,7 (Muta'ali, 2015; Saputra *et al*., 2016). Forage dry matter production is the amount of potential agricultural waste and natural forage potential, using equations that refer to (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

Potential of agricultural waste (ton) = {(wr x 0,4) + (fr x 3 x 0,4) + (cn x 3 x 0,5) + (sb x 3 x 0,55) + (pt x 2 x 0,55) + (sp x 0,25/6) + (cs x 0,25/4)} x 0,65

(wr: wetland rice, fr: field rice, cn: corn, sb: soybean, pt: peanuts, sp: sweet potatoes, cs: cassava. The numbers in the formula are assumptions about the potential waste produced from the production of each type of plant food).

Natural forage potential (ton) = {(Ga x 2,875) + (Fa x 0,6) + (Cpa x 10) + (Cfa x 0,5) + (Cla x 5)} x 0,5

(Ga: garden area, Fa: forest area, Cpa: coconut plant area, Cfa: coffee plant area, Cla: clove plant area. The numbers in the formula are assumed to be natural forage potential produced per hectare of land use area).

Minimum cattle feed requirements.

R= 2,5% x 50% x 365 x 400kg = 1,82 ton DDM/year/AU (Equation 3)

(R = minimum cattle feed requirements (1 AU) in tons of digestible dry matter for 1 year, 2.5% = minimum requirement for the number of forage rations (dry matter) on livestock weight, 50% = average value digestibility power of various types of plants, 365 = Number of days in 1 year, 400 kg = live weight of 1 AU of beef cattle in Semarang Regency). Equations that refer to (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

The results of the calculation of forage dry matter production are then used to determine the carrying capacity of beef cattle farms using the following equations (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

$$\text{CC (AU)} = \frac{\text{Forage Dry Matter Production (tons of DDM / year)}}{\text{Minimum Cattle Feed Requirement (tons of DDM / year / AU)}} \text{ (Equation 4)}$$

The level of animal feed security in a region is measured by forage carrying capacity index. Carrying capacity index values are values that indicate the status of the availability of forage for beef cattle, namely: very critical (≤1), critical (>1-1,5), vulnerable (> 1,5-2), and safe (>2).

$$\text{Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \quad \text{(Equation 5)}$$

Suitability of The Ecological Environment of Beef Cattle

The research sample for the assessment of the suitability ecological environment of beef cattle farms in Semarang Regency is 19 points spread throughout the sub-district area (Table 5). Determination of the sample is using purposive sampling technique. The purposive sampling technique is also called judgment sampling (Tongco, 2007), which is to determine the sample based on research considerations. In each sub-district one village is taken which has the most beef cattle population.

Land available for the development of beef cattle farms is: gardens, grasslands, open land, rice fields, and dry land agriculture. The fields are assumed to be able to be built for housing for beef cattle. The assessment of land suitable for beef cattle farming with intensive maintenance patterns, also takes into account several environmental parameters that influence the growth of livestock.

Land suitability assessment for beef cattle farms begins with making a map of land units. Maps of beef cattle land units refer to research (Rusmana *et al*., 2006) which states that there are four maps needed for overlaying, namely: land type maps, agro-climate maps, regional altitude maps, and slope maps. The final step is to make a "suitability map of the ecological environment of beef cattle". The method used is by overlaying between land unit maps with environmental parameters that affect the growth of beef cattle (Table 1). Land suitability is classified into 4 levels or strata, namely: very suitable (S1), quite suitable (S2), according to marginal (S3), and non-suitable (NS) (Rusmana *et al*., 2006; Suhaema *et al*., 2014; Yuniar *et al*., 2016). The entire process was created and analyzed using GIS software.

RESULTS

Leading Commodity

Leading commodity livestock in an area is determined based on comparative advantage (location quotient analysis) and competitive advantage (shift share analysis). Beef cattle commodities that have LQ>1 and SS (+) values are the leading commodities in the region. The interpretation of the value of LQ>1, is a base or leading sector, beef cattle products (meat) are able to meet markets inside and outside the region. LQ<1 value, is a non-base sector, livestock products have not been able to meet markets inside and outside the region. LQ=1 value, meaning that the sector is balanced with the reference region, livestock products are only able to meet markets in the area. The basis for calculating LQ analysis for livestock commodities is livestock population data (Hendayana, 2003). Data bias in calculations can be minimized by using a minimum 5 year data series (Table 2).

Shift share analysis starts from the basic assumption that economic growth or added value of an activity in a particular region is influenced by three main components which are interconnected with each other, namely: regional growth, sectoral growth, and growth in share or regional competitiveness (Ciptayasa *et al*., 2016). Through these three components, it can be seen which elements have encouraged regional economic growth. The value of each component can be positive or negative, but the total number (shift share) will always be positive if the regional economic growth is positive, and vice versa.

The results of the LQ and SS analysis calculations for beef cattle commodities in Semarang Regency are shown in Table 3. Based on the results of the analysis conducted, the subdistrict areas becoming the beef cattle base sector (LQ> 1) were Bancak (4.93), Banyubiru (3.97), Ambarawa (3.92), Bringin (2.82), and Bawen (2.34). Beef cattle keeping was concentrated in these areas or in other words the economic density of beef cattle was higher than that of in other regions.

Beef cattle commodities that have competitive advantages are seen based on positive shift share (SS) values. Sub-districts with a positive SS value means experiencing growth (competitiveness) related to keeping beef cattle. On the other hand, sub-districts with negative SS value means that the area is not growing (stagnant) and can even experience setbacks. The results of the analysis conducted in Table 3 shows that sub-districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47), Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tengaran (0.026).

The development of beef cattle farms in Semarang Regency is prioritized in the sub-districts with LQ>1 and SS (+) values. The sub-districts are Bringin, Bancak, and Banyubiru.

Carrying Capacity and Carrying Capacity Index of Forage

Potential availability of feed for beef cattle is seen based on the amount of forage dry matter production (tons of DDM) that can be produced by the region concerned. Dry matter is the total feed ingredients without water content, which can come from forages. The region with the largest forage dry matter production has the highest carrying capacity for the development of beef cattle farms, and vice versa. Forage is one of the production inputs that determines the success of livestock business because it directly affects productivity and efficiency (Yuniar *et al*., 2016). Table 4 shows the calculation of carrying capacity and carrying capacity index of forage for beef cattle farms in Semarang Regency.

Based on the results of the analysis conducted in Table 4, it is known that there were three sub-districts with the highest production of forage dry matter, namely Bringin (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons DDM). Sub-district area with the lowest forage dry matter production, namely Bandungan (4,327.55 tons DDM). The status of availability of forage in Bandungan sub-district was categorized as very critical (0.82), while in Tengaran sub-district it was categorized as vulnerable (1.69). Thus, these two sub-districts are not recommended for the development of beef cattle farms. Sub-district areas with carrying capacity index value >2 (safe) means that the area can be recommended for the development of beef cattle farms. The advantage obtained by the area with this safe category is that farmers can reduce the amount of production costs for beef cattle feed.

Semarang Regency has carrying capacity for beef cattle farms of 122,725 AU. The population of beef cattle in 2017 is 33,911 AU, so the Semarang Regency area is assumed to still be able to accommodate 88,814 AU beef cattle in 2018.

Suitability of The Ecological Environment of Beef Cattle

The results of field measurements and secondary data collection conducted on several environmental factors that influence the growth of beef cattle are shown in Table 5. The factors that limit the assessment of the suitability ecological environment of beef cattle farming in Semarang Regency are the Temperature Humidity Index (THI) and water pH. Annual rainfall (<4000 mm) and dry months (<8) are in the appropriate category.

The suitability ecological environment map for beef cattle farms in Semarang Regency is shown in Figure 1. The white area is an area that is not assessed because it is designated as land for settlements, plantations, tourism, and forests. Based on Figure 1, it is known that the level of suitability of the produced beef cattle ecological environment is: very suitable (S1), quite suitable (S2), and according to marginal (S3). Non-suitable (NS) categories are not assessed because the area has a slope >40% (steep - very steep).

The symbol "p" indicates that there is a limiting factor in the area assessed. The limiting factors are the Temperature Humidity Index (THI) and the pH of the water for beef cattle consumption (Table 5). Semarang Regency consists of 19 sub-districts. The development of beef cattle farms is prioritized in sub-districts that have LQ>1, SS (+) value, and carrying capacity index of forage (>2), namely Bringin, Bancak, and Banyubiru. Banyubiru sub-district is not constrained by limiting factors, while Bringin and Bancak are constrained by THI values that exceed the comfort zone for growing cattle (>80). The extent suitability of the ecology of beef cattle farms from the three priority sub-districts is shown in Table 6.

Based on the results of the analysis conducted in Table 6, the sub-districts with the largest land area for the development of beef cattle farms with intensive production systems were respectively Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru (1,451.2 Ha). The limiting factor in the form of temperature humidity index (THI) or water pH can be minimized through the engineering design of livestock housing and provision of materials or neutralizing water acidity solvent (Yani *et al*., 2007; Sarwanto & Hendarto, 2011). Cattle with intensive production systems are generally more susceptible to heat stress than cattle extensively production systems. Efforts that can be done to reduce heat stress in beef cattle include: adding shade around the housing location, install a sprinkle tool or add straw that works to lower the surface temperature of the floor, regulate feed, feed additives and medicine, etc (Suhaema *et al*., 2014).

DISCUSSION

Semarang Regency is a potential area for the development of beef cattle farming because it has abundant natural resources in the form of land for livestock keeping and forage production. The mapping activity is based on the determination of leading livestock commodities, and optimization of regional potential can be one of the benchmarks in realizing sustainable development of beef cattle farms. The concept of sustainable development is to meet the needs of the current generation, without sacrificing future generations and this concept has become a reference for welfare in almost all sectors, including the livestock sector (Wasike *et al*, 2011). The concept of sustainability has been widely debated throughout the world over the past few years (De Longe *et al*., 2016; Keesstra *et al*., 2016; Rasmussen *et al*., 2017), not only concerning issues environmental and social issues, but also discussing economic issues to gain certain market or commodity advantages (Broom *et al.*, 2013; Sabaghi *et al*., 2016). Sustainability assessment is achieved by evaluating the relative contribution of each of the economic, environmental and social factors to the overall goal (Astier & García-Barrios, 2012). Sustainability assessed in this study is economic and environmental sustainability for beef cattle farms.

Economic sustainability is assessed based on the results of the analysis of leading commodity. The leading livestock commodity in an area are determined based on comparative advantage (LQ analysis) and competitive advantage (SS analysis). The concept of comparative advantage is economic feasibility. Commodities that have a comparative advantage (LQ>1) show that the commodity (beef cattle) is supported by the existence of adequate natural resources so that the population level is higher than in other regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a prominent or dominant livestock business compared to the other livestock businesses, so the effort for future development is easier (Yuniar *et al*., 2016; Mulyono & Munibah, 2016). On the other hand, the concept of competitive advantage is financial feasibility. Beef cattle commodities are keeping in effective and efficient ways, so that they have competitiveness from aspects of quality, quantity, continuity and price (Muta'ali, 2015; Mulyono & Munibah, 2016). The results presented in Table 3 show that the Bringin, Bancak, and Banyubiru sub-districts are regions with leading commodity of beef cattle. Accordingly, the three sub-districts are a priority for the development of beef cattle farms in Semarang Regency.

Environmental sustainability for beef cattle farms is assessed based on the results of the carrying capacity analysis and carrying capacity index of forage, and analysis of suitability of the ecological environment of beef cattle. Carrying capacity is defined as the maximum population that can be supported by an ecosystem from time to time. The carrying capacity of an area is not static, there is a kind of reciprocal relationship between organism and their environment. The carrying capacity of a region can vary for different species and change over time due to various factors (Taiwo & Feyisara, 2017). Regional carrying capacity for livestock development is the size of the region's ability to support the livelihoods of a number of livestock populations optimally through the role of forage availability. Based on the results of the analysis presented in Table 4, it is known that the Bringin, Bancak, and Banyubiru sub-districts have a forage carrying capacity index in the safe category.

The production systems of beef cattle that is often found in Semarang Regency is an intensive production systems. Beef cattle are able to show optimal physical conditions if they have superior genetic traits, and are supported by the suitability of their ecological environment (Suhaema *et al*., 2014). Animal ecology is the study of the interactions between animals and their environment. Environmental factors tend to affect the production and productivity of livestock more (Sumarto & Koneri, 2016). Some environmental factors that influence the growth of beef cattle with intensive production systems are: soil type, length of dry season, altitude, slope (Rusmana *et al*., 2006), temperature and relative humidity, rainfall, water pH (Herbut & Angrecka, 2012; Suhaema *et al*., 2014; Yuniar *et al*., 2016; Eirich, 2018).

The results of the analysis in Table 5 show that environmental factors are limiting in the development of beef cattle farms in Semarang Regency are air temperature and humidity, and pH of water for livestock drinking needs. The relationship between the amount of air temperature and humidity is called the Temperature Humidity Index (THI). If THI exceeds the threshold (>80), it can cause stress or heat stress in beef cattle (Eirich, 2018). Long-term heat stress has an impact on increasing drinking water consumption, increasing urine volume, and decreasing feed consumption. The direct effect of heat stress on livestock production causes a decrease in the productivity of beef cattle. This is due to the increasing need for livestock maintenance (Berman, 2005). Furthermore, the THI value that exceeds the threshold influences the decrease in daily body weight gain, depletion of the thickness of meat fat, and the increase of potential for disease occurrence especially in male cattle (Nardone *et al*., 2010). Hydrogen potential (pH) characterizes the balance between acidic and alkaline solvent in water. If the pH of drinking water for beef cattle is below the quality standard or acid (<6,5), the water becomes sour and can cause physiological and digestive disorders in livestock. On the other hand, if the pH of water is too alkaline (>9), the water becomes bitter and causes a decrease in consumption of drinking water which has an impact on decreasing livestock productivity (Sarwanto & Hendarto, 2011).

The synthesis of the assessment results of leading commodity, calculation of carrying capacity and carrying capacity index of forage, as well as land suitability assessment, shows that there are three sub-districts (Bringin, Bancak, and Banyubiru) which are priorities for the development of beef cattle farms in Semarang Regency.

CONCLUSION

Planning for the development of beef cattle farming with intensive production systems in Semarang Regency is recommended in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The assumption of forage production produced from these three sub-districts reaches 55,693.72 tons of DDM. The total carrying capacity for beef cattle farms is 30,601 AU. The total land area suitable for beef cattle farming in the three priority sub-districts is 5,760.141 Ha. The development of beef cattle farms in priority sub-districts is expected to increase livestock production and productivity. Governments, communities (cattleman) and the private sector (investors) must coordinate and cooperate with each other so that the development of sustainable beef cattle farms can be achieved.

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REFERENCES

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Agus, A. & Widi, T. S. M should be Agus, A. & T.S.M. Widi
Please revise all references

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Table 1. Environmental parameters that influence the growth of beef cattle with intensive maintenance patterns

Parameter	**Order of environmental suitability of beef cattle**	
	S (Suitable)	N (Unsuitable)
Temperature Humidity Index (THI)	70-80	<70, >80
Water availability (w)		
Dry month (<100 mm rainfall/month)	<8 months	>8 months
Rainfall / year (mm)	< 4,000	> 4,000
The existence of a water source	Available	Not Available
Water Quality (q)		
pH water	6.5-9.0	<6.5; >9.0
Slope (%)	<40	>40

Source: (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

Table 2. Growth of livestock populations in Semarang Regency

Type of livestock	**Number (head)**				
	2013	**2014**	**2015**	**2016**	**2017**
Pig	32,640	17,300	18,431	15,971	15,850
Goat	197,029	136,999	123,294	117,003	117,373
Sheep	290,764	191,346	172,211	167,374	162,694
Rabbit	20,352	9,375	10,462	11,629	11,916
Horse	1,711	497	515	524	581
Beef cattle	51,901	53,135	49,172	46,238	48,444
Dairy cows	22,308	27,609	25,780	25,690	25,557
Buffalo	2,941	3,168	2,614	2,629	2,589
Laying Chicken	1,821,286	1,813,049	1,452,019	1,331,528	1,572,463
Broiler Chicken	12,046,319	7,501,700	10,144,846	10,754,602	11,812,311
Chicken Breed	819,067	860,408	818,568	861,989	823,226
Duck	206,882	92,963	80,801	127,859	125,261
Quail	122,200	238,930	227,737	176,730	142,856
Muscovy Duck	102,966	72,227	63,889	61,963	54,402

Source: (BPS Kabupaten Semarang, 2018).

Table 3. Value of LQ and SS beef cattle in Semarang Regency in 2018

NO	SUB-DISTRICT	BEEF CATTLE				
		LQ	RS	PS	DF	SS
1	Getasan	0.63	-0.052	-0.014	-0.359	-0.425
2	Tengaran	0.55	-0.052	-0.014	0.092	0.026
3	Susukan	1.11	-0.052	-0.014	-0.137	-0.203
4	Kaliwungu	1.22	-0.052	-0.014	0.048	-0.018
5	Suruh	0.88	-0.052	-0.014	-0.213	-0.279
6	Pabelan	1.75	-0.052	-0.014	0.501	0.435
7	Tuntang	0.28	-0.052	-0.014	-0.689	-0.755
8	Banyubiru	3.97	-0.052	-0.014	0.536	0.47
9	Jambu	0.42	-0.052	-0.014	-0.417	-0.483
10	Sumowono	0.95	-0.052	-0.014	-0.234	-0.3
11	Ambarawa	3.92	-0.052	-0.014	0.006	-0.06
12	Bandungan	1.01	-0.052	-0.014	0.269	0.203
13	Bawen	2.34	-0.052	-0.014	0.0009	-0.0651
14	Bringin	2.82	-0.052	-0.014	0.105	0.039
15	Bancak	4.93	-0.052	-0.014	0.143	0.077
16	Pringapus	1.38	-0.052	-0.014	-0.312	-0.378
17	Bergas	0.77	-0.052	-0.014	-0.106	-0.172
18	Ungaran Barat	0.77	-0.052	-0.014	1.352	1.286
19	Ungaran Timur	0.3	-0.052	-0.014	-0.62	-0.686

LQ = Location quotient, SS = Shift share, RS = Regional share, PS = Proportional shift, DS = Differential shift.

Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency in 2018

SD	Bcp 2017	Bcp 2017 (AU)	Rm	R Bc	F Dmp	CC	CCI	AV
A	b	c	d	e = c x d	f	g = f/d	h = g/c	
Getasan	2,085	1,459.5	1.82	2,656.29	7,802.45	4,287.1	2.94	S
Tengaran	4,881	3,416.7	1.82	6,218.39	10,526.78	5,783.9	1.69	V
Susukan	2,905	2,033.5	1.82	3,700.97	15,301.29	8,407.3	4.13	S
Kaliwungu	4,650	3,255	1.82	5,924.1	13,231.72	7,270.2	2.23	S
Suruh	3,335	2,334.5	1.82	4,248.79	19,522.03	10,726.4	4.59	S
Pabelan	4,251	2,975.7	1.82	5,415.77	12,690.04	6,972.5	2.34	S
Tuntang	211	147.7	1.82	268.81	9,458.6	5,197.03	35.19	S
Banyubiru	3,840	2,688	1.82	4,892.16	11,493.54	6,315.1	2.35	S
Jambu	741	518.7	1.82	944.03	8,816.47	4,844.2	9.34	S
Sumowono	2,228	1,559.6	1.82	2,838.47	10,921.51	6,000.8	3.85	S
Ambarawa	1,661	1,162.7	1.82	2,116.11	4,935.95	2,712.05	2.33	S
Bandungan	4,140	2,898	1.82	5,274.36	4,327.55	2,377.8	0.82	VC
Bawen	2,717	1,901.9	1.82	3,461.46	7,241.14	3,978.6	2.09	S
Bringin	2,349	1,644.3	1.82	2,992.63	28,808.63	15,828.9	9.63	S
Bancak	2,820	1,974	1.82	3,592.68	15,391.55	8,456.9	4.28	S
Pringapus	1,333	933.1	1.82	1,698.24	23,509.36	12,917.2	13.84	S
Bergas	1,828	1,279.6	1.82	2,328.87	7,593.47	4,172.2	3.26	S
Ungaran Barat	2,105	1,473.5	1.82	2,681.77	5,400.34	2,967.2	2.01	S
Ungaran Timur	364	254.8	1.82	463.74	6,387.01	3,509.3	13.77	S
Jumlah	48,444	33,910.8		61,717.64	223,359.43	122,724.7	120.68	

SD = sub-district, Bcp = beef cattle population, Bcp (AU) = beef cattle population in livestock units, Rm = minimum feed requirements for beef cattle (ton DDM /year /AU), R bc = beef cattle feed requirements (tons /DDM/year), F Dmp = forage dry matter production (ton DDM), CC = carrying capacity (AU), CCI = carrying capacity index of forage, AV = forage availability status; S = safe, V = vurnerable, VC = very critical.

Table 5. Results of measurements of environmental factors that influence the growth of beef cattle in Semarang Regency in 2018

Subdistrict	Sample (Village)	Temperature (°C)	Temperature (°F)	Humidity (%)	THI	Rainfall (mm/year)	Dry months	Water pH
Getasan	Samirono	31	87.8	51	79.77	3,403	3	7
Tengaran	Duren	30	86	65	80.61	2,591	3	5.8
Susukan	Timpik	32	89.6	57	82.13	2,618	3	6.5
Kaliwungu	Mukiran	32	89.6	56	81.95	2,618	0	5.5
Suruh	Dadapayam	32	89.6	65	83.52	2,680	4	6.3
Pabelan	Terban	32	89.6	58	82.3	1,927	4	6.5
Tuntang	Tlumpakan	35	95	46	84.01	2,676	0	7
Banyubiru	Wirogomo	30	86	51	78.45	2,066	3	8
Jambu	Genting	31	87.8	49	79.44	2,489	0	6.2
Sumowono	Candi Garon	28	82.4	58	76.76	1,383	4	6.3
Ambarawa	Pasekan	30	86	51	78.45	1,291	3	6.8
Bandungan	Candi	29	84.2	54	77.57	1,291	0	6.7
Bawen	Polosiri	35	95	49	84.62	2,061	4	6.1
Bringin	Banding	35	95	54	85.64	2,211	3	7.9
Bancak	Pucung	33	91.4	58	83.68	2,091	0	6.5
Pringapus	Penawangan	32	89.6	56	81.95	2,290	3	4
Bergas	Munding	32	89.6	48	80.56	3,802	2	5.9
Ungaran Barat	Gogik	32	89.6	49	80.74	3,316	0	7.7
Ungaran Timur	Kawengen	33	91.4	51	82.4	3,316	0	6.6

THI = T - {0.55 (1-RH / 100) (T-58)}, where T = temperature (°F), RH = relative humidity.

Table 6. Extent of suitability ecological environment map of beef cattle farms in Bancak, Banyubiru, and Bringin sub-districts

NO	SUBDISTRICT	Extent of Land Suitability (Ha)						Total
		S1	S1p	S2	S2p	S3	S3p	
1	Bancak	0	40.26	0.06	1,342.25	0	167.51	1,550.079
2	Banyubiru	17.10	0	1,434.10	0	0	0	1,451.2
3	Bringin	0	36.01	0	2,327.42	0	395.43	2,758.862
	TOTAL	17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

S1 = very suitable, S2 = quite suitable, S3 = according to marginal, P = limiting factor in the form of temperature humidity index (THI).

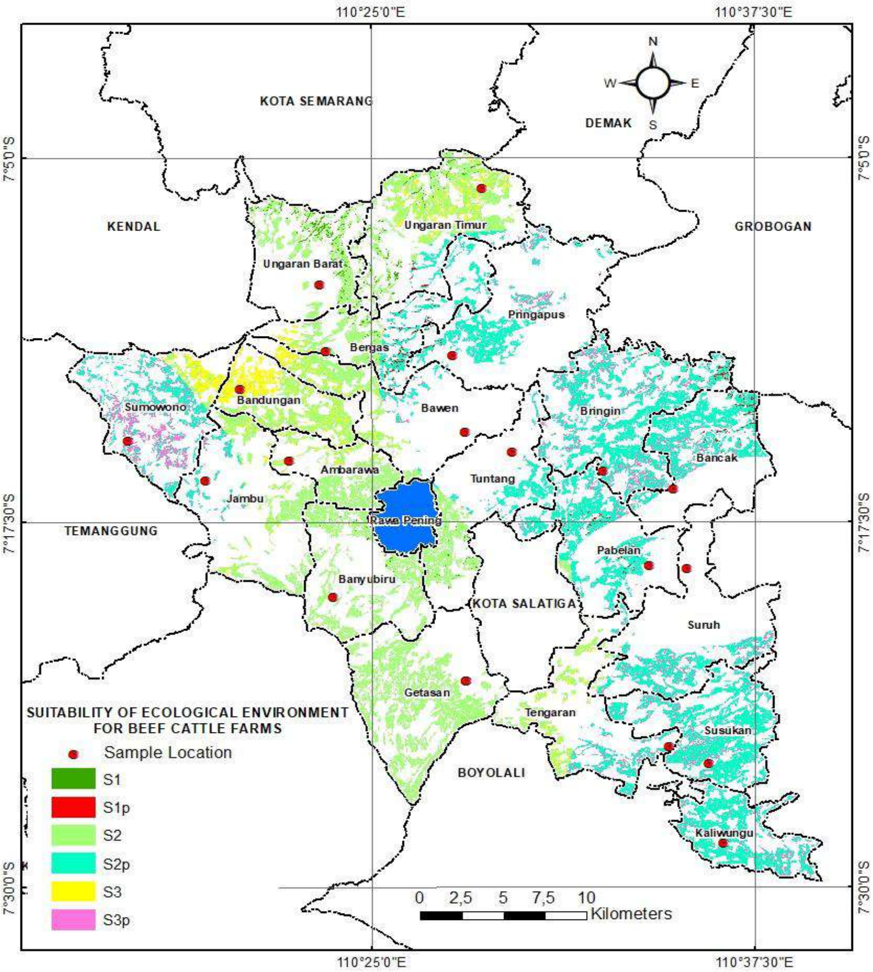

Figure 2. The suitability ecological environment map for beef cattle farms in Semarang Regency

The Regional Analysis of Beef Cattle Farm Development in Semarang Regency

ABSTRACT

One of the reasons for low production and productivity of beef cattle in Indonesia is that information on the allocation of livestock areas development is not yet clear. This study aims to determine the priority areas for developing beef cattle farm in Semarang Regency based on the concept of sustainability. Sustainability is analyzed through the determination of leading commodities (analysis of Location Quotient and Shift Share), optimization of regional potential (analysis of carrying capacity and carrying capacity index of forage, and assessment of suitability ecological environment of beef cattle). The process of spatial analysis used GIS software. Comprehensive planning for the development of beef cattle farm was directed in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of the analysis show that the three sub-districts were beef cattle base areas (LQ>1), had business growth (positive SS), and had a safe status for forage availability (>2). Other results show that the carrying capacity for beef cattle farms in Bringin sub-district was 15,829 AU, Bancak was 8,457 AU, and Banyubiru was 6,315 AU. The land area suitable for beef cattle farm from the three priority sub-districts was 5,760.141 Ha. It can be concluded that the development of beef cattle farm in Semarang Regency is focused on three priority sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of this study can be an input for local governments in determining the direction and pattern of beef cattle farm development to be more sustainable.

Key words: beef cattle, regional analysis, sustainability of livestock sector.

INTRODUCTION

The directed and sustainable development of the livestock sector is believed to be able to contribute positively to regional development. Along with the increase in population, there is an increasing demand for food from animal protein such as beef. Beef consumption in developing countries such as in Indonesia tends to increase every year (Thornton, 2010; Agus & Widi, 2018), however the population of beef cattle in some regions actually decreases due to the complexity of technical and non-technical problems (Paly *et al*., 2013; Ariningsih, 2014; Nuhung, 2015). There is a gap between demand and supply of beef products which are increasingly widening. Many factors causing this gap, including the domestic production of beef cattle is still low because information on the allocation of livestock development areas is not yet clear.

Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009; Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able to meet the high consumption of people against meat. The consumption of beef in 2020 is estimated to reach 3.36 kg per capita per year, but beef production is still not able to fulfill it, there is a deficit in beef supply of 198,350 tons (Kementan, 2016; Agus & Widi, 2018). Most of beef production in Indonesia, 78% comes from traditional livestock, 5% from imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al*., 2017). Imports of beef are indeed relatively larger compared to other types of meat imports, contributing 21.44% to the total import value of livestock, while the import value of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al*., 2014).

Policy efforts to reduce beef imports must be studied, by strengthening domestic production that is beneficial for farmers (Pasandaran *et al*., 2014). The development of

beef cattle farms in potential areas is an effort to strengthen meat production in the country so that the implementation must be carried out with a comprehensive assessment. Semarang Regency is a region in Central Java Province that has the potential to develop beef cattle farms because it has natural resources in the form of land as a place for livestock keeping and forage production. Good quality and always available forage can increase production, especially for increasing body weight of cattle (Suhaema *et al.*, 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha), rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this region during the 2014-2016 period continued to decline, ranging from 53,135, 49,172, and 46,238 (BPS Kabupaten Semarang, 2018).

The development of beef cattle farms in Semarang Regency needs to adopt the concept of sustainability. The concept of sustainability is the achievement of economic, environmental and social goals simultaneously which is represented by various performance indicators (Darnhofer *et al.*, 2010). Sustainability is also defined as the concept of multidimensional (economic, ecological, social) and multiscale (micro, meso, and macro), although in its application it is often limited to one particular aspect (Santos *et al.*, 2017). Economic sustainability is closely related to the value of comparative and competitive advantages of certain commodities (Broom *et al.*, 2013; Sabaghi *et al.*, 2016), while environmental sustainability includes optimizing the availability of natural resources and efficient use (Atanga *et al.*, 2013).

The sustainability of beef cattle farms can be identified through a regional approach, by considering the existence of leading commodities and the potential of the region concerned (Mulyono & Munibah, 2016; Parmawati *et al.*, 2018). Determination of leading commodities characterized by the existence of comparative and competitive advantages is the first step towards efficient development of the livestock sector. The potential of the region to support the development of beef cattle farms is determined by optimizing the carrying capacity and carrying capacity index of forage, as well as assessing the suitability of the land where the livestock grows. Land suitability for beef cattle farms with intensive production systems considers several environmental factors that affect the growth of these cattle.

Mapping activities based on the determination of leading commodities and optimization of regional potential are needed as a basis for planning sustainable development of beef cattle farms. This study aims to determine the priority areas for developing beef cattle farms in Semarang Regency. The results of this study are expected to be one of the considerations in determining the direction and development policy of the beef cattle farms sector in Semarang Regency.

MATERIALS AND METHODS

This research is a type of quantitative research and applies the concept of sustainability. Sustainability assessed is economic and environmental sustainability for beef cattle farm in Semarang Regency. Economic sustainability is identified through the determination of leading commodity of livestock, while environmental sustainability is identified through the calculation of the carrying capacity and carrying capacity index of forage, and assessment of suitability ecological environment of beef cattle. In detail, each step of the analysis is outlined below.

Leading Commodity

Determination of leading livestock commodities in an area uses Locationt Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods is the economic basis theory. LQ analysis is relatively simple, but the benefits are large enough for the initial identification of the ability of a sector in regional development. The shift in the structure of economic activity in beef cattle business, whether experiencing growth or decline is analyzed using Shift Share (SS). SS analysis can be used to see the growth of the economic sectors of a region for two time points (Muta'ali, 2015). LQ and SS analysis uses equations that refer to (Ciptayasa *et al*., 2016; Mulyono & Munibah, 2016).

$$LQ_{ij} = \frac{Xij \;/\; Xi.}{X.j \;/\; X..} \text{ (Equation 1)}$$

(X_{ij} = Beef cattle population in the sub-district A, $X_{i.}$ = Population of all types of livestock in the sub-district A, $X_{.j}$ = Beef cattle population in Semarang Regency, $X_{..}$ = Population of all types of livestock in Semarang Regency).

$$SS = \left[\frac{X..(t1)}{X..(t0)} - 1\right] + \left[\frac{X.i(t1)}{X.i((t0)} - \frac{X..(t1)}{X..(t0)}\right] + \left[\frac{Xij(t1)}{Xij(t0)} - \frac{X.i(t1)}{X.i((t0)}\right] \text{ (Equation 2)}$$

(Regional share, Proportional shift, Differential shift, X .. = Population of all types of livestock in Semarang Regency, Xi = Beef cattle population in Semarang Regency, Xij = Beef cattle population in sub-district A, t0 = Early 2013 year point, t1 = End of year 2017).

Carrying Capacity and Carrying Capacity Index of Forage

The carrying capacity of the region for livestock development is indicated by the ability of the region to produce forage that can accommodate and meet the needs of a number of beef cattle populations. Forages are divided into two types, namely fresh forage (grass, legume) and dry forage (straw). An assessment of the carrying capacity index of forage is conducted to assess the availability of animal feed in a region, whether classified as safe, vulnerable, critical, or very critical.

The carrying capacity of beef cattle farms is calculated based on the production of forage dry matter against the minimum feed requirements of cattle (1 AU) in one year. The animal unit (AU) is a unit for the ruminant livestock population multiplied by the conversion factor. The conversion factor for beef cattle is 0,7 (Muta'ali, 2015; Saputra *et al*., 2016). Forage dry matter production is the amount of potential agricultural waste and natural forage potential, using equations that refer to (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

Potential of agricultural waste (ton) = {(wr x 0,4) + (fr x 3 x 0,4) + (cn x 3 x 0,5) + (sb x 3 x 0,55) + (pt x 2 x 0,55) + (sp x 0,25/6) + (cs x 0,25/4)} x 0,65

(wr: wetland rice, fr: field rice, cn: corn, sb: soybean, pt: peanuts, sp: sweet potatoes, cs: cassava. The numbers in the formula are assumptions about the potential waste produced from the production of each type of plant food).

Natural forage potential (ton) = {(Ga x 2,875) + (Fa x 0,6) + (Cpa x 10) + (Cfa x 0,5) + (Cla x 5)} x 0,5

(Ga: garden area, Fa: forest area, Cpa: coconut plant area, Cfa: coffee plant area, Cla: clove plant area. The numbers in the formula are assumed to be natural forage potential produced per hectare of land use area).

Minimum cattle feed requirements.

R= 2,5% x 50% x 365 x 400kg = 1,82 ton DDM/year/AU (Equation 3)

(R = minimum cattle feed requirements (1 AU) in tons of digestible dry matter for 1 year, 2.5% = minimum requirement for the number of forage rations (dry matter) on livestock weight, 50% = average value digestibility power of various types of plants, 365 = Number of days in 1 year, 400 kg = live weight of 1 AU of beef cattle in Semarang Regency). Equations that refer to (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

The results of the calculation of forage dry matter production are then used to determine the carrying capacity of beef cattle farms using the following equations (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

$$\text{CC (AU)} = \frac{\text{Forage Dry Matter Production (tons of DDM / year)}}{\text{Minimum Cattle Feed Requirement (tons of DDM / year / AU)}} \text{ (Equation 4)}$$

The level of animal feed security in a region is measured by forage carrying capacity index. Carrying capacity index values are values that indicate the status of the availability of forage for beef cattle, namely: very critical (≤1), critical (>1-1,5), vulnerable (> 1,5-2), and safe (>2).

$$\text{Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \quad \text{(Equation 5)}$$

Suitability of The Ecological Environment of Beef Cattle

The research sample for the assessment of the suitability ecological environment of beef cattle farms in Semarang Regency is 19 points spread throughout the sub-district area (Table 5). Determination of the sample is using purposive sampling technique. The purposive sampling technique is also called judgment sampling (Tongco, 2007), which is to determine the sample based on research considerations. In each sub-district one village is taken which has the most beef cattle population.

Land available for the development of beef cattle farms is: gardens, grasslands, open land, rice fields, and dry land agriculture. The fields are assumed to be able to be built for housing for beef cattle. The assessment of land suitable for beef cattle farming with intensive maintenance patterns, also takes into account several environmental parameters that influence the growth of livestock.

Land suitability assessment for beef cattle farms begins with making a map of land units. Maps of beef cattle land units refer to research (Rusmana *et al*., 2006) which states that there are four maps needed for overlaying, namely: land type maps, agro-climate maps, regional altitude maps, and slope maps. The final step is to make a "suitability map of the ecological environment of beef cattle". The method used is by overlaying between land unit maps with environmental parameters that affect the growth of beef cattle (Table 1). Land suitability is classified into 4 levels or strata, namely: very suitable (S1), quite suitable (S2), according to marginal (S3), and non-suitable (NS) (Rusmana *et al*., 2006; Suhaema *et al*., 2014; Yuniar *et al*., 2016). The entire process was created and analyzed using GIS software.

RESULTS

Leading Commodity

Leading commodity livestock in an area is determined based on comparative advantage (location quotient analysis) and competitive advantage (shift share analysis). Beef cattle commodities that have LQ>1 and SS (+) values are the leading commodities in the region. The interpretation of the value of LQ>1, is a base or leading sector, beef cattle products (meat) are able to meet markets inside and outside the region. LQ<1 value, is a non-base sector, livestock products have not been able to meet markets inside and outside the region. LQ=1 value, meaning that the sector is balanced with the reference region, livestock products are only able to meet markets in the area. The basis for calculating LQ analysis for livestock commodities is livestock population data (Hendayana, 2003). Data bias in calculations can be minimized by using a minimum 5 year data series (Table 2).

Shift share analysis starts from the basic assumption that economic growth or added value of an activity in a particular region is influenced by three main components which are interconnected with each other, namely: regional growth, sectoral growth, and growth in share or regional competitiveness (Ciptayasa *et al*., 2016). Through these three components, it can be seen which elements have encouraged regional economic growth. The value of each component can be positive or negative, but the total number (shift share) will always be positive if the regional economic growth is positive, and vice versa.

The results of the LQ and SS analysis calculations for beef cattle commodities in Semarang Regency are shown in Table 3. Based on the results of the analysis conducted, the subdistrict areas becoming the beef cattle base sector (LQ> 1) were Bancak (4.93), Banyubiru (3.97), Ambarawa (3.92), Bringin (2.82), and Bawen (2.34). Beef cattle keeping was concentrated in these areas or in other words the economic density of beef cattle was higher than that of in other regions.

Beef cattle commodities that have competitive advantages are seen based on positive shift share (SS) values. Sub-districts with a positive SS value means experiencing growth (competitiveness) related to keeping beef cattle. On the other hand, sub-districts with negative SS value means that the area is not growing (stagnant) and can even experience setbacks. The results of the analysis conducted in Table 3 shows that sub-districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47), Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tengaran (0.026).

The development of beef cattle farms in Semarang Regency is prioritized in the sub-districts with LQ>1 and SS (+) values. The sub-districts are Bringin, Bancak, and Banyubiru.

Carrying Capacity and Carrying Capacity Index of Forage

Potential availability of feed for beef cattle is seen based on the amount of forage dry matter production (tons of DDM) that can be produced by the region concerned. Dry matter is the total feed ingredients without water content, which can come from forages. The region with the largest forage dry matter production has the highest carrying capacity for the development of beef cattle farms, and vice versa. Forage is one of the production inputs that determines the success of livestock business because it directly affects productivity and efficiency (Yuniar *et al*., 2016). Table 4 shows the calculation of carrying capacity and carrying capacity index of forage for beef cattle farms in Semarang Regency.

Based on the results of the analysis conducted in Table 4, it is known that there were three sub-districts with the highest production of forage dry matter, namely Bringin (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons DDM). Sub-district area with the lowest forage dry matter production, namely Bandungan (4,327.55 tons DDM). The status of availability of forage in Bandungan sub-district was categorized as very critical (0.82), while in Tengaran sub-district it was categorized as vulnerable (1.69). Thus, these two sub-districts are not recommended for the development of beef cattle farms. Sub-district areas with carrying capacity index value >2 (safe) means that the area can be recommended for the development of beef cattle farms. The advantage obtained by the area with this safe category is that farmers can reduce the amount of production costs for beef cattle feed.

Semarang Regency has carrying capacity for beef cattle farms of 122,725 AU. The population of beef cattle in 2017 is 33,911 AU, so the Semarang Regency area is assumed to still be able to accommodate 88,814 AU beef cattle in 2018.

Suitability of The Ecological Environment of Beef Cattle

The results of field measurements and secondary data collection conducted on several environmental factors that influence the growth of beef cattle are shown in Table 5. The factors that limit the assessment of the suitability ecological environment of beef cattle farming in Semarang Regency are the Temperature Humidity Index (THI) and water pH. Annual rainfall (<4000 mm) and dry months (<8) are in the appropriate category.

The suitability ecological environment map for beef cattle farms in Semarang Regency is shown in Figure 1. The white area is an area that is not assessed because it is designated as land for settlements, plantations, tourism, and forests. Based on Figure 1, it is known that the level of suitability of the produced beef cattle ecological environment is: very suitable (S1), quite suitable (S2), and according to marginal (S3). Non-suitable (NS) categories are not assessed because the area has a slope >40% (steep - very steep).

The symbol "p" indicates that there is a limiting factor in the area assessed. The limiting factors are the Temperature Humidity Index (THI) and the pH of the water for beef cattle consumption (Table 5). Semarang Regency consists of 19 sub-districts. The development of beef cattle farms is prioritized in sub-districts that have LQ>1, SS (+) value, and carrying capacity index of forage (>2), namely Bringin, Bancak, and Banyubiru. Banyubiru sub-district is not constrained by limiting factors, while Bringin and Bancak are constrained by THI values that exceed the comfort zone for growing cattle (>80). The extent suitability of the ecology of beef cattle farms from the three priority sub-districts is shown in Table 6.

Based on the results of the analysis conducted in Table 6, the sub-districts with the largest land area for the development of beef cattle farms with intensive production systems were respectively Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru (1,451.2 Ha). The limiting factor in the form of temperature humidity index (THI) or water pH can be minimized through the engineering design of livestock housing and provision of materials or neutralizing water acidity solvent (Yani *et al.*, 2007; Sarwanto & Hendarto, 2011). Cattle with intensive production systems are generally more susceptible to heat stress than cattle extensively production systems. Efforts that can be done to reduce heat stress in beef cattle include: adding shade around the housing location, install a sprinkle tool or add straw that works to lower the surface temperature of the floor, regulate feed, feed additives and medicine, etc (Suhaema *et al*., 2014).

DISCUSSION

Semarang Regency is a potential area for the development of beef cattle farming because it has abundant natural resources in the form of land for livestock keeping and forage production. The mapping activity is based on the determination of leading livestock commodities, and optimization of regional potential can be one of the benchmarks in realizing sustainable development of beef cattle farms. The concept of sustainable development is to meet the needs of the current generation, without sacrificing future generations and this concept has become a reference for welfare in almost all sectors, including the livestock sector (Wasike *et al*, 2011). The concept of sustainability has been widely debated throughout the world over the past few years (De Longe *et al*., 2016; Keesstra *et al*., 2016; Rasmussen *et al*., 2017), not only concerning issues environmental and social issues, but also discussing economic issues to gain certain market or commodity advantages (Broom *et al.*, 2013; Sabaghi *et al*., 2016). Sustainability assessment is achieved by evaluating the relative contribution of each of the economic, environmental and social factors to the overall goal (Astier & García-Barrios, 2012). Sustainability assessed in this study is economic and environmental sustainability for beef cattle farms.

Economic sustainability is assessed based on the results of the analysis of leading commodity. The leading livestock commodity in an area are determined based on comparative advantage (LQ analysis) and competitive advantage (SS analysis). The concept of comparative advantage is economic feasibility. Commodities that have a comparative advantage (LQ>1) show that the commodity (beef cattle) is supported by the existence of adequate natural resources so that the population level is higher than in other regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a prominent or dominant livestock business compared to the other livestock businesses, so the effort for future development is easier (Yuniar *et al*., 2016; Mulyono & Munibah, 2016). On the other hand, the concept of competitive advantage is financial feasibility. Beef cattle commodities are keeping in effective and efficient ways, so that they have competitiveness from aspects of quality, quantity, continuity and price (Muta'ali, 2015; Mulyono & Munibah, 2016). The results presented in Table 3 show that the Bringin, Bancak, and Banyubiru sub-districts are regions with leading commodity of beef cattle. Accordingly, the three sub-districts are a priority for the development of beef cattle farms in Semarang Regency.

Environmental sustainability for beef cattle farms is assessed based on the results of the carrying capacity analysis and carrying capacity index of forage, and analysis of suitability of the ecological environment of beef cattle. Carrying capacity is defined as the maximum population that can be supported by an ecosystem from time to time. The carrying capacity of an area is not static, there is a kind of reciprocal relationship between organism and their environment. The carrying capacity of a region can vary for different species and change over time due to various factors (Taiwo & Feyisara, 2017). Regional carrying capacity for livestock development is the size of the region's ability to support the livelihoods of a number of livestock populations optimally through the role of forage availability. Based on the results of the analysis presented in Table 4, it is known that the Bringin, Bancak, and Banyubiru sub-districts have a forage carrying capacity index in the safe category.

The production systems of beef cattle that is often found in Semarang Regency is an intensive production systems. Beef cattle are able to show optimal physical conditions if they have superior genetic traits, and are supported by the suitability of their ecological environment (Suhaema *et al*., 2014). Animal ecology is the study of the interactions between animals and their environment. Environmental factors tend to affect the production and productivity of livestock more (Sumarto & Koneri, 2016). Some environmental factors that influence the growth of beef cattle with intensive production systems are: soil type, length of dry season, altitude, slope (Rusmana *et al*., 2006), temperature and relative humidity, rainfall, water pH (Herbut & Angrecka, 2012; Suhaema *et al*., 2014; Yuniar *et al*., 2016; Eirich, 2018).

The results of the analysis in Table 5 show that environmental factors are limiting in the development of beef cattle farms in Semarang Regency are air temperature and humidity, and pH of water for livestock drinking needs. The relationship between the amount of air temperature and humidity is called the Temperature Humidity Index (THI). If THI exceeds the threshold (>80), it can cause stress or heat stress in beef cattle (Eirich, 2018). Long-term heat stress has an impact on increasing drinking water consumption, increasing urine volume, and decreasing feed consumption. The direct effect of heat stress on livestock production causes a decrease in the productivity of beef cattle. This is due to the increasing need for livestock maintenance (Berman, 2005). Furthermore, the THI value that exceeds the threshold influences the decrease in daily body weight gain, depletion of the thickness of meat fat, and the increase of potential for disease occurrence especially in male cattle (Nardone *et al*., 2010). Hydrogen potential (pH) characterizes the balance between acidic and alkaline solvent in water. If the pH of drinking water for beef cattle is below the quality standard or acid (<6,5), the water becomes sour and can cause physiological and digestive disorders in livestock. On the other hand, if the pH of water is too alkaline (>9), the water becomes bitter and causes a decrease in consumption of drinking water which has an impact on decreasing livestock productivity (Sarwanto & Hendarto, 2011).

The synthesis of the assessment results of leading commodity, calculation of carrying capacity and carrying capacity index of forage, as well as land suitability assessment, shows that there are three sub-districts (Bringin, Bancak, and Banyubiru) which are priorities for the development of beef cattle farms in Semarang Regency.

CONCLUSION

Planning for the development of beef cattle farming with intensive production systems in Semarang Regency is recommended in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The assumption of forage production produced from these three sub-districts reaches 55,693.72 tons of DDM. The total carrying capacity for beef cattle farms is 30,601 AU. The total land area suitable for beef cattle farming in the three priority sub-districts is 5,760.141 Ha. The development of beef cattle farms in priority sub-districts is expected to increase livestock production and productivity. Governments, communities (cattleman) and the private sector (investors) must coordinate and cooperate with each other so that the development of sustainable beef cattle farms can be achieved.

CONFLICT OF INTEREST

The authors confirm that there are no conflicts of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

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Table 1. Environmental parameters that influence the growth of beef cattle with intensive maintenance patterns

Parameter	**Order of environmental suitability of beef cattle**	
	S (Suitable)	N (Unsuitable)
Temperature Humidity Index (THI)	70-80	<70, >80
Water availability (w)		
Dry month (<100 mm rainfall/month)	<8 months	>8 months
Rainfall / year (mm)	< 4,000	> 4,000
The existence of a water source	Available	Not Available
Water Quality (q)		
pH water	6.5-9.0	<6.5; >9.0
Slope (%)	<40	>40

Source: (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

Table 2. Growth of livestock populations in Semarang Regency

Type of livestock	**Number (head)**				
	2013	**2014**	**2015**	**2016**	**2017**
Pig	32,640	17,300	18,431	15,971	15,850
Goat	197,029	136,999	123,294	117,003	117,373
Sheep	290,764	191,346	172,211	167,374	162,694
Rabbit	20,352	9,375	10,462	11,629	11,916
Horse	1,711	497	515	524	581
Beef cattle	51,901	53,135	49,172	46,238	48,444
Dairy cows	22,308	27,609	25,780	25,690	25,557
Buffalo	2,941	3,168	2,614	2,629	2,589
Laying Chicken	1,821,286	1,813,049	1,452,019	1,331,528	1,572,463
Broiler Chicken	12,046,319	7,501,700	10,144,846	10,754,602	11,812,311
Chicken Breed	819,067	860,408	818,568	861,989	823,226
Duck	206,882	92,963	80,801	127,859	125,261
Quail	122,200	238,930	227,737	176,730	142,856
Muscovy Duck	102,966	72,227	63,889	61,963	54,402

Source: (BPS Kabupaten Semarang, 2018).

Table 3. Value of LQ and SS beef cattle in Semarang Regency in 2018

NO	SUB-DISTRICT	BEEF CATTLE				
		LQ	RS	PS	DF	SS
1	Getasan	0.63	-0.052	-0.014	-0.359	-0.425
2	Tengaran	0.55	-0.052	-0.014	0.092	0.026
3	Susukan	1.11	-0.052	-0.014	-0.137	-0.203
4	Kaliwungu	1.22	-0.052	-0.014	0.048	-0.018
5	Suruh	0.88	-0.052	-0.014	-0.213	-0.279
6	Pabelan	1.75	-0.052	-0.014	0.501	0.435
7	Tuntang	0.28	-0.052	-0.014	-0.689	-0.755
8	Banyubiru	3.97	-0.052	-0.014	0.536	0.47
9	Jambu	0.42	-0.052	-0.014	-0.417	-0.483
10	Sumowono	0.95	-0.052	-0.014	-0.234	-0.3
11	Ambarawa	3.92	-0.052	-0.014	0.006	-0.06
12	Bandungan	1.01	-0.052	-0.014	0.269	0.203
13	Bawen	2.34	-0.052	-0.014	0.0009	-0.0651
14	Bringin	2.82	-0.052	-0.014	0.105	0.039
15	Bancak	4.93	-0.052	-0.014	0.143	0.077
16	Pringapus	1.38	-0.052	-0.014	-0.312	-0.378
17	Bergas	0.77	-0.052	-0.014	-0.106	-0.172
18	Ungaran Barat	0.77	-0.052	-0.014	1.352	1.286
19	Ungaran Timur	0.3	-0.052	-0.014	-0.62	-0.686

LQ = Location quotient, SS = Shift share, RS = Regional share, PS = Proportional shift, DS = Differential shift.

Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency in 2018

SD	**Bcp 2017**	**Bcp 2017 (AU)**	**Rm**	**R Bc**	**F Dmp**	**CC**	**CCI**	**AV**
A	b	c	d	e = c x d	f	g = f/d	h = g/c	
Getasan	2,085	1,459.5	1.82	2,656.29	7,802.45	4,287.1	2.94	S
Tengaran	4,881	3,416.7	1.82	6,218.39	10,526.78	5,783.9	1.69	V
Susukan	2,905	2,033.5	1.82	3,700.97	15,301.29	8,407.3	4.13	S
Kaliwungu	4,650	3,255	1.82	5,924.1	13,231.72	7,270.2	2.23	S
Suruh	3,335	2,334.5	1.82	4,248.79	19,522.03	10,726.4	4.59	S
Pabelan	4,251	2,975.7	1.82	5,415.77	12,690.04	6,972.5	2.34	S
Tuntang	211	147.7	1.82	268.81	9,458.6	5,197.03	35.19	S
Banyubiru	3,840	2,688	1.82	4,892.16	11,493.54	6,315.1	2.35	S
Jambu	741	518.7	1.82	944.03	8,816.47	4,844.2	9.34	S
Sumowono	2,228	1,559.6	1.82	2,838.47	10,921.51	6,000.8	3.85	S
Ambarawa	1,661	1,162.7	1.82	2,116.11	4,935.95	2,712.05	2.33	S
Bandungan	4,140	2,898	1.82	5,274.36	4,327.55	2,377.8	0.82	VC
Bawen	2,717	1,901.9	1.82	3,461.46	7,241.14	3,978.6	2.09	S
Bringin	2,349	1,644.3	1.82	2,992.63	28,808.63	15,828.9	9.63	S
Bancak	2,820	1,974	1.82	3,592.68	15,391.55	8,456.9	4.28	S
Pringapus	1,333	933.1	1.82	1,698.24	23,509.36	12,917.2	13.84	S
Bergas	1,828	1,279.6	1.82	2,328.87	7,593.47	4,172.2	3.26	S
Ungaran Barat	2,105	1,473.5	1.82	2,681.77	5,400.34	2,967.2	2.01	S
Ungaran Timur	364	254.8	1.82	463.74	6,387.01	3,509.3	13.77	S
Jumlah	48,444	33,910.8		61,717.64	223,359.43	122,724.7	120.68	

SD = sub-district, Bcp = beef cattle population, Bcp (AU) = beef cattle population in livestock units, Rm = minimum feed requirements for beef cattle (ton DDM /year /AU), R bc = beef cattle feed requirements (tons /DDM/year), F Dmp = forage dry matter production (ton DDM), CC = carrying capacity (AU), CCI = carrying capacity index of forage, AV = forage availability status; S = safe, V = vurnerable, VC = very critical.

Table 5. Results of measurements of environmental factors that influence the growth of beef cattle in Semarang Regency in 2018

Subdistrict	Sample (Village)	Temperature (°C)	Temperature (°F)	Humidity (%)	THI	Rainfall (mm/year)	Dry months	Water pH
Getasan	Samirono	31	87.8	51	79.77	3,403	3	7
Tengaran	Duren	30	86	65	80.61	2,591	3	5.8
Susukan	Timpik	32	89.6	57	82.13	2,618	3	6.5
Kaliwungu	Mukiran	32	89.6	56	81.95	2,618	0	5.5
Suruh	Dadapayam	32	89.6	65	83.52	2,680	4	6.3
Pabelan	Terban	32	89.6	58	82.3	1,927	4	6.5
Tuntang	Tlumpakan	35	95	46	84.01	2,676	0	7
Banyubiru	Wirogomo	30	86	51	78.45	2,066	3	8
Jambu	Genting	31	87.8	49	79.44	2,489	0	6.2
Sumowono	Candi Garon	28	82.4	58	76.76	1,383	4	6.3
Ambarawa	Pasekan	30	86	51	78.45	1,291	3	6.8
Bandungan	Candi	29	84.2	54	77.57	1,291	0	6.7
Bawen	Polosiri	35	95	49	84.62	2,061	4	6.1
Bringin	Banding	35	95	54	85.64	2,211	3	7.9
Bancak	Pucung	33	91.4	58	83.68	2,091	0	6.5
Pringapus	Penawangan	32	89.6	56	81.95	2,290	3	4
Bergas	Munding	32	89.6	48	80.56	3,802	2	5.9
Ungaran Barat	Gogik	32	89.6	49	80.74	3,316	0	7.7
Ungaran Timur	Kawengen	33	91.4	51	82.4	3,316	0	6.6

THI = T - {0.55 (1-RH / 100) (T-58)}, where T = temperature (°F), RH = relative humidity.

Table 6. Extent of suitability ecological environment map of beef cattle farms in Bancak, Banyubiru, and Bringin sub-districts

NO	SUBDISTRICT	Extent of Land Suitability (Ha)						Total
		S1	S1p	S2	S2p	S3	S3p	
1	Bancak	0	40.26	0.06	1,342.25	0	167.51	1,550.079
2	Banyubiru	17.10	0	1,434.10	0	0	0	1,451.2
3	Bringin	0	36.01	0	2,327.42	0	395.43	2,758.862
	TOTAL	17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

S1 = very suitable, S2 = quite suitable, S3 = according to marginal, P = limiting factor in the form of temperature humidity index (THI).

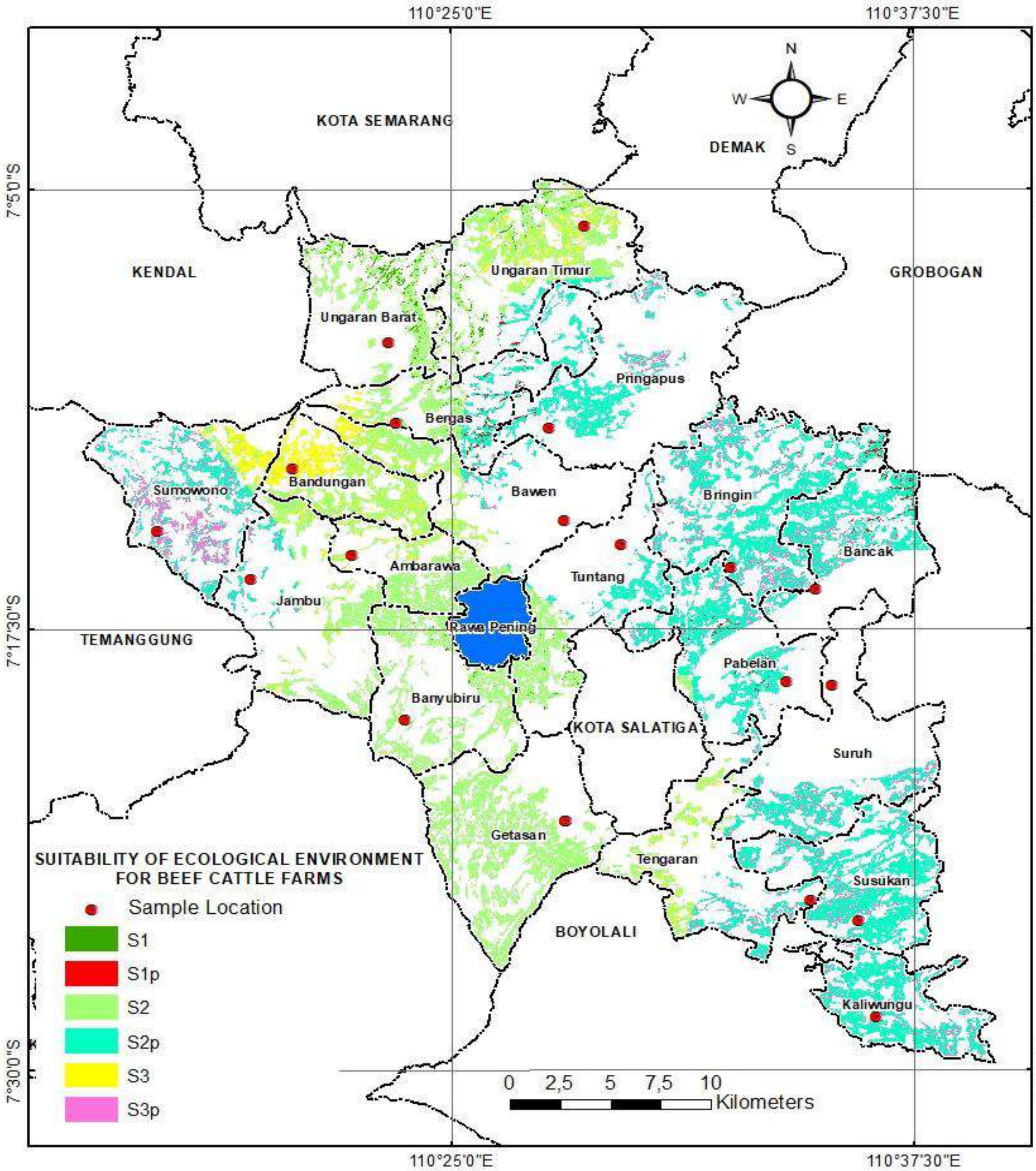
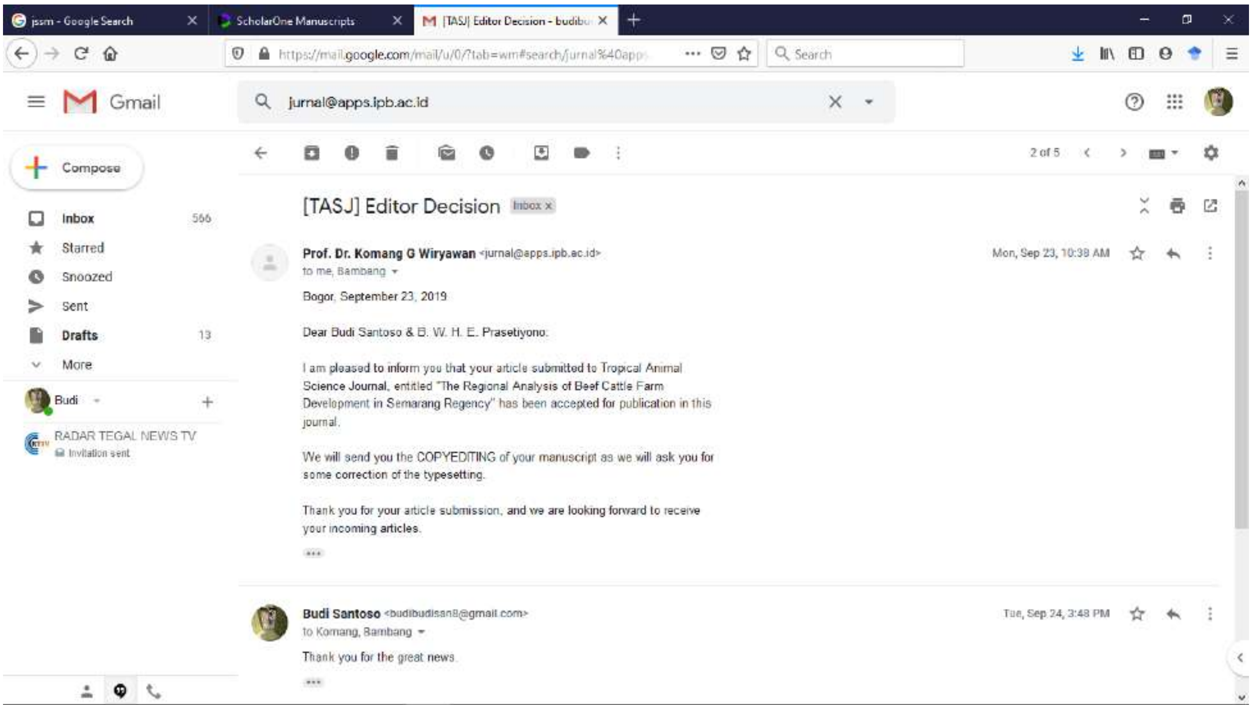


Figure 2. The suitability ecological environment map for beef cattle farms in Semarang Regency



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Dear Budi Santoso & B. W. H. E. Prasetiyono:

I am pleased to inform you that your article submitted to Tropical Animal Science Journal, entitled "The Regional Analysis of Beef Cattle Farm Development in Semarang Regency" has been accepted for publication in this journal.

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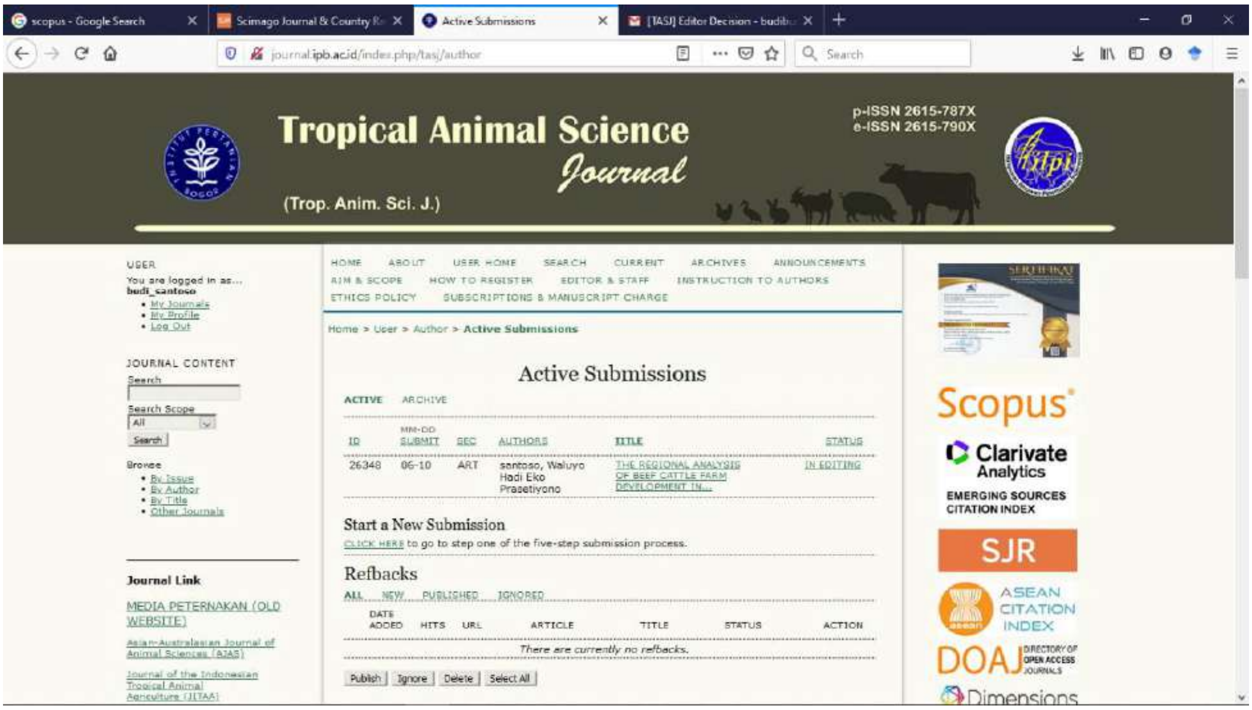
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The Regional Analysis of Beef Cattle Farm Development in Semarang Regency

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ABSTRACT

One of the reasons for the low production and productivity of beef cattle in Indonesia is that information on the allocation of livestock areas development is not yet clear. This study aims to determine the priority areas for developing beef cattle farm in Semarang Regency based on the concept of sustainability. Sustainability was analyzed through the determination of leading commodities (analysis of Location Quotient and Shift Share), optimization of regional potential (analysis of carrying capacity and carrying capacity index of forage, and assessment of suitability of ecological environment of beef cattle). The process of spatial analysis used GIS software. Comprehensive planning for the development of beef cattle farm was directed in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of the analysis showed that the three sub-districts were beef cattle base areas (LQ>1), had business growth (positive SS), and had a safe status for forage availability (>2). Other results showed that the carrying capacity for beef cattle farms in Bringin sub-district was 15,829 AU, Bancak was 8,457 AU, and Banyubiru was 6,315 AU. The land area suitable for beef cattle farm from the three priority sub-districts was 5,760.141 Ha. It can be concluded that the development of beef cattle farm in Semarang Regency is focused on three priority sub-districts, namely: Bringin, Bancak,

and Banyubiru. The results of this study can be an input for local governments in determining the direction and pattern of beef cattle farm development to be more sustainable.

Keywords: beef cattle, regional analysis, sustainability of livestock sector

INTRODUCTION

The directed and sustainable development of the livestock sector is believed to be able to contribute positively to regional development. Along with the increase in population, there is an increasing demand for food from animal protein, such as beef. Beef consumption in developing countries such as in Indonesia tends to increase every year (Thornton, 2010; Agus & Widi, 2018), however the population of beef cattle in some regions actually decreases due to the complexity of technical and non-technical problems (Paly *et al*., 2013; Ariningsih, 2014; Nuhung, 2015). There is a gap between demand and supply of beef products, which is increasingly widening. Many factors causing this gap, including the domestic production of beef cattle is still low because information on the allocation of livestock development areas is not yet clear.

Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009; Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able to meet the high meat consumption of people. The consumption of beef in 2020 is estimated to reach 3.36 kg per capita per year, but beef production is still not able to fulfill it; there is a deficit in beef supply by 198,350 tons (Kementan, 2016; Agus & Widi, 2018). Most of the beef production in Indonesia, 78% comes from traditional livestock, 5% from imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al*., 2017). Imports of beef are indeed relatively larger compared to the other types of meat

imports, contributing 21.44% to the total import value of livestock, while the import value of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al*., 2014).

Policy efforts to reduce beef imports must be studied, by strengthening domestic production that is beneficial for farmers (Pasandaran *et al*., 2014). The development of beef cattle farms in potential areas is an effort to strengthen meat production in the country so that the implementation must be carried out with a comprehensive assessment. Semarang Regency is a region in Central Java Province that has the potential to develop beef cattle farms because it has natural resources in the form of land as a place for livestock keeping and forage production. Good quality and forage availability can increase production, especially for increasing body weight of cattle (Suhaema *et al*., 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha), rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this region during the 2014-2016 period continued to decline, ranging from 53,135; 49,172; and 46,238 (BPS Kabupaten Semarang, 2018).

The development of beef cattle farms in Semarang Regency needs to adopt the concept of sustainability. The concept of sustainability is the achievement of economic, environmental, and social goals simultaneously which is represented by various performance indicators (Darnhofer *et al*., 2010). Sustainability is also defined as the concept of multidimensional (economic, ecological, and social) and multiscale (micro, meso, and macro), although in its application, it is often limited to one particular aspect (Santos *et al*., 2017). Economic sustainability is closely related to the value of comparative and competitive advantages of certain commodities (Broom *et al*., 2013;

Sabaghi *et al*., 2016), while environmental sustainability includes optimizing the availability and efficient use of natural resources (Atanga *et al*., 2013).

The sustainability of beef cattle farms can be identified through a regional approach, by considering the existence of leading commodities and the potential of the region concerned (Mulyono & Munibah, 2016; Parmawati *et al*., 2018). Determination of leading commodities characterized by the existence of comparative and competitive advantages is the first step towards the efficient development of livestock sector. The potential of the region to support the development of beef cattle farms is determined by optimizing the carrying capacity and carrying capacity index of forage, as well as by assessing the suitability of the land where the livestocks are raised. Land suitability for beef cattle farms with intensive production systems considers several environmental factors that affect the growth of these cattle.

Mapping activities based on the determination of leading commodities and optimization of regional potential are needed as a basis for planning sustainable development of beef cattle farms. This study aims to determine the priority areas for developing beef cattle farms in Semarang Regency. The results of this study are expected to be one of the considerations in determining the direction and development policy of the beef cattle farms sector in Semarang Regency.

MATERIALS AND METHODS

This research was a type of quantitative research and applied the concept of sustainability. Sustainabilities assessed were economic and environmental sustainabilities for beef cattle farm in Semarang Regency. Economic sustainability was identified through the determination of the leading commodity of livestock, while environmental

sustainability was identified through the calculation of the carrying capacity and carrying capacity index of forage, and the assessment of suitability of ecological environment of beef cattle. In detail, each step of the analysis was outlined below.

Leading Commodity

Determination of leading livestock commodities in an area used Location Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods was the economic basis theory. LQ analysis was relatively simple, but the benefits were large enough for the initial identification of the ability of a sector in regional development. The shift in the structure of economic activity in beef cattle business, whether experiencing growth or decline was analyzed using Shift Share (SS). SS analysis can be used to see the growth of the economic sectors of a region for two-time points (Muta'ali, 2015). LQ and SS analysis used the following equations (Ciptayasa *et al.*, 2016; Mulyono & Munibah, 2016).

$LQ_{ij} = \frac{Xij\ /\ Xi.}{X.j\ /\ X..}$ (Equation 1)

(X_{ij} = Beef cattle population in the sub-district A, $X_{i.}$ = Population of all types of livestock in the sub-district A, $X_{.j}$ = Beef cattle population in Semarang Regency, $X_{..}$ = Population of all types of livestock in Semarang Regency).

$SS = \left[\frac{X..(t1)}{X..(t0)} - 1\right] + \left[\frac{X.i(t1)}{X.i((t0)} - \frac{X..(t1)}{X..(t0)}\right] + \left[\frac{Xij(t1)}{Xij(t0)} - \frac{X.i(t1)}{X.i((t0)}\right]$ (Equation 2)

(Regional share, Proportional shift, Differential shift, X ..= Population of all types of livestock in Semarang Regency, Xi= Beef cattle population in Semarang Regency, Xij= Beef cattle population in sub-district A, t0= Early 2013 year point, t1= End of year 2017).

Carrying Capacity and Carrying Capacity Index of Forage

The carrying capacity of the region for livestock development is indicated by the ability of the region to produce forage that can accommodate and meet the needs of a

number of beef cattle populations. Forages were divided into two types, namely fresh forage (grass, legume) and dry forage (straw). An assessment of the carrying capacity index of forage was conducted to assess the availability of animal feed in a region, whether it was classified as safe, vulnerable, critical, or very critical.

The carrying capacity of beef cattle farms was calculated based on the production of forage dry matter against the minimum feed requirements of cattle (1 AU) in one year. The animal unit (AU) was a unit for the ruminant livestock population multiplied by the conversion factor. The conversion factor for beef cattle was 0,7 (Muta'ali, 2015; Saputra *et al*., 2016). Forage dry matter production was the amount of potential agricultural waste and natural forage potential, using equations that refer to Suhaema *et al.* (2014) and Yuniar *et al.* (2016).

Commented [MP1]: bagaimana dengan konversi AU livestock lainnya (kelinci, ayam babi dll)?

Potential of agricultural waste (ton) = {(wr x 0.4) + (fr x 3 x 0.4) + (cn x 3 x 0.5) + (sb x 3 x 0.55) + (pt x 2 x 0.55) + (sp x 0.25/6) + (cs x 0.25/4)} x 0.65

Commented [MP2]: fresh forage or dry matter?

(wr is wetland rice, fr is field rice, cn is corn, sb is soybean, pt is peanuts, sp is sweet potatoes, cs is cassava. The numbers in the formula are assumptions about the potential waste produced from the production of each type of plant food).

Natural forage potential (ton) = {(Ga x 2.875) + (Fa x 0.6) + (Cpa x 10) + (Cfa x 0.5) + (Cla x 5)} x 0.5

Commented [MP3]: fresh or dry matter?

(Ga is garden area, Fa is forest area, Cpa is coconut plant area, Cfa is coffee plant area, Cla is clove plant area. The numbers in the formula are assumed to be natural forage potential produced per hectare of land use area).

Minimum cattle feed requirements (R)= 2.5% x 50% x 365 x 400 kg = 1.82 ton DDM/year/AU (Equation 3)

Commented [MP4]: daya cerna 50%, maka pengalinya menjadi 100/50; bukan 50%

(R is minimum cattle feed requirements (1 AU) in tons of digestible dry matter for 1 year, 2.5% is minimum requirement for the number of forage rations (dry matter) on livestock weight, 50% is average value digestibility power of various types of plants, 365 is number of days in 1 year, 400 kg is live weight of 1 AU of beef cattle in Semarang Regency). Equations that refer to Suhaema *et al*. (2014) and Yuniar *et al*. (2016).

The results of the calculation of forage dry matter production were then used to determine the carrying capacity of beef cattle farms using the following equations (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

$$\text{CC (AU)} = \frac{\text{Forage Dry Matter Production (tons of DDM / year)}}{\text{Minimum Cattle Feed Requirement (tons of DDM / year / AU)}} \text{ (Equation 4)}$$

The level of animal feed security in a region was measured by forage carrying capacity index. Carrying capacity index values were values that indicated the status of the availability of forage for beef cattle, namely: very critical (≤1), critical (>1-1.5), vulnerable (> 1.5-2), and safe (>2).

$$\text{Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \text{ (Equation 5)}$$

Suitability of the Ecological Environment of Beef Cattle

The research sample for the assessment of the suitability ecological environment of beef cattle farms in Semarang Regency was 19 points spreading throughout the sub-district area (Table 5). The determination of the sample was using purposive sampling technique. The purposive sampling technique was also called judgment sampling (Tongco, 2007), which was used to determine the sample based on research considerations. In each sub-district, one village was taken which had the most beef cattle population.

Commented [MP5]: kalau daya cerna 50%; maka kebutuhannya menjadi dikali 100/50, bukan dikali 50%

Commented [MP6]: Penghitungan AU menggunakan konversi 0.7 semua. Padahal populasi sapi ada yg muda dan anak2, seharusnya berdasarkan struktur populasi.

Lands available for the development of beef cattle farms are gardens, grasslands, open land, rice fields, and dryland agriculture. The fields are assumed to be able to be used for building housing for beef cattle. The assessment of land suitable for beef cattle farming with intensive maintenance patterns also takes into account several environmental parameters that influence the growth of livestock.

Land suitability assessment for beef cattle farms began by making a map of land units. Maps of beef cattle land units referred to research of Rusmana *et al*. (2006) which stated that there were four maps needed for overlaying, namely: land type maps, agro-climate maps, regional altitude maps, and slope maps. The final step was to make a "suitability map of the ecological environment of beef cattle". The method used was by overlaying between land unit maps with environmental parameters that affected the growth of beef cattle (Table 1). Land suitability was classified into 4 levels or strata, namely: very suitable (S-1), quite suitable (S-2), according to marginal (S-3), and non-suitable (NS) (Rusmana *et al*., 2006; Suhaema *et al*., 2014; Yuniar *et al*., 2016). The entire process was created and analyzed using GIS software.

RESULTS

Leading Commodity

The leading commodity of livestock in an area was determined based on comparative advantage (location quotient analysis) and competitive advantage (shift-share analysis). Beef cattle commodities that had LQ>1 and SS (+) values were the leading commodities in the region. The interpretation of the value of LQ>1, was a base or leading sector, beef cattle products (meat) were able to meet markets inside and outside the region. The value of LQ<1 implied a non-base sector, livestock products had not been able to meet markets inside and outside the region. The value of LQ=1 implied that the sector was balanced with the reference region, livestock products were only able to meet markets in the area. The basis for calculating LQ analysis for livestock commodities was livestock population data (Hendayana, 2003). Data bias in calculations could be minimized by using a minimum 5 year data series (Table 2).

Commented [MP7]: Data 5 tahun untuk LQ metodenya bagaimana? dirata2, dijumlah atau bagaimana?

Shift share analysis started from the basic assumption that economic growth or added value of an activity in a particular region was influenced by three main components which were interconnected with each other, namely: regional growth, sectoral growth, and growth in share or regional competitiveness (Ciptayasa *et al.*, 2016). Through these three components, it could be seen which elements had encouraged regional economic growth. The value of each component could be positive or negative, but the total number (shift-share) would always be positive if the regional economic growth were positive, and vice versa.

The results of the LQ and SS analysis calculations for beef cattle commodities in Semarang Regency are shown in Table 3. Based on the results of the analysis conducted, the subdistrict areas becoming the beef cattle base sector (LQ> 1) were Bancak (4.93),

Banyubiru (3.97), Ambarawa (3.92), Bringin (2.82), and Bawen (2.34). Beef cattle keeping was concentrated in these areas or in the other words the economic density of beef cattle was higher than that of in the other regions.

Beef cattle commodities that had competitive advantages were seen based on positive shift-share (SS) values. Sub-districts with a positive SS value means experiencing growth (competitiveness) related to keeping beef cattle. On the other hand, sub-districts with negative SS value means that the area is not growing (stagnant) and can even experience setbacks. The results of the analysis conducted in Table 3 showed that sub-districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47), Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tengaran (0.026).

The development of beef cattle farms in Semarang Regency is prioritized in the sub-districts with LQ>1 and SS (+) values. The sub-districts are Bringin, Bancak, and Banyubiru.

Carrying Capacity and Carrying Capacity Index of Forage

The potential availability of feed for beef cattle was seen based on the amount of forage dry matter production (tons of DDM) that could be produced by the region concerned. Dry matter is the total feed ingredients without water content, which can come from forages. The region with the largest forage dry matter production has the highest carrying capacity for the development of beef cattle farms, and vice versa. Forage is one of the production inputs that determine the success of livestock business because it directly affects productivity and efficiency (Yuniar *et al*., 2016). Table 4 shows the

calculation of carrying capacity and carrying capacity index of forage for beef cattle farms in Semarang Regency.

Based on the results of the analysis conducted in Table 4, it was known that there were three sub-districts with the highest production of forage dry matter, namely Bringin (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons DDM). Sub-district area with the lowest forage dry matter production was Bandungan (4,327.55 tons DDM). The status of the availability of forage in Bandungan sub-district was categorized as very critical (0.82), while in Tengaran sub-district it was categorized as vulnerable (1.69). Therefore, these two sub-districts are not recommended for the development of beef cattle farms. Sub-district areas with carrying capacity index value >2 (safe) means that the areas can be recommended for the development of beef cattle farms. The advantage obtained by the area with this safe category is that farmers can reduce the amount of production costs for beef cattle feed.

Semarang Regency had a carrying capacity for beef cattle farms of 122,725 AU. The population of beef cattle in 2017 was 33,911 AU, so the Semarang Regency area was assumed to still be able to accommodate 88,814 AU beef cattle in 2018.

The Suitability of Ecological Environment of Beef Cattle

The results of field measurements and secondary data collection conducted on several environmental factors that influence the growth of beef cattle are shown in Table 5. The factors that limited the assessment of the suitability of the ecological environment of beef cattle farming in Semarang Regency were the Temperature Humidity Index (THI) and water pH. Annual rainfall (<4000 mm) and dry months (<8) were in the appropriate category.

Commented [MP8]: penambahan cattle; tidak hanya berdasarkan populasi sapi yg ada, tetapi juga AU ruminansia lain (Table 2) yg menggunakan hijauan (kebau, kuda, domba/kambing)

The suitability of the ecological environment map for beef cattle farms in Semarang Regency is shown in Figure 1. The white area was an area that was not assessed because it was designated as land for settlements, plantations, tourism, and forests. Based on data in Figure 1, the level of suitability of the produced beef cattle ecological environment was: very suitable (S-1), quite suitable (S-2), and according to marginal (S-3). Non-suitable (NS) categories were not assessed because the area had a slope >40% (steep - very steep).

Commented [MP9]: dalam menghitung forage, daerah putih seharusnya menjadi pengurang.

The symbol "p" indicated that there was a limiting factor in the area assessed. The limiting factors were the Temperature Humidity Index (THI) and the pH of the water for beef cattle consumption (Table 5). Semarang Regency consists of 19 sub-districts. The development of beef cattle farms will be prioritized in sub-districts having LQ>1, positive SS (+) value, and carrying capacity index of forage >2, namely Bringin, Bancak, and Banyubiru. Banyubiru sub-district was not constrained by the limiting factors, while Bringin and Bancak were constrained by THI values that exceed the comfort zone for growing cattle (>80). The extent suitability of the ecology of beef cattle farms from the three priority sub-districts is shown in Table 6.

Based on the results of the analysis conducted in Table 6, the sub-districts with the largest land area for the development of beef cattle farms with intensive production systems were Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru (1,451.2 Ha). The limiting factor in the form of temperature humidity index (THI) or water pH can be minimized through the engineering design of livestock housing and the provision of materials or neutralizing water acidity solvent (Yani *et al*., 2007; Sarwanto & Hendarto, 2011). Cattle with intensive production systems are generally more susceptible to heat stress than cattle with extensive production systems. Efforts that can be done to reduce

heat stress in beef cattle include: adding shade around the housing location, install a sprinkle tool or add straw that works to lower the surface temperature of the floor, regulate feed, feed additives, and medicine, etc (Suhaema *et al*., 2014).

DISCUSSION

Semarang Regency is a potential area for the development of beef cattle farming because it has abundant natural resources in the form of land for livestock raising and forage production. The mapping activity is based on the determination of leading livestock commodities, and optimization of regional potential can be one of the benchmarks in realizing sustainable development of beef cattle farms. The concept of sustainable development is to meet the needs of the current generation, without sacrificing future generations and this concept has become a reference for welfare in almost all sectors, including the livestock sector (Wasike *et al.*, 2011). The concept of sustainability was widely debated throughout the world over the past few years (De Longe *et al*., 2016; Keesstra *et al*., 2016; Rasmussen *et al*., 2017), not only concerning environmental and social issues, but also discussing economic issues to gain certain market or commodity advantages (Broom *et al.*, 2013; Sabaghi *et al*., 2016). Sustainability assessment is achieved by evaluating the relative contribution of each of the economic, environmental, and social factors to the overall goal (Astier & García-Barrios, 2012). Sustainability assessed in this study is economical and environmental sustainability for beef cattle farms.

Economic sustainability was assessed based on the results of the analysis of the leading commodity. The leading livestock commodity in an area was determined based on the comparative advantage (LQ analysis) and competitive advantage (SS analysis).

The concept of comparative advantage is economic feasibility. Commodities that have a comparative advantage (LQ>1) show that the commodity (beef cattle) is supported by the existence of adequate natural resources so that the population level is higher than in other regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a prominent or dominant livestock business compared to the other livestock businesses, so the effort for future development is easier (Yuniar *et al.*, 2016; Mulyono & Munibah, 2016). On the other hand, the concept of competitive advantage is financial feasibility. Beef cattle commodities are keeping in effective and efficient ways so that they have competitiveness from the aspects of quality, quantity, continuity, and price (Muta'ali, 2015; Mulyono & Munibah, 2016). The results presented in Table 3 show that the Bringin, Bancak, and Banyubiru sub-districts are regions with a leading commodity of beef cattle. Accordingly, the three sub-districts are a priority for the development of beef cattle farms in Semarang Regency.

Environmental sustainability for beef cattle farms was assessed based on the results of the carrying capacity analysis and carrying capacity index of forage, and analysis of the suitability of the ecological environment of beef cattle. Carrying capacity is defined as the maximum population that can be supported by an ecosystem from time to time. The carrying capacity of an area is not static, there is a kind of reciprocal relationship between organism and their environments. The carrying capacity of a region can vary for different species and change over time due to various factors (Taiwo & Feyisara, 2017). Regional carrying capacity for livestock development is the size of the region's ability to support the livelihoods of a number of livestock populations optimally through the role of forage availability. Based on the results of the analysis presented in

Table 4, it is known that the Bringin, Bancak, and Banyubiru sub-districts have a forage carrying capacity index in the safe category.

The production systems of beef cattle that is often found in Semarang Regency is an intensive production system. Beef cattle are able to show optimal physical conditions if they have superior genetic traits, and are supported by the suitability of their ecological environment (Suhaema *et al*., 2014). Animal ecology is the study of the interactions between animals and their environments. Environmental factors tend to have a greater effect on the production and productivity of livestock (Sumarto & Koneri, 2016). Some environmental factors that influence the growth of beef cattle with intensive production systems are: soil type, length of dry season, altitude, slope (Rusmana *et al*., 2006), temperature and relative humidity, rainfall, and water pH (Herbut & Angrecka, 2012; Suhaema *et al*., 2014; Yuniar *et al*., 2016; Eirich, 2018).

The results of the analysis in Table 5 show that environmental factors that are limiting the development of beef cattle farms in Semarang Regency are air temperature and humidity, as well as pH of water used by livestock for drinking. The relationship between the amount of air temperature and humidity is called the Temperature Humidity Index (THI). If THI exceeds the threshold (>80), it can cause stress or heat stress in beef cattle (Eirich, 2018). Long-term heat stress has an impact on increasing drinking water consumption, increasing urine volume, and decreasing feed consumption. The direct effect of heat stress on livestock production causes a decrease in the productivity of beef cattle. This effect is due to the increasing need for livestock maintenance during stress conditions (Berman, 2005). Furthermore, the THI value that exceeds the threshold will decrease the daily body weight gain, increase the depletion of the thickness of meat fat, and increase the potential for disease occurrence, especially in male cattle (Nardone *et*

al., 2010). Hydrogen potential (pH) characterizes the balance between acidic and alkaline solvent in water. If the pH of drinking water for beef cattle is below the quality standard or acid (<6,5), the water becomes sour and can cause physiological and digestive disorders in livestock. On the other hand, if the pH of water is too alkaline (>9), the water becomes bitter and causes a decrease in the consumption of drinking water which has an impact on decreasing livestock productivity (Sarwanto & Hendarto, 2011).

The synthesis of the assessment results of leading commodity, calculation of carrying capacity and carrying capacity index of forage, as well as land suitability assessment, shows that there are three sub-districts (Bringin, Bancak, and Banyubiru) which have high priorities for the development of beef cattle farms in Semarang Regency.

CONCLUSION

Planning for the development of beef cattle farming with intensive production systems in Semarang Regency is recommended in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The assumption of forage production produced from these three sub-districts reaches 55,693.72 tons of DDM. The total carrying capacity for beef cattle farms is 30,601 AU. The total land area suitable for beef cattle farming in the three priority sub-districts is 5,760.141 Ha. The development of beef cattle farms in the priority sub-districts is expected to increase livestock production and productivity. Governments, communities (cattleman), and the private sector (investors) must coordinate and cooperate with each other so that the development of sustainable beef cattle farms can be achieved.

CONFLICT OF INTEREST

Commented [MP10]: CC semarang 33,911 AU; sementara 3 kecamatan 30,601 AU (?????)

Commented [MP11]: perhitungan CC berdasarkan struktur populasi sapi
tambahan sapi dikoreksi dengan populasi ruminansia yang ada

Commented [MP12]: Di kesimpulan land suitable 5760 jika ditanami jagung (penghasil limbah terbanyak di persamaan 1), produksinya hanya:
5760*3*0.5= 8640 ton /1.82 = 4747 AU. Jauh dibawah kesimpulan 30601 AU

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Table 1. Environmental parameters that influence the growth of beef cattle with intensive maintenance patterns

Parameter	**Order of environmental suitability of beef cattle**	
	S (Suitable)	N (Unsuitable)
Temperature Humidity Index (THI)	70-80	<70, >80
Water availability (w)		
Dry month (<100 mm rainfall/month)	<8 months	>8 months
Rainfall/year (mm)	< 4,000	> 4,000
The existence of a water source	Available	Not Available
Water Quality (q)		
pH water	6.5-9.0	<6.5; >9.0
Slope (%)	<40	>40

Source: (Suhaema *et al.*, 2014; Yuniar *et al.*, 2016).

Table 2. Growth of livestock populations in Semarang Regency

Type of livestock	**Number (head)**				
	2013	**2014**	**2015**	**2016**	**2017**
Pig	32,640	17,300	18,431	15,971	15,850
Goat	197,029	136,999	123,294	117,003	117,373
Sheep	290,764	191,346	172,211	167,374	162,694
Rabbit	20,352	9,375	10,462	11,629	11,916
Horse	1,711	497	515	524	581
Beef cattle	51,901	53,135	49,172	46,238	48,444
Dairy cows	22,308	27,609	25,780	25,690	25,557
Buffalo	2,941	3,168	2,614	2,629	2,589
Laying Chicken	1,821,286	1,813,049	1,452,019	1,331,528	1,572,463
Broiler Chicken	12,046,319	7,501,700	10,144,846	10,754,602	11,812,311
Chicken Breed	819,067	860,408	818,568	861,989	823,226
Duck	206,882	92,963	80,801	127,859	125,261
Quail	122,200	238,930	227,737	176,730	142,856
Muscovy Duck	102,966	72,227	63,889	61,963	54,402

Source: (BPS Kabupaten Semarang, 2018).

Table 3. Value of LQ and SS of beef cattle in Semarang Regency in 2018

NO	SUB-DISTRICT	BEEF CATTLE				
		LQ	RS	PS	DF	SS
1	Getasan	0.63	-0.052	-0.014	-0.359	-0.425
2	Tengaran	0.55	-0.052	-0.014	0.092	0.026
3	Susukan	1.11	-0.052	-0.014	-0.137	-0.203
4	Kaliwungu	1.22	-0.052	-0.014	0.048	-0.018
5	Suruh	0.88	-0.052	-0.014	-0.213	-0.279
6	Pabelan	1.75	-0.052	-0.014	0.501	0.435
7	Tuntang	0.28	-0.052	-0.014	-0.689	-0.755
8	Banyubiru	3.97	-0.052	-0.014	0.536	0.47
9	Jambu	0.42	-0.052	-0.014	-0.417	-0.483
10	Sumowono	0.95	-0.052	-0.014	-0.234	-0.3
11	Ambarawa	3.92	-0.052	-0.014	0.006	-0.06
12	Bandungan	1.01	-0.052	-0.014	0.269	0.203
13	Bawen	2.34	-0.052	-0.014	0.0009	-0.0651
14	Bringin	2.82	-0.052	-0.014	0.105	0.039
15	Bancak	4.93	-0.052	-0.014	0.143	0.077
16	Pringapus	1.38	-0.052	-0.014	-0.312	-0.378
17	Bergas	0.77	-0.052	-0.014	-0.106	-0.172
18	Ungaran Barat	0.77	-0.052	-0.014	1.352	1.286
19	Ungaran Timur	0.3	-0.052	-0.014	-0.62	-0.686

LQ = Location quotient, SS = Shift share, RS = Regional share, PS = Proportional shift, DS = Differential shift.

Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency in 2018

SD	Bcp 2017	Bcp 2017 (AU)	Rm	R Bc	F Dmp	CC	CCI	AV
A	b	c	d	e = c x d	f	g = f/d	h = g/c	
Getasan	2,085	1,459.5	1.82	2,656.29	7,802.45	4,287.1	2.94	S
Tengaran	4,881	3,416.7	1.82	6,218.39	10,526.78	5,783.9	1.69	V
Susukan	2,905	2,033.5	1.82	3,700.97	15,301.29	8,407.3	4.13	S
Kaliwungu	4,650	3,255	1.82	5,924.1	13,231.72	7,270.2	2.23	S
Suruh	3,335	2,334.5	1.82	4,248.79	19,522.03	10,726.4	4.59	S
Pabelan	4,251	2,975.7	1.82	5,415.77	12,690.04	6,972.5	2.34	S
Tuntang	211	147.7	1.82	268.81	9,458.6	5,197.03	35.19	S
Banyubiru	3,840	2,688	1.82	4,892.16	11,493.54	6,315.1	2.35	S
Jambu	741	518.7	1.82	944.03	8,816.47	4,844.2	9.34	S
Sumowono	2,228	1,559.6	1.82	2,838.47	10,921.51	6,000.8	3.85	S
Ambarawa	1,661	1,162.7	1.82	2,116.11	4,935.95	2,712.05	2.33	S
Bandungan	4,140	2,898	1.82	5,274.36	4,327.55	2,377.8	0.82	VC
Bawen	2,717	1,901.9	1.82	3,461.46	7,241.14	3,978.6	2.09	S
Bringin	2,349	1,644.3	1.82	2,992.63	28,808.63	15,828.9	9.63	S
Bancak	2,820	1,974	1.82	3,592.68	15,391.55	8,456.9	4.28	S
Pringapus	1,333	933.1	1.82	1,698.24	23,509.36	12,917.2	13.84	S
Bergas	1,828	1,279.6	1.82	2,328.87	7,593.47	4,172.2	3.26	S
Ungaran Barat	2,105	1,473.5	1.82	2,681.77	5,400.34	2,967.2	2.01	S
Ungaran Timur	364	254.8	1.82	463.74	6,387.01	3,509.3	13.77	S
Jumlah	48,444	33,910.8		61,717.64	223,359.43	122,724.7	120.68	

SD = sub-district, Bcp = beef cattle population, Bcp (AU) = beef cattle population in livestock units, Rm = minimum feed requirements for beef cattle (ton DDM /year /AU), R bc = beef cattle feed requirements (tons /DDM/year), F Dmp = forage dry matter production (ton DDM), CC = carrying capacity (AU), CCI = carrying capacity index of forage, AV = forage availability status; S = safe, V = vurnerable, VC = very critical.

Table 5. Results of measurements of environmental factors that influence the growth of beef cattle in Semarang Regency in 2018

Subdistrict	Sample (Village)	Temperature (°C)	Temperature (°F)	Humidity (%)	THI	Rainfall (mm/year)	Dry months	Water pH
Getasan	Samirono	31	87.8	51	79.77	3,403	3	7
Tengaran	Duren	30	86	65	80.61	2,591	3	5.8
Susukan	Timpik	32	89.6	57	82.13	2,618	3	6.5
Kaliwungu	Mukiran	32	89.6	56	81.95	2,618	0	5.5
Suruh	Dadapayam	32	89.6	65	83.52	2,680	4	6.3
Pabelan	Terban	32	89.6	58	82.3	1,927	4	6.5
Tuntang	Tlumpakan	35	95	46	84.01	2,676	0	7
Banyubiru	Wirogomo	30	86	51	78.45	2,066	3	8
Jambu	Genting	31	87.8	49	79.44	2,489	0	6.2
Sumowono	Candi Garon	28	82.4	58	76.76	1,383	4	6.3
Ambarawa	Pasekan	30	86	51	78.45	1,291	3	6.8
Bandungan	Candi	29	84.2	54	77.57	1,291	0	6.7
Bawen	Polosiri	35	95	49	84.62	2,061	4	6.1
Bringin	Banding	35	95	54	85.64	2,211	3	7.9
Bancak	Pucung	33	91.4	58	83.68	2,091	0	6.5
Pringapus	Penawangan	32	89.6	56	81.95	2,290	3	4
Bergas	Munding	32	89.6	48	80.56	3,802	2	5.9
Ungaran Barat	Gogik	32	89.6	49	80.74	3,316	0	7.7
Ungaran Timur	Kawengen	33	91.4	51	82.4	3,316	0	6.6

THI = T - {0.55 (1-RH / 100) (T-58)}, where T = temperature (°F), RH = relative humidity.

Table 6. Extent of suitability of ecological environment map of beef cattle farms in Bancak, Banyubiru, and Bringin sub-districts

NO	SUBDISTRICT	Extent of Land Suitability (Ha)						Total
		S1	S1p	S2	S2p	S3	S3p	
1	Bancak	0	40.26	0.06	1,342.25	0	167.51	1,550.079
2	Banyubiru	17.10	0	1,434.10	0	0	0	1,451.2
3	Bringin	0	36.01	0	2,327.42	0	395.43	2,758.862
	TOTAL	17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

S1 = very suitable, S2 = quite suitable, S3 = according to marginal, P = limiting factor in the form of temperature humidity index (THI).

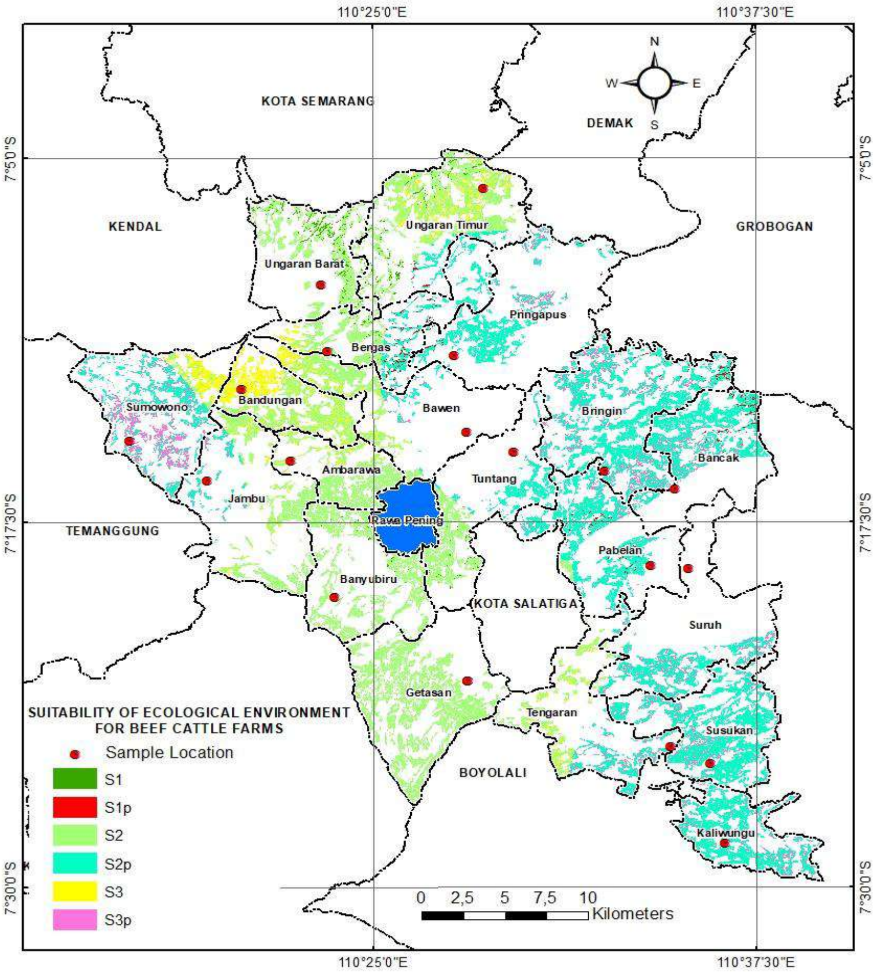

Figure 2. The suitability of ecological environment map for beef cattle farms in Semarang Regency

The Regional Analysis of Beef Cattle Farm Development in Semarang Regency

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ABSTRACT

One of the reasons for the low production and productivity of beef cattle in Indonesia is that information on the allocation of livestock areas development is not yet clear. This study aims to determine the priority areas for developing beef cattle farm in Semarang Regency based on the concept of sustainability. Sustainability was analyzed through the determination of leading commodities (analysis of Location Quotient and Shift Share), optimization of regional potential (analysis of carrying capacity and carrying capacity index of forage, and assessment of suitability of ecological environment of beef cattle). The process of spatial analysis used GIS software. Comprehensive planning for the development of beef cattle farm was directed in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of the analysis showed that the three sub-districts were beef cattle base areas (LQ>1), had business growth (positive SS), and had a safe status for forage availability (>2). Other results showed that the carrying capacity for beef cattle farms in Bringin sub-district was 15,829 AU, Bancak was 8,457 AU, and Banyubiru was 6,315 AU. The land area suitable for beef cattle farm from the three priority sub-districts was 5,760.141 Ha. It can be concluded that the development of beef cattle farm in Semarang Regency is focused on three priority sub-districts, namely: Bringin, Bancak,

and Banyubiru. The results of this study can be an input for local governments in determining the direction and pattern of beef cattle farm development to be more sustainable.

Keywords: beef cattle, regional analysis, sustainability of livestock sector

INTRODUCTION

The directed and sustainable development of the livestock sector is believed to be able to contribute positively to regional development. Along with the increase in population, there is an increasing demand for food from animal protein, such as beef. Beef consumption in developing countries such as in Indonesia tends to increase every year (Thornton, 2010; Agus & Widi, 2018), however the population of beef cattle in some regions actually decreases due to the complexity of technical and non-technical problems (Paly *et al*., 2013; Ariningsih, 2014; Nuhung, 2015). There is a gap between demand and supply of beef products, which is increasingly widening. Many factors causing this gap, including the domestic production of beef cattle is still low because information on the allocation of livestock development areas is not yet clear.

Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009; Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able to meet the high meat consumption of people. The consumption of beef in 2020 is estimated to reach 3.36 kg per capita per year, but beef production is still not able to fulfill it; there is a deficit in beef supply by 198,350 tons (Kementan, 2016; Agus & Widi, 2018). Most of the beef production in Indonesia, 78% comes from traditional livestock, 5% from imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al*., 2017). Imports of beef are indeed relatively larger compared to the other types of meat

imports, contributing 21.44% to the total import value of livestock, while the import value of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al*., 2014).

Policy efforts to reduce beef imports must be studied, by strengthening domestic production that is beneficial for farmers (Pasandaran *et al*., 2014). The development of beef cattle farms in potential areas is an effort to strengthen meat production in the country so that the implementation must be carried out with a comprehensive assessment. Semarang Regency is a region in Central Java Province that has the potential to develop beef cattle farms because it has natural resources in the form of land as a place for livestock keeping and forage production. Good quality and forage availability can increase production, especially for increasing body weight of cattle (Suhaema *et al*., 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha), rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this region during the 2014-2016 period continued to decline, ranging from 53,135; 49,172; and 46,238 (BPS Kabupaten Semarang, 2018).

The development of beef cattle farms in Semarang Regency needs to adopt the concept of sustainability. The concept of sustainability is the achievement of economic, environmental, and social goals simultaneously which is represented by various performance indicators (Darnhofer *et al*., 2010). Sustainability is also defined as the concept of multidimensional (economic, ecological, and social) and multiscale (micro, meso, and macro), although in its application, it is often limited to one particular aspect (Santos *et al*., 2017). Economic sustainability is closely related to the value of comparative and competitive advantages of certain commodities (Broom *et al*., 2013;

Sabaghi *et al*., 2016), while environmental sustainability includes optimizing the availability and efficient use of natural resources (Atanga *et al*., 2013).

The sustainability of beef cattle farms can be identified through a regional approach, by considering the existence of leading commodities and the potential of the region concerned (Mulyono & Munibah, 2016; Parmawati *et al*., 2018). Determination of leading commodities characterized by the existence of comparative and competitive advantages is the first step towards the efficient development of livestock sector. The potential of the region to support the development of beef cattle farms is determined by optimizing the carrying capacity and carrying capacity index of forage, as well as by assessing the suitability of the land where the livestocks are raised. Land suitability for beef cattle farms with intensive production systems considers several environmental factors that affect the growth of these cattle.

Mapping activities based on the determination of leading commodities and optimization of regional potential are needed as a basis for planning sustainable development of beef cattle farms. This study aims to determine the priority areas for developing beef cattle farms in Semarang Regency. The results of this study are expected to be one of the considerations in determining the direction and development policy of the beef cattle farms sector in Semarang Regency.

MATERIALS AND METHODS

This research was a type of quantitative research and applied the concept of sustainability. Sustainabilities assessed were economic and environmental sustainabilities for beef cattle farm in Semarang Regency. Economic sustainability was identified through the determination of the leading commodity of livestock, while environmental

sustainability was identified through the calculation of the carrying capacity and carrying capacity index of forage, and the assessment of suitability of ecological environment of beef cattle. In detail, each step of the analysis was outlined below.

Leading Commodity

Determination of leading livestock commodities in an area used Location Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods was the economic basis theory. LQ analysis was relatively simple, but the benefits were large enough for the initial identification of the ability of a sector in regional development. The shift in the structure of economic activity in beef cattle business, whether experiencing growth or decline was analyzed using Shift Share (SS). SS analysis can be used to see the growth of the economic sectors of a region for two-time points (Muta'ali, 2015). LQ and SS analysis used the following equations (Ciptayasa *et al.*, 2016; Mulyono & Munibah, 2016).

$$LQ_{ij} = \frac{Xij\ /\ Xi.}{X.j\ /\ X..} \text{ (Equation 1)}$$

(X_{ij} = Beef cattle population in the sub-district A, $X_{i.}$ = Population of all types of livestock in the sub-district A, $X_{.j}$ = Beef cattle population in Semarang Regency, $X_{..}$ = Population of all types of livestock in Semarang Regency).

$$SS = \left[\frac{X..(t1)}{X..(t0)} - 1\right] + \left[\frac{X.i(t1)}{X.i((t0)} - \frac{X..(t1)}{X..(t0)}\right] + \left[\frac{Xij(t1)}{Xij(t0)} - \frac{X.i(t1)}{X.i((t0)}\right] \text{ (Equation 2)}$$

(Regional share, Proportional shift, Differential shift, X ..= Population of all types of livestock in Semarang Regency, Xi= Beef cattle population in Semarang Regency, Xij= Beef cattle population in sub-district A, t0= Early 2013 year point, t1= End of year 2017).

Carrying Capacity and Carrying Capacity Index of Forage

The carrying capacity of the region for livestock development is indicated by the ability of the region to produce forage that can accommodate and meet the needs of a

number of beef cattle populations. Forages were divided into two types, namely fresh forage (grass, legume) and dry forage (straw). An assessment of the carrying capacity index of forage was conducted to assess the availability of animal feed in a region, whether it was classified as safe, vulnerable, critical, or very critical.

The carrying capacity of beef cattle farms was calculated based on the production of forage dry matter against the minimum feed requirements of cattle (1 AU) in one year. The animal unit (AU) was a unit for the ruminant livestock population multiplied by the conversion factor. The conversion factor for beef cattle was 0.7 (Muta'ali, 2015; Saputra *et al*., 2016). Forage dry matter production was the amount of potential agricultural waste and natural forage potential, using equations that refer to Suhaema *et al*. (2014) and Yuniar *et al*. (2016).

Potential of agricultural waste (ton) = $\{(wr \times 0.4) + (fr \times 3 \times 0.4) + (cn \times 3 \times 0.5) + (sb \times 3 \times 0.55) + (pt \times 2 \times 0.55) + (sp \times 0.25/6) + (cs \times 0.25/4)\} \times 0.65$

(wr is wetland rice, fr is field rice, cn is corn, sb is soybean, pt is peanuts, sp is sweet potatoes, cs is cassava. The numbers in the formula are assumptions about the potential waste produced from the production of each type of plant food).

Natural forage potential (ton) = $\{(Ga \times 2.875) + (Fa \times 0.6) + (Cpa \times 10) + (Cfa \times 0.5) + (Cla \times 5)\} \times 0.5$

(Ga is garden area, Fa is forest area, Cpa is coconut plant area, Cfa is coffee plant area, Cla is clove plant area. The numbers in the formula are assumed to be natural forage potential produced per hectare of land use area).

Minimum cattle feed requirements (R) = 2.5% x 50% x 365 x 400 kg = 1.82 ton DDM/year/AU (Equation 3)

Commented [MP1]: bagaimana dengan konversi AU livestock lainnya (kelinci, ayam babi dll)?

Commented [BS2R1]: Penelitian ini hanya berfokus untuk pengembangan ternak sapi potong. AU jenis ternak lainnya (kelinci, ayam, dll) tidak diperhitungkan, sesuai dengan penelitian terdahulu dari Suhaema (2014), Yuniar (2016).

Faktor konversi AU (0.7) digunakan untuk perhitungan daya dukung (CC) ternak sapi potong dan indeks daya dukung hijauan (CCI). Secara lebih lengkap dijabarkan pada Tabel 4.

Commented [MP3]: fresh forage or dry matter?

Commented [BS4R3]: Jawabannya adalah fresh forage

Forage dry matter production (ton of DDM/year) = Potential of agricultural waste + Natural forage potential

Angka-angka dalam rumus adalah asumsi potensi limbah yang dihasilkan dari **produksi setiap jenis tanaman pangan.**

Commented [MP5]: fresh or dry matter?

Commented [BS6R5]: Fresh forage

Commented [MP7]: daya cerna 50%, maka pengalinya menjadi 100/50; bukan 50%

Commented [BS8R7]: Menghitung R berdasar penelitian terdahulu dari Suhaema (2014), Muta'ali (2015), Yuniar (2016). 2.5% X 50% = 0.0125 atau 1.25%

1.25% X 365 X 400 = 1,825 kg = 1.82 Ton DDM/year/AU

(R is minimum cattle feed requirements (1 AU) in tons of digestible dry matter for 1 year, 2.5% is minimum requirement for the number of forage rations (dry matter) on livestock weight, 50% is average value digestibility power of various types of plants, 365 is number of days in 1 year, 400 kg is live weight of 1 AU of beef cattle in Semarang Regency). Equations that refer to Suhaema *et al*. (2014) and Yuniar *et al*. (2016).

The results of the calculation of forage dry matter production were then used to determine the carrying capacity of beef cattle farms using the following equations (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

$$\text{CC (AU)} = \frac{\text{Forage Dry Matter Production (tons of DDM / year)}}{\text{Minimum Cattle Feed Requirement (tons of DDM / year / AU)}} \quad \text{(Equation 4)}$$

The level of animal feed security in a region was measured by forage carrying capacity index. Carrying capacity index values were values that indicated the status of the availability of forage for beef cattle, namely: very critical (≤1), critical (>1-1.5), vulnerable (> 1.5-2), and safe (>2).

$$\text{Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \quad \text{(Equation 5)}$$

Suitability of the Ecological Environment of Beef Cattle

The research sample for the assessment of the suitability ecological environment of beef cattle farms in Semarang Regency was 19 points spreading throughout the sub-district area (Table 5). The determination of the sample was using purposive sampling technique. The purposive sampling technique was also called judgment sampling (Tongco, 2007), which was used to determine the sample based on research considerations. In each sub-district, one village was taken which had the most beef cattle population.

Commented [MP9]: kalau daya cerna 50%; maka kebutuhannya menjadi dikali 100/50, bukan dikali 50%

Commented [BS10R9]: Sudah terjawab dalam komentar sebelumnya.

Commented [MP11]: Penghitungan AU menggunakan konversi 0.7 semua. Padahal populasi sapi ada yg muda dan anak2, seharusnya berdasarkan struktur populasi.

Commented [BS12R11]: Menurut Muta'ali (2015), Saputra (2016), faktor konversi untuk ternak sapi 0.7, mewakili populasi sapi yang terdiri dari induk betina, induk jantan, dan anak dengan berbagai tingkatan umur.
Penelitian lebih detail untuk perhitungan AU ternak sapi potong (berdasar struktur populasi), memungkinkan untuk dilakukan di masa mendatang.

Lands available for the development of beef cattle farms are gardens, grasslands, open land, rice fields, and dryland agriculture. The fields are assumed to be able to be used for building housing for beef cattle. The assessment of land suitable for beef cattle farming with intensive maintenance patterns also takes into account several environmental parameters that influence the growth of livestock.

Land suitability assessment for beef cattle farms began by making a map of land units. Maps of beef cattle land units referred to research of Rusmana *et al*. (2006) which stated that there were four maps needed for overlaying, namely: land type maps, agro-climate maps, regional altitude maps, and slope maps. The final step was to make a "suitability map of the ecological environment of beef cattle". The method used was by overlaying between land unit maps with environmental parameters that affected the growth of beef cattle (Table 1). Land suitability was classified into 4 levels or strata, namely: very suitable (S-1), quite suitable (S-2), according to marginal (S-3), and non-suitable (NS) (Rusmana *et al*., 2006; Suhaema *et al*., 2014; Yuniar *et al*., 2016). The entire process was created and analyzed using GIS software.

RESULTS

Leading Commodity

The leading commodity of livestock in an area was determined based on comparative advantage (location quotient analysis) and competitive advantage (shift-share analysis). Beef cattle commodities that had LQ>1 and SS (+) values were the leading commodities in the region. The interpretation of the value of LQ>1, was a base or leading sector, beef cattle products (meat) were able to meet markets inside and outside the region. The value of LQ<1 implied a non-base sector, livestock products had not been able to meet markets inside and outside the region. The value of LQ=1 implied that the sector was balanced with the reference region, livestock products were only able to meet markets in the area. The basis for calculating LQ analysis for livestock commodities was livestock population data (Hendayana, 2003). Data bias in calculations could be minimized by using a minimum 5 year data series (Table 2).

Commented [MP13]: Data 5 tahun untuk LQ metodenya bagaimana? dirata2, dijumlah atau bagaimana?

Commented [BS14R13]: Perhitungan analisis LQ merupakan penjumlahan populasi masing-masing jenis ternak yang terdapat di Kabupaten Semarang (dari tahun 2013-2017).

Setelah data 5 tahun tersebut dijumlahkan, kemudian perhitungan LQ mengikuti pada persamaan 1.

Shift share analysis started from the basic assumption that economic growth or added value of an activity in a particular region was influenced by three main components which were interconnected with each other, namely: regional growth, sectoral growth, and growth in share or regional competitiveness (Ciptayasa *et al.*, 2016). Through these three components, it could be seen which elements had encouraged regional economic growth. The value of each component could be positive or negative, but the total number (shift-share) would always be positive if the regional economic growth were positive, and vice versa.

The results of the LQ and SS analysis calculations for beef cattle commodities in Semarang Regency are shown in Table 3. Based on the results of the analysis conducted, the subdistrict areas becoming the beef cattle base sector (LQ> 1) were Bancak (4.93),

Banyubiru (3.97), Ambarawa (3.92), Bringin (2.82), and Bawen (2.34). Beef cattle keeping was concentrated in these areas or in the other words the economic density of beef cattle was higher than that of in the other regions.

Beef cattle commodities that had competitive advantages were seen based on positive shift-share (SS) values. Sub-districts with a positive SS value means experiencing growth (competitiveness) related to keeping beef cattle. On the other hand, sub-districts with negative SS value means that the area is not growing (stagnant) and can even experience setbacks. The results of the analysis conducted in Table 3 showed that sub-districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47), Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tengaran (0.026).

The development of beef cattle farms in Semarang Regency is prioritized in the sub-districts with LQ>1 and SS (+) values. The sub-districts are Bringin, Bancak, and Banyubiru.

Carrying Capacity and Carrying Capacity Index of Forage

The potential availability of feed for beef cattle was seen based on the amount of forage dry matter production (tons of DDM) that could be produced by the region concerned. Dry matter is the total feed ingredients without water content, which can come from forages. The region with the largest forage dry matter production has the highest carrying capacity for the development of beef cattle farms, and vice versa. Forage is one of the production inputs that determine the success of livestock business because it directly affects productivity and efficiency (Yuniar *et al*., 2016). Table 4 shows the

calculation of carrying capacity and carrying capacity index of forage for beef cattle farms in Semarang Regency.

Based on the results of the analysis conducted in Table 4, it was known that there were three sub-districts with the highest production of forage dry matter, namely Bringin (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons DDM). Sub-district area with the lowest forage dry matter production was Bandungan (4,327.55 tons DDM). The status of the availability of forage in Bandungan sub-district was categorized as very critical (0.82), while in Tengaran sub-district it was categorized as vulnerable (1.69). Therefore, these two sub-districts are not recommended for the development of beef cattle farms. Sub-district areas with carrying capacity index value >2 (safe) means that the areas can be recommended for the development of beef cattle farms. The advantage obtained by the area with this safe category is that farmers can reduce the amount of production costs for beef cattle feed.

Semarang Regency had a carrying capacity for beef cattle farms of 122,725 AU. The population of beef cattle in 2017 was 33,911 AU, so the Semarang Regency area was assumed to still be able to accommodate 88,814 AU beef cattle in 2018.

Commented [MP15]: penambahan cattle; tidak hanya berdasarkan populasi sapi yg ada, tetapi juga AU ruminansia lain (Table 2) yg menggunakan hijauan (kebau, kuda, domba/kambing)

Commented [BS16R15]: Asumsi penambahan sapi potong dalam penelitian ini berdasar perhitungan daya dukung (CC) pada Tabel 4, yang mengacu pada penelitian terdahulu dari Suhaema (2014) dan Yuniar (2016).

The Suitability of Ecological Environment of Beef Cattle

The results of field measurements and secondary data collection conducted on several environmental factors that influence the growth of beef cattle are shown in Table 5. The factors that limited the assessment of the suitability of the ecological environment of beef cattle farming in Semarang Regency were the Temperature Humidity Index (THI) and water pH. Annual rainfall (<4000 mm) and dry months (<8) were in the appropriate category.

The suitability of the ecological environment map for beef cattle farms in Semarang Regency is shown in Figure 1. The white area was an area that was not assessed because it was designated as land for settlements, plantations, tourism, and forests. Based on data in Figure 1, the level of suitability of the produced beef cattle ecological environment was: very suitable (S-1), quite suitable (S-2), and according to marginal (S-3). Non-suitable (NS) categories were not assessed because the area had a slope >40% (steep - very steep).

The symbol "p" indicated that there was a limiting factor in the area assessed. The limiting factors were the Temperature Humidity Index (THI) and the pH of the water for beef cattle consumption (Table 5). Semarang Regency consists of 19 sub-districts. The development of beef cattle farms will be prioritized in sub-districts having LQ>1, positive SS (+) value, and carrying capacity index of forage >2, namely Bringin, Bancak, and Banyubiru. Banyubiru sub-district was not constrained by the limiting factors, while Bringin and Bancak were constrained by THI values that exceed the comfort zone for growing cattle (>80). The extent suitability of the ecology of beef cattle farms from the three priority sub-districts is shown in Table 6.

Based on the results of the analysis conducted in Table 6, the sub-districts with the largest land area for the development of beef cattle farms with intensive production systems were Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru (1,451.2 Ha). The limiting factor in the form of temperature humidity index (THI) or water pH can be minimized through the engineering design of livestock housing and the provision of materials or neutralizing water acidity solvent (Yani *et al*., 2007; Sarwanto & Hendarto, 2011). Cattle with intensive production systems are generally more susceptible to heat stress than cattle with extensive production systems. Efforts that can be done to reduce

Commented [MP17]: dalam menghitung forage, daerah putih seharusnya menjadi pengurang.

Commented [BS18R17]: Wilayah berwarna putih tidak diperhitungkan dalam penelitian ini karena:

1. Merupakan penggunaan lahan yang **tidak potensial** untuk pengembangan peternakan sapi potong karena berupa lahan permukiman, industri & pariwisata, badan air, perkebunan, hutan,
2. Mempunyai kemiringan lereng >40% (curam-sangat terjal), sehingga tidak memungkinkan mengambil hijauan (misal dari hutan) di wilayah ini.

heat stress in beef cattle include: adding shade around the housing location, install a sprinkle tool or add straw that works to lower the surface temperature of the floor, regulate feed, feed additives, and medicine, etc (Suhaema *et al*., 2014).

DISCUSSION

Semarang Regency is a potential area for the development of beef cattle farming because it has abundant natural resources in the form of land for livestock raising and forage production. The mapping activity is based on the determination of leading livestock commodities, and optimization of regional potential can be one of the benchmarks in realizing sustainable development of beef cattle farms. The concept of sustainable development is to meet the needs of the current generation, without sacrificing future generations and this concept has become a reference for welfare in almost all sectors, including the livestock sector (Wasike *et al.*, 2011). The concept of sustainability was widely debated throughout the world over the past few years (De Longe *et al*., 2016; Keesstra *et al*., 2016; Rasmussen *et al*., 2017), not only concerning environmental and social issues, but also discussing economic issues to gain certain market or commodity advantages (Broom *et al.*, 2013; Sabaghi *et al*., 2016). Sustainability assessment is achieved by evaluating the relative contribution of each of the economic, environmental, and social factors to the overall goal (Astier & García-Barrios, 2012). Sustainability assessed in this study is economical and environmental sustainability for beef cattle farms.

Economic sustainability was assessed based on the results of the analysis of the leading commodity. The leading livestock commodity in an area was determined based on the comparative advantage (LQ analysis) and competitive advantage (SS analysis).

The concept of comparative advantage is economic feasibility. Commodities that have a comparative advantage (LQ>1) show that the commodity (beef cattle) is supported by the existence of adequate natural resources so that the population level is higher than in other regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a prominent or dominant livestock business compared to the other livestock businesses, so the effort for future development is easier (Yuniar *et al*., 2016; Mulyono & Munibah, 2016). On the other hand, the concept of competitive advantage is financial feasibility. Beef cattle commodities are keeping in effective and efficient ways so that they have competitiveness from the aspects of quality, quantity, continuity, and price (Muta'ali, 2015; Mulyono & Munibah, 2016). The results presented in Table 3 show that the Bringin, Bancak, and Banyubiru sub-districts are regions with a leading commodity of beef cattle. Accordingly, the three sub-districts are a priority for the development of beef cattle farms in Semarang Regency.

Environmental sustainability for beef cattle farms was assessed based on the results of the carrying capacity analysis and carrying capacity index of forage, and analysis of the suitability of the ecological environment of beef cattle. Carrying capacity is defined as the maximum population that can be supported by an ecosystem from time to time. The carrying capacity of an area is not static, there is a kind of reciprocal relationship between organism and their environments. The carrying capacity of a region can vary for different species and change over time due to various factors (Taiwo & Feyisara, 2017). Regional carrying capacity for livestock development is the size of the region's ability to support the livelihoods of a number of livestock populations optimally through the role of forage availability. Based on the results of the analysis presented in

Table 4, it is known that the Bringin, Bancak, and Banyubiru sub-districts have a forage carrying capacity index in the safe category.

The production systems of beef cattle that is often found in Semarang Regency is an intensive production system. Beef cattle are able to show optimal physical conditions if they have superior genetic traits, and are supported by the suitability of their ecological environment (Suhaema *et al*., 2014). Animal ecology is the study of the interactions between animals and their environments. Environmental factors tend to have a greater effect on the production and productivity of livestock (Sumarto & Koneri, 2016). Some environmental factors that influence the growth of beef cattle with intensive production systems are: soil type, length of dry season, altitude, slope (Rusmana *et al*., 2006), temperature and relative humidity, rainfall, and water pH (Herbut & Angrecka, 2012; Suhaema *et al*., 2014; Yuniar *et al*., 2016; Eirich, 2018).

The results of the analysis in Table 5 show that environmental factors that are limiting the development of beef cattle farms in Semarang Regency are air temperature and humidity, as well as pH of water used by livestock for drinking. The relationship between the amount of air temperature and humidity is called the Temperature Humidity Index (THI). If THI exceeds the threshold (>80), it can cause stress or heat stress in beef cattle (Eirich, 2018). Long-term heat stress has an impact on increasing drinking water consumption, increasing urine volume, and decreasing feed consumption. The direct effect of heat stress on livestock production causes a decrease in the productivity of beef cattle. This effect is due to the increasing need for livestock maintenance during stress conditions (Berman, 2005). Furthermore, the THI value that exceeds the threshold will decrease the daily body weight gain, increase the depletion of the thickness of meat fat, and increase the potential for disease occurrence, especially in male cattle (Nardone *et*

al., 2010). Hydrogen potential (pH) characterizes the balance between acidic and alkaline solvent in water. If the pH of drinking water for beef cattle is below the quality standard or acid (<6,5), the water becomes sour and can cause physiological and digestive disorders in livestock. On the other hand, if the pH of water is too alkaline (>9), the water becomes bitter and causes a decrease in the consumption of drinking water which has an impact on decreasing livestock productivity (Sarwanto & Hendarto, 2011).

The synthesis of the assessment results of leading commodity, calculation of carrying capacity and carrying capacity index of forage, as well as land suitability assessment, shows that there are three sub-districts (Bringin, Bancak, and Banyubiru) which have high priorities for the development of beef cattle farms in Semarang Regency.

CONCLUSION

Planning for the development of beef cattle farming with intensive production systems in Semarang Regency is recommended in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The assumption of forage production produced from these three sub-districts reaches 55,693.72 tons of DDM. The total carrying capacity for beef cattle farms is 30,601 AU. The total land area suitable for beef cattle farming in the three priority sub-districts is 5,760.141 Ha. The development of beef cattle farms in the priority sub-districts is expected to increase livestock production and productivity. Governments, communities (cattleman), and the private sector (investors) must coordinate and cooperate with each other so that the development of sustainable beef cattle farms can be achieved.

CONFLICT OF INTEREST

Commented [MP19]: CC semarang 33,911 AU; sementara 3 kecamatan 30,601 AU (?????)

Commented [BS20R19]: angka 33,911 bukan CC, tapi merupakan jumlah seluruh populasi sapi potong di Kabupaten Semarang (dalam AU) pada tahun 2017. Sementara estimasi CC ternak sapi potong pada tahun 2018 di tiga wilayah prioritas pengembangan (Bringin, Bancak, & Banyubiru) yaitu 30,601 AU. Angka yang dihasilkan tersebut berdasar hasil perhitungan (equation 4 dan Tabel 4).

Commented [MP21]: perhitungan CC berdasarkan struktur populasi sapi
tambahan sapi dikoreksi dengan populasi ruminansia yang ada

Commented [BS22R21]: Pada bagian kesimpulan, CC yang dijelaskan sebesar 30,601 AU. Ini merupakan CC dari ketiga wilayah prioritas pengembangan ternak sapi potong (Bringin, Bancak, Banyubiru).
Perhitungan CC mengikuti persamaan 4.

Commented [MP23]: Di kesimpulan land suitable 5760 jika ditanami jagung (penghasil limbah terbanyak di persamaan 1), produksinya hanya:
5760*3*0.5= 8640 ton /1.82 = 4747 AU. Jauh dibawah kesimpulan 30601 AU

Commented [BS24R23]: Berdasarkan hasil perhitungan pada Tabel 6, luas lahan yang sesuai untuk pengembangan peternakan sapi potong (di tiga wilayah prioritas) yaitu 5,760.1 Ha.
Untuk menghitung daya dukung (CC) tidak bisa hanya menggunakan asumsi potensi limbah tanaman jagung. CC dihitung menggunakan persamaan 4.
Sebelum menghitung CC, produksi bahan kering hijauan (Forage dry matter production/F dmp) perlu dihitung. F dmp merupakan hasil penjumlahan antara potensi limbah pertanian dan potensi hijauan alami (satuan ton).

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Table 1. Environmental parameters that influence the growth of beef cattle with intensive maintenance patterns

Parameter	**Order of environmental suitability of beef cattle**	
	S (Suitable)	N (Unsuitable)
Temperature Humidity Index (THI)	70-80	<70, >80
Water availability (w)		
Dry month (<100 mm rainfall/month)	<8 months	>8 months
Rainfall/year (mm)	< 4,000	> 4,000
The existence of a water source	Available	Not Available
Water Quality (q)		
pH water	6.5-9.0	<6.5; >9.0
Slope (%)	<40	>40

Source: (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

Table 2. Growth of livestock populations in Semarang Regency

Type of livestock	**Number (head)**				
	2013	**2014**	**2015**	**2016**	**2017**
Pig	32,640	17,300	18,431	15,971	15,850
Goat	197,029	136,999	123,294	117,003	117,373
Sheep	290,764	191,346	172,211	167,374	162,694
Rabbit	20,352	9,375	10,462	11,629	11,916
Horse	1,711	497	515	524	581
Beef cattle	51,901	53,135	49,172	46,238	48,444
Dairy cows	22,308	27,609	25,780	25,690	25,557
Buffalo	2,941	3,168	2,614	2,629	2,589
Laying Chicken	1,821,286	1,813,049	1,452,019	1,331,528	1,572,463
Broiler Chicken	12,046,319	7,501,700	10,144,846	10,754,602	11,812,311
Chicken Breed	819,067	860,408	818,568	861,989	823,226
Duck	206,882	92,963	80,801	127,859	125,261
Quail	122,200	238,930	227,737	176,730	142,856
Muscovy Duck	102,966	72,227	63,889	61,963	54,402

Source: (BPS Kabupaten Semarang, 2018).

Table 3. Value of LQ and SS of beef cattle in Semarang Regency in 2018

NO	SUB-DISTRICT	BEEF CATTLE				
		LQ	RS	PS	DF	SS
1	Getasan	0.63	-0.052	-0.014	-0.359	-0.425
2	Tengaran	0.55	-0.052	-0.014	0.092	0.026
3	Susukan	1.11	-0.052	-0.014	-0.137	-0.203
4	Kaliwungu	1.22	-0.052	-0.014	0.048	-0.018
5	Suruh	0.88	-0.052	-0.014	-0.213	-0.279
6	Pabelan	1.75	-0.052	-0.014	0.501	0.435
7	Tuntang	0.28	-0.052	-0.014	-0.689	-0.755
8	Banyubiru	3.97	-0.052	-0.014	0.536	0.47
9	Jambu	0.42	-0.052	-0.014	-0.417	-0.483
10	Sumowono	0.95	-0.052	-0.014	-0.234	-0.3
11	Ambarawa	3.92	-0.052	-0.014	0.006	-0.06
12	Bandungan	1.01	-0.052	-0.014	0.269	0.203
13	Bawen	2.34	-0.052	-0.014	0.0009	-0.0651
14	Bringin	2.82	-0.052	-0.014	0.105	0.039
15	Bancak	4.93	-0.052	-0.014	0.143	0.077
16	Pringapus	1.38	-0.052	-0.014	-0.312	-0.378
17	Bergas	0.77	-0.052	-0.014	-0.106	-0.172
18	Ungaran Barat	0.77	-0.052	-0.014	1.352	1.286
19	Ungaran Timur	0.3	-0.052	-0.014	-0.62	-0.686

LQ = Location quotient, SS = Shift share, RS = Regional share, PS = Proportional shift, DS = Differential shift.

Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency in 2018

SD	Bcp 2017	Bcp 2017 (AU)	Rm	R Bc	F Dmp	CC	CCI	AV
A	b	c	d	e = c x d	f	g = f/d	h = g/c	
Getasan	2,085	1,459.5	1.82	2,656.29	7,802.45	4,287.1	2.94	S
Tengaran	4,881	3,416.7	1.82	6,218.39	10,526.78	5,783.9	1.69	V
Susukan	2,905	2,033.5	1.82	3,700.97	15,301.29	8,407.3	4.13	S
Kaliwungu	4,650	3,255	1.82	5,924.1	13,231.72	7,270.2	2.23	S
Suruh	3,335	2,334.5	1.82	4,248.79	19,522.03	10,726.4	4.59	S
Pabelan	4,251	2,975.7	1.82	5,415.77	12,690.04	6,972.5	2.34	S
Tuntang	211	147.7	1.82	268.81	9,458.6	5,197.03	35.19	S
Banyubiru	3,840	2,688	1.82	4,892.16	11,493.54	6,315.1	2.35	S
Jambu	741	518.7	1.82	944.03	8,816.47	4,844.2	9.34	S
Sumowono	2,228	1,559.6	1.82	2,838.47	10,921.51	6,000.8	3.85	S
Ambarawa	1,661	1,162.7	1.82	2,116.11	4,935.95	2,712.05	2.33	S
Bandungan	4,140	2,898	1.82	5,274.36	4,327.55	2,377.8	0.82	VC
Bawen	2,717	1,901.9	1.82	3,461.46	7,241.14	3,978.6	2.09	S
Bringin	2,349	1,644.3	1.82	2,992.63	28,808.63	15,828.9	9.63	S
Bancak	2,820	1,974	1.82	3,592.68	15,391.55	8,456.9	4.28	S
Pringapus	1,333	933.1	1.82	1,698.24	23,509.36	12,917.2	13.84	S
Bergas	1,828	1,279.6	1.82	2,328.87	7,593.47	4,172.2	3.26	S
Ungaran Barat	2,105	1,473.5	1.82	2,681.77	5,400.34	2,967.2	2.01	S
Ungaran Timur	364	254.8	1.82	463.74	6,387.01	3,509.3	13.77	S
Jumlah	48,444	33,910.8		61,717.64	223,359.43	122,724.7	120.68	

SD = sub-district, Bcp = beef cattle population, Bcp (AU) = beef cattle population in livestock units, Rm = minimum feed requirements for beef cattle (ton DDM /year /AU), R bc = beef cattle feed requirements (tons /DDM/year), F Dmp = forage dry matter production (ton DDM), CC = carrying capacity (AU), CCI = carrying capacity index of forage, AV = forage availability status; S = safe, V = vurnerable, VC = very critical.

Table 5. Results of measurements of environmental factors that influence the growth of beef cattle in Semarang Regency in 2018

Subdistrict	Sample (Village)	Temperature (°C)	Temperature (°F)	Humidity (%)	THI	Rainfall (mm/year)	Dry months	Water pH
Getasan	Samirono	31	87.8	51	79.77	3,403	3	7
Tengaran	Duren	30	86	65	80.61	2,591	3	5.8
Susukan	Timpik	32	89.6	57	82.13	2,618	3	6.5
Kaliwungu	Mukiran	32	89.6	56	81.95	2,618	0	5.5
Suruh	Dadapayam	32	89.6	65	83.52	2,680	4	6.3
Pabelan	Terban	32	89.6	58	82.3	1,927	4	6.5
Tuntang	Tlumpakan	35	95	46	84.01	2,676	0	7
Banyubiru	Wirogomo	30	86	51	78.45	2,066	3	8
Jambu	Genting	31	87.8	49	79.44	2,489	0	6.2
Sumowono	Candi Garon	28	82.4	58	76.76	1,383	4	6.3
Ambarawa	Pasekan	30	86	51	78.45	1,291	3	6.8
Bandungan	Candi	29	84.2	54	77.57	1,291	0	6.7
Bawen	Polosiri	35	95	49	84.62	2,061	4	6.1
Bringin	Banding	35	95	54	85.64	2,211	3	7.9
Bancak	Pucung	33	91.4	58	83.68	2,091	0	6.5
Pringapus	Penawangan	32	89.6	56	81.95	2,290	3	4
Bergas	Munding	32	89.6	48	80.56	3,802	2	5.9
Ungaran Barat	Gogik	32	89.6	49	80.74	3,316	0	7.7
Ungaran Timur	Kawengen	33	91.4	51	82.4	3,316	0	6.6

THI = T - {0.55 (1-RH / 100) (T-58)}, where T = temperature (°F), RH = relative humidity.

Table 6. Extent of suitability of ecological environment map of beef cattle farms in Bancak, Banyubiru, and Bringin sub-districts

NO	SUBDISTRICT	Extent of Land Suitability (Ha)						Total
		S1	S1p	S2	S2p	S3	S3p	
1	Bancak	0	40.26	0.06	1,342.25	0	167.51	1,550.079
2	Banyubiru	17.10	0	1,434.10	0	0	0	1,451.2
3	Bringin	0	36.01	0	2,327.42	0	395.43	2,758.862
	TOTAL	17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

S1 = very suitable, S2 = quite suitable, S3 = according to marginal, P = limiting factor in the form of temperature humidity index (THI).

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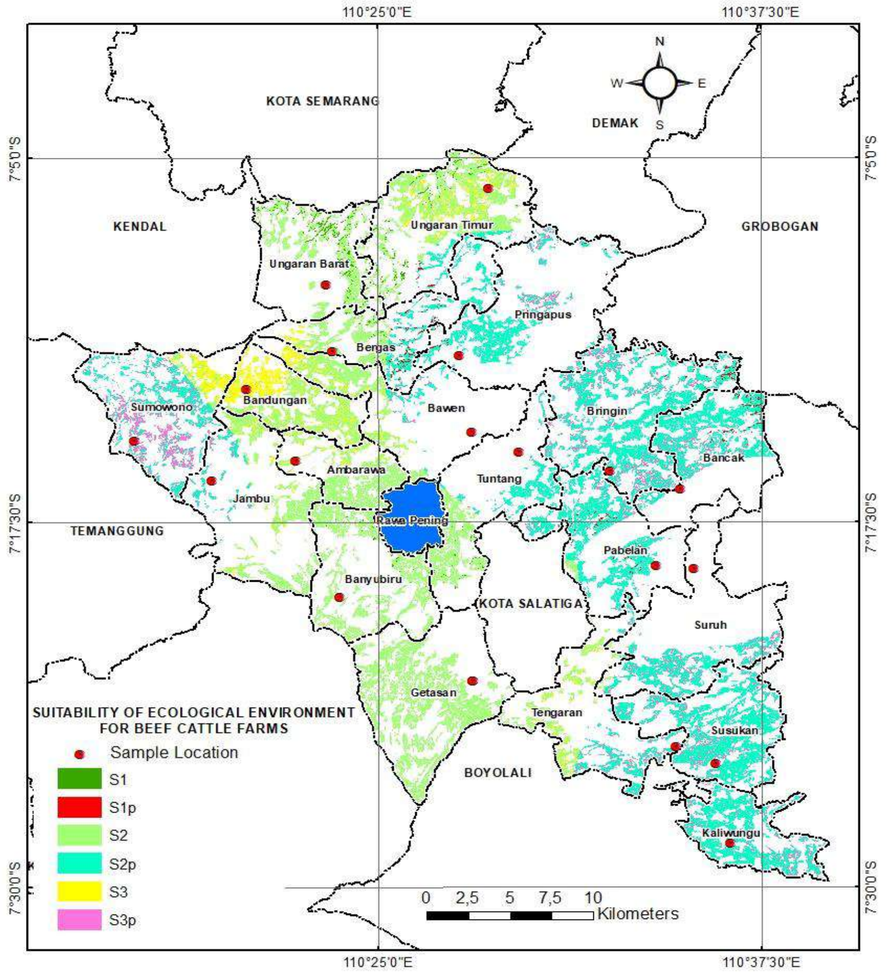

539 Figure 1. The suitability of ecological environment map for beef cattle farms in
540 Semarang Regency

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The Regional Analysis of Beef Cattle Farm Development in Semarang Regency

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ABSTRACT

One of the reasons for the low production and productivity of beef cattle in Indonesia is that information on the allocation of livestock areas development is not yet clear. This study aims to determine the priority areas for developing beef cattle farm in Semarang Regency based on the concept of sustainability. Sustainability was analyzed through the determination of leading commodities (analysis of Location Quotient and Shift Share), optimization of regional potential (analysis of carrying capacity and carrying capacity index of forage, and assessment of suitability of ecological environment of beef cattle). The process of spatial analysis used GIS software. Comprehensive planning for the development of beef cattle farm was directed in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of the analysis showed that the three sub-districts were beef cattle base areas (LQ>1), had business growth (positive SS), and had a safe status for forage availability (>2). Other results showed that the carrying capacity for beef cattle farms in Bringin sub-district was 15,829 AU, Bancak was 8,457 AU, and Banyubiru was 6,315 AU. The land area suitable for beef cattle farm from the three priority sub-districts was 5,760.141 Ha. It can be concluded that the development of beef cattle farm in Semarang Regency is focused on three priority sub-districts, namely: Bringin, Bancak,

and Banyubiru. The results of this study can be an input for local governments in determining the direction and pattern of beef cattle farm development to be more sustainable.

Keywords: beef cattle, regional analysis, sustainability of livestock sector

INTRODUCTION

The directed and sustainable development of the livestock sector is believed to be able to contribute positively to regional development. Along with the increase in population, there is an increasing demand for food from animal protein, such as beef. Beef consumption in developing countries such as in Indonesia tends to increase every year (Thornton, 2010; Agus & Widi, 2018), however the population of beef cattle in some regions actually decreases due to the complexity of technical and non-technical problems (Paly *et al*., 2013; Ariningsih, 2014; Nuhung, 2015). There is a gap between demand and supply of beef products, which is increasingly widening. Many factors causing this gap, including the domestic production of beef cattle is still low because information on the allocation of livestock development areas is not yet clear.

Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009; Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able to meet the high meat consumption of people. The consumption of beef in 2020 is estimated to reach 3.36 kg per capita per year, but beef production is still not able to fulfill it; there is a deficit in beef supply by 198,350 tons (Kementan, 2016; Agus & Widi, 2018). Most of the beef production in Indonesia, 78% comes from traditional livestock, 5% from imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al*., 2017). Imports of beef are indeed relatively larger compared to the other types of meat

imports, contributing 21.44% to the total import value of livestock, while the import value of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al*., 2014).

Policy efforts to reduce beef imports must be studied, by strengthening domestic production that is beneficial for farmers (Pasandaran *et al*., 2014). The development of beef cattle farms in potential areas is an effort to strengthen meat production in the country so that the implementation must be carried out with a comprehensive assessment. Semarang Regency is a region in Central Java Province that has the potential to develop beef cattle farms because it has natural resources in the form of land as a place for livestock keeping and forage production. Good quality and forage availability can increase production, especially for increasing body weight of cattle (Suhaema *et al*., 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha), rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this region during the 2014-2016 period continued to decline, ranging from 53,135; 49,172; and 46,238 (BPS Kabupaten Semarang, 2018).

The development of beef cattle farms in Semarang Regency needs to adopt the concept of sustainability. The concept of sustainability is the achievement of economic, environmental, and social goals simultaneously which is represented by various performance indicators (Darnhofer *et al*., 2010). Sustainability is also defined as the concept of multidimensional (economic, ecological, and social) and multiscale (micro, meso, and macro), although in its application, it is often limited to one particular aspect (Santos *et al*., 2017). Economic sustainability is closely related to the value of comparative and competitive advantages of certain commodities (Broom *et al*., 2013;

Sabaghi *et al*., 2016), while environmental sustainability includes optimizing the availability and efficient use of natural resources (Atanga *et al*., 2013).

The sustainability of beef cattle farms can be identified through a regional approach, by considering the existence of leading commodities and the potential of the region concerned (Mulyono & Munibah, 2016; Parmawati *et al*., 2018). Determination of leading commodities characterized by the existence of comparative and competitive advantages is the first step towards the efficient development of livestock sector. The potential of the region to support the development of beef cattle farms is determined by optimizing the carrying capacity and carrying capacity index of forage, as well as by assessing the suitability of the land where the livestocks are raised. Land suitability for beef cattle farms with intensive production systems considers several environmental factors that affect the growth of these cattle.

Mapping activities based on the determination of leading commodities and optimization of regional potential are needed as a basis for planning sustainable development of beef cattle farms. This study aims to determine the priority areas for developing beef cattle farms in Semarang Regency. The results of this study are expected to be one of the considerations in determining the direction and development policy of the beef cattle farms sector in Semarang Regency.

MATERIALS AND METHODS

This research was a type of quantitative research and applied the concept of sustainability. Sustainabilities assessed were economic and environmental sustainabilities for beef cattle farm in Semarang Regency. Economic sustainability was identified through the determination of the leading commodity of livestock, while environmental

sustainability was identified through the calculation of the carrying capacity and carrying capacity index of forage, and the assessment of suitability of ecological environment of beef cattle. In detail, each step of the analysis was outlined below.

Leading Commodity

Determination of leading livestock commodities in an area used Location Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods was the economic basis theory. LQ analysis was relatively simple, but the benefits were large enough for the initial identification of the ability of a sector in regional development. The shift in the structure of economic activity in beef cattle business, whether experiencing growth or decline was analyzed using Shift Share (SS). SS analysis can be used to see the growth of the economic sectors of a region for two-time points (Muta'ali, 2015). LQ and SS analysis used the following equations (Ciptayasa *et al*., 2016; Mulyono & Munibah, 2016).

$LQ_{ij} = \frac{Xij\ /\ Xi.}{X.j\ /\ X..}$ (Equation 1)

(X_{ij} = Beef cattle population in the sub-district A, $X_{i.}$ = Population of all types of livestock in the sub-district A, $X_{.j}$ = Beef cattle population in Semarang Regency, $X_{..}$ = Population of all types of livestock in Semarang Regency).

$SS = \left[\frac{X..(t1)}{X..(t0)} - 1\right] + \left[\frac{X.i(t1)}{X.i((t0)} - \frac{X..(t1)}{X..(t0)}\right] + \left[\frac{Xij(t1)}{Xij(t0)} - \frac{X.i(t1)}{X.i((t0)}\right]$ (Equation 2)

(Regional share, Proportional shift, Differential shift, X ..= Population of all types of livestock in Semarang Regency, Xi= Beef cattle population in Semarang Regency, Xij= Beef cattle population in sub-district A, t0= Early 2013 year point, t1= End of year 2017).

Carrying Capacity and Carrying Capacity Index of Forage

The carrying capacity of the region for livestock development is indicated by the ability of the region to produce forage that can accommodate and meet the needs of a

number of beef cattle populations. Forages were divided into two types, namely fresh forage (grass, legume) and dry forage (straw). An assessment of the carrying capacity index of forage was conducted to assess the availability of animal feed in a region, whether it was classified as safe, vulnerable, critical, or very critical.

The carrying capacity of beef cattle farms was calculated based on the production of forage dry matter against the minimum feed requirements of cattle (1 AU) in one year. The animal unit (AU) was a unit for the ruminant livestock population multiplied by the conversion factor. The conversion factor for beef cattle was 0.7 (Muta'ali, 2015; Saputra *et al*., 2016). Forage dry matter production was the amount of potential agricultural waste and natural forage potential, using equations that refer to Suhaema *et al*. (2014) and Yuniar *et al*. (2016).

Potential of agricultural waste (ton) = {(wr x 0.4) + (fr x 3 x 0.4) + (cn x 3 x 0.5) + (sb x 3 x 0.55) + (pt x 2 x 0.55) + (sp x 0.25/6) + (cs x 0.25/4)} x 0.65

(wr is wetland rice, fr is field rice, cn is corn, sb is soybean, pt is peanuts, sp is sweet potatoes, cs is cassava. The numbers in the formula are assumptions about the potential waste produced from the production of each type of plant food).

Natural forage potential (ton) = {(Ga x 2.875) + (Fa x 0.6) + (Cpa x 10) + (Cfa x 0.5) + (Cla x 5)} x 0.5

(Ga is garden area, Fa is forest area, Cpa is coconut plant area, Cfa is coffee plant area, Cla is clove plant area. The numbers in the formula are assumed to be natural forage potential produced per hectare of land use area).

Minimum cattle feed requirements (R) = 2.5% x 50% x 365 x 400 kg = 1.82 ton DDM/year/AU (Equation 3)

Commented [MP1]: bagaimana dengan konversi AU livestock lainnya (kelinci, ayam babi dll)?

Commented [BS2R1]: Penelitian ini hanya berfokus untuk pengembangan ternak sapi potong. AU jenis ternak lainnya (kelinci, ayam, dll) tidak diperhitungkan, sesuai dengan penelitian terdahulu dari Suhaema (2014), Yuniar (2016).

Faktor konversi AU (0.7) digunakan untuk perhitungan daya dukung (CC) ternak sapi potong dan indeks daya dukung hijauan (CCI). Secara lebih lengkap dijabarkan pada Tabel 4.

Commented [MP3]: fresh forage or dry matter?

Commented [BS4R3]: Jawabannya adalah fresh forage

Forage dry matter production (ton of DDM/year) = Potential of agricultural waste + Natural forage potential

Angka-angka dalam rumus adalah asumsi potensi limbah yang dihasilkan dari **produksi setiap jenis tanaman pangan.**

Commented [MP5]: fresh or dry matter?

Commented [BS6R5]: Fresh forage

Commented [MP7]: daya cerna 50%, maka pengalinya menjadi 100/50; bukan 50%

Commented [BS8R7]: Menghitung R berdasar penelitian terdahulu dari Suhaema (2014), Muta'ali (2015), Yuniar (2016). 2.5% X 50% = 0.0125 atau 1.25%

1.25% X 365 X 400 = 1,825 kg = 1.82 Ton DDM/year/AU

(R is minimum cattle feed requirements (1 AU) in tons of digestible dry matter for 1 year, 2.5% is minimum requirement for the number of forage rations (dry matter) on livestock weight, 50% is average value digestibility power of various types of plants, 365 is number of days in 1 year, 400 kg is live weight of 1 AU of beef cattle in Semarang Regency). Equations that refer to Suhaema *et al.* (2014) and Yuniar *et al.* (2016).

The results of the calculation of forage dry matter production were then used to determine the carrying capacity of beef cattle farms using the following equations (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

$$\text{CC (AU)} = \frac{\text{Forage Dry Matter Production (tons of DDM / year)}}{\text{Minimum Cattle Feed Requirement (tons of DDM / year / AU)}} \quad \text{(Equation 4)}$$

The level of animal feed security in a region was measured by forage carrying capacity index. Carrying capacity index values were values that indicated the status of the availability of forage for beef cattle, namely: very critical (≤1), critical (>1-1.5), vulnerable (> 1.5-2), and safe (>2).

$$\text{Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \quad \text{(Equation 5)}$$

Suitability of the Ecological Environment of Beef Cattle

The research sample for the assessment of the suitability ecological environment of beef cattle farms in Semarang Regency was 19 points spreading throughout the sub-district area (Table 5). The determination of the sample was using purposive sampling technique. The purposive sampling technique was also called judgment sampling (Tongco, 2007), which was used to determine the sample based on research considerations. In each sub-district, one village was taken which had the most beef cattle population.

Commented [MP9]: kalau daya cerna 50%; maka kebutuhannya menjadi dikali 100/50, bukan dikali 50%

Commented [BS10R9]: Sudah terjawab dalam komentar sebelumnya.

Commented [MP11]: Penghitungan AU menggunakan konversi 0.7 semua. Padahal populasi sapi ada yg muda dan anak2, seharusnya berdasarkan struktur populasi.

Commented [BS12R11]: Menurut Muta'ali (2015), Saputra (2016), faktor konversi untuk ternak sapi 0.7, mewakili populasi sapi yang terdiri dari induk betina, induk jantan, dan anak dengan berbagai tingkatan umur.
Penelitian lebih detail untuk perhitungan AU ternak sapi potong (berdasar struktur populasi), memungkinkan untuk dilakukan di masa mendatang.

Lands available for the development of beef cattle farms are gardens, grasslands, open land, rice fields, and dryland agriculture. The fields are assumed to be able to be used for building housing for beef cattle. The assessment of land suitable for beef cattle farming with intensive maintenance patterns also takes into account several environmental parameters that influence the growth of livestock.

Land suitability assessment for beef cattle farms began by making a map of land units. Maps of beef cattle land units referred to research of Rusmana *et al*. (2006) which stated that there were four maps needed for overlaying, namely: land type maps, agro-climate maps, regional altitude maps, and slope maps. The final step was to make a "suitability map of the ecological environment of beef cattle". The method used was by overlaying between land unit maps with environmental parameters that affected the growth of beef cattle (Table 1). Land suitability was classified into 4 levels or strata, namely: very suitable (S-1), quite suitable (S-2), according to marginal (S-3), and non-suitable (NS) (Rusmana *et al*., 2006; Suhaema *et al*., 2014; Yuniar *et al*., 2016). The entire process was created and analyzed using GIS software.

RESULTS

Leading Commodity

The leading commodity of livestock in an area was determined based on comparative advantage (location quotient analysis) and competitive advantage (shift-share analysis). Beef cattle commodities that had LQ>1 and SS (+) values were the leading commodities in the region. The interpretation of the value of LQ>1, was a base or leading sector, beef cattle products (meat) were able to meet markets inside and outside the region. The value of LQ<1 implied a non-base sector, livestock products had not been able to meet markets inside and outside the region. The value of LQ=1 implied that the sector was balanced with the reference region, livestock products were only able to meet markets in the area. The basis for calculating LQ analysis for livestock commodities was livestock population data (Hendayana, 2003). Data bias in calculations could be minimized by using a minimum 5 year data series (Table 2).

Shift share analysis started from the basic assumption that economic growth or added value of an activity in a particular region was influenced by three main components which were interconnected with each other, namely: regional growth, sectoral growth, and growth in share or regional competitiveness (Ciptayasa *et al.*, 2016). Through these three components, it could be seen which elements had encouraged regional economic growth. The value of each component could be positive or negative, but the total number (shift-share) would always be positive if the regional economic growth were positive, and vice versa.

The results of the LQ and SS analysis calculations for beef cattle commodities in Semarang Regency are shown in Table 3. Based on the results of the analysis conducted, the subdistrict areas becoming the beef cattle base sector (LQ> 1) were Bancak (4.93),

Commented [MP13]: Data 5 tahun untuk LQ metodenya bagaimana? dirata2, dijumlah atau bagaimana?

Commented [BS14R13]: Perhitungan analisis LQ merupakan penjumlahan populasi masing-masing jenis ternak yang terdapat di Kabupaten Semarang (dari tahun 2013-2017).

Setelah data 5 tahun tersebut dijumlahkan, kemudian perhitungan LQ mengikuti pada persamaan 1.

Banyubiru (3.97), Ambarawa (3.92), Bringin (2.82), and Bawen (2.34). Beef cattle keeping was concentrated in these areas or in the other words the economic density of beef cattle was higher than that of in the other regions.

Beef cattle commodities that had competitive advantages were seen based on positive shift-share (SS) values. Sub-districts with a positive SS value means experiencing growth (competitiveness) related to keeping beef cattle. On the other hand, sub-districts with negative SS value means that the area is not growing (stagnant) and can even experience setbacks. The results of the analysis conducted in Table 3 showed that sub-districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47), Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tengaran (0.026).

The development of beef cattle farms in Semarang Regency is prioritized in the sub-districts with LQ>1 and SS (+) values. The sub-districts are Bringin, Bancak, and Banyubiru.

Carrying Capacity and Carrying Capacity Index of Forage

The potential availability of feed for beef cattle was seen based on the amount of forage dry matter production (tons of DDM) that could be produced by the region concerned. Dry matter is the total feed ingredients without water content, which can come from forages. The region with the largest forage dry matter production has the highest carrying capacity for the development of beef cattle farms, and vice versa. Forage is one of the production inputs that determine the success of livestock business because it directly affects productivity and efficiency (Yuniar *et al*., 2016). Table 4 shows the

calculation of carrying capacity and carrying capacity index of forage for beef cattle farms in Semarang Regency.

Based on the results of the analysis conducted in Table 4, it was known that there were three sub-districts with the highest production of forage dry matter, namely Bringin (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons DDM). Sub-district area with the lowest forage dry matter production was Bandungan (4,327.55 tons DDM). The status of the availability of forage in Bandungan sub-district was categorized as very critical (0.82), while in Tengaran sub-district it was categorized as vulnerable (1.69). Therefore, these two sub-districts are not recommended for the development of beef cattle farms. Sub-district areas with carrying capacity index value >2 (safe) means that the areas can be recommended for the development of beef cattle farms. The advantage obtained by the area with this safe category is that farmers can reduce the amount of production costs for beef cattle feed.

Semarang Regency had a carrying capacity for beef cattle farms of 122,725 AU. The population of beef cattle in 2017 was 33,911 AU, so the Semarang Regency area was assumed to still be able to accommodate 88,814 AU beef cattle in 2018.

Commented [MP15]: penambahan cattle; tidak hanya berdasarkan populasi sapi yg ada, tetapi juga AU ruminansia lain (Table 2) yg menggunakan hijauan (kebau, kuda, domba/kambing)

Commented [BS16R15]: Asumsi penambahan sapi potong dalam penelitian ini berdasar perhitungan daya dukung (CC) pada Tabel 4, yang mengacu pada penelitian terdahulu dari Suhaema (2014) dan Yuniar (2016).

The Suitability of Ecological Environment of Beef Cattle

The results of field measurements and secondary data collection conducted on several environmental factors that influence the growth of beef cattle are shown in Table 5. The factors that limited the assessment of the suitability of the ecological environment of beef cattle farming in Semarang Regency were the Temperature Humidity Index (THI) and water pH. Annual rainfall (<4000 mm) and dry months (<8) were in the appropriate category.

The suitability of the ecological environment map for beef cattle farms in Semarang Regency is shown in Figure 1. The white area was an area that was not assessed because it was designated as land for settlements, plantations, tourism, and forests. Based on data in Figure 1, the level of suitability of the produced beef cattle ecological environment was: very suitable (S-1), quite suitable (S-2), and according to marginal (S-3). Non-suitable (NS) categories were not assessed because the area had a slope >40% (steep - very steep).

The symbol "p" indicated that there was a limiting factor in the area assessed. The limiting factors were the Temperature Humidity Index (THI) and the pH of the water for beef cattle consumption (Table 5). Semarang Regency consists of 19 sub-districts. The development of beef cattle farms will be prioritized in sub-districts having LQ>1, positive SS (+) value, and carrying capacity index of forage >2, namely Bringin, Bancak, and Banyubiru. Banyubiru sub-district was not constrained by the limiting factors, while Bringin and Bancak were constrained by THI values that exceed the comfort zone for growing cattle (>80). The extent suitability of the ecology of beef cattle farms from the three priority sub-districts is shown in Table 6.

Based on the results of the analysis conducted in Table 6, the sub-districts with the largest land area for the development of beef cattle farms with intensive production systems were Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru (1,451.2 Ha). The limiting factor in the form of temperature humidity index (THI) or water pH can be minimized through the engineering design of livestock housing and the provision of materials or neutralizing water acidity solvent (Yani *et al*., 2007; Sarwanto & Hendarto, 2011). Cattle with intensive production systems are generally more susceptible to heat stress than cattle with extensive production systems. Efforts that can be done to reduce

Commented [MP17]: dalam menghitung forage, daerah putih seharusnya menjadi pengurang.

Commented [BS18R17]: Wilayah berwarna putih tidak diperhitungkan dalam penelitian ini karena:

1. Merupakan penggunaan lahan yang **tidak potensial** untuk pengembangan peternakan sapi potong karena berupa lahan permukiman, industri & pariwisata, badan air, perkebunan, hutan,
2. Mempunyai kemiringan lereng >40% (curam-sangat terjal), sehingga tidak memungkinkan mengambil hijauan (misal dari hutan) di wilayah ini.

heat stress in beef cattle include: adding shade around the housing location, install a sprinkle tool or add straw that works to lower the surface temperature of the floor, regulate feed, feed additives, and medicine, etc (Suhaema *et al*., 2014).

DISCUSSION

Semarang Regency is a potential area for the development of beef cattle farming because it has abundant natural resources in the form of land for livestock raising and forage production. The mapping activity is based on the determination of leading livestock commodities, and optimization of regional potential can be one of the benchmarks in realizing sustainable development of beef cattle farms. The concept of sustainable development is to meet the needs of the current generation, without sacrificing future generations and this concept has become a reference for welfare in almost all sectors, including the livestock sector (Wasike *et al.*, 2011). The concept of sustainability was widely debated throughout the world over the past few years (De Longe *et al*., 2016; Keesstra *et al*., 2016; Rasmussen *et al*., 2017), not only concerning environmental and social issues, but also discussing economic issues to gain certain market or commodity advantages (Broom *et al.*, 2013; Sabaghi *et al*., 2016). Sustainability assessment is achieved by evaluating the relative contribution of each of the economic, environmental, and social factors to the overall goal (Astier & García-Barrios, 2012). Sustainability assessed in this study is economical and environmental sustainability for beef cattle farms.

Economic sustainability was assessed based on the results of the analysis of the leading commodity. The leading livestock commodity in an area was determined based on the comparative advantage (LQ analysis) and competitive advantage (SS analysis).

The concept of comparative advantage is economic feasibility. Commodities that have a comparative advantage (LQ>1) show that the commodity (beef cattle) is supported by the existence of adequate natural resources so that the population level is higher than in other regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a prominent or dominant livestock business compared to the other livestock businesses, so the effort for future development is easier (Yuniar *et al*., 2016; Mulyono & Munibah, 2016). On the other hand, the concept of competitive advantage is financial feasibility. Beef cattle commodities are keeping in effective and efficient ways so that they have competitiveness from the aspects of quality, quantity, continuity, and price (Muta'ali, 2015; Mulyono & Munibah, 2016). The results presented in Table 3 show that the Bringin, Bancak, and Banyubiru sub-districts are regions with a leading commodity of beef cattle. Accordingly, the three sub-districts are a priority for the development of beef cattle farms in Semarang Regency.

Environmental sustainability for beef cattle farms was assessed based on the results of the carrying capacity analysis and carrying capacity index of forage, and analysis of the suitability of the ecological environment of beef cattle. Carrying capacity is defined as the maximum population that can be supported by an ecosystem from time to time. The carrying capacity of an area is not static, there is a kind of reciprocal relationship between organism and their environments. The carrying capacity of a region can vary for different species and change over time due to various factors (Taiwo & Feyisara, 2017). Regional carrying capacity for livestock development is the size of the region's ability to support the livelihoods of a number of livestock populations optimally through the role of forage availability. Based on the results of the analysis presented in

Table 4, it is known that the Bringin, Bancak, and Banyubiru sub-districts have a forage carrying capacity index in the safe category.

The production systems of beef cattle that is often found in Semarang Regency is an intensive production system. Beef cattle are able to show optimal physical conditions if they have superior genetic traits, and are supported by the suitability of their ecological environment (Suhaema *et al*., 2014). Animal ecology is the study of the interactions between animals and their environments. Environmental factors tend to have a greater effect on the production and productivity of livestock (Sumarto & Koneri, 2016). Some environmental factors that influence the growth of beef cattle with intensive production systems are: soil type, length of dry season, altitude, slope (Rusmana *et al*., 2006), temperature and relative humidity, rainfall, and water pH (Herbut & Angrecka, 2012; Suhaema *et al*., 2014; Yuniar *et al*., 2016; Eirich, 2018).

The results of the analysis in Table 5 show that environmental factors that are limiting the development of beef cattle farms in Semarang Regency are air temperature and humidity, as well as pH of water used by livestock for drinking. The relationship between the amount of air temperature and humidity is called the Temperature Humidity Index (THI). If THI exceeds the threshold (>80), it can cause stress or heat stress in beef cattle (Eirich, 2018). Long-term heat stress has an impact on increasing drinking water consumption, increasing urine volume, and decreasing feed consumption. The direct effect of heat stress on livestock production causes a decrease in the productivity of beef cattle. This effect is due to the increasing need for livestock maintenance during stress conditions (Berman, 2005). Furthermore, the THI value that exceeds the threshold will decrease the daily body weight gain, increase the depletion of the thickness of meat fat, and increase the potential for disease occurrence, especially in male cattle (Nardone *et*

al., 2010). Hydrogen potential (pH) characterizes the balance between acidic and alkaline solvent in water. If the pH of drinking water for beef cattle is below the quality standard or acid (<6,5), the water becomes sour and can cause physiological and digestive disorders in livestock. On the other hand, if the pH of water is too alkaline (>9), the water becomes bitter and causes a decrease in the consumption of drinking water which has an impact on decreasing livestock productivity (Sarwanto & Hendarto, 2011).

The synthesis of the assessment results of leading commodity, calculation of carrying capacity and carrying capacity index of forage, as well as land suitability assessment, shows that there are three sub-districts (Bringin, Bancak, and Banyubiru) which have high priorities for the development of beef cattle farms in Semarang Regency.

CONCLUSION

Planning for the development of beef cattle farming with intensive production systems in Semarang Regency is recommended in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The assumption of forage production produced from these three sub-districts reaches 55,693.72 tons of DDM. The total carrying capacity for beef cattle farms is 30,601 AU. The total land area suitable for beef cattle farming in the three priority sub-districts is 5,760.141 Ha. The development of beef cattle farms in the priority sub-districts is expected to increase livestock production and productivity. Governments, communities (cattleman), and the private sector (investors) must coordinate and cooperate with each other so that the development of sustainable beef cattle farms can be achieved.

CONFLICT OF INTEREST

Commented [MP19]: CC semarang 33,911 AU; sementara 3 kecamatan 30,601 AU (?????)

Commented [BS20R19]: angka 33,911 bukan CC, tapi merupakan jumlah seluruh populasi sapi potong di Kabupaten Semarang (dalam AU) pada tahun 2017. Sementara estimasi CC ternak sapi potong pada tahun 2018 di tiga wilayah prioritas pengembangan (Bringin, Bancak, & Banyubiru) yaitu 30,601 AU. Angka yang dihasilkan tersebut berdasar hasil perhitungan (equation 4 dan Tabel 4).

Commented [MP21]: perhitungan CC berdasarkan struktur populasi sapi
tambahan sapi dikoreksi dengan populasi ruminansia yang ada

Commented [BS22R21]: Pada bagian kesimpulan, CC yang dijelaskan sebesar 30,601 AU. Ini merupakan CC dari ketiga wilayah prioritas pengembangan ternak sapi potong (Bringin, Bancak, Banyubiru).
Perhitungan CC mengikuti persamaan 4.

Commented [MP23]: Di kesimpulan land suitable 5760 jika ditanami jagung (penghasil limbah terbanyak di persamaan 1), produksinya hanya:
5760*3*0.5= 8640 ton /1.82 = 4747 AU. Jauh dibawah kesimpulan 30601 AU

Commented [BS24R23]: Berdasarkan hasil perhitungan pada Tabel 6, luas lahan yang sesuai untuk pengembangan peternakan sapi potong (di tiga wilayah prioritas) yaitu 5,760.1 Ha.
Untuk menghitung daya dukung (CC) tidak bisa hanya menggunakan asumsi potensi limbah tanaman jagung. CC dihitung menggunakan persamaan 4.
Sebelum menghitung CC, produksi bahan kering hijauan (Forage dry matter production/F dmp) perlu dihitung. F dmp merupakan hasil penjumlahan antara potensi limbah pertanian dan potensi hijauan alami (satuan ton).

The authors confirm that there are no conflicts of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

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Table 1. Environmental parameters that influence the growth of beef cattle with intensive maintenance patterns

Parameter	**Order of environmental suitability of beef cattle**	
	S (Suitable)	N (Unsuitable)
Temperature Humidity Index (THI)	70-80	<70, >80
Water availability (w)		
Dry month (<100 mm rainfall/month)	<8 months	>8 months
Rainfall/year (mm)	< 4,000	> 4,000
The existence of a water source	Available	Not Available
Water Quality (q)		
pH water	6.5-9.0	<6.5; >9.0
Slope (%)	<40	>40

Source: (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

Table 2. Growth of livestock populations in Semarang Regency

Type of livestock	**Number (head)**				
	2013	**2014**	**2015**	**2016**	**2017**
Pig	32,640	17,300	18,431	15,971	15,850
Goat	197,029	136,999	123,294	117,003	117,373
Sheep	290,764	191,346	172,211	167,374	162,694
Rabbit	20,352	9,375	10,462	11,629	11,916
Horse	1,711	497	515	524	581
Beef cattle	51,901	53,135	49,172	46,238	48,444
Dairy cows	22,308	27,609	25,780	25,690	25,557
Buffalo	2,941	3,168	2,614	2,629	2,589
Laying Chicken	1,821,286	1,813,049	1,452,019	1,331,528	1,572,463
Broiler Chicken	12,046,319	7,501,700	10,144,846	10,754,602	11,812,311
Chicken Breed	819,067	860,408	818,568	861,989	823,226
Duck	206,882	92,963	80,801	127,859	125,261
Quail	122,200	238,930	227,737	176,730	142,856
Muscovy Duck	102,966	72,227	63,889	61,963	54,402

Source: (BPS Kabupaten Semarang, 2018).

Table 3. Value of LQ and SS of beef cattle in Semarang Regency in 2018

NO	SUB-DISTRICT	BEEF CATTLE				
		LQ	RS	PS	DF	SS
1	Getasan	0.63	-0.052	-0.014	-0.359	-0.425
2	Tengaran	0.55	-0.052	-0.014	0.092	0.026
3	Susukan	1.11	-0.052	-0.014	-0.137	-0.203
4	Kaliwungu	1.22	-0.052	-0.014	0.048	-0.018
5	Suruh	0.88	-0.052	-0.014	-0.213	-0.279
6	Pabelan	1.75	-0.052	-0.014	0.501	0.435
7	Tuntang	0.28	-0.052	-0.014	-0.689	-0.755
8	Banyubiru	3.97	-0.052	-0.014	0.536	0.47
9	Jambu	0.42	-0.052	-0.014	-0.417	-0.483
10	Sumowono	0.95	-0.052	-0.014	-0.234	-0.3
11	Ambarawa	3.92	-0.052	-0.014	0.006	-0.06
12	Bandungan	1.01	-0.052	-0.014	0.269	0.203
13	Bawen	2.34	-0.052	-0.014	0.0009	-0.0651
14	Bringin	2.82	-0.052	-0.014	0.105	0.039
15	Bancak	4.93	-0.052	-0.014	0.143	0.077
16	Pringapus	1.38	-0.052	-0.014	-0.312	-0.378
17	Bergas	0.77	-0.052	-0.014	-0.106	-0.172
18	Ungaran Barat	0.77	-0.052	-0.014	1.352	1.286
19	Ungaran Timur	0.3	-0.052	-0.014	-0.62	-0.686

LQ = Location quotient, SS = Shift share, RS = Regional share, PS = Proportional shift, DS = Differential shift.

Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency in 2018

SD	Bcp 2017	Bcp 2017 (AU)	Rm	R Bc	F Dmp	CC	CCI	AV
A	b	c	d	e = c x d	f	g = f/d	h = g/c	
Getasan	2,085	1,459.5	1.82	2,656.29	7,802.45	4,287.1	2.94	S
Tengaran	4,881	3,416.7	1.82	6,218.39	10,526.78	5,783.9	1.69	V
Susukan	2,905	2,033.5	1.82	3,700.97	15,301.29	8,407.3	4.13	S
Kaliwungu	4,650	3,255	1.82	5,924.1	13,231.72	7,270.2	2.23	S
Suruh	3,335	2,334.5	1.82	4,248.79	19,522.03	10,726.4	4.59	S
Pabelan	4,251	2,975.7	1.82	5,415.77	12,690.04	6,972.5	2.34	S
Tuntang	211	147.7	1.82	268.81	9,458.6	5,197.03	35.19	S
Banyubiru	3,840	2,688	1.82	4,892.16	11,493.54	6,315.1	2.35	S
Jambu	741	518.7	1.82	944.03	8,816.47	4,844.2	9.34	S
Sumowono	2,228	1,559.6	1.82	2,838.47	10,921.51	6,000.8	3.85	S
Ambarawa	1,661	1,162.7	1.82	2,116.11	4,935.95	2,712.05	2.33	S
Bandungan	4,140	2,898	1.82	5,274.36	4,327.55	2,377.8	0.82	VC
Bawen	2,717	1,901.9	1.82	3,461.46	7,241.14	3,978.6	2.09	S
Bringin	2,349	1,644.3	1.82	2,992.63	28,808.63	15,828.9	9.63	S
Bancak	2,820	1,974	1.82	3,592.68	15,391.55	8,456.9	4.28	S
Pringapus	1,333	933.1	1.82	1,698.24	23,509.36	12,917.2	13.84	S
Bergas	1,828	1,279.6	1.82	2,328.87	7,593.47	4,172.2	3.26	S
Ungaran Barat	2,105	1,473.5	1.82	2,681.77	5,400.34	2,967.2	2.01	S
Ungaran Timur	364	254.8	1.82	463.74	6,387.01	3,509.3	13.77	S
Jumlah	48,444	33,910.8		61,717.64	223,359.43	122,724.7	120.68	

SD = sub-district, Bcp = beef cattle population, Bcp (AU) = beef cattle population in livestock units, Rm = minimum feed requirements for beef cattle (ton DDM /year /AU), R bc = beef cattle feed requirements (tons /DDM/year), F Dmp = forage dry matter production (ton DDM), CC = carrying capacity (AU), CCI = carrying capacity index of forage, AV = forage availability status; S = safe, V = vurnerable, VC = very critical.

Table 5. Results of measurements of environmental factors that influence the growth of beef cattle in Semarang Regency in 2018

Subdistrict	Sample (Village)	Temperature (°C)	Temperature (°F)	Humidity (%)	THI	Rainfall (mm/year)	Dry months	Water pH
Getasan	Samirono	31	87.8	51	79.77	3,403	3	7
Tengaran	Duren	30	86	65	80.61	2,591	3	5.8
Susukan	Timpik	32	89.6	57	82.13	2,618	3	6.5
Kaliwungu	Mukiran	32	89.6	56	81.95	2,618	0	5.5
Suruh	Dadapayam	32	89.6	65	83.52	2,680	4	6.3
Pabelan	Terban	32	89.6	58	82.3	1,927	4	6.5
Tuntang	Tlumpakan	35	95	46	84.01	2,676	0	7
Banyubiru	Wirogomo	30	86	51	78.45	2,066	3	8
Jambu	Genting	31	87.8	49	79.44	2,489	0	6.2
Sumowono	Candi Garon	28	82.4	58	76.76	1,383	4	6.3
Ambarawa	Pasekan	30	86	51	78.45	1,291	3	6.8
Bandungan	Candi	29	84.2	54	77.57	1,291	0	6.7
Bawen	Polosiri	35	95	49	84.62	2,061	4	6.1
Bringin	Banding	35	95	54	85.64	2,211	3	7.9
Bancak	Pucung	33	91.4	58	83.68	2,091	0	6.5
Pringapus	Penawangan	32	89.6	56	81.95	2,290	3	4
Bergas	Munding	32	89.6	48	80.56	3,802	2	5.9
Ungaran Barat	Gogik	32	89.6	49	80.74	3,316	0	7.7
Ungaran Timur	Kawengen	33	91.4	51	82.4	3,316	0	6.6

THI = T - {0.55 (1-RH / 100) (T-58)}, where T = temperature (°F), RH = relative humidity.

Table 6. Extent of suitability of ecological environment map of beef cattle farms in Bancak, Banyubiru, and Bringin sub-districts

NO	SUBDISTRICT	Extent of Land Suitability (Ha)						Total
		S1	S1p	S2	S2p	S3	S3p	
1	Bancak	0	40.26	0.06	1,342.25	0	167.51	1,550.079
2	Banyubiru	17.10	0	1,434.10	0	0	0	1,451.2
3	Bringin	0	36.01	0	2,327.42	0	395.43	2,758.862
	TOTAL	17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

S1 = very suitable, S2 = quite suitable, S3 = according to marginal, P = limiting factor in the form of temperature humidity index (THI).

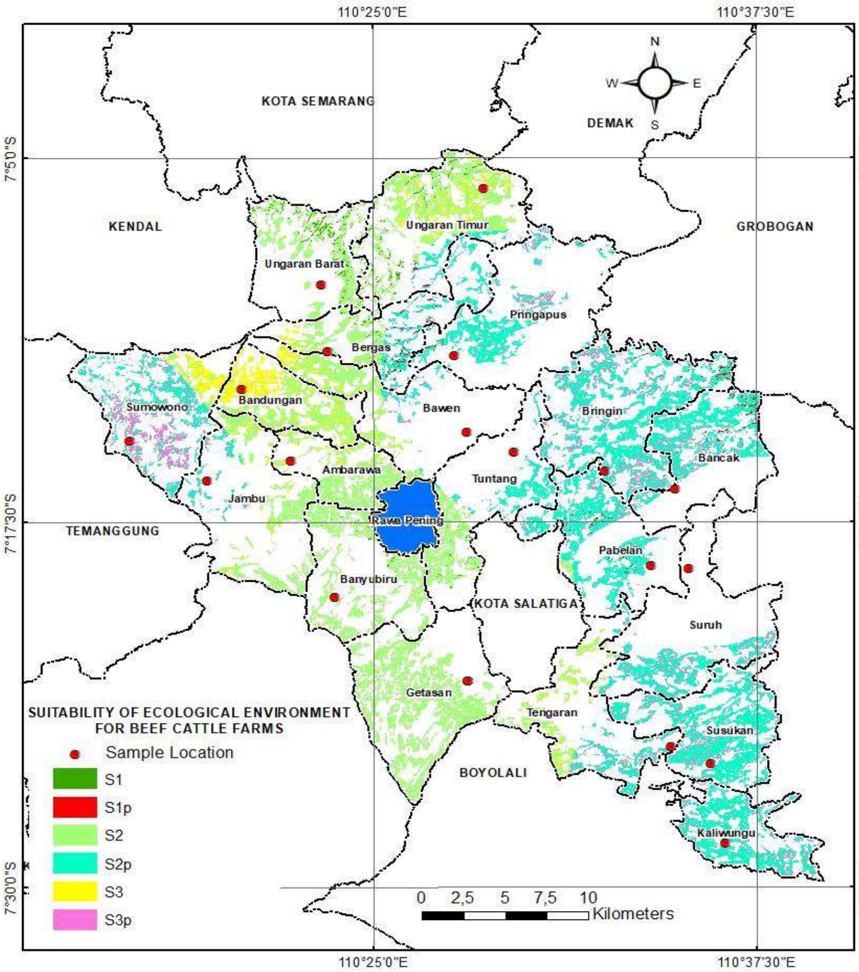

Figure 1. The suitability of ecological environment map for beef cattle farms in Semarang Regency

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The Regional Analysis of Beef Cattle Farm Development in Semarang Regency

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ABSTRACT

One of the reasons for the low production and productivity of beef cattle in Indonesia is that information on the allocation of livestock areas development is not yet clear. This study aimed to determine the priority areas for developing beef cattle farm in Semarang Regency based on the concept of sustainability. Sustainability was analyzed through the determination of leading commodities (analysis of Location Quotient and Shift Share), optimization of regional potential (analysis of carrying capacity and carrying capacity index of forage, and assessment of suitability of ecological environment of beef cattle). The process of spatial analysis used GIS software. Comprehensive planning for the development of beef cattle farm was directed in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of the analysis showed that the three sub-districts were beef cattle base areas (LQ>1), had business growth (positive SS), and had a safe status for forage availability (>2). Other results showed that the carrying capacity for beef cattle farms in Bringin sub-district was 15,829 AU, Bancak was 8,457 AU, and Banyubiru was 6,315 AU. The land area suitable for beef cattle farm from the three priority sub-districts was 5,760.141 Ha. It can be concluded that the development of beef cattle farm in Semarang Regency is focused on three priority sub-districts, namely: Bringin, Bancak, and Banyubiru. The results of this study can be an input for local governments in determining the direction and pattern of beef cattle farm development to be more sustainable.

Keywords: beef cattle, regional analysis, sustainability of livestock sector

INTRODUCTION

The directed and sustainable development of the livestock sector is believed to be able to contribute positively to regional development. Along with the increase in population, there is an increasing demand for food from animal protein, such as beef. Beef consumption in developing countries such as in Indonesia tends to increase every year (Thornton, 2010; Agus & Widi, 2018), however the population of beef cattle in some regions actually decreases due to the complexity of technical and non-technical problems (Paly *et al*., 2013; Ariningsih, 2014; Nuhung, 2015). There is a gap between demand and supply of beef products, which is increasingly widening. Many factors causing this gap, including the domestic production of beef cattle is still low because information on the allocation of livestock development areas is not yet clear.

Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009; Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able to meet the high meat consumption of people. The consumption of beef in 2020 is estimated to reach 3.36 kg per capita per year, but beef production is still not able to fulfill it; there is a deficit in beef supply by 198,350 tons (Kementan, 2016; Agus & Widi, 2018). Most of the beef production in Indonesia, 78% comes from traditional livestock, 5% from imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al*., 2017). Imports of beef are indeed relatively larger compared to the other types of meat imports, contributing 21.44% to the total import value of livestock, while the import value of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al*., 2014).

Policy efforts to reduce beef imports must be studied, by strengthening domestic production that is beneficial for farmers (Pasandaran *et al*., 2014). The development of beef cattle farms in potential areas is an effort to strengthen meat production in the country so that the implementation must be carried out with a comprehensive assessment. Semarang Regency is a region in Central Java Province that has the potential to develop beef cattle farms because it has natural resources in the form of land as a place for livestock keeping and forage production. Good quality and forage availability can increase production, especially for increasing body weight of cattle (Suhaema *et al*., 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha), rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this region during the 2014-2016 period continued to decline, ranging from 53,135; 49,172; and 46,238 (BPS Kabupaten Semarang, 2018).

The development of beef cattle farms in Semarang Regency needs to adopt the concept of sustainability. The concept of sustainability is the achievement of economic, environmental, and social goals simultaneously which is represented by various performance indicators (Darnhofer *et al*., 2010). Sustainability is also defined as the concept of multidimensional (economic, ecological, and social) and multiscale (micro, meso, and macro), although in its application, it is often limited to one particular aspect (Santos *et al*., 2017). Economic sustainability is closely related to the value of comparative and competitive advantages of certain commodities (Broom *et al*., 2013; Sabaghi *et al*., 2016), while environmental sustainability includes optimizing the availability and efficient use of natural resources (Atanga *et al*., 2013).

The sustainability of beef cattle farms can be identified through a regional approach, by considering the existence of leading commodities and the potential of the region concerned (Mulyono & Munibah, 2016; Parmawati *et al*., 2018). Determination of leading commodities characterized by the existence of comparative and competitive advantages is the first step towards the efficient development of livestock sector. The potential of the region to support the development of beef cattle farms is determined by optimizing the carrying capacity and carrying capacity index of forage, as well as by assessing the suitability of the land where the livestocks are raised. Land suitability for beef cattle farms with intensive production systems considers several environmental factors that affect the growth of these cattle.

Mapping activities based on the determination of leading commodities and optimization of regional potential are needed as a basis for planning sustainable development of beef cattle farms. This study aims to determine the priority areas for developing beef cattle farms in Semarang Regency. The results of this study are expected to be one of the considerations in determining the direction and development policy of the beef cattle farms sector in Semarang Regency.

MATERIALS AND METHODS

This research was a type of quantitative research and applied the concept of sustainability. Sustainabilities assessed were economic and environmental sustainabilities for beef cattle farm in Semarang Regency. Economic sustainability was identified through the determination of the leading commodity of livestock, while environmental sustainability was identified through the calculation of the carrying capacity and carrying capacity index of forage, and the assessment of suitability of ecological environment of beef cattle. In detail, each step of the analysis was outlined below.

Leading Commodity

Determination of leading livestock commodities in an area used Location Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods was the economic basis theory. LQ analysis was relatively simple, but the benefits were large enough for the initial identification of the ability of a sector in regional development. The shift in the structure of economic activity in beef cattle business, whether experiencing growth or decline was analyzed using Shift Share (SS). SS analysis can be used to see the growth of the economic sectors of a region for two-time points (Muta'ali, 2015). LQ and SS analysis used the following equations (Ciptayasa *et al*., 2016; Mulyono & Munibah, 2016).

LQ_{ij} = (Xij / Xi.)/(X.j / X..) (Equation 1)

where X_{ij} is Beef cattle population in the sub-district A, $X_{i.}$ is Population of all types of livestock in the sub-district A, $X_{.j}$ is Beef cattle population in Semarang Regency, and $X_{..}$ is Population of all types of livestock in Semarang Regency).

SS= [(X..(t1))/(X..(t0))-1] + [(X.i(t1))/(X.i(t0)) - (X..(t1))/(X..(t0))] + [(Xij(t1))/(Xij(t0)) - (X.i(t1))/(X.i((t0))] (Equation 2)

(Regional share, Proportional shift, Differential shift, X.. is Population of all types of livestock in Semarang Regency, Xi is Beef cattle population in Semarang Regency, Xij is Beef cattle population in sub-district A, t0 is Early 2013 year point, and t1 is End of year 2017).

Carrying Capacity and Carrying Capacity Index of Forage

The carrying capacity of the region for livestock development is indicated by the ability of the region to produce forage that can accommodate and meet the needs of a number of beef cattle populations. Forages were divided into two types, namely fresh forage (grass, legume) and dry forage (straw). An assessment of the carrying capacity index of forage was conducted to assess the availability of animal feed in a region, whether it was classified as safe, vulnerable, critical, or very critical.

The carrying capacity of beef cattle farms was calculated based on the production of forage dry matter against the minimum feed requirements of cattle (1 AU) in one year. The animal unit (AU) was a unit for the ruminant livestock population multiplied by the conversion factor. The conversion factor for beef cattle was 0,7 (Muta'ali, 2015; Saputra *et al*., 2016). Forage dry matter production was the amount of potential agricultural waste and natural forage potential, using equations that refer to Suhaema *et al*. (2014) and Yuniar *et al*. (2016).

Potential of agricultural waste (ton) = {(wr x 0.4) + (fr x 3 x 0.4) + (cn x 3 x 0.5) + (sb x 3 x 0.55) + (pt x 2 x 0.55) + (sp x 0.25/6) + (cs x 0.25/4)} x 0.65

where wr is wetland rice, fr is field rice, cn is corn, sb is soybean, pt is peanuts, sp is sweet potatoes, cs is cassava. The numbers in the formula are assumptions about the potential waste produced from the production of each type of plant food.

Natural forage potential (ton) =
{(Ga x 2.875) + (Fa x 0.6) + (Cpa x 10) + (Cfa x 0.5) + (Cla x 5)} x 0.5
where Ga is garden area, Fa is forest area, Cpa is coconut plant area, Cfa is coffee plant area, Cla is clove plant area. The numbers in the formula are assumed to be natural forage potential produced per hectare of land use area.
Minimum cattle feed requirements (R)**=**
2.5% x 50% x 365 x 400 kg = 1.82 ton DDM/year/AU (Equation 3)

where R is minimum cattle feed requirements (1 AU) in tons of digestible dry matter for 1 year, 2.5% is minimum requirement for the number of forage rations (dry matter) on livestock weight, 50% is average value digestibility power of various types of plants, 365 is number of days in 1 year, 400 kg is live weight of 1 AU of beef cattle in Semarang Regency. Equations that refer to Suhaema *et al*. (2014) and Yuniar *et al*. (2016).

The results of the calculation of forage dry matter production were then used to determine the carrying capacity of beef cattle farms using the following equations (Suhaema *et al*., 2014; Yuniar *et al*., 2016).
CC (AU)= Forage dry matter production (tons of DDM/year) / Minimum cattle feed requirement (tons of DDM/year/AU) (Equation 4)

The level of animal feed security in a region was measured by forage carrying capacity index. Carrying capacity index values were values that indicated the status of the availability of forage for beef cattle, namely: very critical (≤1), critical (>1-1.5), vulnerable (> 1.5-2), and safe (>2).
Forage carrying capacity index=
Carrying capacity (AU) / Amount of beef cattle population in 2017 (AU) (Equation 5)

Suitability of the Ecological Environment of Beef Cattle

The research sample for the assessment of the suitability ecological environment of beef cattle farms in Semarang Regency was 19 points spreading throughout the sub-district area (Table 5). The determination of the sample was using purposive sampling technique. The purposive sampling technique was also called judgment sampling (Tongco, 2007), which was used to determine the sample based on research considerations. In each sub-district, one village was taken which had the most beef cattle population.

Lands available for the development of beef cattle farms are gardens, grasslands, open land, rice fields, and dryland agriculture. The fields are assumed to be able to be used for building housing for beef cattle. The assessment of land suitable for beef cattle farming with intensive maintenance patterns also takes into account several environmental parameters that influence the growth of livestock.

Land suitability assessment for beef cattle farms began by making a map of land units. Maps of beef cattle land units referred to research of Rusmana *et al*. (2006) which stated that there were four maps needed for overlaying, namely: land type maps, agro-climate maps, regional altitude maps, and slope maps. The final step was to make a "suitability map of the ecological environment of beef cattle". The method used was by overlaying between land unit maps with environmental parameters that affected the growth of beef cattle (Table 1). Land suitability was classified into 4 levels or strata, namely: very suitable (S-1), quite suitable (S-2), according to marginal (S-3), and non-suitable (NS) (Rusmana *et al*., 2006; Suhaema *et al*., 2014; Yuniar *et al*., 2016). The entire process was created and analyzed using GIS software.

RESULTS

Leading Commodity

The leading commodity of livestock in an area was determined based on comparative advantage (location quotient analysis) and competitive advantage (shift-share analysis). Beef cattle commodities that had LQ>1 and SS (+) values were the leading commodities in the region. The interpretation of the value of LQ>1, was a base or leading sector, beef cattle products (meat) were able to meet markets inside and outside the region. The value of LQ<1 implied a non-base sector, livestock products had not been able to meet markets inside and outside the region. The value of LQ=1 implied that the sector was balanced with the reference region, livestock products were only able to meet markets in the area. The basis for calculating LQ analysis for livestock commodities was livestock population data (Hendayana, 2003). Data bias in calculations could be minimized by using a minimum 5 year data series (Table 2).

Shift share analysis started from the basic assumption that economic growth or added value of an activity in a particular region was influenced by three main components which were interconnected with each other, namely: regional growth, sectoral growth, and growth in share or regional competitiveness (Ciptayasa *et al*., 2016). Through these three components, it could be seen which elements had encouraged regional economic

Table 1. Environmental parameters that influence the growth of beef cattle with intensive maintenance patterns

Parameter	Order of environmental suitability of beef cattle	
	S (Suitable)	N (Unsuitable)
Temperature Humidity Index (THI)	70-80	<70, >80
Water availability (w)		
Dry month (<100 mm rainfall/month)	<8 months	>8 months
Rainfall/year (mm)	< 4,000	> 4,000
The existence of a water source	Available	Not Available
Water quality (q)		
pH water	6.5-9.0	<6.5; >9.0
Slope (%)	<40	>40

Source: (Suhaema *et al*., 2014; Yuniar *et al*., 2016).

growth. The value of each component could be positive or negative, but the total number (shift-share) would always be positive if the regional economic growth were positive, and vice versa.

The results of the LQ and SS analysis calculations for beef cattle commodities in Semarang Regency are shown in Table 3. Based on the results of the analysis conducted, the subdistrict areas becoming the beef cattle base sector (LQ> 1) were Bancak (4.93), Banyubiru (3.97), Ambarawa (3.92), Bringin (2.82), and Bawen (2.34). Beef cattle keeping was concentrated in these areas or in the other words the economic density of beef cattle was higher than that of in the other regions.

Beef cattle commodities that had competitive advantages were seen based on positive shift-share (SS) values. Sub-districts with a positive SS value means experiencing growth (competitiveness) related to keeping beef cattle. On the other hand, sub-districts with negative SS value means that the area is not growing (stagnant) and can even experience setbacks. The results of the analysis conducted in Table 3 showed that sub-districts with positive SS values were in West Ungaran (1.286), Banyubiru (0.47), Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tengaran (0.026).

Table 2. Growth of livestock populations in Semarang Regency (heads)

Type of livestock	Year				
	2013	2014	2015	2016	2017
Pig	32,640	17,300	18,431	15,971	15,850
Goat	197,029	136,999	123,294	117,003	117,373
Sheep	290,764	191,346	172,211	167,374	162,694
Rabbit	20,352	9,375	10,462	11,629	11,916
Horse	1,711	497	515	524	581
Beef cattle	51,901	53,135	49,172	46,238	48,444
Dairy cows	22,308	27,609	25,780	25,690	25,557
Buffalo	2,941	3,168	2,614	2,629	2,589
Laying chicken	1,821,286	1,813,049	1,452,019	1,331,528	1,572,463
Broiler chicken	12,046,319	7,501,700	10,144,846	10,754,602	11,812,311
Chicken breed	819,067	860,408	818,568	861,989	823,226
Duck	206,882	92,963	80,801	127,859	125,261
Quail	122,200	238,930	227,737	176,730	142,856
Muscovy duck	102,966	72,227	63,889	61,963	54,402

Source: (BPS Kabupaten Semarang, 2018).

Table 3. Value of LQ and SS of beef cattle in Semarang Regency in 2018

No	Sub-district	LQ	RS	PS	DF	SS
1	Getasan	0.63	-0.052	-0.014	-0.359	-0.425
2	Tengaran	0.55	-0.052	-0.014	0.092	0.026
3	Susukan	1.11	-0.052	-0.014	-0.137	-0.203
4	Kaliwungu	1.22	-0.052	-0.014	0.048	-0.018
5	Suruh	0.88	-0.052	-0.014	-0.213	-0.279
6	Pabelan	1.75	-0.052	-0.014	0.501	0.435
7	Tuntang	0.28	-0.052	-0.014	-0.689	-0.755
8	Banyubiru	3.97	-0.052	-0.014	0.536	0.47
9	Jambu	0.42	-0.052	-0.014	-0.417	-0.483
10	Sumowono	0.95	-0.052	-0.014	-0.234	-0.3
11	Ambarawa	3.92	-0.052	-0.014	0.006	-0.06
12	Bandungan	1.01	-0.052	-0.014	0.269	0.203
13	Bawen	2.34	-0.052	-0.014	0.0009	-0.0651
14	Bringin	2.82	-0.052	-0.014	0.105	0.039
15	Bancak	4.93	-0.052	-0.014	0.143	0.077
16	Pringapus	1.38	-0.052	-0.014	-0.312	-0.378
17	Bergas	0.77	-0.052	-0.014	-0.106	-0.172
18	West Ungaran	0.77	-0.052	-0.014	1.352	1.286
19	East Ungaran	0.30	-0.052	-0.014	-0.62	-0.686

Note: LQ= Location quotient, SS= Shift share, RS= Regional share, PS= Proportional shift, DS= Differential shift.

The development of beef cattle farms in Semarang Regency is prioritized in the sub-districts with LQ>1 and SS (+) values. The sub-districts are Bringin, Bancak, and Banyubiru.

Carrying Capacity and Carrying Capacity Index of Forage

The potential availability of feed for beef cattle was seen based on the amount of forage dry matter production (tons of DDM) that could be produced by the region concerned. Dry matter is the total feed ingredients without water content, which can come from forages. The region with the largest forage dry matter production has the highest carrying capacity for the development of beef cattle farms, and vice versa. Forage is one of the production inputs that determine the success of livestock business because it directly affects productivity and efficiency (Yuniar *et al*., 2016). Table 4 shows the calculation of carrying capacity and carrying capacity index of forage for beef cattle farms in Semarang Regency.

Based on the results of the analysis conducted in Table 4, it was known that there were three sub-districts with the highest production of forage dry matter, namely Bringin (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons DDM). Sub-district area with the lowest forage dry matter production was Bandungan (4,327.55 tons DDM). The status of the availability of forage in Bandungan sub-district was categorized as very critical (0.82), while in Tengaran sub-district it was categorized as vulnerable (1.69). Therefore, these two sub-districts are not recommended for the development of beef cattle farms. Sub-district areas with carrying capacity index value >2 (safe) means that the areas can be recommended for the development of beef cattle farms. The advantage obtained by the area with this safe category is that farmers can reduce the amount of production costs for beef cattle feed.

Semarang Regency had a carrying capacity for beef cattle farms of 122,725 AU. The population of beef cattle in 2017 was 33,911 AU, so the Semarang Regency area was assumed to still be able to accommodate 88,814 AU beef cattle in 2018.

The Suitability of Ecological Environment of Beef Cattle

The results of field measurements and secondary data collection conducted on several environmental factors that influence the growth of beef cattle are shown in Table 5. The factors that limited the assessment of the suitability of the ecological environment of beef cattle farming in Semarang Regency were the Temperature Humidity Index (THI) and water pH. Annual rainfall (<4000 mm) and dry months (<8) were in the appropriate category.

The suitability of the ecological environment map for beef cattle farms in Semarang Regency is shown in Figure 1. The white area was an area that was not assessed because it was designated as land for settlements, plantations, tourism, and forests. Based on data in Figure 1, the level of suitability of the produced beef

Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency in 2018

SD	Bcp 2017	Bcp 2017 (AU)	Rm	R Bc	F Dmp	CC	CCI	AV
A	b	c	d	e = c x d	f	g = f/d	h = g/c	
Getasan	2,085	1,459.5	1.82	2,656.29	7,802.45	4,287.1	2.94	S
Tengaran	4,881	3,416.7	1.82	6,218.39	10,526.78	5,783.9	1.69	V
Susukan	2,905	2,033.5	1.82	3,700.97	15,301.29	8,407.3	4.13	S
Kaliwungu	4,650	3,255	1.82	5,924.10	13,231.72	7,270.2	2.23	S
Suruh	3,335	2,334.5	1.82	4,248.79	19,522.03	10,726.4	4.59	S
Pabelan	4,251	2,975.7	1.82	5,415.77	12,690.04	6,972.5	2.34	S
Tuntang	211	147.7	1.82	268.81	9,458.60	5,197.03	35.19	S
Banyubiru	3,840	2,688.0	1.82	4,892.16	11,493.54	6,315.1	2.35	S
Jambu	741	518.7	1.82	944.03	8,816.47	4,844.2	9.34	S
Sumowono	2,228	1,559.6	1.82	2,838.47	10,921.51	6,000.8	3.85	S
Ambarawa	1,661	1,162.7	1.82	2,116.11	4,935.95	2,712.05	2.33	S
Bandungan	4,140	2,898	1.82	5,274.36	4,327.55	2,377.8	0.82	VC
Bawen	2,717	1,901.9	1.82	3,461.46	7,241.14	3,978.6	2.09	S
Bringin	2,349	1,644.3	1.82	2,992.63	28,808.63	15,828.9	9.63	S
Bancak	2,820	1,974	1.82	3,592.68	15,391.55	8,456.9	4.28	S
Pringapus	1,333	933.1	1.82	1,698.24	23,509.36	12,917.2	13.84	S
Bergas	1,828	1,279.6	1.82	2,328.87	7,593.47	4,172.2	3.26	S
West Ungaran	2,105	1,473.5	1.82	2,681.77	5,400.34	2,967.2	2.01	S
East Ungaran	364	254.8	1.82	463.74	6,387.01	3,509.3	13.77	S
Total	48,444	33,910.8		61,717.64	223,359.43	122,724.7	120.68	

Note: SD = sub-district, Bcp= beef cattle population, Bcp (AU)= beef cattle population in livestock units, Rm= minimum feed requirements for beef cattle (ton DDM /year /AU), R bc= beef cattle feed requirements (tons /DDM/year), F Dmp= forage dry matter production (ton DDM), CC= carrying capacity (AU), CCI= carrying capacity index of forage, AV= forage availability status; S= safe, V= vurnerable, VC= very critical.

Table 5. Results of measurements of environmental factors that influence the growth of beef cattle in Semarang Regency in 2018

Subdistrict	Sample (Village)	Temperature (°C)	Temperature (°F)	Humidity (%)	THI	Rainfall (mm/year)	Dry months	Water pH
Getasan	Samirono	31	87.8	51	79.77	3,403	3	7
Tengaran	Duren	30	86	65	80.61	2,591	3	5.8
Susukan	Timpik	32	89.6	57	82.13	2,618	3	6.5
Kaliwungu	Mukiran	32	89.6	56	81.95	2,618	0	5.5
Suruh	Dadapayam	32	89.6	65	83.52	2,680	4	6.3
Pabelan	Terban	32	89.6	58	82.3	1,927	4	6.5
Tuntang	Tlumpakan	35	95	46	84.01	2,676	0	7
Banyubiru	Wirogomo	30	86	51	78.45	2,066	3	8
Jambu	Genting	31	87.8	49	79.44	2,489	0	6.2
Sumowono	Candi Garon	28	82.4	58	76.76	1,383	4	6.3
Ambarawa	Pasekan	30	86	51	78.45	1,291	3	6.8
Bandungan	Candi	29	84.2	54	77.57	1,291	0	6.7
Bawen	Polosiri	35	95	49	84.62	2,061	4	6.1
Bringin	Banding	35	95	54	85.64	2,211	3	7.9
Bancak	Pucung	33	91.4	58	83.68	2,091	0	6.5
Pringapus	Penawangan	32	89.6	56	81.95	2,290	3	4
Bergas	Munding	32	89.6	48	80.56	3,802	2	5.9
West Ungaran	Gogik	32	89.6	49	80.74	3,316	0	7.7
East Ungaran	Kawengen	33	91.4	51	82.4	3,316	0	6.6

Note: THI= T - {0.55 (1-RH / 100) (T-58)}, where T= temperature (°F), RH= relative humidity.

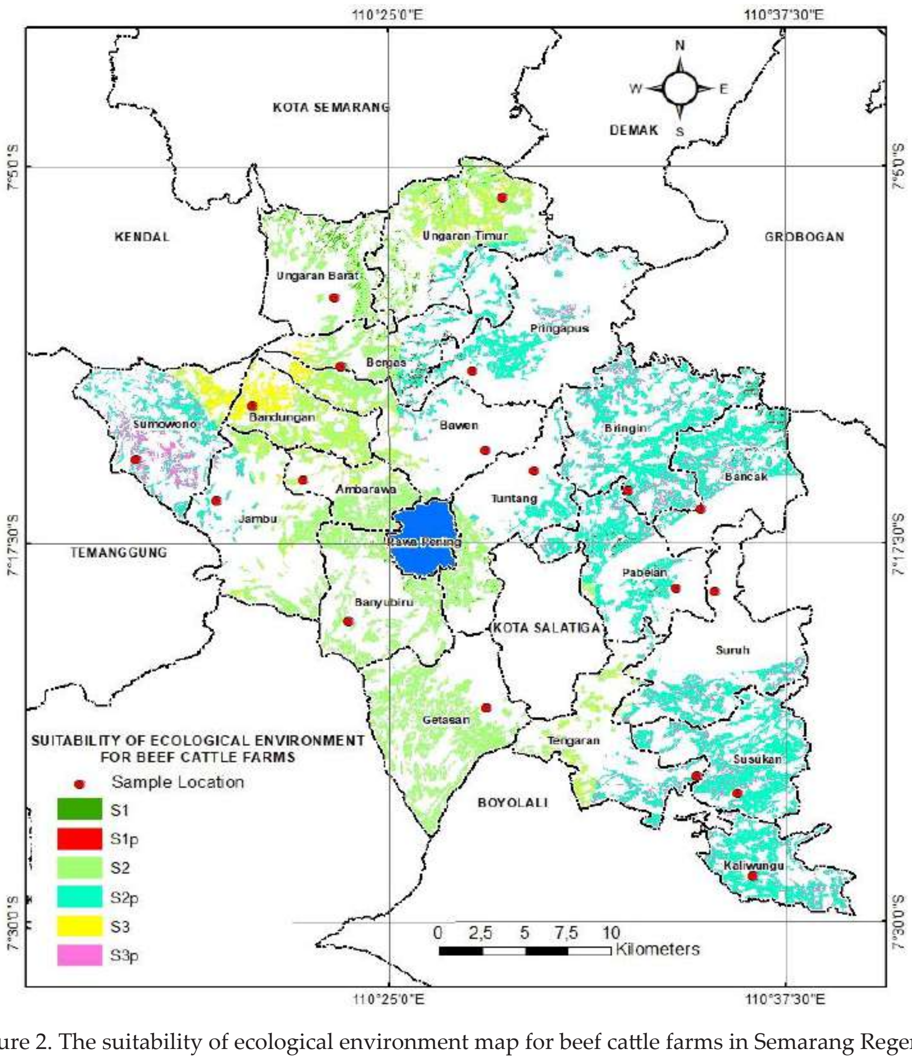

Figure 2. The suitability of ecological environment map for beef cattle farms in Semarang Regency

cattle ecological environment was: very suitable (S-1), quite suitable (S-2), and according to marginal (S-3). Non-suitable (NS) categories were not assessed because the area had a slope >40% (steep - very steep).

The symbol "p" indicated that there was a limiting factor in the area assessed. The limiting factors were the Temperature Humidity Index (THI) and the pH of the water for beef cattle consumption (Table 5). Semarang Regency consists of 19 sub-districts. The development of beef cattle farms will be prioritized in sub-districts having LQ>1, positive SS (+) value, and carrying capacity index of forage >2, namely Bringin, Bancak, and Banyubiru. Banyubiru sub-district was not constrained by the limiting factors, while Bringin and Bancak were constrained by THI values that exceed the comfort zone for growing cattle (>80). The extent suitability of the ecology of beef cattle farms from the three priority sub-districts is shown in Table 6.

Based on the results of the analysis conducted in Table 6, the sub-districts with the largest land area for the development of beef cattle farms with intensive production systems were Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru (1,451.2 Ha). The limiting factor in the form of temperature humidity index (THI) or water pH can be minimized through the engineering design of livestock housing and the provision of materials or neutralizing water acidity solvent (Yani *et al*., 2007; Sarwanto & Hendarto, 2011). Cattle with intensive production systems are generally more susceptible to heat stress than cattle with extensive production systems. Efforts that can be done to reduce heat stress in beef cattle include: adding shade around the housing location, install a sprinkle tool or add straw that works to lower the surface temperature of the floor, regulate feed, feed additives, and medicine, etc (Suhaema *et al*., 2014).

DISCUSSION

Semarang Regency is a potential area for the development of beef cattle farming because it has abundant natural resources in the form of land for livestock raising and forage production. The mapping activity is based on the determination of leading livestock commodities, and optimization of regional potential can be one of the benchmarks in realizing sustainable development of beef cattle farms. The concept of sustainable development is to meet the needs of the current generation, without sacrificing future generations and this concept has become a reference for welfare in almost all sectors, including the livestock sector (Wasike *et al*., 2011). The concept of sustainability was widely debated throughout the world over the past few years (De Longe *et al*., 2016; Keesstra *et al*., 2016; Rasmussen *et al*., 2017), not only concerning environmental and social issues, but also discussing economic issues to gain certain market or commodity advantages (Broom *et al*., 2013; Sabaghi *et al*., 2016). Sustainability assessment is achieved by evaluating the relative contribution of each of the economic, environmental, and social factors to the overall goal (Astier & García-Barrios, 2012). Sustainability assessed in this study is economical and environmental sustainability for beef cattle farms.

Economic sustainability was assessed based on the results of the analysis of the leading commodity. The leading livestock commodity in an area was determined based on the comparative advantage (LQ analysis) and competitive advantage (SS analysis). The concept of comparative advantage is economic feasibility. Commodities that have a comparative advantage (LQ>1) show that the commodity (beef cattle) is supported by the existence of adequate natural resources so that the population level is higher than in other regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a prominent or dominant livestock business compared to the other livestock businesses, so the effort for future development is easier (Yuniar *et al*., 2016; Mulyono & Munibah, 2016). On the other hand, the concept of competitive advantage is financial feasibility. Beef cattle commodities are keeping in effective and efficient ways so that they have competitiveness from the aspects of quality, quantity, continuity, and price (Muta'ali, 2015; Mulyono & Munibah, 2016). The results presented in Table 3 show that the Bringin, Bancak, and Banyubiru sub-districts are regions with a leading commodity of beef cattle. Accordingly, the three sub-districts are prioritized for the development of beef cattle farms in Semarang Regency.

Environmental sustainability for beef cattle farms was assessed based on the results of the carrying capacity analysis and carrying capacity index of forage, and analysis of the suitability of the ecological environment of beef cattle. Carrying capacity is defined as the maximum population that can be supported by an ecosystem from time to time. The carrying capacity of an area is not static, there is a kind of reciprocal relationship between organism and their environments. The carrying capacity of a region can vary for different species and change over time due to various factors (Taiwo & Feyisara, 2017). Regional carrying capacity for livestock development is the size of the region's ability to support the livelihoods of a number of livestock populations optimally through the role of forage availability. Based

Table 6. Extent of suitability of ecological environment map of beef cattle farms in Bancak, Banyubiru, and Bringin sub-districts

No	Subdistrict	Extent of land suitability (Ha)						Total
		S1	S1p	S2	S2p	S3	S3p	
1	Bancak	0	40.26	0.06	1,342.25	0	167.51	1,550.079
2	Banyubiru	17.10	0	1,434.10	0	0	0	1,451.2
3	Bringin	0	36.01	0	2,327.42	0	395.43	2,758.862
	Total	17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

Note: S1= very suitable, S2= quite suitable, S3= according to marginal, P= limiting factor in the form of temperature humidity index (THI).

on the results of the analysis presented in Table 4, it is known that the Bringin, Bancak, and Banyubiru sub-districts have a forage carrying capacity index in the safe category.

The production systems of beef cattle that is often found in Semarang Regency is an intensive production system. Beef cattle are able to show optimal physical conditions if they have superior genetic traits, and are supported by the suitability of their ecological environment (Suhaema *et al*., 2014). Animal ecology is the study of the interactions between animals and their environments. Environmental factors tend to have a greater effect on the production and productivity of livestock (Sumarto & Koneri, 2016). Some environmental factors that influence the growth of beef cattle with intensive production systems are: soil type, length of dry season, altitude, slope (Rusmana *et al*., 2006), temperature and relative humidity, rainfall, and water pH (Herbut & Angrecka, 2012; Suhaema *et al*., 2014; Yuniar *et al*., 2016; Eirich, 2018).

The results of the analysis in Table 5 show that environmental factors that are limiting the development of beef cattle farms in Semarang Regency are air temperature and humidity, as well as pH of water used by livestock for drinking. The relationship between the amount of air temperature and humidity is called the Temperature Humidity Index (THI). If THI exceeds the threshold (>80), it can cause stress or heat stress in beef cattle (Eirich, 2018). Long-term heat stress has an impact on increasing drinking water consumption, increasing urine volume, and decreasing feed consumption. The direct effect of heat stress on livestock production causes a decrease in the productivity of beef cattle. This effect is due to the increasing need for livestock maintenance during stress conditions (Berman, 2005). Furthermore, the THI value that exceeds the threshold will decrease the daily body weight gain, increase the depletion of the thickness of meat fat, and increase the potential for disease occurrence, especially in male cattle (Nardone *et al*., 2010). Hydrogen potential (pH) characterizes the balance between acidic and alkaline solvent in water. If the pH of drinking water for beef cattle is below the quality standard or acid (<6,5), the water becomes sour and can cause physiological and digestive disorders in livestock. On the other hand, if the pH of water is too alkaline (>9), the water becomes bitter and causes a decrease in the consumption of drinking water which has an impact on decreasing livestock productivity (Sarwanto & Hendarto, 2011).

The synthesis of the assessment results of leading commodity, calculation of carrying capacity and carrying capacity index of forage, as well as land suitability assessment, shows that there are three sub-districts (Bringin, Bancak, and Banyubiru) which have high priorities for the development of beef cattle farms in Semarang Regency.

CONCLUSION

Planning for the development of beef cattle farming with intensive production systems in Semarang Regency is recommended in three sub-districts, namely: Bringin, Bancak, and Banyubiru. The development of beef cattle farms in the priority sub-districts is expected to increase livestock production and productivity. Governments, communities (cattleman), and the private sector (investors) must coordinate and cooperate with each other so that the development of sustainable beef cattle farms can be achieved.

CONFLICT OF INTEREST

The authors confirm that there are no conflicts of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

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