



# Tropical Animal Science Journal



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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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We declare that all listed names are entitled to become an author and all have agreed the final form of submitted manuscripts.

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# Authorship confirmation

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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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Chief Editor



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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
<b>A</b>	<b>Reviewer I</b>	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	<b>There is overlapping between results and discussion.</b> 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 <b>economic factors</b> (determination of leading commodity through LQ and SS) and <b>environmental factors</b> (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>B</b>	<b>Reviewer II</b>	Terimakasih untuk reviewnya. Komentar sangat membangun.
1	I will use Bahasa in my comments	Saya menggunakan Bahasa Indonesia untuk Response.
2	Penelitian menggunakan 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 ringkas dan sepadat mungkin. Konsep <b>analisis wilayah</b> untuk pengembangan dalam sektor apapun, selalu mempertimbangkan banyak faktor (ekonomi, lingkungan, sosial). Secara eksplisit, kata-kata <b>analisis wilayah</b> 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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	<p>perumusan masalah di pendahuluan, berbeda maksudnya dengan sustainability pada metode penelitian.</p>	<p>masalah di bagian pendahuluan, menurut saya sudah sinkron dengan yang terdapat pada metode penelitian. Hal tersebut dibuktikan pada <b>paragraph 4 dan 5</b> dalam pendahuluan, yaitu bahwa <b>keberlanjutan ekonomi</b> ditentukan melalui analisis komoditas unggulan (LQ dan SS), sementara itu <b>keberlanjutan lingkungan</b> 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.</p>
4	<p>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</p>	<p>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:</p> <ul style="list-style-type: none"> <li>• Wilayah yang menjadi basis ternak sapi potong dan wilayah yang mengalami pertumbuhan ekonomi terkait aktivitas peternakan sapi potong,</li> <li>• Ketersediaan hijauan pakan ternak pada suatu wilayah (<b>aman, rawan, kritis, sangat kritis</b>) sehingga pemeliharaan atau pengembangan peternakan sapi potong yang over kapasitas dapat dihindarkan,</li> <li>• Wilayah yang sesuai untuk pengembangan peternakan sapi potong, dilihat dari kesesuaian lingkungan ekologi ternak tersebut.</li> </ul>



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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 <b>tidak berhubungan</b> 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 <b>data seluruh jenis ternak</b> . Ternak di Kabupaten Semarang meliputi <b>Ternak besar</b> (kuda, sapi potong, sapi perah, kerbau), <b>Ternak kecil</b> (babi, kambing, domba, kelinci), dan <b>Unggas</b> (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 <b><math>a+b+c</math></b> 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 <b>potensi limbah pertanian + potensi hijauan alami</b> . Sumber: (Suhaema, Widiatmaka, & Tjahjono, 2014; Yuniar, Fuah, & Widiatmaka, 2016). Satuan dari rumus potensi limbah pertanian dan potensi hijauan alami adalah <b>ton</b> . Setiap rumus yang digunakan juga terdapat keterangan lengkap di bagian bawahnya.
8	Tabel 1: satuan Dry month (<100mm rainfall/month?); slope (land slope?)	<b>Dry month</b> = 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). <b>Slope</b> = 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 <b>hanya difokuskan</b> untuk pengembangan <b>peternakan sapi potong</b> , 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.

## 26 INTRODUCTION

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

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

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

50 beef cattle farms in potential areas is an effort to strengthen meat production in the country  
51 so that the implementation must be carried out with a comprehensive assessment.  
52 Semarang Regency is a region in Central Java Province that has the potential to develop  
53 beef cattle farms because it has natural resources in the form of land as a place for  
54 **livestock cultivation** and forage production. Good quality and always available forage can  
55 increase production, especially for increasing body weight of cattle (Suhaema *et al.*,  
56 2014). Forage producing areas in Semarang Regency include gardens (25.562,04 Ha),  
57 rice fields (23.745,96 Ha), and forests (6.032,77 Ha). The beef cattle population in this  
58 region during the 2014-2016 period continued to decline, ranging from 53.135, 49.172,  
59 and 46.238 (BPS Kabupaten Semarang, 2018).

60         The development of beef cattle farms in Semarang Regency needs to adopt the  
61 concept of sustainability. The concept of sustainability is the achievement of economic,  
62 environmental and social goals simultaneously which is represented by various  
63 performance indicators (Darnhofer *et al.*, 2010). Sustainability is also defined as the  
64 concept of multidimensional (economic, ecological, social) and multiscale (micro, meso,  
65 and macro), although in its application it is often limited to one particular aspect (Santos  
66 *et al.*, 2017). Economic sustainability is closely related to the value of comparative and  
67 competitive advantages of certain commodities (Broom *et al.*, 2013; Sabaghi *et al.*,  
68 2016), while environmental sustainability includes optimizing the availability of natural  
69 resources and efficient use (Atanga *et al.*, 2013).

70         The sustainability of beef cattle farms can be identified through a regional  
71 approach, by considering the existence of leading commodities and the potential of the  
72 region concerned (Mulyono & Munibah, 2016; Parmawati *et al.*, 2018). Determination  
73 of leading commodities characterized by the existence of comparative and competitive

74 advantages is the first step towards efficient development of the livestock sector  
75 (Hendayana, 2003). The potential of the region to support the development of beef cattle  
76 farms is determined by optimizing the carrying capacity and carrying capacity index of  
77 forage, as well as assessing the suitability of the land where the livestock grows. Land  
78 suitability for beef cattle farms with **intensive maintenance patterns** considers several  
79 environmental factors that affect the growth of these cattle.

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

86

87

## MATERIALS AND METHODS

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

92

### Leading Commodity

93 Determination of leading livestock commodities in an area uses Location  
94 Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods is the  
95 economic basis theory. LQ analysis is relatively simple, but the benefits are large enough  
96 for the initial identification of the ability of a sector in regional development. The shift in  
97 the structure of economic activity in beef cattle business, whether experiencing growth or

98 decline is analyzed using Shift Share (SS). SS analysis can be used to see the growth of  
 99 the economic sectors of a region for two time points (Muta'ali, 2015). LQ and SS analysis  
 100 uses equations that refer to (Ciptayasa *et al.*, 2016; Mulyono & Munibah, 2016).

$$101 \quad LQ_{ij} = \frac{X_{ij} / X_i}{X_j / X_{..}} \text{ (Equation 1)}$$

102 ( $X_{ij}$  = Beef cattle population in the sub-district A,  $X_i$  = Population of all types of livestock in the sub-  
 103 district A,  $X_j$  = Beef cattle population in Semarang Regency,  $X_{..}$  = Population of all types of livestock in  
 104 Semarang Regency).

$$105 \quad SS = \left[ \frac{X_{..}(t1)}{X_{..}(t0)} - 1 \right] + \left[ \frac{X_i(t1)}{X_i(t0)} - \frac{X_{..}(t1)}{X_{..}(t0)} \right] + \left[ \frac{X_{ij}(t1)}{X_{ij}(t0)} - \frac{X_i(t1)}{X_i(t0)} \right] \text{ (Equation 2)}$$

106 (SS = a + b + c, where a = Regional share, b = Proportional shift, c = Differential shift,  $X_{..}$  = Population  
 107 of all types of livestock in Semarang Regency,  $X_i$  = Beef cattle population in Semarang Regency,  $X_{ij}$  =  
 108 Beef cattle population in sub-district A,  $t_0$  = Early 2013 year point,  $t_1$  = End of year 2017).

109

### 110 **Carrying Capacity and Carrying Capacity Index of Forage**

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

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

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

124 Potential of agricultural waste (ton) =  $\{(wr \times 0,4) + (fr \times 3 \times 0,4) + (cn \times 3 \times 0,5) + (sb \times$   
125  $3 \times 0,55) + (pt \times 2 \times 0,55) + (sp \times 0,25/6) + (cs \times 0,25/4)\} \times 0,65$

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

129 Natural forage potential (ton) =  $\{(Ga \times 2,875) + (Fa \times 0,6) + (Cpa \times 10) + (Cfa \times 0,5) +$   
130  $(Cla \times 5)\} \times 0,5$

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

133 Minimum cattle feed requirements.

134  $R = 2,5\% \times 50\% \times 365 \times 400\text{kg} = 1,82 \text{ ton DDM/year/AU}$  (Equation 3)

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

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

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

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

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

148

### 149 **Suitability of The Ecological Environment of Beef Cattle**

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

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

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

168

169



## RESULTS

### Leading Commodity

170  
171  
172       Leading commodity livestock in an area is determined based on comparative  
173 advantage (location quotient analysis) and competitive advantage (shift share analysis).  
174 Beef cattle commodities that have  $LQ > 1$  and SS (+) values are the leading commodities  
175 in the region. The interpretation of the value of  $LQ > 1$ , is a base or leading sector, beef  
176 cattle products (meat) are able to meet markets inside and outside the region.  $LQ < 1$  value,  
177 is a non-base sector, livestock products have not been able to meet markets inside and  
178 outside the region.  $LQ = 1$  value, meaning that the sector is balanced with the reference  
179 region, livestock products are only able to meet markets in the area. The basis for  
180 calculating LQ analysis for livestock commodities is livestock population data  
181 (Hendayana, 2003). Data bias in calculations can be minimized by using a minimum 5  
182 year data series (Table 2).

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

190       The results of the calculation of LQ and SS analysis for beef cattle commodities  
191 in Semarang Regency are shown in Table 3. The sub-districts which are the base sectors  
192 of beef cattle livestock ( $LQ > 1$ ) are: Bancak (4,93), Banyubiru (3,97), Ambarawa (3,92),  
193 Bringin (2,82), and Bawen (2,34). Cultivation of beef cattle is concentrated in these areas

194 or in other words the economic density of beef cattle is higher than in other regions. Beef  
195 cattle commodity in the base sub-district is a prominent or dominant livestock business  
196 compared to the other livestock businesses, so the effort for future development is easier  
197 (Yuniar *et al.*, 2016; Mulyono & Munibah, 2016). The concept of comparative advantage  
198 is economic feasibility. According to Mulyono (2016), commodities that have a  
199 comparative advantage ( $LQ > 1$ ) show that the commodity (beef cattle) is supported by the  
200 existence of adequate natural resources so that the population level is higher than in other  
201 regions (Mulyono & Munibah, 2016).

202 Beef cattle commodities that have competitive advantages are seen based on  
203 positive shift share (SS) values. Sub-districts with a positive SS value means experiencing  
204 growth (competitiveness) related to cultivated beef cattle. On the contrary, sub-districts  
205 with negative SS value means that the area is not growing (stagnant) and can even  
206 experience setbacks. As seen in Table 3, sub-districts with positive SS values include:  
207 Ungaran Barat (1,286), Banyubiru (0,47), Pabelan (0,435), Bandungan (0,203), Bancak  
208 (0,077), Bringin (0,039), and Tengeran (0,026). The concept of competitive advantage is  
209 financial feasibility. Beef cattle commodities are cultivated in effective and efficient  
210 ways, so that they have competitiveness from aspects of quality, quantity, continuity and  
211 price (Saptana, 2008; Muta'ali, 2015; Mulyono & Munibah, 2016).

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

215

216

## 217 **Carrying Capacity and Carrying Capacity Index of Forage**

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

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

234 Based on the calculation results of Table 4, it is known that there are three sub-  
235 districts with the largest production of forage dry matter, namely Bringin (28.808,63 tons  
236 DDM), Pringapus (23.509,36 tons DDM), and Suruh (19.522,03 tons DDM). Sub-district  
237 area with the smallest forage dry matter production, namely Bandungan (4.327,55 tons  
238 DDM). The status of availability of forage in Bandungan sub-district was categorized as  
239 very critical (0,82), while in Tengaran sub-district it was categorized as vulnerable (1,69).  
240 Thus, these two sub-districts are not recommended for the development of beef cattle

241 farms. Sub-district areas with carrying capacity index value  $>2$  (safe) means that the area  
242 can be recommended for the development of beef cattle farms. The advantage obtained  
243 by the area with this safe category is that farmers can reduce the amount of production  
244 costs for beef cattle feed.

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

248

### 249 **Suitability of The Ecological Environment of Beef Cattle**

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

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

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

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

279 The symbol "p" indicates that there is a limiting factor in the area assessed. The  
280 limiting factors are the Temperature Humidity Index (THI) and the pH of the water for  
281 beef cattle consumption (Table 5). Semarang Regency consists of 19 sub-districts. The  
282 development of beef cattle farms is prioritized in sub-districts that have  $LQ>1$ , SS (+)  
283 value, and carrying capacity index of forage ( $>2$ ), namely Banyubiru, Bringin, and  
284 Bancak. Banyubiru sub-district is not constrained by limiting factors, while Bringin and  
285 Bancak are constrained by THI values that exceed the comfort zone for growing cattle  
286 ( $>80$ ). The extent suitability of the ecology of beef cattle farms from the three priority  
287 sub-districts is shown in Table 6.

288

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

300

301

## DISCUSSION

302           Semarang Regency is a potential area for the development of beef cattle farming  
303 because it has abundant natural resources in the form of land for livestock cultivation and  
304 forage production. The maintenance pattern of beef cattle that is often found in Semarang  
305 Regency is an intensive maintenance pattern. Beef cattle are able to show optimal  
306 physical conditions if they have superior genetic traits, and are supported by the suitability  
307 of their ecological environment (Suhaema *et al.*, 2014). Animal ecology is the study of  
308 the interactions between animals and their environment (Sumarto & Koneri, 2016).  
309 Environmental factors tend to affect the production and productivity of livestock more  
310 (Gunawan *et al.*, 2008). Some environmental factors that influence the growth of beef  
311 cattle with intensive maintenance patterns are: soil type, length of dry season, altitude,  
312 slope (Kadarsih, 2004; Calderon *et al.*, 2005; Rusmana *et al.*, 2006), temperature and

313 relative humidity, rainfall, water pH (Chantalakhana & Skunmun, 2002; Dobson *et al.*,  
314 2003; Rumetor, 2003; Yani *et al.*, 2007; Herbut & Angrecka, 2012; Eirich, 2018).

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

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

336



**CONCLUSION**

337

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

346

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- 500
- 501



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

Parameter	Order of environmental suitability of beef cattle	
	S (Suitable)	N (Unsuitable)
<i>Temperature Humidity Index</i> (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

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

505 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

506 Source: (BPS Kabupaten Semarang, 2018).

507

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.

511

512

513 Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency  
 514 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	

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

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521

522

523 Table 5. Results of measurements of environmental factors that influence the growth of  
524 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

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

526

527

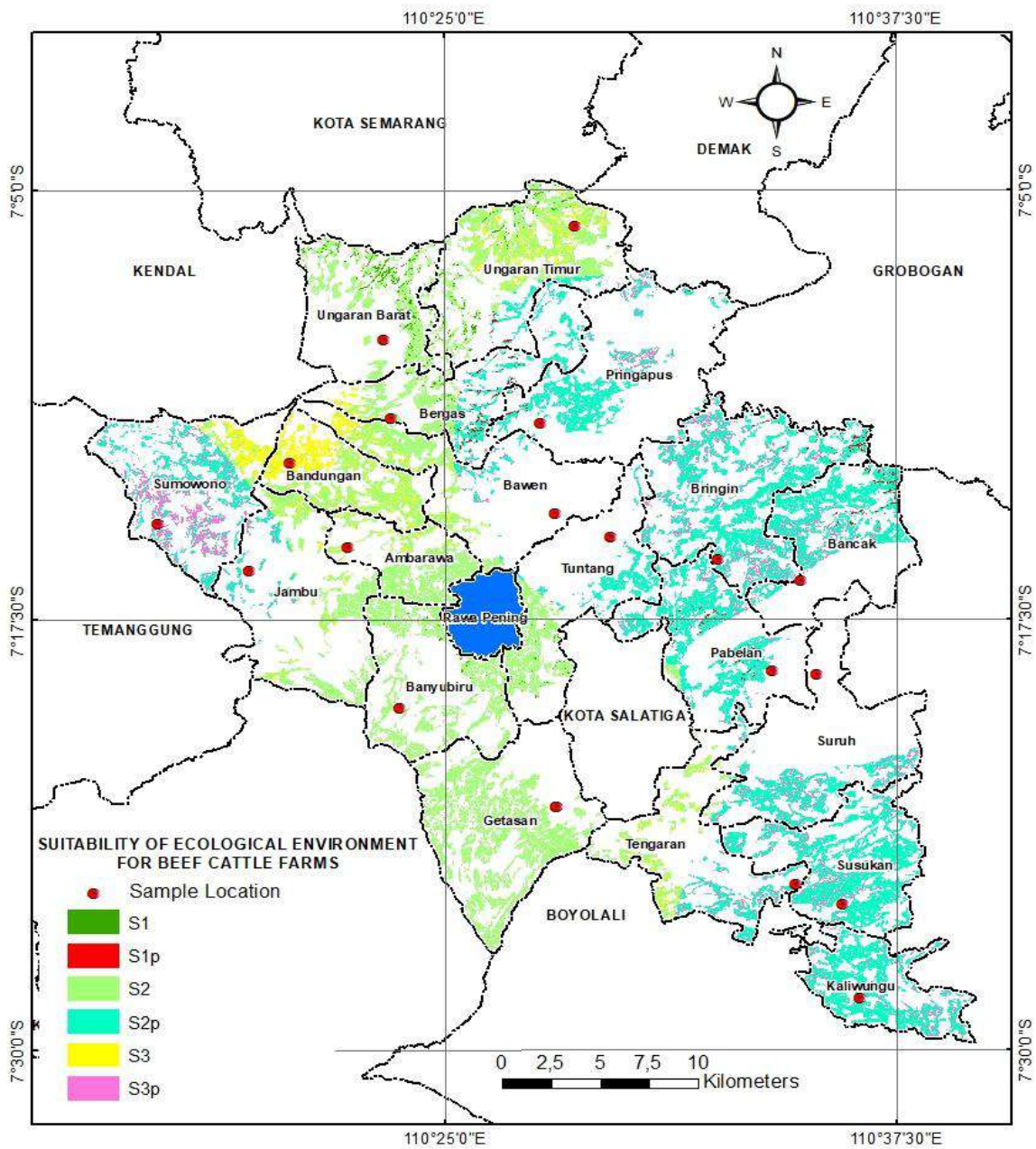
528 Table 6. Extent of suitability ecological environment map of beef cattle farms in Bancak,  
529 Banyubiru, and Bringin sub-districts

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
<b>TOTAL</b>		17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

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

532

533



534

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

537



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## PAPER EVALUATION

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

No	Comments	Author's response
<b>A</b>	<b>Reviewer</b>	
1	Please add Conflict of Interest Statement. Please see journal's guidelines on how to write it.	Yes, I have added conflict of interest statement in the manuscript.
2	Please see journal's guidelines on how to write references. Surname for 2nd, 3rd, etc authors should be placed before front name, for example : Agus, A. & Widi, T. S. M <b>should be</b> Agus, A. & T.S.M. Widi Please revise all references	Yes, I have revised the references according to journal guidelines.

**The Regional Analysis of Beef Cattle Farm Development in Semarang Regency**

**Commented [MP1]:** Generally this manuscript has been revised according to the advice of reviewers. However, please see comment in the References and please add Conflict of Interest Statement after Conclusion

**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.

26

**INTRODUCTION**

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

37           Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009;  
38 Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able  
39 to meet the high consumption of people against meat. The consumption of beef in 2020  
40 is estimated to reach 3.36 kg per capita per year, but beef production is still not able to  
41 fulfill it, there is a deficit in beef supply of 198,350 tons (Kementan, 2016; Agus & Widi,  
42 2018). Most of beef production in Indonesia, 78% comes from traditional livestock, 5%  
43 from imports, and 17% from live livestock imports, especially from Australia (Zakiah *et*  
44 *al.*, 2017). Imports of beef are indeed relatively larger compared to other types of meat  
45 imports, contributing 21.44% to the total import value of livestock, while the import value  
46 of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al.*,  
47 2014).

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



50 beef cattle farms in potential areas is an effort to strengthen meat production in the country  
51 so that the implementation must be carried out with a comprehensive assessment.  
52 Semarang Regency is a region in Central Java Province that has the potential to develop  
53 beef cattle farms because it has natural resources in the form of land as a place for  
54 livestock keeping and forage production. Good quality and always available forage can  
55 increase production, especially for increasing body weight of cattle (Suhaema *et al.*,  
56 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha),  
57 rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this  
58 region during the 2014-2016 period continued to decline, ranging from 53,135, 49,172,  
59 and 46,238 (BPS Kabupaten Semarang, 2018).

60         The development of beef cattle farms in Semarang Regency needs to adopt the  
61 concept of sustainability. The concept of sustainability is the achievement of economic,  
62 environmental and social goals simultaneously which is represented by various  
63 performance indicators (Darnhofer *et al.*, 2010). Sustainability is also defined as the  
64 concept of multidimensional (economic, ecological, social) and multiscale (micro, meso,  
65 and macro), although in its application it is often limited to one particular aspect (Santos  
66 *et al.*, 2017). Economic sustainability is closely related to the value of comparative and  
67 competitive advantages of certain commodities (Broom *et al.*, 2013; Sabaghi *et al.*,  
68 2016), while environmental sustainability includes optimizing the availability of natural  
69 resources and efficient use (Atanga *et al.*, 2013).

70         The sustainability of beef cattle farms can be identified through a regional  
71 approach, by considering the existence of leading commodities and the potential of the  
72 region concerned (Mulyono & Munibah, 2016; Parmawati *et al.*, 2018). Determination  
73 of leading commodities characterized by the existence of comparative and competitive

74 advantages is the first step towards efficient development of the livestock sector. The  
75 potential of the region to support the development of beef cattle farms is determined by  
76 optimizing the carrying capacity and carrying capacity index of forage, as well as  
77 assessing the suitability of the land where the livestock grows. Land suitability for beef  
78 cattle farms with intensive production systems considers several environmental factors  
79 that affect the growth of these cattle.

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

86

## 87 **MATERIALS AND METHODS**

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

### 95 **Leading Commodity**

96 Determination of leading livestock commodities in an area uses Location  
97 Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods is the

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

$$104 \text{ LQ}_{ij} = \frac{X_{ij}/X_i}{X_j/X_{..}} \text{ (Equation 1)}$$

105 ( $X_{ij}$  = Beef cattle population in the sub-district A,  $X_i$  = Population of all types of livestock in the sub-  
 106 district A,  $X_j$  = Beef cattle population in Semarang Regency,  $X_{..}$  = Population of all types of livestock in  
 107 Semarang Regency).

$$108 \text{ SS} = \left[ \frac{X_{..}(t1)}{X_{..}(t0)} - 1 \right] + \left[ \frac{X_i(t1)}{X_i(t0)} - \frac{X_{..}(t1)}{X_{..}(t0)} \right] + \left[ \frac{X_{ij}(t1)}{X_{ij}(t0)} - \frac{X_i(t1)}{X_i(t0)} \right] \text{ (Equation 2)}$$

109 (Regional share, Proportional shift, Differential shift,  $X_{..}$  = Population of all types of livestock in Semarang  
 110 Regency,  $X_i$  = Beef cattle population in Semarang Regency,  $X_{ij}$  = Beef cattle population in sub-district A,  
 111  $t_0$  = Early 2013 year point,  $t_1$  = End of year 2017).

112

### 113 **Carrying Capacity and Carrying Capacity Index of Forage**

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

120 The carrying capacity of beef cattle farms is calculated based on the production of  
 121 forage dry matter against the minimum feed requirements of cattle (1 AU) in one year.  
 122 The animal unit (AU) is a unit for the ruminant livestock population multiplied by the

123 conversion factor. The conversion factor for beef cattle is 0,7 (Muta'ali, 2015; Saputra  
 124 *et al.*, 2016). Forage dry matter production is the amount of potential agricultural waste  
 125 and natural forage potential, using equations that refer to (Suhaema *et al.*, 2014; Yuniar  
 126 *et al.*, 2016).

127 Potential of agricultural waste (ton) =  $\{(wr \times 0,4) + (fr \times 3 \times 0,4) + (cn \times 3 \times 0,5) + (sb \times$   
 128  $3 \times 0,55) + (pt \times 2 \times 0,55) + (sp \times 0,25/6) + (cs \times 0,25/4)\} \times 0,65$

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

132 Natural forage potential (ton) =  $\{(Ga \times 2,875) + (Fa \times 0,6) + (Cpa \times 10) + (Cfa \times 0,5) +$   
 133  $(Cla \times 5)\} \times 0,5$

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

136 Minimum cattle feed requirements.

137  $R = 2,5\% \times 50\% \times 365 \times 400\text{kg} = 1,82 \text{ ton DDM/year/AU}$  (Equation 3)

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

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

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

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

$$151 \text{ Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \text{ (Equation 5)}$$

152

### 153 **Suitability of The Ecological Environment of Beef Cattle**

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

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

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

## TASJ-1928

171 of beef cattle (Table 1). Land suitability is classified into 4 levels or strata, namely: very  
172 suitable (S1), quite suitable (S2), according to marginal (S3), and non-suitable (NS)  
173 (Rusmana *et al.*, 2006; Suhaema *et al.*, 2014; Yuniar *et al.*, 2016). The entire process  
174 was created and analyzed using GIS software.

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**RESULTS****Leading Commodity**

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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

201 keeping was concentrated in these areas or in other words the economic density of beef  
202 cattle was higher than that of in other regions.

203 Beef cattle commodities that have competitive advantages are seen based on  
204 positive shift share (SS) values. Sub-districts with a positive SS value means experiencing  
205 growth (competitiveness) related to keeping beef cattle. On the other hand, sub-districts  
206 with negative SS value means that the area is not growing (stagnant) and can even  
207 experience setbacks. The results of the analysis conducted in Table 3 shows that sub-  
208 districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47),  
209 Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tenganan  
210 (0.026).

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

214

#### 215 **Carrying Capacity and Carrying Capacity Index of Forage**

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



225 Based on the results of the analysis conducted in Table 4, it is known that there  
226 were three sub-districts with the highest production of forage dry matter, namely Bringin  
227 (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons  
228 DDM). Sub-district area with the lowest forage dry matter production, namely  
229 Bandungan (4,327.55 tons DDM). The status of availability of forage in Bandungan sub-  
230 district was categorized as very critical (0.82), while in Tengaran sub-district it was  
231 categorized as vulnerable (1.69). Thus, these two sub-districts are not recommended for  
232 the development of beef cattle farms. Sub-district areas with carrying capacity index value  
233  $>2$  (safe) means that the area can be recommended for the development of beef cattle  
234 farms. The advantage obtained by the area with this safe category is that farmers can  
235 reduce the amount of production costs for beef cattle feed.

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

239

#### 240 **Suitability of The Ecological Environment of Beef Cattle**

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

247 The suitability ecological environment map for beef cattle farms in Semarang  
248 Regency is shown in Figure 1. The white area is an area that is not assessed because it is

249 designated as land for settlements, plantations, tourism, and forests. Based on Figure 1, it  
250 is known that the level of suitability of the produced beef cattle ecological environment  
251 is: very suitable (S1), quite suitable (S2), and according to marginal (S3). Non-suitable  
252 (NS) categories are not assessed because the area has a slope  $>40\%$  (steep - very steep).

253 The symbol "p" indicates that there is a limiting factor in the area assessed. The  
254 limiting factors are the Temperature Humidity Index (THI) and the pH of the water for  
255 beef cattle consumption (Table 5). Semarang Regency consists of 19 sub-districts. The  
256 development of beef cattle farms is prioritized in sub-districts that have  $LQ > 1$ , SS (+)  
257 value, and carrying capacity index of forage ( $> 2$ ), namely Bringin, Bancak, and  
258 Banyubiru. Banyubiru sub-district is not constrained by limiting factors, while Bringin  
259 and Bancak are constrained by THI values that exceed the comfort zone for growing cattle  
260 ( $> 80$ ). The extent suitability of the ecology of beef cattle farms from the three priority  
261 sub-districts is shown in Table 6.

262 Based on the results of the analysis conducted in Table 6, the sub-districts with  
263 the largest land area for the development of beef cattle farms with intensive production  
264 systems were respectively Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru  
265 (1,451.2 Ha). The limiting factor in the form of temperature humidity index (THI) or  
266 water pH can be minimized through the engineering design of livestock housing and  
267 provision of materials or neutralizing water acidity solvent (Yani *et al.*, 2007; Sarwanto  
268 & Hendarto, 2011). Cattle with intensive production systems are generally more  
269 susceptible to heat stress than cattle extensively production systems. Efforts that can be  
270 done to reduce heat stress in beef cattle include: adding shade around the housing location,  
271 install a sprinkle tool or add straw that works to lower the surface temperature of the floor,  
272 regulate feed, feed additives and medicine, etc (Suhaema *et al.*, 2014).

273

274

**DISCUSSION**

275 Semarang Regency is a potential area for the development of beef cattle farming  
276 because it has abundant natural resources in the form of land for livestock keeping and  
277 forage production. The mapping activity is based on the determination of leading  
278 livestock commodities, and optimization of regional potential can be one of the  
279 benchmarks in realizing sustainable development of beef cattle farms. The concept of  
280 sustainable development is to meet the needs of the current generation, without sacrificing  
281 future generations and this concept has become a reference for welfare in almost all  
282 sectors, including the livestock sector (Wasike *et al.*, 2011). The concept of sustainability  
283 has been widely debated throughout the world over the past few years (De Longe *et al.*,  
284 2016; Keesstra *et al.*, 2016; Rasmussen *et al.*, 2017), not only concerning issues  
285 environmental and social issues, but also discussing economic issues to gain certain  
286 market or commodity advantages (Broom *et al.*, 2013; Sabaghi *et al.*, 2016).  
287 Sustainability assessment is achieved by evaluating the relative contribution of each of  
288 the economic, environmental and social factors to the overall goal (Astier & García-  
289 Barrios, 2012). Sustainability assessed in this study is economic and environmental  
290 sustainability for beef cattle farms.

291 Economic sustainability is assessed based on the results of the analysis of leading  
292 commodity. The leading livestock commodity in an area are determined based on  
293 comparative advantage (LQ analysis) and competitive advantage (SS analysis). The  
294 concept of comparative advantage is economic feasibility. Commodities that have a  
295 comparative advantage ( $LQ > 1$ ) show that the commodity (beef cattle) is supported by the  
296 existence of adequate natural resources so that the population level is higher than in other

297 regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a  
298 prominent or dominant livestock business compared to the other livestock businesses, so  
299 the effort for future development is easier (Yuniar *et al.*, 2016; Mulyono & Munibah,  
300 2016). On the other hand, the concept of competitive advantage is financial feasibility.  
301 Beef cattle commodities are keeping in effective and efficient ways, so that they have  
302 competitiveness from aspects of quality, quantity, continuity and price (Muta'ali, 2015;  
303 Mulyono & Munibah, 2016). The results presented in Table 3 show that the Bringin,  
304 Bancak, and Banyubiru sub-districts are regions with leading commodity of beef cattle.  
305 Accordingly, the three sub-districts are a priority for the development of beef cattle farms  
306 in Semarang Regency.

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

319 The production systems of beef cattle that is often found in Semarang Regency is  
320 an intensive production systems. Beef cattle are able to show optimal physical conditions

321 if they have superior genetic traits, and are supported by the suitability of their ecological  
322 environment (Suhaema *et al.*, 2014). Animal ecology is the study of the interactions  
323 between animals and their environment. Environmental factors tend to affect the  
324 production and productivity of livestock more (Sumarto & Koneri, 2016). Some  
325 environmental factors that influence the growth of beef cattle with intensive production  
326 systems are: soil type, length of dry season, altitude, slope (Rusmana *et al.*, 2006),  
327 temperature and relative humidity, rainfall, water pH (Herbut & Angrecka, 2012;  
328 Suhaema *et al.*, 2014; Yuniar *et al.*, 2016; Eirich, 2018).

329         The results of the analysis in Table 5 show that environmental factors are limiting  
330 in the development of beef cattle farms in Semarang Regency are air temperature and  
331 humidity, and pH of water for livestock drinking needs. The relationship between the  
332 amount of air temperature and humidity is called the Temperature Humidity Index (THI).  
333 If THI exceeds the threshold (>80), it can cause stress or heat stress in beef cattle (Eirich,  
334 2018). Long-term heat stress has an impact on increasing drinking water consumption,  
335 increasing urine volume, and decreasing feed consumption. The direct effect of heat stress  
336 on livestock production causes a decrease in the productivity of beef cattle. This is due to  
337 the increasing need for livestock maintenance (Berman, 2005). Furthermore, the THI  
338 value that exceeds the threshold influences the decrease in daily body weight gain,  
339 depletion of the thickness of meat fat, and the increase of potential for disease occurrence  
340 especially in male cattle (Nardone *et al.*, 2010). Hydrogen potential (pH) characterizes  
341 the balance between acidic and alkaline solvent in water. If the pH of drinking water for  
342 beef cattle is below the quality standard or acid (<6,5), the water becomes sour and can  
343 cause physiological and digestive disorders in livestock. On the other hand, if the pH of  
344 water is too alkaline (>9), the water becomes bitter and causes a decrease in consumption

345 of drinking water which has an impact on decreasing livestock productivity (Sarwanto &  
346 Hendarto, 2011).

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

351

### 352 CONCLUSION

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

362

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Surname for 2<sup>nd</sup>, 3<sup>rd</sup>, etc authors should be placed before front  
name, for example :

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

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- 479  
480

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

Parameter	Order of environmental suitability of beef cattle	
	S (Suitable)	N (Unsuitable)
<i>Temperature Humidity Index</i> (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

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

484 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

485 Source: (BPS Kabupaten Semarang, 2018).

486

487 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

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

490

491

492 Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency  
 493 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	

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

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500

501

502 Table 5. Results of measurements of environmental factors that influence the growth of  
 503 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	Thumpakan	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

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

505

506

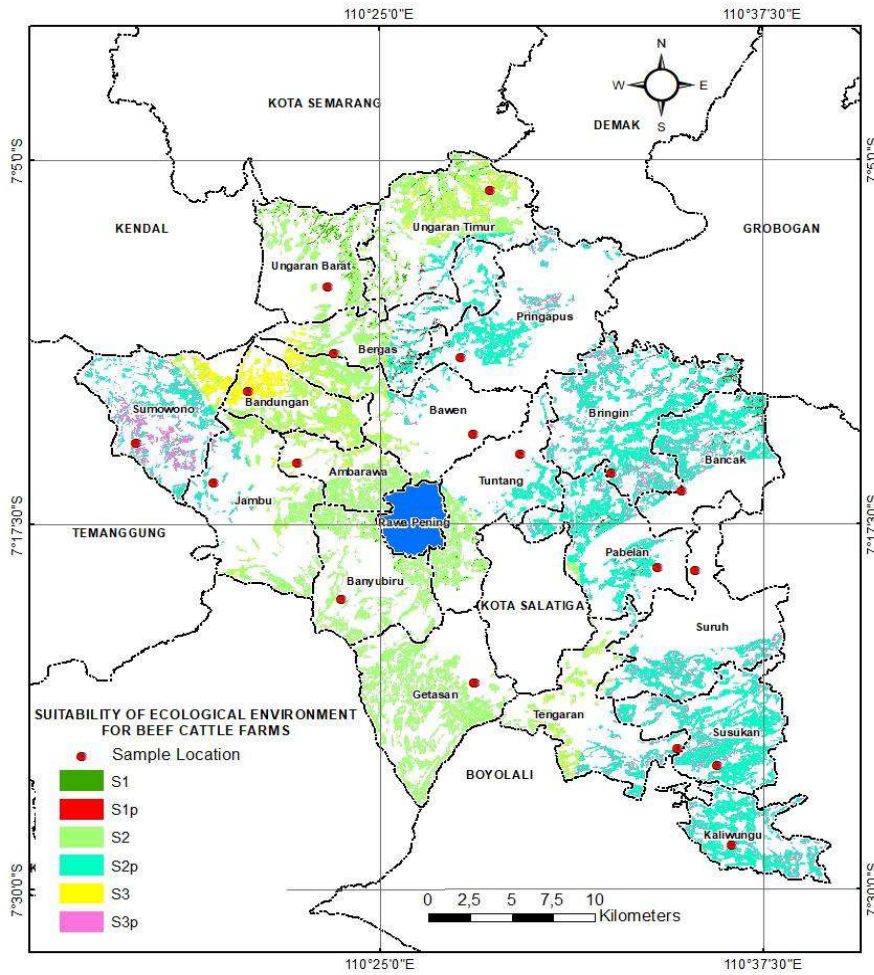
507 Table 6. Extent of suitability ecological environment map of beef cattle farms in Bancak,  
 508 Banyubiru, and Bringin sub-districts

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
<b>TOTAL</b>		17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

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

511

512



513

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

516



## 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.

## 26 INTRODUCTION

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

37 Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009;  
38 Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able  
39 to meet the high consumption of people against meat. The consumption of beef in 2020  
40 is estimated to reach 3.36 kg per capita per year, but beef production is still not able to  
41 fulfill it, there is a deficit in beef supply of 198,350 tons (Kementan, 2016; Agus & Widi,  
42 2018). Most of beef production in Indonesia, 78% comes from traditional livestock, 5%  
43 from imports, and 17% from live livestock imports, especially from Australia (Zakiah *et*  
44 *al.*, 2017). Imports of beef are indeed relatively larger compared to other types of meat  
45 imports, contributing 21.44% to the total import value of livestock, while the import value  
46 of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al.*,  
47 2014).

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

50 beef cattle farms in potential areas is an effort to strengthen meat production in the country  
51 so that the implementation must be carried out with a comprehensive assessment.  
52 Semarang Regency is a region in Central Java Province that has the potential to develop  
53 beef cattle farms because it has natural resources in the form of land as a place for  
54 livestock keeping and forage production. Good quality and always available forage can  
55 increase production, especially for increasing body weight of cattle (Suhaema *et al.*,  
56 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha),  
57 rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this  
58 region during the 2014-2016 period continued to decline, ranging from 53,135, 49,172,  
59 and 46,238 (BPS Kabupaten Semarang, 2018).

60         The development of beef cattle farms in Semarang Regency needs to adopt the  
61 concept of sustainability. The concept of sustainability is the achievement of economic,  
62 environmental and social goals simultaneously which is represented by various  
63 performance indicators (Darnhofer *et al.*, 2010). Sustainability is also defined as the  
64 concept of multidimensional (economic, ecological, social) and multiscale (micro, meso,  
65 and macro), although in its application it is often limited to one particular aspect (Santos  
66 *et al.*, 2017). Economic sustainability is closely related to the value of comparative and  
67 competitive advantages of certain commodities (Broom *et al.*, 2013; Sabaghi *et al.*,  
68 2016), while environmental sustainability includes optimizing the availability of natural  
69 resources and efficient use (Atanga *et al.*, 2013).

70         The sustainability of beef cattle farms can be identified through a regional  
71 approach, by considering the existence of leading commodities and the potential of the  
72 region concerned (Mulyono & Munibah, 2016; Parmawati *et al.*, 2018). Determination  
73 of leading commodities characterized by the existence of comparative and competitive

74 advantages is the first step towards efficient development of the livestock sector. The  
75 potential of the region to support the development of beef cattle farms is determined by  
76 optimizing the carrying capacity and carrying capacity index of forage, as well as  
77 assessing the suitability of the land where the livestock grows. Land suitability for beef  
78 cattle farms with intensive production systems considers several environmental factors  
79 that affect the growth of these cattle.

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

86

87

## **MATERIALS AND METHODS**

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

95

### **Leading Commodity**

96 Determination of leading livestock commodities in an area uses Location  
97 Quotient (LQ) and Shift Share (SS) analysis. The rationale for the two methods is the

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

$$104 \quad LQ_{ij} = \frac{X_{ij} / X_i}{X_j / X_{..}} \text{ (Equation 1)}$$

105 ( $X_{ij}$  = Beef cattle population in the sub-district A,  $X_i$  = Population of all types of livestock in the sub-  
 106 district A,  $X_j$  = Beef cattle population in Semarang Regency,  $X_{..}$  = Population of all types of livestock in  
 107 Semarang Regency).

$$108 \quad SS = \left[ \frac{X_{..}(t1)}{X_{..}(t0)} - 1 \right] + \left[ \frac{X_i(t1)}{X_i(t0)} - \frac{X_{..}(t1)}{X_{..}(t0)} \right] + \left[ \frac{X_{ij}(t1)}{X_{ij}(t0)} - \frac{X_i(t1)}{X_i(t0)} \right] \text{ (Equation 2)}$$

109 (Regional share, Proportional shift, Differential shift,  $X_{..}$  = Population of all types of livestock in Semarang  
 110 Regency,  $X_i$  = Beef cattle population in Semarang Regency,  $X_{ij}$  = Beef cattle population in sub-district A,  
 111  $t_0$  = Early 2013 year point,  $t_1$  = End of year 2017).

112

### 113 **Carrying Capacity and Carrying Capacity Index of Forage**

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

120 The carrying capacity of beef cattle farms is calculated based on the production of  
 121 forage dry matter against the minimum feed requirements of cattle (1 AU) in one year.  
 122 The animal unit (AU) is a unit for the ruminant livestock population multiplied by the

123 conversion factor. The conversion factor for beef cattle is 0,7 (Muta'ali, 2015; Saputra  
 124 *et al.*, 2016). Forage dry matter production is the amount of potential agricultural waste  
 125 and natural forage potential, using equations that refer to (Suhaema *et al.*, 2014; Yuniar  
 126 *et al.*, 2016).

127 Potential of agricultural waste (ton) =  $\{(wr \times 0,4) + (fr \times 3 \times 0,4) + (cn \times 3 \times 0,5) + (sb \times$   
 128  $3 \times 0,55) + (pt \times 2 \times 0,55) + (sp \times 0,25/6) + (cs \times 0,25/4)\} \times 0,65$

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

132 Natural forage potential (ton) =  $\{(Ga \times 2,875) + (Fa \times 0,6) + (Cpa \times 10) + (Cfa \times 0,5) +$   
 133  $(Cla \times 5)\} \times 0,5$

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

136 Minimum cattle feed requirements.

137  $R = 2,5\% \times 50\% \times 365 \times 400\text{kg} = 1,82 \text{ ton DDM/year/AU}$  (Equation 3)

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

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

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

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

$$151 \text{ Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \text{ (Equation 5)}$$

152

### 153 **Suitability of The Ecological Environment of Beef Cattle**

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

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

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

171 of beef cattle (Table 1). Land suitability is classified into 4 levels or strata, namely: very  
172 suitable (S1), quite suitable (S2), according to marginal (S3), and non-suitable (NS)  
173 (Rusmana *et al.*, 2006; Suhaema *et al.*, 2014; Yuniar *et al.*, 2016). The entire process  
174 was created and analyzed using GIS software.

175

176



## RESULTS

### Leading Commodity

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178  
179       Leading commodity livestock in an area is determined based on comparative  
180 advantage (location quotient analysis) and competitive advantage (shift share analysis).  
181 Beef cattle commodities that have  $LQ > 1$  and SS (+) values are the leading commodities  
182 in the region. The interpretation of the value of  $LQ > 1$ , is a base or leading sector, beef  
183 cattle products (meat) are able to meet markets inside and outside the region.  $LQ < 1$  value,  
184 is a non-base sector, livestock products have not been able to meet markets inside and  
185 outside the region.  $LQ = 1$  value, meaning that the sector is balanced with the reference  
186 region, livestock products are only able to meet markets in the area. The basis for  
187 calculating LQ analysis for livestock commodities is livestock population data  
188 (Hendayana, 2003). Data bias in calculations can be minimized by using a minimum 5  
189 year data series (Table 2).

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

197       The results of the LQ and SS analysis calculations for beef cattle commodities in  
198 Semarang Regency are shown in Table 3. Based on the results of the analysis conducted,  
199 the subdistrict areas becoming the beef cattle base sector ( $LQ > 1$ ) were Bancak (4.93),  
200 Banyubiru (3.97), Ambarawa (3.92), Bringin (2.82), and Bawen (2.34). Beef cattle

201 keeping was concentrated in these areas or in other words the economic density of beef  
202 cattle was higher than that of in other regions.

203 Beef cattle commodities that have competitive advantages are seen based on  
204 positive shift share (SS) values. Sub-districts with a positive SS value means experiencing  
205 growth (competitiveness) related to keeping beef cattle. On the other hand, sub-districts  
206 with negative SS value means that the area is not growing (stagnant) and can even  
207 experience setbacks. The results of the analysis conducted in Table 3 shows that sub-  
208 districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47),  
209 Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tenganan  
210 (0.026).

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

214

### 215 **Carrying Capacity and Carrying Capacity Index of Forage**

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

225           Based on the results of the analysis conducted in Table 4, it is known that there  
226 were three sub-districts with the highest production of forage dry matter, namely Bringin  
227 (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons  
228 DDM). Sub-district area with the lowest forage dry matter production, namely  
229 Bandungan (4,327.55 tons DDM). The status of availability of forage in Bandungan sub-  
230 district was categorized as very critical (0.82), while in Tengaran sub-district it was  
231 categorized as vulnerable (1.69). Thus, these two sub-districts are not recommended for  
232 the development of beef cattle farms. Sub-district areas with carrying capacity index value  
233  $>2$  (safe) means that the area can be recommended for the development of beef cattle  
234 farms. The advantage obtained by the area with this safe category is that farmers can  
235 reduce the amount of production costs for beef cattle feed.

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

239

#### 240           **Suitability of The Ecological Environment of Beef Cattle**

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

247           The suitability ecological environment map for beef cattle farms in Semarang  
248 Regency is shown in Figure 1. The white area is an area that is not assessed because it is

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

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

262 Based on the results of the analysis conducted in Table 6, the sub-districts with  
263 the largest land area for the development of beef cattle farms with intensive production  
264 systems were respectively Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru  
265 (1,451.2 Ha). The limiting factor in the form of temperature humidity index (THI) or  
266 water pH can be minimized through the engineering design of livestock housing and  
267 provision of materials or neutralizing water acidity solvent (Yani *et al.*, 2007; Sarwanto  
268 & Hendarto, 2011). Cattle with intensive production systems are generally more  
269 susceptible to heat stress than cattle extensively production systems. Efforts that can be  
270 done to reduce heat stress in beef cattle include: adding shade around the housing location,  
271 install a sprinkle tool or add straw that works to lower the surface temperature of the floor,  
272 regulate feed, feed additives and medicine, etc (Suhaema *et al.*, 2014).

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## DISCUSSION

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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.

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296

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

297 regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a  
298 prominent or dominant livestock business compared to the other livestock businesses, so  
299 the effort for future development is easier (Yuniar *et al.*, 2016; Mulyono & Munibah,  
300 2016). On the other hand, the concept of competitive advantage is financial feasibility.  
301 Beef cattle commodities are keeping in effective and efficient ways, so that they have  
302 competitiveness from aspects of quality, quantity, continuity and price (Muta'ali, 2015;  
303 Mulyono & Munibah, 2016). The results presented in Table 3 show that the Bringin,  
304 Bancak, and Banyubiru sub-districts are regions with leading commodity of beef cattle.  
305 Accordingly, the three sub-districts are a priority for the development of beef cattle farms  
306 in Semarang Regency.

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

319         The production systems of beef cattle that is often found in Semarang Regency is  
320 an intensive production systems. Beef cattle are able to show optimal physical conditions

321 if they have superior genetic traits, and are supported by the suitability of their ecological  
322 environment (Suhaema *et al.*, 2014). Animal ecology is the study of the interactions  
323 between animals and their environment. Environmental factors tend to affect the  
324 production and productivity of livestock more (Sumarto & Koneri, 2016). Some  
325 environmental factors that influence the growth of beef cattle with intensive production  
326 systems are: soil type, length of dry season, altitude, slope (Rusmana *et al.*, 2006),  
327 temperature and relative humidity, rainfall, water pH (Herbut & Angrecka, 2012;  
328 Suhaema *et al.*, 2014; Yuniar *et al.*, 2016; Eirich, 2018).

329         The results of the analysis in Table 5 show that environmental factors are limiting  
330 in the development of beef cattle farms in Semarang Regency are air temperature and  
331 humidity, and pH of water for livestock drinking needs. The relationship between the  
332 amount of air temperature and humidity is called the Temperature Humidity Index (THI).  
333 If THI exceeds the threshold ( $>80$ ), it can cause stress or heat stress in beef cattle (Eirich,  
334 2018). Long-term heat stress has an impact on increasing drinking water consumption,  
335 increasing urine volume, and decreasing feed consumption. The direct effect of heat stress  
336 on livestock production causes a decrease in the productivity of beef cattle. This is due to  
337 the increasing need for livestock maintenance (Berman, 2005). Furthermore, the THI  
338 value that exceeds the threshold influences the decrease in daily body weight gain,  
339 depletion of the thickness of meat fat, and the increase of potential for disease occurrence  
340 especially in male cattle (Nardone *et al.*, 2010). Hydrogen potential (pH) characterizes  
341 the balance between acidic and alkaline solvent in water. If the pH of drinking water for  
342 beef cattle is below the quality standard or acid ( $<6,5$ ), the water becomes sour and can  
343 cause physiological and digestive disorders in livestock. On the other hand, if the pH of  
344 water is too alkaline ( $>9$ ), the water becomes bitter and causes a decrease in consumption

345 of drinking water which has an impact on decreasing livestock productivity (Sarwanto &  
346 Hendarto, 2011).

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

351

352

### **CONCLUSION**

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

362

363

### **CONFLICT OF INTEREST**

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

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- 486

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

Parameter	Order of environmental suitability of beef cattle	
	S (Suitable)	N (Unsuitable)
<i>Temperature Humidity Index</i> (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

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

490 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

491 Source: (BPS Kabupaten Semarang, 2018).

492

493 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

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

496

497

498 Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency  
 499 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	

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

505

506

507



508 Table 5. Results of measurements of environmental factors that influence the growth of  
509 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

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

511

512

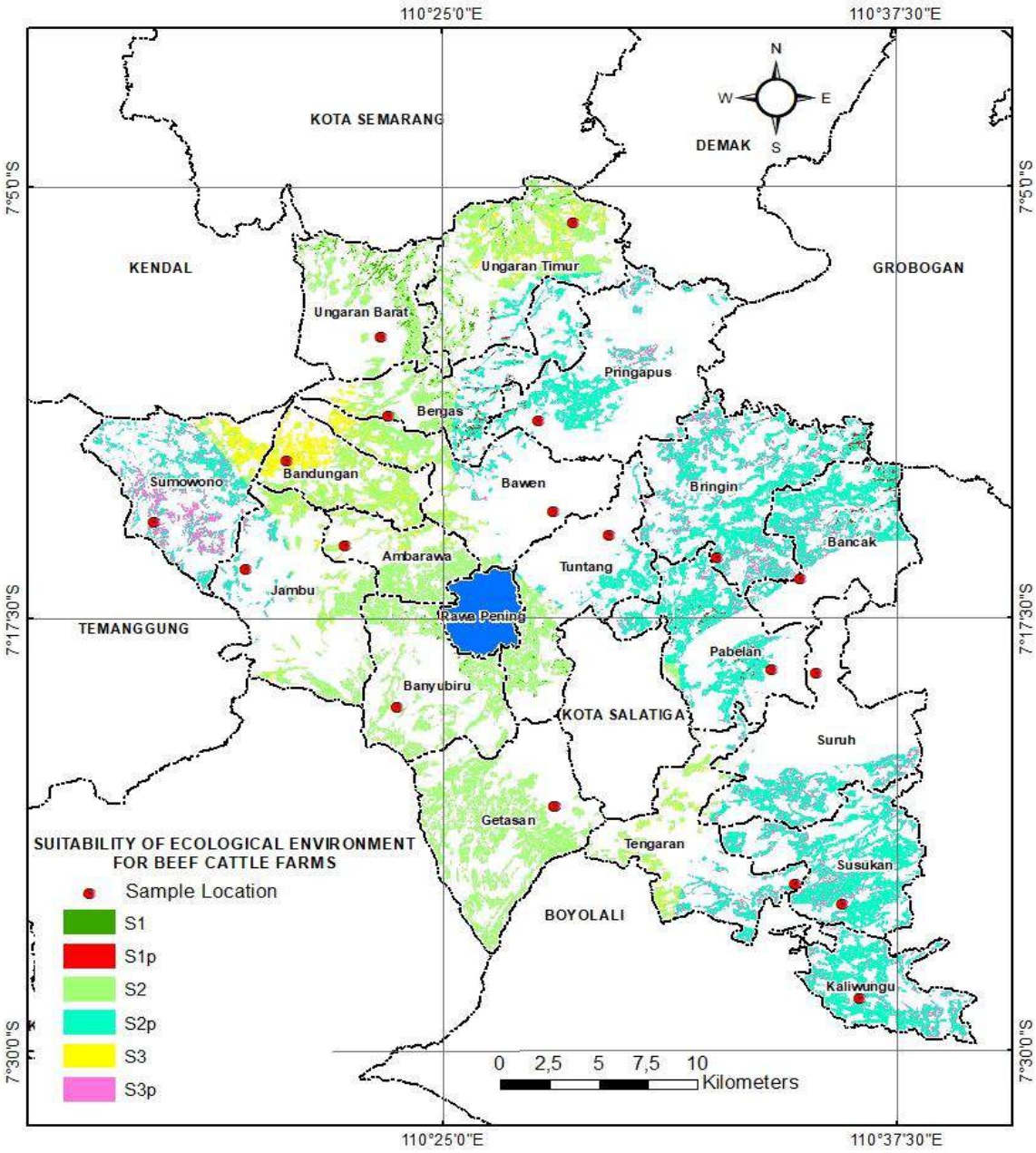
513 Table 6. Extent of suitability ecological environment map of beef cattle farms in Bancak,  
514 Banyubiru, and Bringin sub-districts

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
<b>TOTAL</b>		17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

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

517

518



519

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

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**Prof. Dr. Komang G Wiryawan** <jurnal@apps.ipb.ac.id>  
to me, Bambang

Mon, Sep 23, 10:39 AM

Bogor, September 23, 2019

Dear Budi Santoso & B. W. H. E. Prasetyono.

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.

We will send you the COPYEDITING of your manuscript as we will ask you for some correction of the typesetting.

Thank you for your article submission, and we are looking forward to receive your incoming articles.

...

**Budi Santoso** <budibudisan@gmail.com>  
To Komang, Bambang

Tue, Sep 24, 3:48 PM

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Budi Santoso, & B. W. H. E. Prasetyono:

Your submission "The Regional Analysis of Beef Cattle Farm Development in Semarang Regency" for Tropical Animal Science Journal has been discussed in the Editorial meeting.

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1 **The Regional Analysis of Beef Cattle Farm Development in Semarang Regency**  
2

3 **Budi Santoso<sup>a</sup>, & B. W. H. E. Prasetyono<sup>b,\*</sup>**

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8  
9 **ABSTRACT**

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

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

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

30

### 31 INTRODUCTION

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

42 Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009;  
43 Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able  
44 to meet the high meat consumption of people. The consumption of beef in 2020 is  
45 estimated to reach 3.36 kg per capita per year, but beef production is still not able to fulfill  
46 it; there is a deficit in beef supply by 198,350 tons (Kementan, 2016; Agus & Widi, 2018).  
47 Most of the beef production in Indonesia, 78% comes from traditional livestock, 5% from  
48 imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al.*,  
49 2017). Imports of beef are indeed relatively larger compared to the other types of meat

50 imports, contributing 21.44% to the total import value of livestock, while the import value  
51 of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al.*,  
52 2014).

53 Policy efforts to reduce beef imports must be studied, by strengthening domestic  
54 production that is beneficial for farmers (Pasandaran *et al.*, 2014). The development of  
55 beef cattle farms in potential areas is an effort to strengthen meat production in the country  
56 so that the implementation must be carried out with a comprehensive assessment.  
57 Semarang Regency is a region in Central Java Province that has the potential to develop  
58 beef cattle farms because it has natural resources in the form of land as a place for  
59 livestock keeping and forage production. Good quality and forage availability can  
60 increase production, especially for increasing body weight of cattle (Suhaema *et al.*,  
61 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha),  
62 rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this  
63 region during the 2014-2016 period continued to decline, ranging from 53,135; 49,172;  
64 and 46,238 (BPS Kabupaten Semarang, 2018).

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



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

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

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

91

92

#### **MATERIALS AND METHODS**

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

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

### 100 **Leading Commodity**

101 Determination of leading livestock commodities in an area used Location Quotient  
 102 (LQ) and Shift Share (SS) analysis. The rationale for the two methods was the economic  
 103 basis theory. LQ analysis was relatively simple, but the benefits were large enough for  
 104 the initial identification of the ability of a sector in regional development. The shift in the  
 105 structure of economic activity in beef cattle business, whether experiencing growth or  
 106 decline was analyzed using Shift Share (SS). SS analysis can be used to see the growth  
 107 of the economic sectors of a region for two-time points (Muta'ali, 2015). LQ and SS  
 108 analysis used the following equations (Ciptayasa *et al.*, 2016; Mulyono & Munibah,  
 109 2016).

$$110 \text{ LQ}_{ij} = \frac{X_{ij} / X_i}{X_j / X_{..}} \text{ (Equation 1)}$$

111 ( $X_{ij}$  = Beef cattle population in the sub-district A,  $X_i$  = Population of all types of livestock in the sub-  
 112 district A,  $X_j$  = Beef cattle population in Semarang Regency,  $X_{..}$  = Population of all types of livestock in  
 113 Semarang Regency).

$$114 \text{ SS} = \left[ \frac{X_{..}(t1)}{X_{..}(t0)} - 1 \right] + \left[ \frac{X_i(t1)}{X_i(t0)} - \frac{X_{..}(t1)}{X_{..}(t0)} \right] + \left[ \frac{X_{ij}(t1)}{X_{ij}(t0)} - \frac{X_i(t1)}{X_i(t0)} \right] \text{ (Equation 2)}$$

115 (Regional share, Proportional shift, Differential shift,  $X_{..}$  = Population of all types of livestock in Semarang  
 116 Regency,  $X_i$  = Beef cattle population in Semarang Regency,  $X_{ij}$  = Beef cattle population in sub-district A,  
 117  $t_0$  = Early 2013 year point,  $t_1$  = End of year 2017).

118

### 119 **Carrying Capacity and Carrying Capacity Index of Forage**

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

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

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

133 Potential of agricultural waste (ton) =  $\{(wr \times 0.4) + (fr \times 3 \times 0.4) + (cn \times 3 \times 0.5) + (sb \times$   
134  $3 \times 0.55) + (pt \times 2 \times 0.55) + (sp \times 0.25/6) + (cs \times 0.25/4)\} \times 0.65$   
135 (wr is wetland rice, fr is field rice, cn is corn, sb is soybean, pt is peanuts, sp is sweet  
136 potatoes, cs is cassava. The numbers in the formula are assumptions about the potential  
137 waste produced from the production of each type of plant food).

138 Natural forage potential (ton) =  $\{(Ga \times 2.875) + (Fa \times 0.6) + (Cpa \times 10) + (Cfa \times 0.5) +$   
139  $(Cla \times 5)\} \times 0.5$   
140 (Ga is garden area, Fa is forest area, Cpa is coconut plant area, Cfa is coffee plant area,  
141 Cla is clove plant area. The numbers in the formula are assumed to be natural forage  
142 potential produced per hectare of land use area).

143 Minimum cattle feed requirements (R) =  $2.5\% \times 50\% \times 365 \times 400 \text{ kg} = 1.82 \text{ ton}$   
144 DDM/year/AU (Equation 3)

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

**Commented [MP2]:** fresh forage or dry matter?

**Commented [MP3]:** fresh or dry matter?

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

145 (R is minimum cattle feed requirements (1 AU) in tons of digestible dry matter  
 146 for 1 year, 2.5% is minimum requirement for the number of forage rations (dry matter)  
 147 on livestock weight, 50% is average value digestibility power of various types of plants,  
 148 365 is number of days in 1 year, 400 kg is live weight of 1 AU of beef cattle in Semarang  
 149 Regency). Equations that refer to Suhaema *et al.* (2014) and Yuniar *et al.* (2016).

**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.

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

$$153 \text{ CC (AU)} = \frac{\text{Forage Dry Matter Production (tons of DDM / year)}}{\text{Minimum Cattle Feed Requirement (tons of DDM / year / AU)}} \text{ (Equation 4)}$$

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

$$158 \text{ Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \text{ (Equation 5)}$$

159

### 160 Suitability of the Ecological Environment of Beef Cattle

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

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

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

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**RESULTS****Leading Commodity**

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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).

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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.

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

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

212 Beef cattle commodities that had competitive advantages were seen based on  
213 positive shift-share (SS) values. Sub-districts with a positive SS value means  
214 experiencing growth (competitiveness) related to keeping beef cattle. On the other hand,  
215 sub-districts with negative SS value means that the area is not growing (stagnant) and can  
216 even experience setbacks. The results of the analysis conducted in Table 3 showed that  
217 sub-districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47),  
218 Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tenganan  
219 (0.026).

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

223

#### 224 **Carrying Capacity and Carrying Capacity Index of Forage**

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

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

234 Based on the results of the analysis conducted in Table 4, it was known that there  
235 were three sub-districts with the highest production of forage dry matter, namely Bringin  
236 (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons  
237 DDM). Sub-district area with the lowest forage dry matter production was Bandungan  
238 (4,327.55 tons DDM). The status of the availability of forage in Bandungan sub-district  
239 was categorized as very critical (0.82), while in Tengaran sub-district it was categorized  
240 as vulnerable (1.69). Therefore, these two sub-districts are not recommended for the  
241 development of beef cattle farms. Sub-district areas with carrying capacity index value  
242  $>2$  (safe) means that the areas can be recommended for the development of beef cattle  
243 farms. The advantage obtained by the area with this safe category is that farmers can  
244 reduce the amount of production costs for beef cattle feed.

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

**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)

248

#### 249 **The Suitability of Ecological Environment of Beef Cattle**

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



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

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

272 Based on the results of the analysis conducted in Table 6, the sub-districts with  
273 the largest land area for the development of beef cattle farms with intensive production  
274 systems were Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru (1,451.2 Ha).  
275 The limiting factor in the form of temperature humidity index (THI) or water pH can be  
276 minimized through the engineering design of livestock housing and the provision of  
277 materials or neutralizing water acidity solvent (Yani *et al.*, 2007; Sarwanto & Hendarto,  
278 2011). Cattle with intensive production systems are generally more susceptible to heat  
279 stress than cattle with extensive production systems. Efforts that can be done to reduce

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

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

283

284

#### **DISCUSSION**

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

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

304 The concept of comparative advantage is economic feasibility. Commodities that have a  
305 comparative advantage ( $LQ > 1$ ) show that the commodity (beef cattle) is supported by the  
306 existence of adequate natural resources so that the population level is higher than in other  
307 regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a  
308 prominent or dominant livestock business compared to the other livestock businesses, so  
309 the effort for future development is easier (Yuniar *et al.*, 2016; Mulyono & Munibah,  
310 2016). On the other hand, the concept of competitive advantage is financial feasibility.  
311 Beef cattle commodities are keeping in effective and efficient ways so that they have  
312 competitiveness from the aspects of quality, quantity, continuity, and price (Muta'ali,  
313 2015; Mulyono & Munibah, 2016). The results presented in Table 3 show that the  
314 Bringin, Bancak, and Banyubiru sub-districts are regions with a leading commodity of  
315 beef cattle. Accordingly, the three sub-districts are a priority for the development of beef  
316 cattle farms in Semarang Regency.

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

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

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

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

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

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

### 361 362 CONCLUSION

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

### 373 374 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:  $5760 * 3 * 0.5 = 8640 \text{ ton} / 1.82 = 4747 \text{ AU}$ . Jauh dibawah kesimpulan 30601 AU

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376 personal, or other relationships with other people or organization related to the material  
377 discussed in the manuscript.

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

Parameter	Order of environmental suitability of beef cattle	
	S (Suitable)	N (Unsuitable)
<i>Temperature Humidity Index</i> (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

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

509 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

510 Source: (BPS Kabupaten Semarang, 2018).

511

512 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

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

515

516

517 Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency  
 518 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	

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

524

525

526

527 Table 5. Results of measurements of environmental factors that influence the growth of  
 528 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

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

530

531

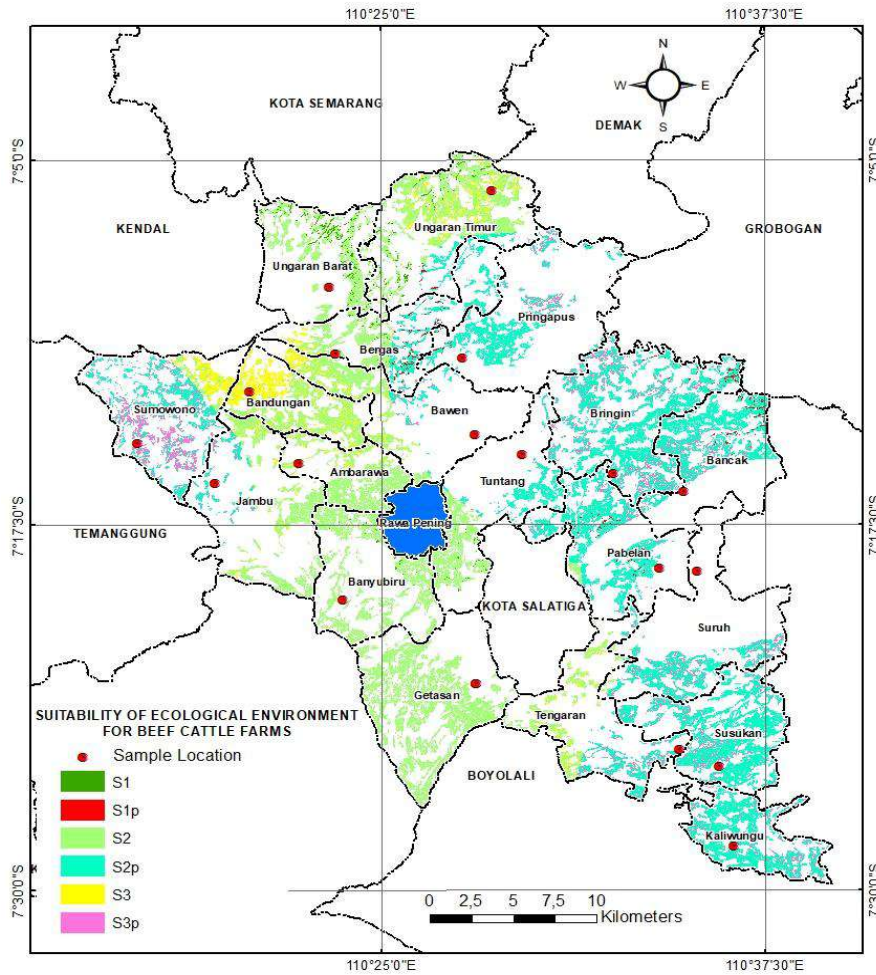
532 Table 6. Extent of suitability of ecological environment map of beef cattle farms in  
 533 Bancak, Banyubiru, and Bringin sub-districts

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
<b>TOTAL</b>		17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

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

536

537



538

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

541



1 **The Regional Analysis of Beef Cattle Farm Development in Semarang Regency**  
2

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8

9 **ABSTRACT**

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

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

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

30

31

### INTRODUCTION

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

42 Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009;  
43 Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able  
44 to meet the high meat consumption of people. The consumption of beef in 2020 is  
45 estimated to reach 3.36 kg per capita per year, but beef production is still not able to fulfill  
46 it; there is a deficit in beef supply by 198,350 tons (Kementan, 2016; Agus & Widi, 2018).  
47 Most of the beef production in Indonesia, 78% comes from traditional livestock, 5% from  
48 imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al.*,  
49 2017). Imports of beef are indeed relatively larger compared to the other types of meat

50 imports, contributing 21.44% to the total import value of livestock, while the import value  
51 of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al.*,  
52 2014).

53 Policy efforts to reduce beef imports must be studied, by strengthening domestic  
54 production that is beneficial for farmers (Pasandaran *et al.*, 2014). The development of  
55 beef cattle farms in potential areas is an effort to strengthen meat production in the country  
56 so that the implementation must be carried out with a comprehensive assessment.  
57 Semarang Regency is a region in Central Java Province that has the potential to develop  
58 beef cattle farms because it has natural resources in the form of land as a place for  
59 livestock keeping and forage production. Good quality and forage availability can  
60 increase production, especially for increasing body weight of cattle (Suhaema *et al.*,  
61 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha),  
62 rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this  
63 region during the 2014-2016 period continued to decline, ranging from 53,135; 49,172;  
64 and 46,238 (BPS Kabupaten Semarang, 2018).

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

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

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

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

91

92

#### **MATERIALS AND METHODS**

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

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

### 100 **Leading Commodity**

101 Determination of leading livestock commodities in an area used Location Quotient  
 102 (LQ) and Shift Share (SS) analysis. The rationale for the two methods was the economic  
 103 basis theory. LQ analysis was relatively simple, but the benefits were large enough for  
 104 the initial identification of the ability of a sector in regional development. The shift in the  
 105 structure of economic activity in beef cattle business, whether experiencing growth or  
 106 decline was analyzed using Shift Share (SS). SS analysis can be used to see the growth  
 107 of the economic sectors of a region for two-time points (Muta'ali, 2015). LQ and SS  
 108 analysis used the following equations (Ciptayasa *et al.*, 2016; Mulyono & Munibah,  
 109 2016).

$$110 \text{ LQ}_{ij} = \frac{X_{ij} / X_i}{X_j / X_{..}} \text{ (Equation 1)}$$

111 ( $X_{ij}$  = Beef cattle population in the sub-district A,  $X_i$  = Population of all types of livestock in the sub-  
 112 district A,  $X_j$  = Beef cattle population in Semarang Regency,  $X_{..}$  = Population of all types of livestock in  
 113 Semarang Regency).

$$114 \text{ SS} = \left[ \frac{X_{..}(t1)}{X_{..}(t0)} - 1 \right] + \left[ \frac{X_i(t1)}{X_i(t0)} - \frac{X_{..}(t1)}{X_{..}(t0)} \right] + \left[ \frac{X_{ij}(t1)}{X_{ij}(t0)} - \frac{X_i(t1)}{X_i(t0)} \right] \text{ (Equation 2)}$$

115 (Regional share, Proportional shift, Differential shift,  $X_{..}$  = Population of all types of livestock in Semarang  
 116 Regency,  $X_i$  = Beef cattle population in Semarang Regency,  $X_{ij}$  = Beef cattle population in sub-district A,  
 117  $t_0$  = Early 2013 year point,  $t_1$  = End of year 2017).

118

### 119 **Carrying Capacity and Carrying Capacity Index of Forage**

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

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

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

133 Potential of agricultural waste (ton) =  $\{(wr \times 0.4) + (fr \times 3 \times 0.4) + (cn \times 3 \times 0.5) + (sb \times$   
 134  $3 \times 0.55) + (pt \times 2 \times 0.55) + (sp \times 0.25/6) + (cs \times 0.25/4)\} \times 0.65$   
 135 (wr is wetland rice, fr is field rice, cn is corn, sb is soybean, pt is peanuts, sp is sweet  
 136 potatoes, cs is cassava. The numbers in the formula are assumptions about the potential  
 137 waste produced from the production of each type of plant food).

138 Natural forage potential (ton) =  $\{(Ga \times 2.875) + (Fa \times 0.6) + (Cpa \times 10) + (Cfa \times 0.5) +$   
 139  $(Cla \times 5)\} \times 0.5$   
 140 (Ga is garden area, Fa is forest area, Cpa is coconut plant area, Cfa is coffee plant area,  
 141 Cla is clove plant area. The numbers in the formula are assumed to be natural forage  
 142 potential produced per hectare of land use area).

143 Minimum cattle feed requirements (R) =  $2.5\% \times 50\% \times 365 \times 400 \text{ kg} = 1.82 \text{ ton}$   
 144 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).  $2.5\% \times 50\% = 0.0125$  atau  $1.25\%$

$1.25\% \times 365 \times 400 = 1,825 \text{ kg} = 1.82 \text{ Ton DDM/year/AU}$

145 (R is minimum cattle feed requirements (1 AU) in tons of digestible dry matter  
 146 for 1 year, 2.5% is minimum requirement for the number of forage rations (dry matter)  
 147 on livestock weight, 50% is average value digestibility power of various types of plants,  
 148 365 is number of days in 1 year, 400 kg is live weight of 1 AU of beef cattle in Semarang  
 149 Regency). Equations that refer to Suhaema *et al.* (2014) and Yuniar *et al.* (2016).

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

153 
$$CC (AU) = \frac{\text{Forage Dry Matter Production (tons of DDM / year)}}{\text{Minimum Cattle Feed Requirement (tons of DDM / year / AU)}} \text{ (Equation 4)}$$

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

158 
$$\text{Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \text{ (Equation 5)}$$

159

160 **Suitability of the Ecological Environment of Beef Cattle**

161 The research sample for the assessment of the suitability ecological environment  
 162 of beef cattle farms in Semarang Regency was 19 points spreading throughout the sub-  
 163 district area (Table 5). The determination of the sample was using purposive sampling  
 164 technique. The purposive sampling technique was also called judgment sampling  
 165 (Tongco, 2007), which was used to determine the sample based on research  
 166 considerations. In each sub-district, one village was taken which had the most beef cattle  
 167 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.

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

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

183

184



## RESULTS

### Leading Commodity

185  
186  
187 The leading commodity of livestock in an area was determined based on  
188 comparative advantage (location quotient analysis) and competitive advantage (shift-  
189 share analysis). Beef cattle commodities that had  $LQ > 1$  and SS (+) values were the  
190 leading commodities in the region. The interpretation of the value of  $LQ > 1$ , was a base  
191 or leading sector, beef cattle products (meat) were able to meet markets inside and outside  
192 the region. The value of  $LQ < 1$  implied a non-base sector, livestock products had not been  
193 able to meet markets inside and outside the region. The value of  $LQ = 1$  implied that the  
194 sector was balanced with the reference region, livestock products were only able to meet  
195 markets in the area. The basis for calculating LQ analysis for livestock commodities was  
196 livestock population data (Hendayana, 2003). Data bias in calculations could be  
197 minimized by using a minimum 5 year data series (Table 2).

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

206 The results of the LQ and SS analysis calculations for beef cattle commodities in  
207 Semarang Regency are shown in Table 3. Based on the results of the analysis conducted,  
208 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.

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

212 Beef cattle commodities that had competitive advantages were seen based on  
213 positive shift-share (SS) values. Sub-districts with a positive SS value means  
214 experiencing growth (competitiveness) related to keeping beef cattle. On the other hand,  
215 sub-districts with negative SS value means that the area is not growing (stagnant) and can  
216 even experience setbacks. The results of the analysis conducted in Table 3 showed that  
217 sub-districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47),  
218 Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tenganan  
219 (0.026).

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

223

#### 224 **Carrying Capacity and Carrying Capacity Index of Forage**

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

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

234 Based on the results of the analysis conducted in Table 4, it was known that there  
235 were three sub-districts with the highest production of forage dry matter, namely Bringin  
236 (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons  
237 DDM). Sub-district area with the lowest forage dry matter production was Bandungan  
238 (4,327.55 tons DDM). The status of the availability of forage in Bandungan sub-district  
239 was categorized as very critical (0.82), while in Tengaran sub-district it was categorized  
240 as vulnerable (1.69). Therefore, these two sub-districts are not recommended for the  
241 development of beef cattle farms. Sub-district areas with carrying capacity index value  
242 >2 (safe) means that the areas can be recommended for the development of beef cattle  
243 farms. The advantage obtained by the area with this safe category is that farmers can  
244 reduce the amount of production costs for beef cattle feed.

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

248

### 249 The Suitability of Ecological Environment of Beef Cattle

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

**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).

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

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

272 Based on the results of the analysis conducted in Table 6, the sub-districts with  
 273 the largest land area for the development of beef cattle farms with intensive production  
 274 systems were Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru (1,451.2 Ha).  
 275 The limiting factor in the form of temperature humidity index (THI) or water pH can be  
 276 minimized through the engineering design of livestock housing and the provision of  
 277 materials or neutralizing water acidity solvent (Yani *et al.*, 2007; Sarwanto & Hendarto,  
 278 2011). Cattle with intensive production systems are generally more susceptible to heat  
 279 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.

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

283

284

#### **DISCUSSION**

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

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

304 The concept of comparative advantage is economic feasibility. Commodities that have a  
305 comparative advantage ( $LQ > 1$ ) show that the commodity (beef cattle) is supported by the  
306 existence of adequate natural resources so that the population level is higher than in other  
307 regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a  
308 prominent or dominant livestock business compared to the other livestock businesses, so  
309 the effort for future development is easier (Yuniar *et al.*, 2016; Mulyono & Munibah,  
310 2016). On the other hand, the concept of competitive advantage is financial feasibility.  
311 Beef cattle commodities are keeping in effective and efficient ways so that they have  
312 competitiveness from the aspects of quality, quantity, continuity, and price (Muta'ali,  
313 2015; Mulyono & Munibah, 2016). The results presented in Table 3 show that the  
314 Bringin, Bancak, and Banyubiru sub-districts are regions with a leading commodity of  
315 beef cattle. Accordingly, the three sub-districts are a priority for the development of beef  
316 cattle farms in Semarang Regency.

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

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

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

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

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

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

362 **CONCLUSION**

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

374 **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:  $5760 \times 3 \times 0.5 = 8640 \text{ ton} / 1.82 = 4747 \text{ AU}$ . 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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506 Table 1. Environmental parameters that influence the growth of beef cattle with intensive  
 507 maintenance patterns

Parameter	Order of environmental suitability of beef cattle	
	S (Suitable)	N (Unsuitable)
<i>Temperature Humidity Index</i> (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

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

509 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

510 Source: (BPS Kabupaten Semarang, 2018).

511

512 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

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

515

516



517 Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency  
 518 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	

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

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527 Table 5. Results of measurements of environmental factors that influence the growth of  
 528 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

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

530

531

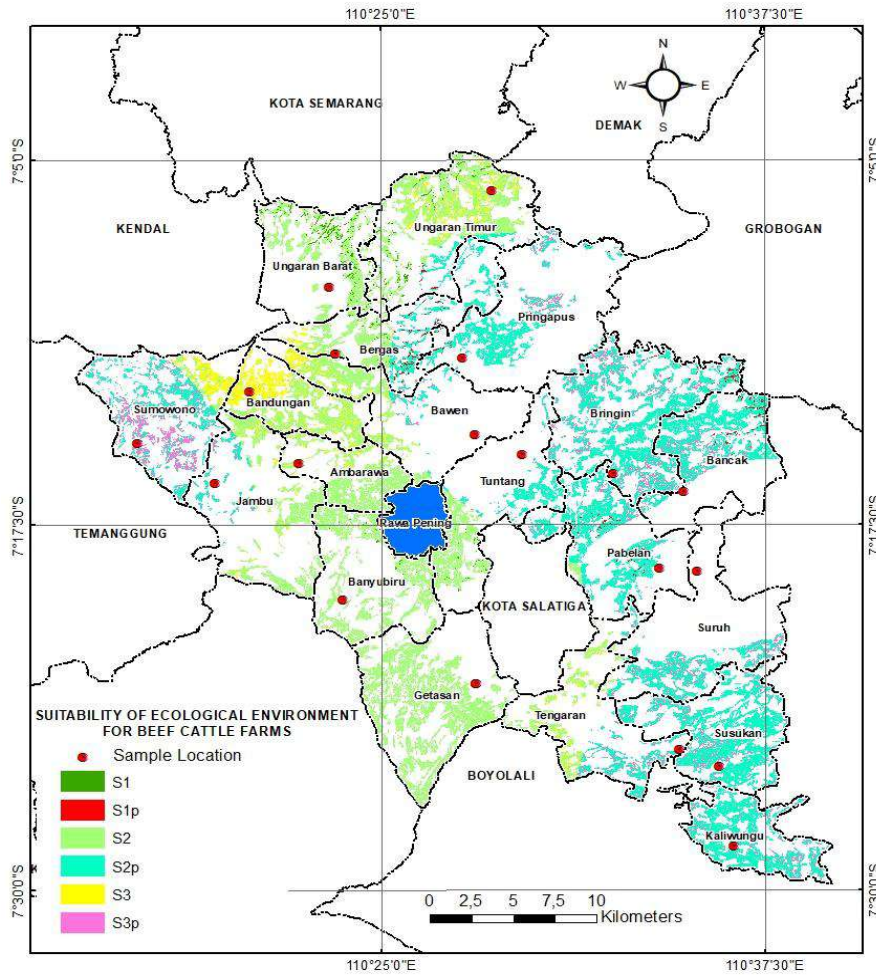
532 Table 6. Extent of suitability of ecological environment map of beef cattle farms in  
 533 Bancak, Banyubiru, and Bringin sub-districts

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
<b>TOTAL</b>		17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

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

536

537



538

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

541

1 **The Regional Analysis of Beef Cattle Farm Development in Semarang Regency**  
2

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8

9 **ABSTRACT**

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

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

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

30

31

### INTRODUCTION

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

42 Cattle farmings in Indonesia are categorized as unsustainable (Syarifuddin, 2009;  
43 Sutanto & Hendraningsih, 2011). The number of available beef cattle has not been able  
44 to meet the high meat consumption of people. The consumption of beef in 2020 is  
45 estimated to reach 3.36 kg per capita per year, but beef production is still not able to fulfill  
46 it; there is a deficit in beef supply by 198,350 tons (Kementan, 2016; Agus & Widi, 2018).  
47 Most of the beef production in Indonesia, 78% comes from traditional livestock, 5% from  
48 imports, and 17% from live livestock imports, especially from Australia (Zakiah *et al.*,  
49 2017). Imports of beef are indeed relatively larger compared to the other types of meat

50 imports, contributing 21.44% to the total import value of livestock, while the import value  
51 of livestock is 18.29% of the total value of agricultural imports nationally (Rouf *et al.*,  
52 2014).

53 Policy efforts to reduce beef imports must be studied, by strengthening domestic  
54 production that is beneficial for farmers (Pasandaran *et al.*, 2014). The development of  
55 beef cattle farms in potential areas is an effort to strengthen meat production in the country  
56 so that the implementation must be carried out with a comprehensive assessment.  
57 Semarang Regency is a region in Central Java Province that has the potential to develop  
58 beef cattle farms because it has natural resources in the form of land as a place for  
59 livestock keeping and forage production. Good quality and forage availability can  
60 increase production, especially for increasing body weight of cattle (Suhaema *et al.*,  
61 2014). Forage producing areas in Semarang Regency include gardens (25,562.04 Ha),  
62 rice fields (23,745.96 Ha), and forests (6,032.77 Ha). The beef cattle population in this  
63 region during the 2014-2016 period continued to decline, ranging from 53,135; 49,172;  
64 and 46,238 (BPS Kabupaten Semarang, 2018).

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

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

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

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

91

92

#### **MATERIALS AND METHODS**

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

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

### 100 **Leading Commodity**

101 Determination of leading livestock commodities in an area used Location Quotient  
 102 (LQ) and Shift Share (SS) analysis. The rationale for the two methods was the economic  
 103 basis theory. LQ analysis was relatively simple, but the benefits were large enough for  
 104 the initial identification of the ability of a sector in regional development. The shift in the  
 105 structure of economic activity in beef cattle business, whether experiencing growth or  
 106 decline was analyzed using Shift Share (SS). SS analysis can be used to see the growth  
 107 of the economic sectors of a region for two-time points (Muta'ali, 2015). LQ and SS  
 108 analysis used the following equations (Ciptayasa *et al.*, 2016; Mulyono & Munibah,  
 109 2016).

$$110 \text{LQ}_{ij} = \frac{X_{ij} / X_i}{X_j / X_{..}} \text{(Equation 1)}$$

111 ( $X_{ij}$  = Beef cattle population in the sub-district A,  $X_i$  = Population of all types of livestock in the sub-  
 112 district A,  $X_j$  = Beef cattle population in Semarang Regency,  $X_{..}$  = Population of all types of livestock in  
 113 Semarang Regency).

$$114 \text{SS} = \left[ \frac{X_{..}(t1)}{X_{..}(t0)} - 1 \right] + \left[ \frac{X_i(t1)}{X_i(t0)} - \frac{X_{..}(t1)}{X_{..}(t0)} \right] + \left[ \frac{X_{ij}(t1)}{X_{ij}(t0)} - \frac{X_i(t1)}{X_i(t0)} \right] \text{(Equation 2)}$$

115 (Regional share, Proportional shift, Differential shift,  $X_{..}$  = Population of all types of livestock in Semarang  
 116 Regency,  $X_i$  = Beef cattle population in Semarang Regency,  $X_{ij}$  = Beef cattle population in sub-district A,  
 117  $t_0$  = Early 2013 year point,  $t_1$  = End of year 2017).

118

### 119 **Carrying Capacity and Carrying Capacity Index of Forage**

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



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

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

133 Potential of agricultural waste (ton) =  $\{(wr \times 0.4) + (fr \times 3 \times 0.4) + (cn \times 3 \times 0.5) + (sb \times$   
 134  $3 \times 0.55) + (pt \times 2 \times 0.55) + (sp \times 0.25/6) + (cs \times 0.25/4)\} \times 0.65$   
 135 (wr is wetland rice, fr is field rice, cn is corn, sb is soybean, pt is peanuts, sp is sweet  
 136 potatoes, cs is cassava. The numbers in the formula are assumptions about the potential  
 137 waste produced from the production of each type of plant food).

138 Natural forage potential (ton) =  $\{(Ga \times 2.875) + (Fa \times 0.6) + (Cpa \times 10) + (Cfa \times 0.5) +$   
 139  $(Cla \times 5)\} \times 0.5$   
 140 (Ga is garden area, Fa is forest area, Cpa is coconut plant area, Cfa is coffee plant area,  
 141 Cla is clove plant area. The numbers in the formula are assumed to be natural forage  
 142 potential produced per hectare of land use area).

143 Minimum cattle feed requirements (R) =  $2.5\% \times 50\% \times 365 \times 400 \text{ kg} = 1.82 \text{ ton}$   
 144 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).  $2.5\% \times 50\% = 0.0125$  atau  $1.25\%$

$1.25\% \times 365 \times 400 = 1,825 \text{ kg} = 1.82 \text{ Ton DDM/year/AU}$

145 (R is minimum cattle feed requirements (1 AU) in tons of digestible dry matter  
 146 for 1 year, 2.5% is minimum requirement for the number of forage rations (dry matter)  
 147 on livestock weight, 50% is average value digestibility power of various types of plants,  
 148 365 is number of days in 1 year, 400 kg is live weight of 1 AU of beef cattle in Semarang  
 149 Regency). Equations that refer to Suhaema *et al.* (2014) and Yuniar *et al.* (2016).

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

$$153 \text{ CC (AU)} = \frac{\text{Forage Dry Matter Production (tons of DDM / year)}}{\text{Minimum Cattle Feed Requirement (tons of DDM / year / AU)}} \text{ (Equation 4)}$$

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

$$158 \text{ Forage carrying capacity index} = \frac{\text{Carrying capacity (AU)}}{\text{Amount of Beef Cattle Population in 2017 (AU)}} \text{ (Equation 5)}$$

159

### 160 Suitability of the Ecological Environment of Beef Cattle

161 The research sample for the assessment of the suitability ecological environment  
 162 of beef cattle farms in Semarang Regency was 19 points spreading throughout the sub-  
 163 district area (Table 5). The determination of the sample was using purposive sampling  
 164 technique. The purposive sampling technique was also called judgment sampling  
 165 (Tongco, 2007), which was used to determine the sample based on research  
 166 considerations. In each sub-district, one village was taken which had the most beef cattle  
 167 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.

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

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

183

184

## 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.

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

212 Beef cattle commodities that had competitive advantages were seen based on  
213 positive shift-share (SS) values. Sub-districts with a positive SS value means  
214 experiencing growth (competitiveness) related to keeping beef cattle. On the other hand,  
215 sub-districts with negative SS value means that the area is not growing (stagnant) and can  
216 even experience setbacks. The results of the analysis conducted in Table 3 showed that  
217 sub-districts with positive SS values were in Ungaran Barat (1.286), Banyubiru (0.47),  
218 Pabelan (0.435), Bandungan (0.203), Bancak (0.077), Bringin (0.039), and Tenganan  
219 (0.026).

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

223

#### 224 **Carrying Capacity and Carrying Capacity Index of Forage**

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

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

234 Based on the results of the analysis conducted in Table 4, it was known that there  
 235 were three sub-districts with the highest production of forage dry matter, namely Bringin  
 236 (28,808.63 tons DDM), Pringapus (23,509.36 tons DDM), and Suruh (19,522.03 tons  
 237 DDM). Sub-district area with the lowest forage dry matter production was Bandungan  
 238 (4,327.55 tons DDM). The status of the availability of forage in Bandungan sub-district  
 239 was categorized as very critical (0.82), while in Tengaran sub-district it was categorized  
 240 as vulnerable (1.69). Therefore, these two sub-districts are not recommended for the  
 241 development of beef cattle farms. Sub-district areas with carrying capacity index value  
 242 >2 (safe) means that the areas can be recommended for the development of beef cattle  
 243 farms. The advantage obtained by the area with this safe category is that farmers can  
 244 reduce the amount of production costs for beef cattle feed.

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

248

### 249 The Suitability of Ecological Environment of Beef Cattle

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

**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).

## TASJ-1928

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

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

272 Based on the results of the analysis conducted in Table 6, the sub-districts with  
273 the largest land area for the development of beef cattle farms with intensive production  
274 systems were Bringin (2,758.86 Ha), Bancak (1,550.08 Ha), and Banyubiru (1,451.2 Ha).  
275 The limiting factor in the form of temperature humidity index (THI) or water pH can be  
276 minimized through the engineering design of livestock housing and the provision of  
277 materials or neutralizing water acidity solvent (Yani *et al.*, 2007; Sarwanto & Hendarto,  
278 2011). Cattle with intensive production systems are generally more susceptible to heat  
279 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.

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

283

284

#### **DISCUSSION**

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

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



304 The concept of comparative advantage is economic feasibility. Commodities that have a  
305 comparative advantage ( $LQ > 1$ ) show that the commodity (beef cattle) is supported by the  
306 existence of adequate natural resources so that the population level is higher than in other  
307 regions (Mulyono & Munibah, 2016). Beef cattle commodity in the base sub-district is a  
308 prominent or dominant livestock business compared to the other livestock businesses, so  
309 the effort for future development is easier (Yuniar *et al.*, 2016; Mulyono & Munibah,  
310 2016). On the other hand, the concept of competitive advantage is financial feasibility.  
311 Beef cattle commodities are keeping in effective and efficient ways so that they have  
312 competitiveness from the aspects of quality, quantity, continuity, and price (Muta'ali,  
313 2015; Mulyono & Munibah, 2016). The results presented in Table 3 show that the  
314 Bringin, Bancak, and Banyubiru sub-districts are regions with a leading commodity of  
315 beef cattle. Accordingly, the three sub-districts are a priority for the development of beef  
316 cattle farms in Semarang Regency.

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

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

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

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

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

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

362 **CONCLUSION**

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

374 **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:  $5760 \times 3 \times 0.5 = 8640 \text{ ton} / 1.82 = 4747 \text{ AU}$ . 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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506 Table 1. Environmental parameters that influence the growth of beef cattle with intensive  
 507 maintenance patterns

Parameter	Order of environmental suitability of beef cattle	
	S (Suitable)	N (Unsuitable)
<i>Temperature Humidity Index</i> (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

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

509 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

510 Source: (BPS Kabupaten Semarang, 2018).

511

512 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

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

515

516

517 Table 4. Carrying capacity and carrying capacity index of forage in Semarang Regency  
 518 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	

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

524

525

526

527 Table 5. Results of measurements of environmental factors that influence the growth of  
528 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

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

530

531

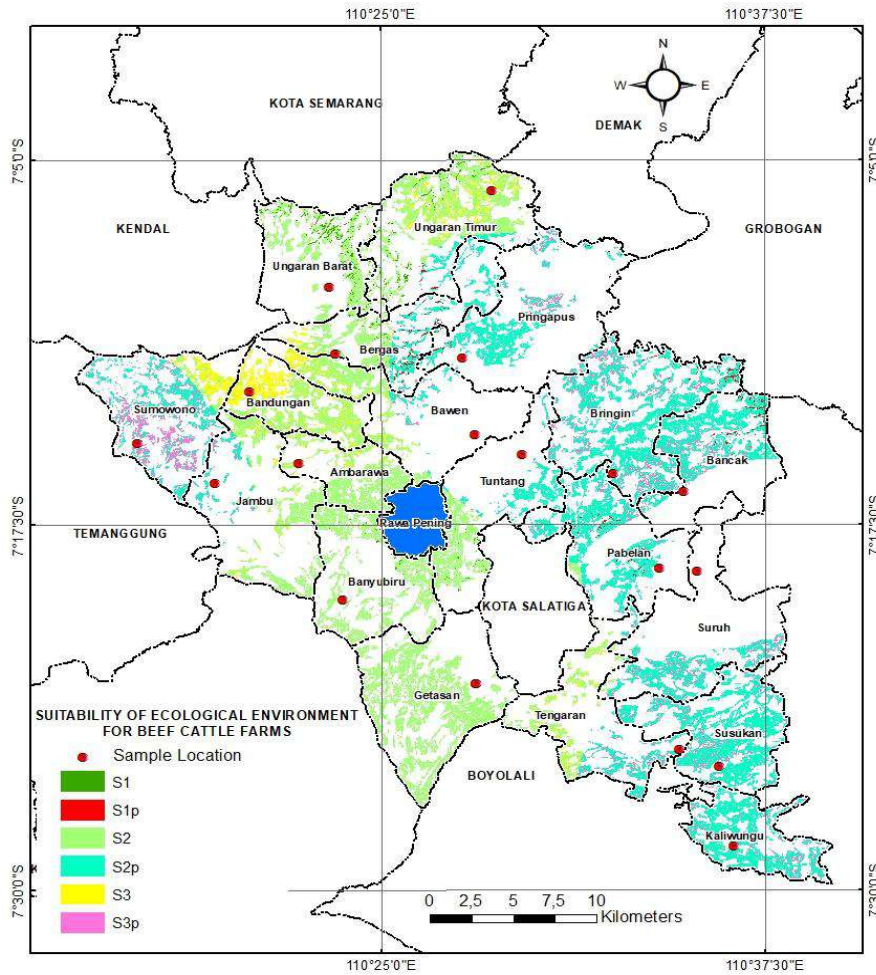
532 Table 6. Extent of suitability of ecological environment map of beef cattle farms in  
533 Bancak, Banyubiru, and Bringin sub-districts

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
<b>TOTAL</b>		17.10	76.27	1,434.16	3,669.67	0	562.94	5,760.141

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

536

537



538

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

541



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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 livestock 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. Sustainable 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).

$$LQ_{ij} = (X_{ij} / X_i) / (X_j / X_{..}) \text{ (Equation 1)}$$

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).

$$SS = [(X_{..}(t1)) / (X_{..}(t0)) - 1] + [(X_i(t1)) / (X_i(t0)) - (X_{..}(t1)) / (X_{..}(t0))] + [(X_{ij}(t1)) / (X_{ij}(t0)) - (X_i(t1)) / (X_i(t0))] \text{ (Equation 2)}$$

(Regional share, Proportional shift, Differential shift,  $X_{..}$  is Population of all types of livestock in Semarang Regency,  $X_i$  is Beef cattle population in Semarang Regency,  $X_{ij}$  is Beef cattle population in sub-district A,  $t_0$  is Early 2013 year point, and  $t_1$  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).

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

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

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)=  
 $2.5\% \times 50\% \times 365 \times 400 \text{ kg} = 1.82 \text{ ton DDM/year/AU}$   
 (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 ( $\leq 1$ ), critical ( $>1-1.5$ ), vulnerable ( $> 1.5-2$ ), and safe ( $>2$ ).

Forage carrying capacity index=  
 $\text{Carrying capacity (AU)} / \text{Amount of beef cattle population in 2017 (AU)}$   
 (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 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 Tenganan (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	Tenganan	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 Tenganan 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
Tenganan	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= vulnerable, 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	Plumpakan	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.

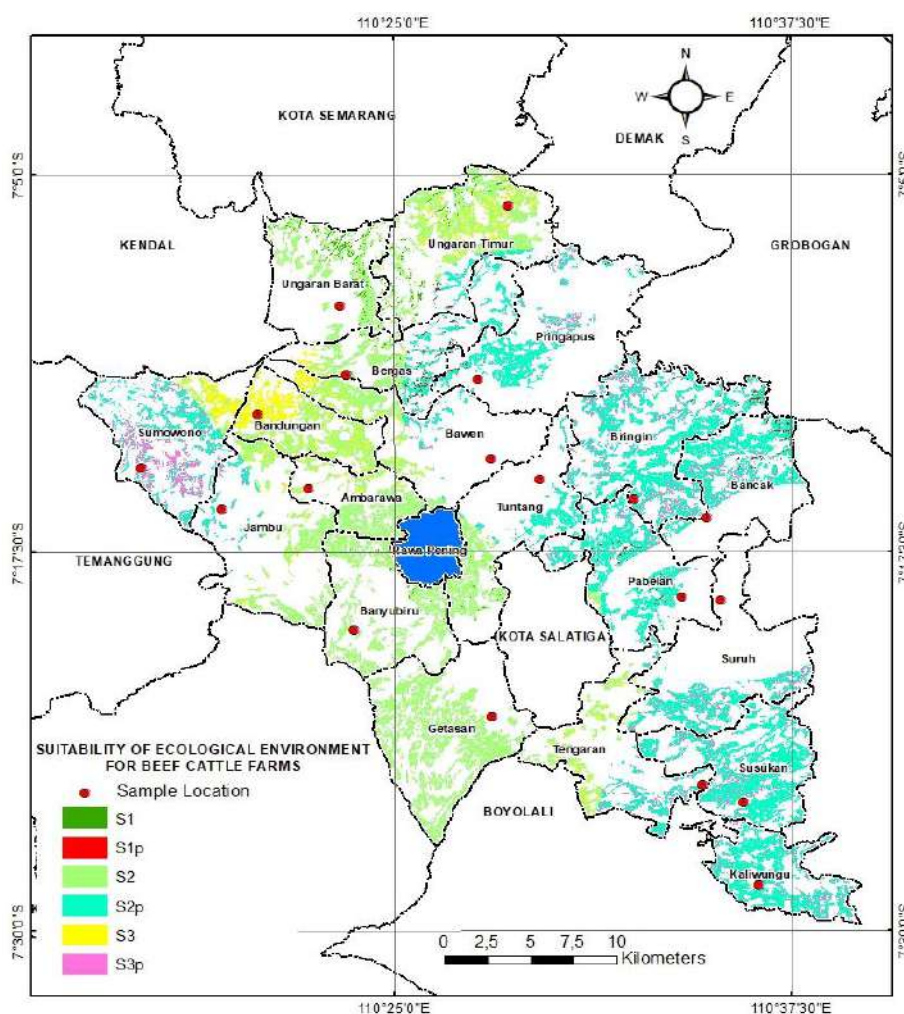


Figure 2. The suitability of ecological environment map for beef cattle farms in Semarang Regency

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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