Analysis of land suitability for Aceh cattle based on environmental physical characteristics (case study in Aceh Besar district)

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Abstract. The excellent germplasm of Aceh cattle, which are an important genetic resource for local breeds in Indonesia, need to be protected and preserved to maintain their population. Animals can reach optimal physical conditions, if they are allowed to grow in areas with a suitable environmental. The purpose of this study is to evaluate the topography of different areas to determine land suitability for different breeds of cattle in Aceh, Indonesia. This article discusses concepts of land suitability and its potential as a tool to measure the success of animal husbandry. The focus of evaluation of this method is by combining various geographical GIS information, including spatial for kinds of soils, land elevation, slope, climate, rainfall and temperature, with the FAO standard in order to determine land suitability. For approval of the function of this application, it is required to analyze the geospatial data arranged based on FAO standards for land suitability. The results of the study indicated that about 96.48% of all areas in Aceh Besar district were categorized as suitable (S) for the area of cattle Aceh (orders) and only 3.52% of the areas were not suitable (N) for cattle.

1. Introduction

Aceh cattle is one of the local breeds of cattle in Indonesia that has original geographical distribution in the Aceh Province and was domesticated many years ago. Aceh cattle is a source of animal genetic wealth in Indonesia and should be preserved and protected based on the Decision Letter of the Ministry of Agriculture No. 2907/Kpts/OT.140/6/2011 on 17 June 2011 [1]. In order to fulfill the needs of Aceh cattle, the Indonesian National Standard (SNI) 7651.3:2013 has been appointed as a guideline to determine the quality of Aceh cattle [2]. The primacy of Aceh cattle is highly adaptable at marginal environments, extreme temperatures, low quality feed, resistance to some diseases such as worms, bacteria and high fertility. Aceh cattle are also able to grow and proliferate on marginal land with poor qualities of pasture. Aceh cattle can grow in coastal areas (brackish), from low to high land areas, forests, and various kinds of swamp ecosystems and natural pastures [3].

The Aceh Besar district is one of the district administrative areas in the Aceh Province, Indonesia with the geographical position of 5.05-5.75 north latitude and 94.99- 95.93 east longitude. This district...
is located in a tropical zone with various topography consisting of coastal, lowland, hill and mountainous areas [4]. Animals will express their optimal conditions, if it is supported by a suitable physical environment in which the animals can continuously grow and breed over their entire life cycle. Before raising animals in any location, one should consider land suitability; which is an important strategy in making use of the optimal natural resources. It is also important to have a basic understanding of the natural land characteristics and animals’ habits [5].

Geographic Information System (GIS) is an important tool that can be applied to evaluate land suitability. GIS can be used to map evaluation results of land suitability and present its result in land suitability mapping. This map indicates geographically spatial distributions including suitable characteristics of land anywhere on the planet [6]. The evaluation results were classified according to suitable class and sub-class based on the constrain factors [7].

The purpose of this study is to evaluate topography of study areas to determine land suitability for Aceh cattle. The focus of this study is applying GIS to handle spatial data according to FAO standards for suitability of land [8]. To make sure this application functions well, it requires geospatial analyses that are arranged according to soil characteristics, elevation, slope, climate, rainfall, and temperature which is observed and measured for the appropriate physical environments required for Aceh cattle to thrive.

2. Material and methods

This study was conducted at the Remote Sensing and Cartography Laboratory, located in the Faculty of Agriculture, at the Universitas Syiah Kuala, in the Aceh Besar District, from January to June 2020.

The equipment and materials for this study were as follows: a computer with QGIS 3.10.8 software [9], and an Aceh Besar District Map which included information pertaining to land use, soil types, elevation, slope, climate, rainfall and temperature [10][11][12]. Evaluation of physical environment characteristics was performed by using difference sources of compiled criteria as presented in the Table 1.

| Parameters | Class Suitability |
|------------|------------------|
|            | S1 | S2 | S3 | N  |
| Agro-climate (w) |     |     |    |    |
| - Dry Month (<100mm)[8][13] | 0 - 6 month | >6 - 7 month | >7 - 8 month | >8 month |
| - Rainfall/year (mm)[8][13][14] | 1.500 - 3.000 | 1.000 - <1.500 | 750 - <1.000 | <750 |
| - The average of temperature (°C) |     |     |    |    |
| [8][15][16] | 18 - 28 | 13 - <18 | 10 - <13 | <10 |
| Terrain (s) |     |     |    |    |
| - Slope (%)[8][16][17] | 0 - 15 | >15 - 25 | >25 - 40 | >40 |
| - Elevation (m.a.s.l)[8][16] | 0 - 500 | >500 - 1.000 | >1.000 - 1.500 | >1.500 |
| Soil Types[8][16] | fertile | moderate | not fertile |    |

Sources: [8][13][14][15][16][17] with modification
Note: S1: highly suitable, S2: moderately suitable, S3: marginally suitable and N: not suitable

The parameters applied in this study are for agro-climate (dry month, rainfall and temperature), terrain conditions (slope and elevation) and soil types. Overlay was performed with the spatial by using a GIS digital map. Matching method [18] was carried out between physical land elements in Aceh Besar district in minimal barriers.
Areas for development for the raising of Aceh cattle can be determined based on union overlay of physical environment suitability between maps for the whole parameters including dry month, rainfall and temperature, terrain condition (slope and elevation) and soil types. By overlaying both parameters, physically environmental suitability can be determined.

The suitability of a land unit refers to its fitness for a defined use. There are four levels of suitability in the classification: land suitability orders, classes, subclasses and units. These categories are applied at all degrees of detail for evaluation, and are assessed separately for each land use in every land unit in the study area [19, 25].

3. Result and discussion

3.1. Orders for land suitability

Land suitability orders separate land units assessed as suitable from those that are not suitable for a given land use. There are two orders: suitable (S) and not suitable (N) [8]. To get the land suitability distribution at the order level, namely S (suitable) and N (not suitable) in the study area, an analysis was carried out using the Geographical Information System GIS. Approach of GIS is by performing queries, matching and overlay (union) between the attributes of the map of the physical elements of the environment for Aceh cattle consisting of soil type maps, elevation maps, slope maps, climate maps, rainfall maps and temperature maps with environmental suitability criteria that have been prepared by assessing climatic conditions, terrain and soil types.
The results of orders analysis for land suitability is presented in the Table 2. The result of the study indicated that most of the areas 278,109.30 ha (96.48%) was categorized as suitable area for development of Aceh cattle raising and only area 10,151.57 ha (3.52%) was categorized as not suitable (N) for development of Aceh cattle raising. Land suitability distribution is shown in the Figure 2.

Table 2. Distribution of physical environment suitability of Aceh cattle raising based on orders in Aceh Besar District.

| No | Land suitability orders | Hectare       | Percent |
|----|-------------------------|---------------|---------|
| 1  | S (Suitable)            | 278109.30     | 96.48   |
| 2  | N (Not suitable)        | 10151.57      | 3.52    |
| Total |                      | 288260.87     | 100.00  |

Figure 2. Map for land suitability for Aceh cattle raising based on orders in Aceh Besar District.

3.2. Classes for land suitability

Land suitability classes indicate degrees of suitability. Within the order ‘suitable’ there are normally three classes: highly, moderately and marginally suitable, indicated by the symbols S1, S2 and S3 respectively. The boundaries between these classes are in terms of lessening degrees of suitability [8].

The analysis results for physical environment suitability of Aceh cattle is presented in Table 3. The results indicated that the areas for development of Aceh cattle raising in Aceh Besar were 160,633.66 ha (55.73%), 60,851,73 ha (21.11%), 56,623.91 ha (19.64%) and 10,151.57 ha (3.52%) for S2, S1, S3 and N respectively. Distribution of physical environment suitability of Aceh cattle is presented in Figure 3.

Table 3. Distribution of physical environment suitability of Aceh cattle raising based on classes in the Aceh Besar District.

| No | Land suitability classes   | Hectare       | Percent |
|----|----------------------------|---------------|---------|
| 1  | Class S1 (highly suitable) | 60851.73      | 21.11   |
| 2  | Class S2 (moderately suitable) | 160633.66     | 55.73   |
| 3  | Class S3 (marginally suitable) | 56623.91      | 19.64   |
| 4  | N (not suitable)           | 10151.57      | 3.52    |
| Total |                          | 288260.87     | 100.00  |
3.3. Subclasses for land suitability

Land suitability subclasses reflect the kinds of improvement measures required within classes, such as soil type, elevation and slope. They are indicated by lower case letters, e.g. Subclasses S2s, S2h, S3g. There are no subclasses to class S1 and there is no limit to the number of subclass symbols that can be used in a particular evaluation [8].

The subclasses results for physical environment suitability of Aceh cattle is presented in Table 4 while those of spatial analysis can be seen in Figure 4.

Table 4. Distribution of physical environment suitability of Aceh cattle raising based on subclasses in Aceh Besar District.

| Subclasses – Constraints Factors | Hectare | Percent |
|----------------------------------|---------|---------|
| S1                               | 60851.73| 21.11   |
| S2 s                             | 50207.12| 17.42   |
| S2 sh                            | 10260.89| 3.56    |
| S2 sg                            | 6413.98 | 2.23    |
| S2 sw                            | 882.87  | 0.31    |
| S2 shg                           | 10129   | 3.51    |
| S2 h                             | 21319.48| 7.40    |
| S2 hg                            | 12366.1 | 4.29    |
| S2 hw                            | 4419.69 | 1.53    |
| S2 hgw                           | 2282.4  | 0.79    |
| S2 g                             | 5597.94 | 1.94    |
| S2 w                             | 35400.73| 12.28   |
| S2 gw                            | 1353.46 | 0.47    |
| S3 s                             | 36556.01| 12.68   |
| S3 g                             | 2470.01 | 0.86    |
| S3 w                             | 16549.78| 5.74    |
| S3 sg                            | 1048.11 | 0.36    |
| N h                              | 5387.54 | 1.87%   |
| N g                              | 4537.87 | 1.57%   |
| N hg                             | 226.16  | 0.08%   |

Note: S1: highly suitable, S2: moderately suitable, S3: marginally suitable and N: not suitable

s = soil type; h = elevation; g = slope; w = climate
Figure 4. Map for land suitability for Aceh cattle raising based on subclasses in Aceh Besar District.

The Aceh Besar District, which is the area highlighted in this study, is located close to the equator. This region is classified as a tropical region, as generally Indonesia has only two seasons; namely the dry season, which lasts from April to the month of August, and the rainy season from September to February. The Aceh Besar District has a varied topography which consists of coastlines, lowlands, hills and mountains [4].

The results of the analysis in the study area show that almost all areas are physically very suitable environments for Aceh cattle to thrive. This is in line with the results of previous research which stated that Aceh cattle are one of the local cattle types suitable for development in Indonesia. [1], [3], [20]-[24]. The original geographic distribution of these cattle is in the Aceh Province, where they have been cultivated from generation to generation [1].

4. Conclusion
This study concluded that most of the area in Aceh Besar district (96.48%) was suitable for the development of Aceh cattle raising, based on orders in Aceh Besar. Conversely 3.52% was not suitable for development of Aceh cattle raising based on orders in Aceh Besar.

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Acknowledgments
This article is part of the thesis for magister program at the Animal Husbandry Department of Universitas Syiah Kuala. I would like to thank all the people who supported the finalizing of this article.