GIS-based agroecological assessment of land suitability for food crop development at a regional scale: A study case of Buton Island.

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Abstract. Agriculture has long become a prime sector for regional development in Buton Island, although local government emphasis on perennial crops. Food crop have been developed in very limited land areas, mainly on transmigration areas, as parts of central government programs. Today, the central government has launched a national strategic program on food self-sufficiency and has imposed the local government to optimize available land for cultivating food crop. The primary aim of study is to develop rapid assessment on a spatial basis using GIS for agricultural land suitability evaluation of agriculture commodities, i.e., rice (irrigated paddy field, rainfed rice) and corn (Zea maize L.). The study was undertaken using the following procedures: (i) conducting reconnaissance soil survey based on land units; (ii) constructing soil database in a GIS; and (iii) classifying land suitability using the FAO method. Spatial data were generated from digital topographic map, soil survey, soil characteristics, as well as climate data. Preliminary results indicate that quite large area available for food crop cultivation both in the context of land suitability (mostly in S2 and S3 classes) and land availability. All data bases were managed in GIS, then it is amenable to various operations in GIS to accommodate possible additional assessment including socio-economic and policy assessment.

1. Introduction
Agricultural development program essentially needs availability of information on land resources which is clear and accurate [1, 2]. The lack of success in agricultural development is often caused by incomplete data and information on land resources. To support the agricultural development program in Buton island, it is necessary to provide reliable agroecological information. The use of land and commodity options in different areas appropriate for development can be established within a GIS. Through agroecological zone mapping activities for planned commodity zoning within a predetermined timeframe, it is hoped that a map of agroecological information and important commodity development alternatives can be generated in a more informative and interactive GIS form.

Along this frame, the local government of Buton regency has formulated development policies that emphasizing agriculture as the strategic sector, where the main activities are agriculture commodity zoning. The objective of commodity zoning, as this paper presents is to regionalize land suitability for
the importance of allocation of activities to increase the volume of yields in every part of the region in accordance with local agroecology and agroeconomics.

2. Research objectives
The purposes of research are as follows:
- Detecting, monitoring, and analysing the development of the use of food crop lands on Buton island;
- Analysing the suitability and productivity of food crop commodities in Buton island;
- Building an evaluation system, through zoning of land management units based on agroecological character, based on spatially referenced data in GIS.

3. Methodology

3.1. Research sites
The project was conducted in Buton island, Southeast Sulawesi for 8 months (April-November 2017). Laboratory analysis was conducted at Department of Soil Science, Faculty of Agriculture, Hasanuddin University and soil research station, Agriculture Department of Republic of Indonesia, Maros.

3.2. The stages of research
3.2.1. Preparation of the base map. A base map was developed from a simplified 1: 50,000 topographic maps. The base map was used later to generate the land unit and the commodity zoning map. The base map was digitized and stored in a spatial database [1].

Soil characteristics were obtained from land systems map (RePPProT map) at scale 1:250,000 [3]. Land system map was being detailed by landform approach using topographic maps which result 58 land units. Field observation and soil sampling was established on the land unit.

3.2.2. Terrain analysis. Terrain analysis was carried out from topographic maps. Land units were developed by means of topographical data namely; lithology, reliefs and slopes, elevation, and land use. Relief and slope estimated based on contour line, elevation or altitude obtained from contour lines; landform and lithology are extracted from geological maps.

The results of terrain analysis were then depicted as the base map that used as a working map for ground observation. Terrain data was acquired from DEM (digital elevation model) of SRTM (shuttle radar topography mission) which has 30 m pixel resolution. Data processing was completed to generate slope in percent unit. The procedure was started by extracting data and converting coordinate system from geographic coordinate system to UTM (Universal Transverse Mercator) coordinate system. Determination of slope unit was generated by means of geographic information system module.

3.2.3. Observation of soil in the field. Land observation in the field was conducted by transect or toposquence (A distinctive soil characteristics related to topographic situation) [2, 4]. Soil classification was determined according to Soil Survey Staff to sub-group level [5]. Field observation and soil sampling were established on the land unit. The field survey included the identification of morphological parameters such as effective depth, soil drainage, slope, soil surface rock, outcrop rock, flood frequency, and others. This stage included analysis of climate data.

3.2.4. Analysis of soil and water samples. Soil sample analysis was conducted primarily for land evaluation. Soil properties analysed include soil physics and chemical. Properties of soil physics consist of: a). soil texture, b). drainage, c). soil depth, d). rock surface, and e). inundation (flooding). Properties of soil chemical are: a). soil acidity (pH), b). base saturation, c). organic matter, d). cation exchange capacity (CEC), and e). salinity.
3.2.5. Database and data processing. Spatial data were also stored in digital form and then processed for land suitability classification. This stage consisted of activities of developing, organizing, and managing digital databases to the mapping of results.

3.2.6. Land evaluation. Land suitability analysis was conducted based on land direction technical guidance [6, 7]. Evaluated crops namely; rice paddy, paddy fields, corn, peanuts, soybeans, sweet potatoes, cassava, green beans.

4. Results and discussion

4.1. Research sites characteristics
Buton county was located in the Buton islands (Buton island and Muna island), the south-eastern island of Sulawesi. This area includes parts of Muna island and Buton island. The most widespread districts are Pasarwajo District with 356.40 km$^2$, Lasalimu District 327.29 km$^2$ and Mawasangka District with an area of 271.55 km$^2$ or 14.31%, 13.14% and 10.89% respectively of the total area of Buton Regency. Meanwhile, the smallest area was Batu Atas District which consist of 7.18 km$^2$ or 0.29% of the total area of Buton Regency.

Climatic conditions in Buton according to Schmidt and Ferguson [8], was an area of varying rain type that include type B, C and D. According to Koppen classification, the climate type is tropical rain characterized by dry months (<60 mm/month). The dry months (less rainfall 60 mm/month) between 0 to 4 months and the number of wet (rainfall over 100 mm / month) between 6 to 10 months. Average rainfall varies from 1,233 mm to 3,020 mm, the highest is in Kaongkeongkea area of 3,020 mm and the lowest around Mawasangka is 1,403 mm.

Buton Island has a more complex geological, consisting of Mesozoic red mesoxic rocks, etersier sediment, river deposits and ultrabasic rocks [9]. The region also was divided toward 7 main landform units, namely: alluvium plains, coastal plains (marine), piedmont terrain, marine terraces, limestone limestones, hill systems and mountain systems. Soil order was divided into 6 classes, namely: Entisols, Inceptisols, Vertisols, Alfisols, Ultisols and Oxisols. Most areas of Buton (46.79%) were located at 0 - 115 m above the sea level, where the highest altitude is at 808 m above sea level.

4.2. Land unit as evaluation basis
Soil survey was conducted by means of existing map for sampling purposes, namely: soil map of Muna island and Buton island, Southeast Sulawesi [10] and land system of regional physical planning project for transmigration [11]. Map detailing is completed by conducting land survey on land units and recorded using GPS.

4.3. Land suitability classification
Land suitability class reflected degrees of suitability. The class of suitability consists of; S1 = highly suitable; S2 = moderately suitable; S3 = marginally suitable, N1 = currently not suitable and N2 = not suitable permanently. The most potential commodities to be developed were corn and beans, which has potentially more 6,000 ha (class S1) and 120,000 ha (class S2) for corn. While beans (peanuts and green beans) has potentially 79,000 ha (S1) (table 1). Soybeans potentially to be developed in 118,000 ha but has a significant limitation. The barrier varies different limiting factors for each land unit. Potential development of other commodities were cassava, sweet potatoes, and rice fields. Rice is only in the range of S2 and S3 classes.
Table 1. Land suitability and development area of food crops in Buton regency (ha)

| Crops            | Land Suitability | Potential Area | Existing Crop | Potential Development |
|------------------|------------------|----------------|---------------|-----------------------|
|                  | S1   | S2   | S3   |                |                     |
| 1. Irrigated paddy | -    | -    | 237,088 | 237,088         | 989                  |
| 2. Paddy field    | -    | 10,580 | 228,299 | 238,879        | 3                    |
| 3. Corn           | 6,845 | 120,460 | 23,012 | 150,317        | 8                    |
| 4. Soybean        | -    | 118,673 | 117,542 | 236,215        | 498                  |
| 5. Peanut         | 6,420 | 79,894 | 119,524 | 205,838        | 498                  |
| 6. Green bean     | 6,420 | 79,894 | 119,524 | 205,838        | 71                   |
| 7. Sweet potato   | -    | 37,027 | 134,376 | 171,403        | 217                  |
| 8. Cassava        | -    | 193,944 | 49,447 | 243,390        | 5                    |

Soil acidity in this area is generally quite good, organic content (C-Organic) is generally medium, while nitrogen, cation exchange capacity and base saturation are generally moderate level. Potassium and nitrogen takes at medium to high level. The degree of limiting factor of soil chemical is relatively mild to be overcome, while the efforts of handling physical barriers such as soil depth, coral, drainage and water table are high in some area of land unit.

Micro-constraints are the limits to the development commodities such as low pH, exchangeable bases, phosphor, phosphate, and nitrogen, as well as organic matter in some land units. So that the improvement to overcome the limiting factor through fertilization and calcification [12, 13].

Potential development of food crops is quite good (generally S2 and S3) and there is still a wide development area. Corn is the most prospective commodity, including beans. The barrier that should be considered in land development is the existence of land use. Another thing is mainly in terms of the status of the area which in the middle of the island of Buton is generally occupied by forests with protected functions.

Land suitability analysis of paddy rice field indicated that this commodity could be developed in area of 238,879 ha, which consist of 10,580 ha in S2 and 228,298.9 ha in S3. Corn available at S1 located at 6,845 ha and potentially to be developed become 120,460 ha at S2 level. Soybean are suitable to be cultivated at 118,673 ha (S2) and 117,542 ha (S3). Peanut has potentially to be cultivated toward 205,808 ha which consist of 6,420 ha (S1), 79,894 ha (S2) and 119,524 ha (S3). The suitable area for green bean located class S1 is 6,420 ha, class S2 79,894 ha and class S3 119,524 ha, where dominantly located in Lapandewa sub district. Sweet potato is suitable at 37,027 ha (S2) and 134,376 ha (S3). There is no available location (class S1) for sweet potato in Buton region. Sampolawa sub-district has the extensive area for sweet potato, while Mawasang sub-district has the widest. The other location for sweet potato plant is 71,987 ha (N1) and 64,102 ha (N2). Land suitability analysis of cassava indicated that class S2 reached 193,944 ha and 49,447 ha in class S3, while N1 is 2,664 ha. The examples of land suitability distribution in Buton presented in the figures below (figure 1).
Figure 1 Land suitability map of corn (a) and peanut (b).

5. Conclusion
From this analysis, it was found that there are still available land areas for cultivating food crops in this region. Most potential food crop commodities with good suitability class include: corn and beans (peanut, corn), which may be cultivated in most parts of available land units. It was found that the main limiting factors to the development of food commodities in this region are rock outcrops, soil fertility, and topography. The results of spatial analysis in GIS confirms that some suitable land units are found within the forest area with conservation status, according to local spatial planning map.

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