Land use and land suitability assessment within the context of spatial planning regulation

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Abstract. This paper presents the results of study aimed at assessing land suitability at a regional scale, and examining spatial matching between suitability classes and spatial planning regulations for Mamminasata, one of the strategic regions in Indonesia. We focussed on assessing areas for producing food crop, in Gowa Regency, using integrated techniques of ground surveys and geographic information systems (GIS) technology. We used available soil and climate information to generate land suitability for food crops. Ground survey was carried out to verify several soil data, and SPOT XS images (resolution 20 meters) were employed to map land use in the area of interest. A set of spatial planning data bases developed by local government was used to understand planned land use types. Spatial matching procedures within GIS were performed to see the best fit between suitability classes and planned land use according to spatial planning regulation of Mamminasata region. The same procedure was also performed between present and planned land use types. The results show that some suitable areas for food crops have been allocated for residential development. Similarly, areas that should be protected according to the spatial planning scheme, in fact, have been converted or practiced for long as, intensive agriculture and residential. The results of this study may give insights into the future anticipation of land use development in this region.

1. Introduction
Land use planning is a complex area where different approaches may be used to solve a variety of problems in land use and management. Land suitability assessment is one of important components of land use planning which is directed towards the evaluation of diverse phenomena and indicators related to the land in terms of potential use and change, value, suitability, or possible level of degradation, through a series of principles and methodologies. From a regional planning perspective, different steps can be distinguished in land resource assessment, notably, investigation of problems, identification of opportunities for change, selection of feasible land use alternatives, and choice of suitable scenarios before implementation as well as monitoring. In essence, these steps are context dependent and site specific. For a complex area like Mamminasata and within a such context of land suitability assessment, land use model is a useful tool that can be reproduced, to complement the mental capability to analyse changes in land use and to make more informed decisions on land use planning and implementation [1]. On the other hands, land use planning is needed to guide decision makers in choosing the right type of land use, determining the optimal spatial location of the planned activities, identify
opportunities and formulate land use changes, and anticipate the consequences of changes in land use policy [2, 3].

This study was carried out in the Mamminasata (as an acronym for Makassar, Maros, Sungguminasa, and Takalar) region, one of the strategic regions in Indonesia according to Government Act number 26, 2008. The Mamminasata region covers four districts in the southern parts of South Sulawesi Province, including the whole area of Makassar City, and some parts of Maros, Gowa, and Takalar regencies. Spatial planning regulation was devised to cope with the rapid change in land use, and the fact that rapid land use changes has occurred within the last decade, due to intensive urban development. Therefore, as stated in [3], spatial model in GIS is useful to describe the complexity of the biophysical and spatial patterns of land use for now and the future. This study is aimed at assessing land suitability at a regional scale, and examining spatial matching between suitability classes and spatial planning regulations for Mamminasata region.

2. Materials and Methods

This study was carried out in a spatial context, using integrated techniques of ground surveys and geographic information systems (GIS) technology [4, 5]. We used available soil and climate information to generate land suitability for food crops. Ground survey was carried out to verify several soil data, and SPOT XS images (resolution 20 meters) were employed to map land use in the area of interest.

Field surveys were conducted using a GPS and base maps to find out actual condition on the ground that represents a wide range of physical environments within the study area. Such sets of information were used for refining soil and land use information (obtained from satellite images), and for assessing the actual conditions in conjunction with spatial planning regulation. A set of spatial planning data bases developed by local government was used to understand planned land use types.

In the present study, suitability classification is undertaken at a class and sub-class levels according to the FAO Framework for Land Evaluation [4]. The classification at class level adopted is as follows [5]:

- **Class S1** (highly suitable): land having no significant limitation or only have minor limitations to sustain a given land utilization type without significant reduction in productivity or benefits and will not require major inputs above acceptable level.
- **Class S2** (moderately suitable): land having limitations which in aggregate are moderately severe for sustained application of the given land utilization type; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciable compared to that expected from Class S1 land.
- **Class S3** (marginally suitable): land having limita- tions which in aggregate are severe for sustained application of the given land utilization type and will so reduce productivity or benefits, or increase required inputs, that any expenditure will only be marginally justified.
- **Class N** (not suitable): This class consists of two categories: N1 for currently not suitable, and N2 for permanently not suitable.

Spatial matching procedures within GIS [6] were performed to see the best fit between suitability classes and planned land use according to spatial planning regulation of Mamminasata region. The same procedure was also performed between present and planned land use types. A procedure was developed in GIS to integrate all sets of the information obtained from field surveys, digitized GIS data, and local government vector-based spatial data bases related to spatial planning regulation for the Mamminasata region [7, 8].

3. Results and Discussion

3.1. Land suitability classification

Distribution of land suitability derived from applying the FAO method [4, 9] can be seen in figure 1. The result from land suitability analysis in Gowa Regency for maize cultivation indicates that around 9% of land areas have class of moderately suitable, ±51% fall within marginally suitable, and ±40%
are not suitable) (figure 1). The main limiting factor for maize cultivation in this region is land surface, especially slope gradient(s).

The figures indicate that nearly half of the study area is not suitable for the development of maize, and predominantly caused by slope gradient factors, although it was found that soil attributes are in a good condition. Furthermore, more than half of the study area is available (as appropriate) for the development of maize, by assuming that the decision makers will give the highest priority to areas like marginally and moderately suitable).

![Map of land suitability for maize development](image)

**Figure 1.** Map of land suitability for maize development

### 3.2. Land Use Classification

A basic procedures of image classification were undertaken to produce present land use/land cover of the study area, using a combination technique of visual interpretation and image analysis. The result of image analysis is presented in figure 2, and the statistics of the analysis for the image classification can be seen in table 1.

![Land use/land cover map of Mamminasata](image)

**Figure 2.** Land use/land cover map of Mamminasata
Table 1. Land use types and their coverage area derived from SPOT XS images

| Land use type                  | Area (ha) | Percent |
|--------------------------------|-----------|---------|
| Mangrove (secondary)           | 1,099     | 0.4     |
| Primary forest                 | 133       | 0.1     |
| Secondary forest               | 14,767    | 6.0     |
| Planted forest                 | 5,031     | 2.0     |
| Residential                     | 10,035    | 4.1     |
| Dryand agriculture             | 7,180     | 2.9     |
| Mixed dryland agriculture      | 72,886    | 29.6    |
| Swamp                          | 124       | 0.1     |
| Grassland                      | 302       | 0.1     |
| Paddy field                    | 88,015    | 35.7    |
| Scrubs                         | 27,076    | 11.0    |
| Water body                     | 1,945     | 0.8     |
| Fishponds/tambak               | 15,948    | 6.5     |
| Bare land and Extraction       | 501       | 0.2     |
| Dam/reservoir                  | 1,203     | 0.5     |
| **Total area**                 | **246,244**| **100.0**|

As the table shows, mixed dryland agriculture and paddy field cover the dominant part of the region approximately 72,886 ha and 88,015 ha, respectively, followed by scrub (27,076 ha), fish pond/tambak (15,948 ha), and secondary forest (14,767 ha). Forest is dominantly found in the upland of Maros and Gowa regencies, and may become protected and conserved zones for the region. Land use conversion for the last five years is greatly found for residential, and other built-up areas. This is due to a rapid growing urban area in many parts of the region.

3.3. Spatial Planning Database

Based on the local government vector data base (see figure 3), an analysis was performed in GIS to calculate the distribution of land function/status that should be used by the local government in directing land use within a period of 20 years. According to the land zoning or status/function map, conservation forest, protected forest, and other protected areas cover a total area of 16,426 ha, 14,072 ha, and 14,489 ha, respectively (table 2).

Figure 3. Land use zoning according to land use planning scheme (Presidential Decree No. 55, 2011 about Spatial Planning of Mamminasata Region)
Table 2. Land use protection zones (Code L) from government database

| Land use zoning                                           | Area (ha)  |
|----------------------------------------------------------|------------|
| Conservation forest (L3=wildlife protection, mangrove, national park) | 16,425.50  |
| Protected forest (L1)                                    | 14,071.85  |
| Other protected areas                                   | 14,489.45  |

Spatial analysis was also underway to examine the spatial matching between land use types and the land status according to the spatial planning regulation stated by the government under the Government Act No. 26, 2007 about Spatial Planning. The same procedure was also applied to see the corresponding phenomenon between land suitability classes and the zoning map as stated in the spatial planning regulation of Government. It is important to note here that that according to spatial planning regulation of Mamminasata region, conservation forest consists of land zoning code L3=wildlife protection, mangrove, national park and other protected areas consists of land zoning code L2=small island, coastal buffer zone, river buffer zone, L6=hunting park (see table 2). It should be also pointed out that this study focused only on protected zone, while the statistics for management zones (B1, B2, B3, B4, B5, and B6) (see figure 2) are not presented here. These zones should be functioned for various land use activities for the sake of increasing economic values of the land.

The results show that, for Gowa Regency, land suitability classes mostly correspond to the spatial planning zones. Most of Not Suitable land classes fall within the protection zones with L1, L2, and L3 codes. This implies that most suitable land classes have been practiced for developing agricultural land like paddy fields, mixed agriculture, etc. within management zone (code B). In the contrary, present land use type of some proportions of the area do not match according to their function as stated in the spatial planning map produced by the government, particularly for those already been determined as protected forest and other types of conservation zones. For example, some areas of mixed dryland agriculture, in fact are found on the protected forest, conservation forest, and other protected areas. Based on this detailed analysis assisted by ground truth data, other types of protected areas (L2=small island, coastal buffer zone, river buffer zone, and L6=hunting park) were occupied by quite a large area of mixed agriculture, dryland agriculture, and rice field, with some proportion of residential areas. This phenomenon can be found in most developed region [10].

4. Conclusion
This study has resulted in two different phenomena in relation to the development of food crops particularly maize. First, the results for Gowa Regency shows that land suitability classes mostly correspond to the spatial planning zones, where most of Not Suitable land classes fall within the protection zones with L1, L2, and L3 codes. This implies that most suitable land classes have been practiced for developing agricultural land like paddy fields, mixed agriculture, etc. within management zone (code B). Second, present land use type of some proportions of the area do not match according to their function as stated in the spatial planning map produced by the government, particularly for those already been determined as protected forest and other types of conservation zones. This indicates that agriculture practices, especially food crops were not only developed in the management zone, but also has expanded to areas prone to degradation in the sloping zone hat by regulation assigned as protection zone. This study is thus useful for land resource management and monitoring in Mamminasata region, and may give insights into the future anticipation of land use development on the region on a spatial basis.

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