

Identification of Land Resource Potential for Agricultural Landscape Planning Using Land Capability Evaluation Approach and GIS Application (a Case in Central Kalimantan Province, Indonesia)

Identifikasi Potensi Sumberdaya Lahan Untuk Perencanaan Lanskap Pertanian Menggunakan Pendekatan Evaluasi Kemampuan Lahan dan Aplikasi GIS (Studi Kasus di Provinsi Kalimantan Tengah, Indonesia)

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ABSTRAK

Alokasi lahan untuk pertanian diperlukan ketika suatu wilayah memiliki potensi untuk dikembangkan namun aspek-aspek konservasi tetap harus dipertimbangkan. Wilayah Provinsi Kalimantan Tengah dengan luas mencapai 15, 451, 287 hektare memiliki potensi ketersediaan lahan untuk pengembangan pertanian. Pada tahap awal, kajian potensi sumberdaya lahan diperlukan untuk kepentingan perencanaan pada skala lanskap. Tujuan penelitian ini adalah untuk merancang konsep kewilayahan pada perencanaan lanskap pertanian berbasis keberlanjutan. Metodologi yang digunakan adalah pendekatan konsep evaluasi kemampuan lahan dan aplikasi sistem informasi geografis. Hasil dari evaluasi menunjukkan bahwa wilayah Kalimantan Tengah terbagi dalam 6 kelas kemampuan lahan yaitu kelas II, III, IV, VI, VII, dan VIII dengan beberapa faktor pembatas seperti kedalaman gambut, drainase, kelerengan dan tekstur. Berdasarkan sistem informasi geografis, hasil analisis spasial menunjukkan bahwa luas kawasan untuk lahan-lahan pertanian adalah 9.571231 hektare atau 61,95% dari luas total wilayah provinsi Kalimantan Tengah. Hal ini menunjukkan bahwa lahan-lahan masih tersedia cukup luas untuk pengembangan pertanian. Kawasan-kawasan ini terdapat pada tipologi lahan basah maupun lahan kering. Untuk selanjutnya program-program khusus spesifik lokasi dapat dirancang dalam rangka untuk pengembangan wilayah.

Kata kunci: perencanaan, lahan pertanian, sumberdaya lahan, kemampuan lahan

ABSTRACT

Land allocation for agricultural lands is required when the region have potency to be developed while the same time, conservation aspects are still considered. Central Kalimantan Province with total areas of 15, 451, 287 hectares has potential land available for agricultural development. At initial stage, with a landscape scale, land resource

potential is needed to be assessed for planning purposes. The aimed of this study was to design the spatial concept of agricultural landscape planning on sustained basis. Methodology used in this include concept of land capability evaluation (LCE) approach and geographic information system (GIS) application. The result of evaluation showed that Central Kalimantan was classified into 6 land capability classes *i.e* class II, III, IV, VI, VII, and VIII with several limiting factors such as peat depth, drainage, slope, and texture. Within GIS environment, the result of spatial analysis shown that total areas of agricultural land region was 9,571,231 hectares or 61.95% of total Central Kalimantan province. This indicates that the lands are still widely available for agricultural development. These areas are located not only in wetlands typology but also found in dryland areas. Specific program that specific to location can then be formulated in order to develop the areas.

Keywords: planning, agricultural lands, land resource, land capability

INTRODUCTION

In spatial planning process, determination of arable lands for agriculture on sustained basis cannot be ignored and should even be considered. Land allocation for agricultural lands is required when the region have potency to be developed while the same time, conservation aspects are still considered. Appropriate land allocation referring to conservation aspect should be implemented to achieve sustainable agricultural system through protecting agrarian soils from its degradation (González-Sánchez et al., 2016). As an integrated system, sustainable agriculture can promote sustainable farming through producing adequate amounts of high-quality food, protect its resources and safe and profitable environmentally (Velten et al., 2015).

In Central Kalimantan, agricultural is a strategic sector that plays an important role. It contributes the highest value to total Gross Regional Domestic Product (BPS-Statistics of Kalimantan Tengah Province, 2020). This is in line with government policy by establishing a superior sustainable industrial agricultural system based on local resources to increase food self-sufficiency, added value, exports and farmer welfare as a vision of agricultural development (<https://kalimantan.bisnis.com/read/20190808/408/1134087/kalteng-maksimalkan-potensi-komoditas-pertanian-perkebunan>). Central Kalimantan Province with total areas of up to 15 million hectares has

potency for agricultural development. The result of preliminary study showed that the lands that have been opened for agricultural purposes only 3,091,280 hectares or 20% of total areas of Central Kalimantan Province.

This indicate that land resources are still available for agriculture with considering the other land use purposes. In order to support agricultural development programs on the basis of sustainability, the availability of potential lands is an important factor that needs to be considered carefully. Furthermore, land use allocation base on biophysics potential for agriculture needs to be planned through a systematic and rational spatial planning concept. Land use planning should be designed according to land potential to ensure sustainability of available land resources (Lv et al., 2021; Metternicht, 2017; Baja, 2012;). Proper land use not only guarantees that land resources can be used for present uses, but also ensures that these natural resources can be useful for future use (Nimisha et al., 2015).

Land capability evaluation (LCE) is an analysis approach to assess and identify land resources for specific kind of use. Systematically, it can determine capability classes based on potential and limiting characteristics for their sustainable use. The delineation of land use allocation for agriculture can then be determined rationally based on land capability classification criteria (Harjiyanto et al., 2016; Maryati, 2013).

Land resource information is required for agricultural landscape planning (Winfried, 2013). Because of lack of data, this study was conducted at reconnaissance level with scale of 250,000. However, with this scale, adequate information based on reconnaissance soil survey can be used for strategic planning and basic consideration for decision and policy makers at regional Province level (Anda et al., 2011). The data available was then used for LCE and further spatial analysis and this study was conducted to identify land resource potential for agricultural land use and landscape planning purposes. The aimed of this study was to design the spatial concept of agricultural landscape planning on sustained basis.

MATERIALS AND METHODS

This study was conducted through deskwork study and field verification. For case study, it was focused on Central Kalimantan Province in Indonesia that covers 15,451,287 hectares (Figure 1). The concept of land capability evaluation (LCE) approach was used to classify their land capability within each land unit. The LCE proposed by USDA (United State Department of Agriculture) was then used in which class I, II, III, and IV were suitable for agricultural land utilization, while for class V, VI, VII, and VIII, the lands were established as non-arable lands (Girmay et

al., 2018). The method of matching process to land characteristics and capability class criteria was used in land evaluation procedure to define land class within each land unit. Several main land characteristics as basic consideration for land evaluation include landform represented as slope, erosion conditions, drainage, effective depth, texture, flood conditions and presence of rocks on the ground surface (ICALRRD, 2016).

The results of land evaluation were integrated into geographic information system (GIS) environment. The GIS technology as useful tool was then applied for spatial analysis and mapping process (Taryadi et al., 2019; Wahyutomo et al., 2016; Dibs, 2013). The application of remote sensing technology was also employed in the beginning of study to generate hillshade function that represent terrain surface based on digital elevation model (DEM). Furthermore, this terrain information was used as basic analysis for landform such as slope in order to complement base maps information.

Several land resources information used in this study as base digital maps at reconnaissance include the maps of land system, soil types, peat distribution, agroclimatic, Indonesian topographic (selected regions for this study), administrative and other relevant data. The general stage of methodology was described at Figure 2.



Figure 1. Situation map of location of study in Central Kalimantan Province, Indonesia

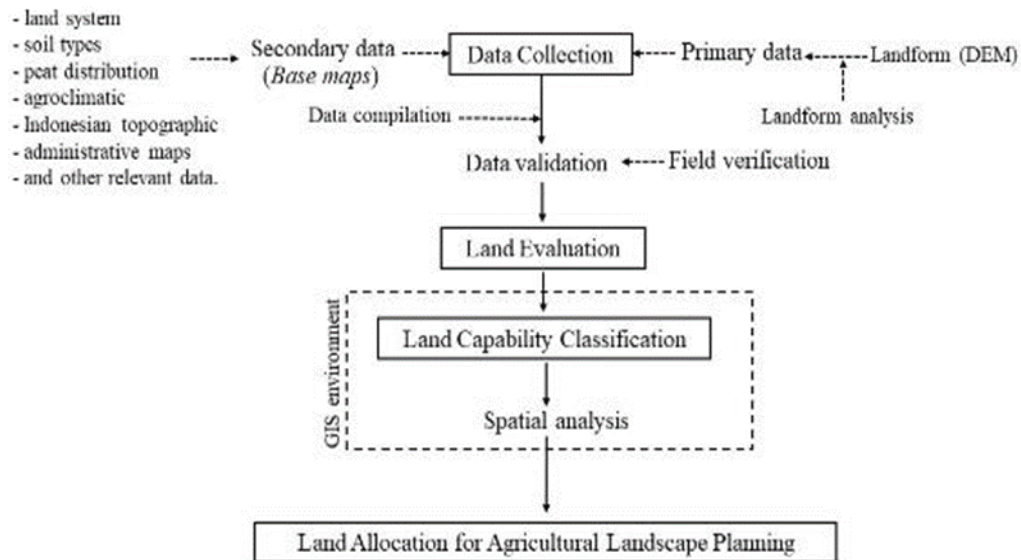


Figure 2. General stage of methodology used in this study

RESULTS AND DISCUSSION

Land Resources and Climate Information

Based on pre-eliminary study, Central Kalimantan Province with coverage areas of 15,451,287 hectares was primarily divided into 2 land typologies. Drylands typology were located in the central to the northern parts with several characteristics such as were highly weathered, acidic, infertile and poorly buffered soils. Meanwhile, wetlands typology that mostly found in the southern parts were dominated by peatlands and swamplands. There were several major soil types that occupy these land typologies. For drylands, these regions were dominated by orders of Mollisols, Alfisols and Ultisols. While at wetlands, they were covered by Entisols, Inceptisols, and Histosols. In the several parts, in the southern parts were also found order of Spodosols (Soil Survey Staff, 2014). General land identification for agriculture was initially carried out through landform analysis using digital elevation model (DEM). The regions which suitable for agriculture falls into flat to middle slopes with slope class of $> 2\%$ to 30% . (Bayu et al., 2018; ICALRRD, 2016). Based on visual interpretation using hillshade function that represent 3D of

terrain surface, flat regions were mostly found in the central parts to the south. Furthermore, these areas could be allocated for agriculture. While in the north, the areas were mostly dominated by slopes of hilly to mountainous in which suitable only for natural vegetation (Figure 3). In the northern part, in which steep and very steep slopes found, they also play an important role on impacting soil erosion. Therefore, in land use planning, they could be considered as critical and limiting factor for agricultural development (Zhang et al., 2015). In order to support environmental sustainability these regions were recommended for private forest or plantation forest (Harjianto et al., 2016).

For climate, because of its geographical position on the equator line, this region has moist, equatorial air masses and frequent heavy convectional rainfall during most of the year (Webster & Wilson, 1980). By the end of 2022, annual precipitation of this region was 2858 mm with average temperature 27.7° Celcius and average humidity 82%. According to Oldeman's agroclimatic system (1980), number period of consecutive wet months ranged between 10–12 months while dry months occur between 0–2 months.

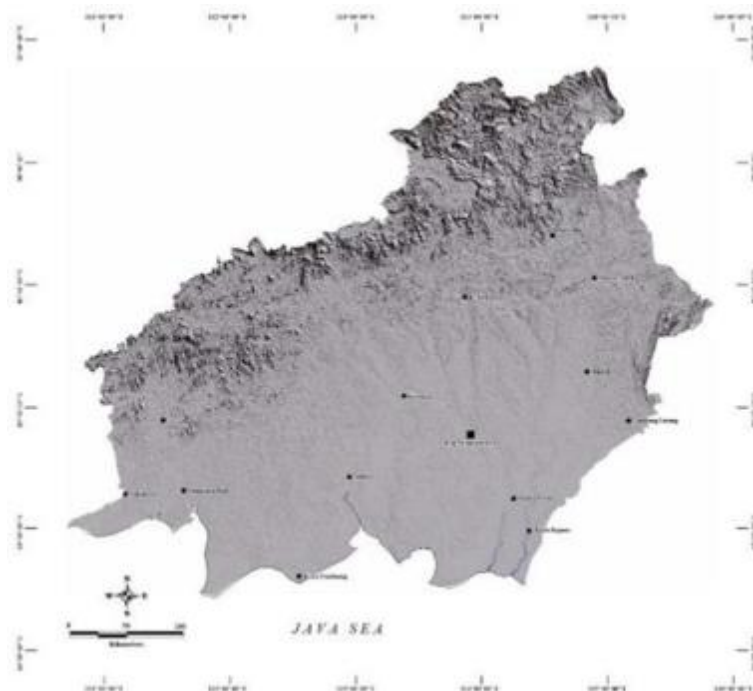


Figure 3. General description of landform based on terrain surface in Central Kalimantan

Land Capability Classification

The classification based on land capability was designed for long-term arable lands and non-arable lands due to the presence of limiting factors and risk of damage to natural resources if they are not properly managed (Klingebiel and Montgomery, 1973). The delineation agricultural land regions can then be determined rationally based on their capabilities (Budiarta, 2014). The result of LCE showed that Central Kalimantan Province as case study was primarily classified into 6 classes (class II, III, IV,

VI, VII, and VIII) with several main limiting factors such as peat depth, drainage, slope, and texture (Table 1). Class I, V, and VIII were not found because there was no land parameter that match with land criteria. Several criteria, not match with general condition of land resources in Central Kalimantan involve land slope more than 65%, present of rock outcrop, and flooding hazard. The result of evaluation was also integrated into GIS environment to assist further spatial analysis (Figure 4).

Table 1. Classification of land capability for Central Kalimantan region

| Land Capability Class | Limiting Factors | Area (ha) | % of Total Area of Central Kalimantan Region |
|-----------------------|--|------------|--|
| II | Slope (> 3–8%); drainage (poor) | 3.975.452 | 25.73 |
| III | Slope (8–15%) | 1.595.127 | 10.32 |
| IV | Slope (> 15–30%) | 4.000.652 | 25.89 |
| VI | Slope (> 30–45%); peat depth (> 1,5 m) | 3.318.026 | 21.47 |
| VII | Slope (> 45%) | 1.006.013 | 6.51 |
| VIII | Texture (coarse) | 1.556.017 | 10.07 |
| Total areas | | 15.451.287 | 100 |

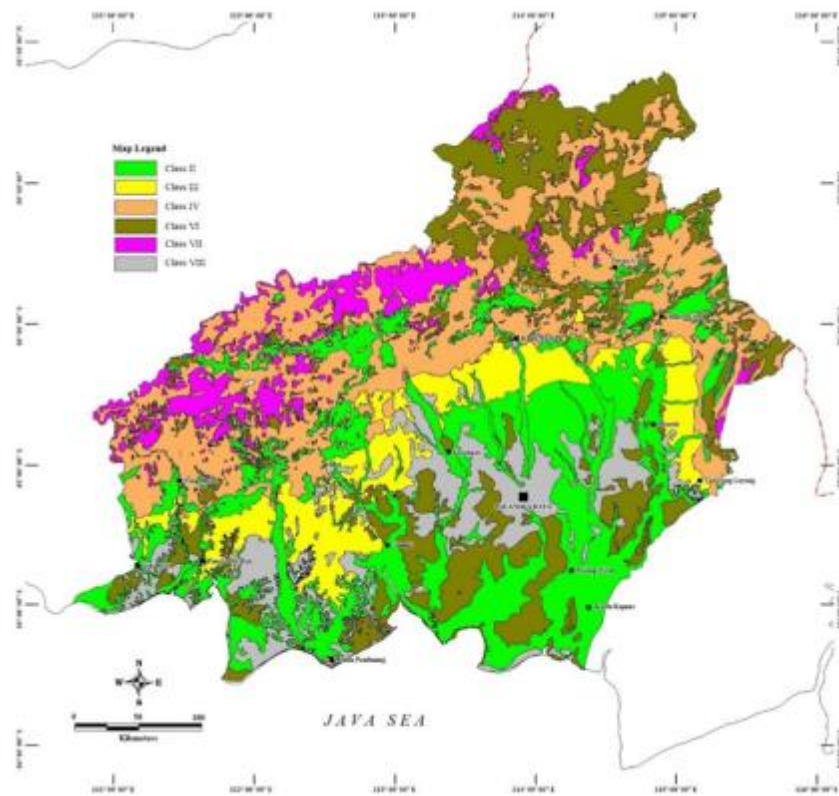


Figure 4. The map of land capability classification in Central Kalimantan

Determination of Agricultural Land Regions

The result of land capability classification can be used to assist spatial analysis for land use planning based on land potential for agricultural production on a sustain basis with considering the aspects of environment/topography, and proper land management (Mujiyo et al., 2018). Therefore, it leads to determine land allocation for arable lands as agricultural land regions and non-arable lands. This spatial concept can then be implemented for developed areas for appropriate lands for agriculture and basic consideration for land use planning as well.

Referring to LCE criteria for agriculture, in the case of Central Kalimantan, class II, III, and IV were then allocate for agricultural land regions. While class VI, VII, and VIII were designated for forest and conservation purposes. Spatial concept of

agricultural landscape planning as recommendation for agricultural development was represent at Figure 5.

The result of spatial analysis shown that total areas of agricultural land region is 9,571,231 hectares or 61,95% of total Central Kalimantan Province. This indicates that the lands are still widely available for agricultural development. These areas are located not only in wetlands but also found in dryland areas. Specific program that specific to location can then be formulated in order to develop the areas. At a landscape scale, this spatial concept has fulfil ecological management of agroecosystem principle in achieving sustainable agriculture and this spatial concept was inline with local government program to achieve the Green Economical Growth in Central Kalimantan (Government of Central Kalimantan and Bappenas, 2015).

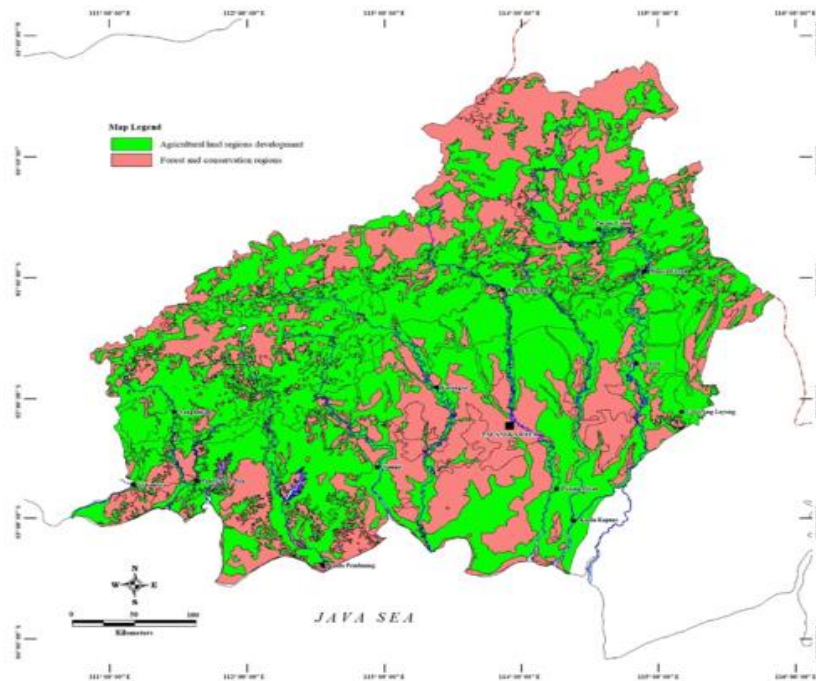


Figure 5. Spatial concept of agricultural landscape planning on sustained basis in Central Kalimantan

CONCLUSION

At a landscape scale, spatial concept of agricultural land regions can be developed through land capability evaluation (LCE) and the resulting information can be used a basic reference for land use planning. Using landscape approach, in the case of Central Kalimantan Province, land allocation for agricultural land region is 9,571,231 hectares or 61,95% of total Central Kalimantan Province and this indicates that the lands are still widely available for agricultural development.

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REFERENCES

- Anda M, Sarwani M, Nugroho K. 2011. Soil Map Information in Indonesia. In: Anda, M., Rizatus S., Nugroho, K., Yiyi S., and Mamat H.S. Proceeding of International Workshop On GlobalSoilMap.net Oceania Node. Bogor, Indonesia 7–9 February 2011. Indonesian Center for Agricultural Land Resources Research and Development (ICALRD): 1–10.
- Baja S. 2012. Land Use Planning for Region Development. Spatial and application approach. Penerbit Andi. Yogyakarta.
- Bayu SB, Prpto Y, Sriyanto W. 2018. Evaluation of the Agricultural Land Utilization Types for Mitigation of Land Degradation in Giritirta, Pejawaran, Banjarnegara. *Vegetalika*. 7 (2): 1–15.
- ICALRRD (Indonesian Center for Agricultural Land Resources Research and Development). 2016. Technical Guidelines. Land Suitability Assessment for Strategic Agricultural Commodities at Semi Detail Level 1:50,000. Indonesian Agency for Agricultural Research and Development.
- BPS-Statistics of Kalimantan Tengah Province. 2020. Kalimantan Tengah Province In Figures 2020.

- Budiarta IG. 2014. Land capability analysis for land use recommendation in lereng timur laut gunung agung, karang asem Regency-Bali. *Media Komunikasi Geografi*. 15 (1): 19–32.
- Dibs H. 2013. Spatial Analysis by using Arc GIS.
- Girmay G, Sebnie W, Reda Y. 2018. Land capability classification and suitability assessment for selected crops in Gateno watershed, Ethiopia. *Cogent Food & Agriculture*. 4: 1532863.
- González-Sánchez EJ, Kassam A, Basch G, Streit B, Holgado-Cabrera A, Trivino-Tarradas P. 2016. Conservation agriculture and its contribution to the achievement of agri-environmental and economic challenges in Europe. *AIMS Agriculture and Food*. 1 (4): 387–408. DOI: 10.3934/agrfood.2016.4.387.
- Government of Central Kalimantan and Bappenas, 2015. Central Kalimantan for Green Economic Growth.
- Harjianto M, Naik S, Suria DT, Oteng H. 2016. Land capability evaluation for land use planning in watershed areas of lawo river, South Sulawesi. *Jurnal Penelitian Kehutanan Wallacea*. 5 (1): 1–11.
- Lv T, Wang L, Xie H, Zhang X, Zhang Y. 2021. Exploring the global research trends of land use planning based on a bibliometric analysis: current status and future prospects. *Land* 2021. 10: 304. DOI: 10.3390/land10030304.
- Maryati S. 2013. Land Capability Evaluation of Reclamation Area in Indonesia Coal Mining using LCLP Software. *Procedia Earth and Planetary Science*. 6. 2013: 465–473.
- Metternicht G. 2017. Land use planning. global land outlook (working paper). September 2017.
- Mujiyo, Sutarno, Rafirman R. 2018. The impact of land use change on land capability in Tirtomoyo-Wonogiri. *J. Degrade. Min. Land Manage*. 6 (1): 1449–1456. DOI: 10.15243/jdmlm.2018.061.1449.
- Nimisha T, Singh RK, Pal D, Singh RS. 2015. Agroecology and sustainability of agriculture in India: An Overview”. *EC Agriculture*. 2.1 (2015): 241–248.
- Oldeman LR, Irsal L, Muladi. 1980. Agroclimatic map of Kalimantan. Central Research Institute for Agriculture. Bogor. Indonesia.
- Taryadi SW, Binabar, Dicke JS. 2019. Geographic information system for mapping the potency of batik industry centre. *Journal of Information Systems Engineering and Business Intelligence*. 5 (1): 40–47.
- Soil Survey Staff. 2014. Keys to soil taxonomy. twelfth edition. united states department of agriculture. natural resources conservation services.
- Velten S, Julia L, Nicolas J, Pandey, Jens N. 2015. What is sustainable agriculture? a systematic review. *Sustainability* 2015. 7: 7833–7865. DOI:10.3390/su7067833.
- Wahyutomo PK, Suprayogi A, Wijaya AP. 2016. The application web-based geographic information system for post office distribution in Semarang using google maps API. *Jurnal Deodesi UNDIP*. 5 (3): 70–80.
- Winfried EHB. 2013. Soil and land resources for agricultural production: general trends and future scenarios-a worldwide perspective. *International Soil and Water Conservation Research*. 1 (3): 1-14.
- Zhang Z, Sheng L, Yang J, Xiao-An C, Kong L, Wagan B. 2015. Effects of land use and slope gradient on soil erosion in a red soil hilly watershed of southern China. *Sustainability* 2015. 7: 4309–14325. DOI: 10.3390/su71014309.