

Integrated Spatial Concept Based on Harmony in Nature for Sustainable Agriculture in Wetlands of Central Kalimantan

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Abstract. The wetlands of Central Kalimantan that cover approximately 3,721,122 hectares or 24.08% of total region has the potency of land resource to support agricultural development. This study was then conducted to develop the concept of integrated spatial as framework of land use planning for sustainable agricultural systems while still preserving the agroecosystem to be safe and profitable ecologically. The land evaluation approach and GIS technology were applied to determine and identify the land suitability of specific groups of crops as agricultural system. Spatially, land use allocation for food crops, estate crops and forestry are 604,427 hectares (16.24%), 1,159,682 hectares (31.16%), and 1,957,013 hectares (52.59%) respectively. This concept can then be used as a basic consideration to propose land use policy and land management specific to location in order to develop sustainable agriculture in Central Kalimantan wetlands.

1 Introduction

By the end of 2023, the agricultural sector is a part of strategic contributors in economical acceleration and development in Central Kalimantan province [1]. The local government policy to support agricultural development has established an extensification program through opening new lands for farming practices in addition to intensification programs. Moreover, nowadays, the existence of a new nation's capital in East Kalimantan province indicates that the agricultural sector plays an important role in supporting the supply of agricultural products.

Nowadays, in Central Kalimantan, proper land use has not been implemented in land utilization. At several wetland areas, the function of buffer zones has been converted become agricultural lands. Therefore, it is important to province agricultural land region as production area in order to meet food needs or even plantation products while at the same time conserving and protecting land resources [2]. The appropriate land use planning as spatial concept is then required to allocate agricultural land region that also consider protected areas such as conservation and preservation areas in order to achieve harmony in nature and sustainable agricultural system [3,4].

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Table 1. Crop growth requirement for paddy fields and rubber representing food crops and estate crops

Land characteristics	Class of land suitability											
	S1 (very suitable)			S2 (moderately suitable)			S3 (marginally suitable)			N (not suitable)		
	Paddy	Rubber		Paddy	Rubber		Paddy	Rubber		Paddy	Rubber	
Average temperature (°C)	24-29	26-30		29-32	30-34		32-35	22-24		>35		Rubber >34
Rainfall (mm/year)	> 1500	2500-3000		1200-1500	3000-3500		800-<1200	3500-4000		-		>4000
Length of dry season (month)	<3	1-2		3-8	2-3		9-10	3-4		-		>4
Drainage	Poor	Well drained		Imperfectly drained	Moderately well drained		Moderately well drained	Imperfectly drained		Well drained		Poor
Texture	Fine	Fine		Medium	Medium		Moderate coarse	Moderate coarse		Coarse		Coarse
Effective soil depth (cm)	>50	>100		40-50	75-100		25-40	50-75		<25		<50
Peat depth (cm)	<60	<60		60-140	60-140		140-200	140-200		>400		>200
Peat ripeness	Sapristis	Sapristis		Sapristis/Hemists	Sapristis/Hemists		Hemists/Fibrists	Hemists/Fibrists		Fibrists		Fibrists
CEC (cmol/kg)	>16	-		<16	-		-	-		-		-
Base saturation (%)	>50	<35		35-50	35-50		<35	>50		-		-
Soil acidity (H ₂ O)	5.5-8.2	5.0-6.0		4.5-5.5	4.5-5.0		<4.5	<4.5		-		-
C-organic (%)	>1.5	>0.8		0.8-1.5	<0.8		<0.8	-		-		-
Slope class (%)	<3	<8		3-5	8-16		5-8	16-30		>8		>30
Erosion hazard	Very low	Very low		Low	Low		Medium	Medium		High		High
Flooding hazard	Slight	Slight		Moderate	Moderate		Severe	Severe		Very severe		Very severe
Outcrop of rock (%)	<5	<5		5-15	5-15		15-40	15-40		>40		>40

Based on previous studies, this province that covers more than 15 million hectares consist mainly of dryland and wetland areas. This study was focused on wetlands since the Indonesian Ministry of Agriculture has established Regulation Number 41/PERMENTAN/OT. 140/9/2009, in order to utilize wetlands for agricultural purposes based on sustainability. Wetlands of Central Kalimantan mainly consist of tidal swampland and peatland are considered as sub-optimal land due to the existence of several restrictive factors such as acidic soil condition, poor soil nutrient, pyrite poisoning

and seawater intrusion [5]. Sub-optimal land, however, has potential and it can be utilized for future agricultural production areas by introducing appropriate land management [6].

The aims of this study were to provide integrated spatial concepts as part of planning in achieving sustainable agricultural system and harmony in nature as well in Central Kalimantan wetlands. Additional information about land resource potential in wetlands can also be considered as reference in planning process and formulating land use policy in wetlands for agricultural development.

2 Research method

The main method used in this study is evaluation of land suitability approach. The procedure of matching crop growth requirement and characteristic of land was implemented to define land suitability class for specific crops or group of crops [7,8]. Two selected crops, i.e. paddy field and rubber, were used in the land evaluation process representing the system of agriculture for food crop and estate crop. In addition, the geographic information system (GIS) technology was also applied in this study in order to manage and generate systems of information and spatial analysis as well within geospatial environment [9,10].

The location of the study was directed in Central Kalimantan province. The basic data compiled in this study was based on data available with the view of lacking data. Therefore, information about land resource was collected and managed at reconnaissance level (scale of 250,000). At this reconnaissance level, the basic information can be used for planning purposes for provincial regional scope [11,12].

Several land resource information as basic data consists of land system information, geological maps, soil maps with scales of 250,000, agroclimatic maps, and administrative maps as well. Additional information used for land assessment includes crop growth requirements for rice and rubber in which each crop represents system of agriculture especially for food crops and estate crops (Table 1) [7,8]. The output of land evaluation was compiled and managed within the environment of GIS with spatial format including tabular format as basic in mapping process followed with spatial analysis [13,14].

3 Results and Discussion

3.1 Overview of Central Kalimantan Wetlands

The previous study has identified that Central Kalimantan province in accordance with information of land system and soil types is spatially consist of dryland and wetland typology. Drylands, also known as uplands, are mostly found in the northern parts. While in the southern part, the region is mostly dominated by wetlands (Figure 1) [15]. Further spatial analysis showed that total areas of wetlands are 3,721,122 hectares (24.08% of total Central Kalimantan province). Unlike dry lands with topography of undulating plain to hilly or even mountainous, in wetland areas, the major topography is flat with slope <8%. This slope class is a supporting factor in farming practices, and it is not vulnerable to land erosion [16].

The agroecosystem of wetlands in Central Kalimantan is dominated by tidal swampland and peat lands with predominant orders include Entisols, Inceptisols, and Histosols developed from fluvial sediment and organic material. In several locations, the order of Spodosols is also found [15,17,18].

The general climatic condition in this region is classified as wet equator climate which is recognized by moist, deep air masses and frequent rainfall throughout the year heavily [19]. As reported by several climate stations, in the year of 2023, the annual rainfall is 2900 mm and average temperature, and humidity is 28.4° Celcius and 82%. Oldeman's agroclimatic

system also added that the number period of consecutive dry months occurs only 0-2 months whereas wet months ranged between 10-12 months [20]. This condition indicates that climatic characteristics in wetlands of Central Kalimantan are appropriate for agricultural practices not only for food crops commodities but also estate crops [21].

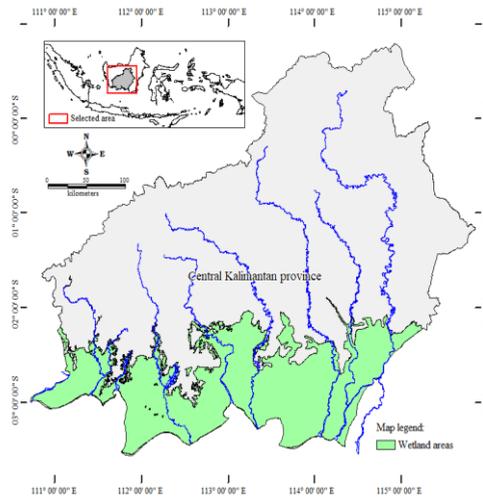


Fig. 1. The map showing the distribution of wetlands in Central Kalimantan province

3.2 The Concept of Integrated Spatial Planning

An appropriate framework of land use planning for wetland development is required because of the specific land characteristics of this ecosystem. Rational and systematic planning of land allocation for agriculture with considering conservation aspect should be taken into account in achieving harmony in nature and sustainable agricultural system through protecting preservation areas [22].

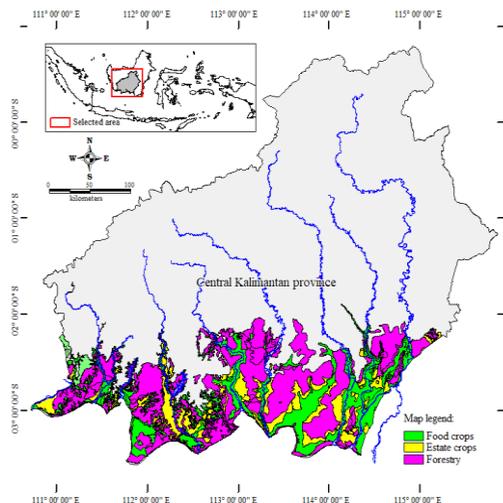


Fig. 2. The map showing the allocation of land for agricultural development (food and estate crops) and forestry in the wetlands of Central Kalimantan

In this study, land use planning was then designed in the form of integrated spatial concept through delineating the areas for food crops and estate crop agricultural systems including

forestry. The land evaluation approach was used to determine land units that are suitable for agriculture and non- agriculture (forest) based on limiting factors of land characteristics in wetlands [7,8]. The result of land evaluation as integral part of spatial format showed that wetlands of Central Kalimantan can primarily be divided into 3 agricultural systems, namely food crops and estate crops and forest (Figure 2).

The result of land evaluation generated information of land suitability of specific kind of use in the form of spatial format within GIS environment. Mainly on the basis of land evaluation and GIS analysis, the allocation of land for forestry occupies the largest areas in wetlands with total areas of 1,957,013 hectares (52.59% of wetland region). While for agriculture system allocation, the total areas of food crops and estate crops are 1,159,682 hectares (31.16%) and 604,427 hectares (16.24%) respectively.

The result of land evaluation for several crops showed that in general, the suitability class is marginally suitable because there are several main limiting factors that should be considered in farming practices in wetlands such as soil acidity, nutrient retention and nutrient availability [23,24]. These obstacles lead to the conclusion that specific land management is required in wetlands.

3.3 Land Use Policy Recommendation

The framework and concept of land use planning especially for specific land characteristics and ecosystem of wetlands is then required in achieving not only for sustainable agricultural system but also for harmony in nature. In this study, rational and systematic planning of land allocation for agriculture was described through integrated spatial concept of sustainable agricultural system in wetlands. In addition to contributing basic consideration in planning process, especially for land utilization, this concept can be used to promote sustainable production of land resources in wetlands including preserving the agroecosystem to be safe and profitable ecologically [25].

The concept of integrated spatial recommends that food crops development can be implemented in the areas that have been cultivated through intensification and extensification program. The specific program that has been existed such as intensification, it can be priority and implemented in the locations in which farming practice has been performed. Based on field observation and spatial analysis, land allocation for food crops was mostly found along the big rivers in which many human settlements also exist. The site-location technology of wetlands may also be introduced to increase productivity such as water management with well-organized water circulation, soil tillage management, the selection of adaptive crops, and site-specific technology of cultivation including diversification pattern and intercrop cultivation pattern as well [26]. The program of extensification can be implemented through new arable land expansion starting from intensification areas with considering the availability of human resources and infrastructures to support farming activities in general. While for estate crops, in accordance with the regulation of the Indonesian Ministry of Agriculture (Regulation Number 41/Permentan/OT. 140/9/2009), they can be allocated at peat lands that have shallow peat thickness and peat ripeness of hemist or saprist.

The remaining areas were then allocated only forestry, and they cover half of wetlands areas. The main limiting factor in these areas include peat depth >100 cm in addition to other obstacles in which not suitable farming activities should be kept in their natural condition.

4 Conclusion and recommendation

The concept of integrated spatial is necessary since the land resource has potential to be managed for development of agriculture. This concept can be used to promote sustainable production of land resources in wetlands, including preserving the agroecosystem to be safe

and profitable ecologically. Central Kalimantan wetlands as case of study, the spatial composition of land use recommendation for agricultural system of food crop, estate crop and forestry are 604,427 hectares (16.24%), 1,159,682 hectares (31.16%), and 1,957,013 hectares or 52.59% respectively. Therefore, land use policy and programs including appropriate site-location land management are required in order to achieve sustainable agriculture based on harmony in nature in wetlands.

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