Identification and Evaluation of Potential Land Resources to Support the Development of Agricultural Commodities for Food Crops Zone

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ABSTRACT

To support the goverment purpose to reach the food security, a land use study is needed. The aim of the research was to provide an information of characteristics of land resources through the identification and evaluation of potential landresources and that suitable for food crops in Mamuju District South Sulawesi. The research method used landscape approach to mapping land units as the basis for preparing the soil map unit/DEM compared with field data survey. A case study was done in Mamuju District, West Sulawesi the results showed that the land in Mamuju for paddy covering was suitable enough of 115,250 ha and 54,883 ha of marginal fit, while for dryland crops were 106 978 ha was quite suitable and appropriate marginal was 82,592 ha. However, for cocoa fit enough land was 153,397 ha and corresponding marginal was 485,743 ha. Biophysical constraints were the erosion of land use/steep slopes, drainage, seasonal flooding, toxicity and nutrient retention. Direction of land use for agriculture in Mamuju for Rice crop area was 49,345 ha (6.23%), food crops rice and dry land was 10,680 ha (1.35%), dryland crops/crops was 101,785 ha (12.85%), perennial/Cocoa was 90,488 ha (11.42%), and conservation land was 532,245 ha (67.18%).

Keywords : Cland crops, land identification, soil evaluation

INTRODUCTION

To support the government on accelerating the development of the national economy in the agricultural sector, increasing agricultural production of food crops and plantation crops are needed. Increased agricultural production can be done with intensification and extension programs which are strongly associated with the potential and the availability of land resources. Intensification program can be conducted in the areas that have agricultural production centers such as Java, while the extension program can be conducted outside the java island because it still has enough potential of land resources and a relatively low population density.

Sulawesi Island is an island that is potential as a priority area to develop food crops and to have a strategic role to support national food security. These areas should be directed as special areas that have ample potential land and undeveloped.

One of potential area is Mamuju, a regency of West Sulawesi province which is located at 1039'50 "- 2054'52" south latitude and coordinate 172043'15 "- 173054'03 'east longitude. Mamuju consists of 16 districts with a total area of 794,276 ha (BPS Prov Sulawesi Barat 2011).The population of the region was 336,973 people consisting of 173,413 men and 163,560 women.

The average rainfall in Mamuju station was 2635 mm, the rainy season falls between November / December to June, while the relatively short dry season occurs between July - October. In general, type of precipitation of Mamuju according to Schmidt and Ferguson was type A.

This area is part of an active tectonic zone that many have complex geological processes, such as

Table 1. Distribution of soil parent material in Mamuju.

No	Type of parent material	Area	
		Ha	%
1	Sediment Alluvium	64.166	8.10
2	Sediment Marin	3.135	0.40
3	Limestone	3.534	0.45
4	Sedimentary Rocks	177.210	22.37
5	Andesite-basalt Volcanic Rocks	233.125	29.42
6	Andesitic-dacitic Volcanic Rocks	53.523	6.76
7	Metamorphic Rocks	137.078	17.30
8	Granite and Granodiorite Intrusive Rocks	115.091	14.53
9	Other	5.462	0.69

Source: Geological map sheet of Mamuju

folds (folded), force (uplifted) and faults (faulted) and is part of the junction of three tectonic plates (Sukamto 1975; 1978). According to the 1:250.000 scale geological map sheet of Mamuju, rock formations of this area were formed from Quaternary, Tertiary and Pre-Tertiary. Based on field observations, soil parent materials can be divided into: deposition of alluvium, sedimentary rocks, granite intrusive rocks, volcanic rocks, and older metamorphic rocks (Table 1; Figure 1)

The purpose of the study was to obtain a landuse information to provide a characteristics of land resources through the identification and evaluation of potential land resources and that suitable for food crops in Mamuju district, West Sulawesi.

MATERIALS AND METHODS

Study Area

The study area was located on Mamuju District, West part of West Sulawesi Province, Indonesia (Figure 1).

Materials

The material used in this study consisted of (1) digital Data resolution Landsat imagery and SRTM 30 m; (2) map earth manner Indonesia published by 1:50,000 scale Spatial Information Agency; (3) digital contour map / digital evaluation model (DEM) with interval from 25 to 12.5 m; (4) 1:250,000 scale
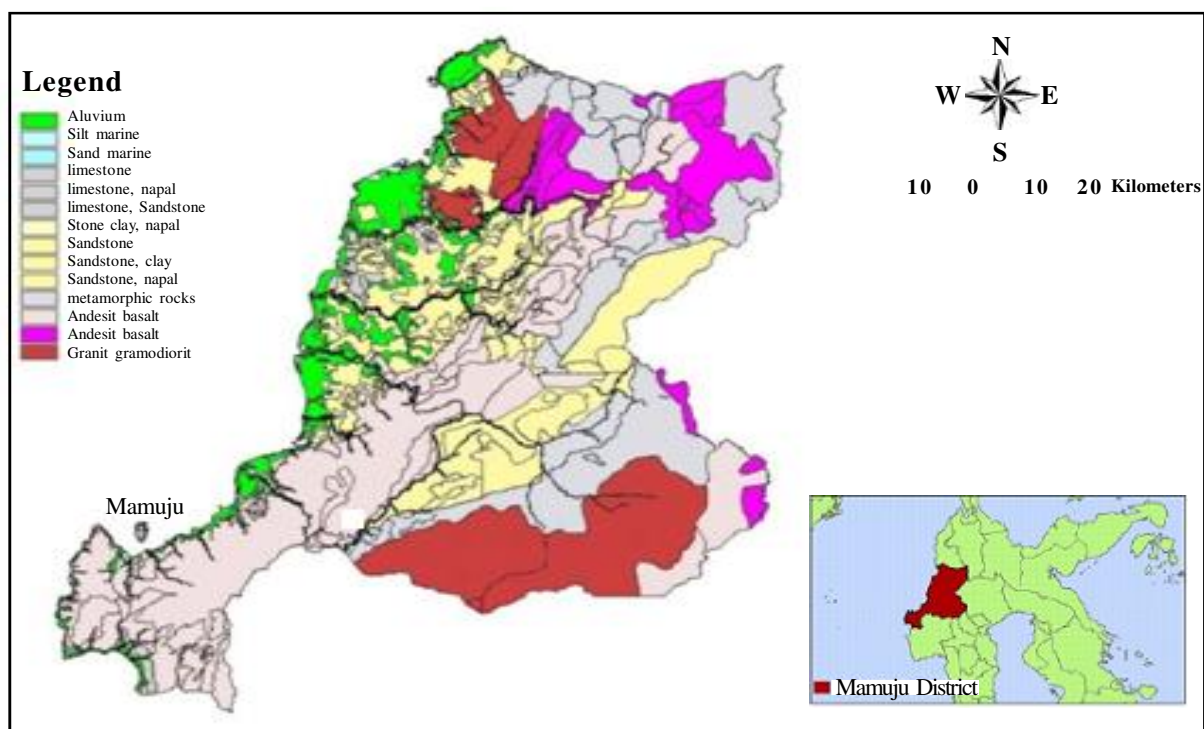

Figure 1. Distribution of parent material's map of Mamuju Disrict, West Sulawesi.

geological maps published by Bandung Geology Research Institute; (5) Map 1:3.000.000 scale agro Sulawesi (Oldeman *et al.* 1977); (6) Map of the status of land / forest of Sulawesi (Menteri Kehutanan 2009); (7) Books counties in number; (8) Several reports on the results of surveys and semi-detailed soil mapping scale of 1:50,000.

The other materials were needed for field equipments consisted of compass, altimeter, GPS, Abney level, pH-meter, ArcView and ArcGIS program software for spatial analysis and data entry field observations.

Mapping method essentially uses the principles of landscape approach to mapping or land units (Marsoedi *et al.* 1997; Buurman and Balsem 1990) delineated from remote sensing imagery other data supported it. Land units were used as the basis for field observations. Therefore the availability of remote sensing image data was one important part of this study. Identification and evaluation of resource potential semi-detailed level of land began

with desk work, then followed by field observations and data processing / preparation of maps. Application of GIS and digital analysis were used to speed up data processing and presentation of research results. To helped details and acceleration analysis of land units, an analysis relief was derived from Shuttle Radar Topography Mission (SRTM) data using ArcGIS software.

Activity analysis and delineation of land units were done on desk work and it was the main activity that must be done before the research field. Therefore, the preparatory activities for the analysis of land units were conducted more intensively, in order to facilitate field operations planning and preparation of soil maps in the field.

Methods

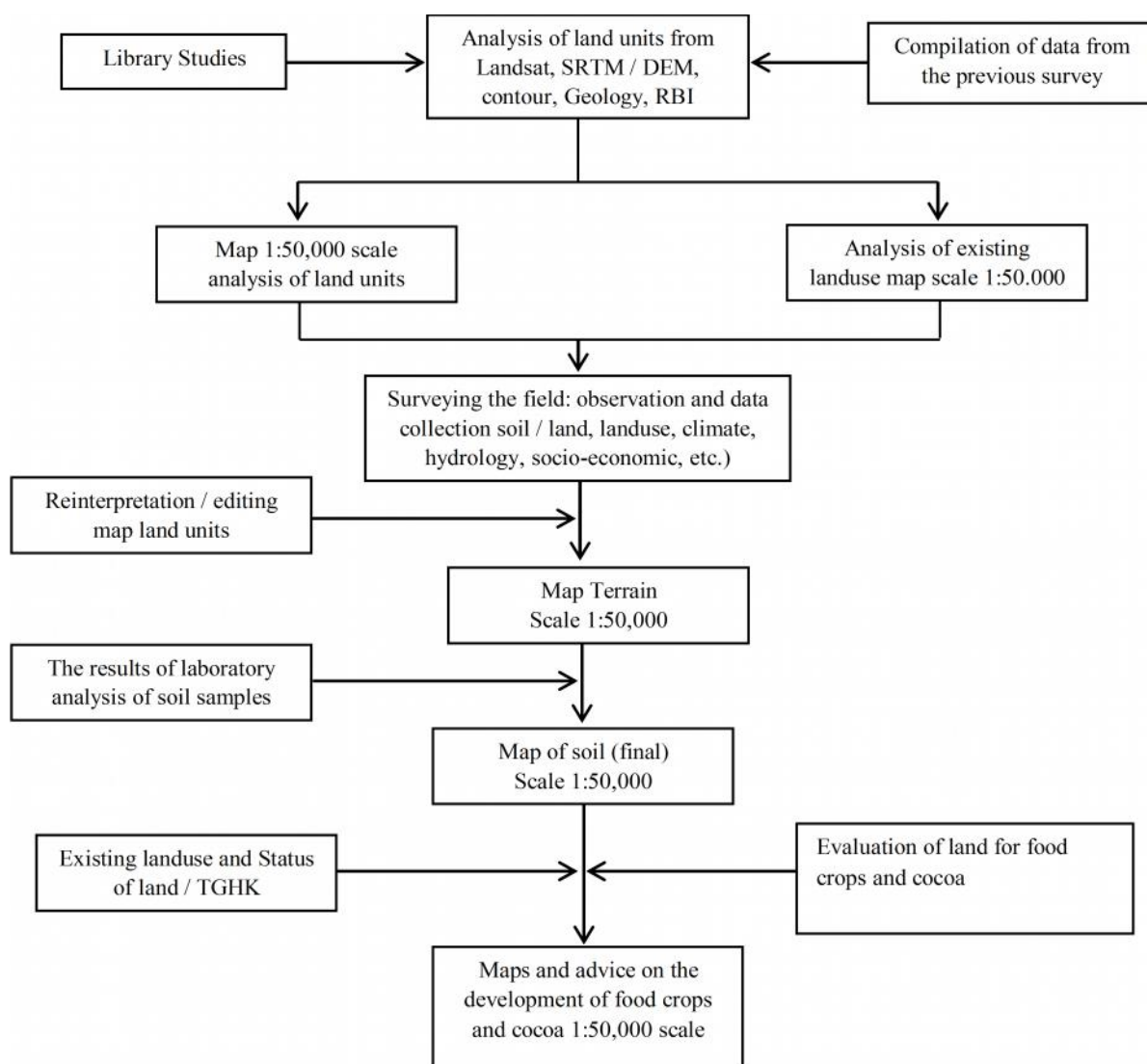Methods used were: (1) Surveying; (2) Collecting and processing data; and (3) Evaluating and Intrepretating (Figure 2).

Figure 2. Schematic diagram of collecting and processing data.

Preparation

Collection and compilation of data - Data collected from the research were reviewed and evaluated prior to completion of the relevant data and then did the data entry and ploted delineation of maps and observation points on the base map. Data compilation would be used as reference data or represent additional territory. Compilation of data was stored in databases and Horizon Site Description (SHD). In addition, the literature study were done to study the general physical condition of the environment and the availability of data supporting the survey area.

*Preparation of base maps-digital-*Base map used was derived from 1 : 50,000 scale *Bakosurtanal / Badan Informasi Geospasial*. If it was not available, the base map was created from 1:50,000 scale maps or topographic features.

Table 2. Land Form Group Distribution.

No	Type of parent material	Area	
		Ha	%
1	Aluvial (A)	60.855	7.68
2	Fluvio-Marin	3.311	0.42
3	Marin	3.135	0.40
4	Karst	3.534	0.45
5	Plain tectonic	79.884	10.08
6	Hills tectonic	99.010	12.50
7	Mountains tectonic	135.394	17.09
8	Plain old volcanic	19.037	2.40
9	Old volcanic hills	94.264	11.90
10	Old volcanic mountains	173.347	21.88

Landsat image was scanned and then digitized by a few important attributes necessary maps. *Preparation of Soil Map Unit Analysis-*Analysis of digital data Landsat imagery and radar/SRTM was conducted to delineate the components of land units and land use right now. Land units consisted of the elements of Land Form, parent material, relief and slope, altitude, rate of incision and drainage patterns. For areas where no data available, it was done by using overlay delineation between Landsat imagery with digital elevation data, geological maps and map topographic features visually on a computer screen using ArcView. DEM data was used specifically detailed analysis of existing land units, using the slope parameter and the height difference was computerized processed by ArcGIS. Areas that can not be analyzed from the image delineation of land units were assisted by analysis of digital elevation/DEM, geological maps and RBI. Results delineation of land units and land use were transferred to the base map that had been adapted coordinate with remote sensing image data.

Fieldwork

Pre-survey - The event was held prior to the main survey in order to prepare the technical stuff as well as non-technical. Non-technical activities included consultation with local governments for confirmation and determination of the areas to be mapped; additional information, labor, and transportation/accessibility of the area etc. Technical matters such as conducting orientation and field observations were done to obtain an
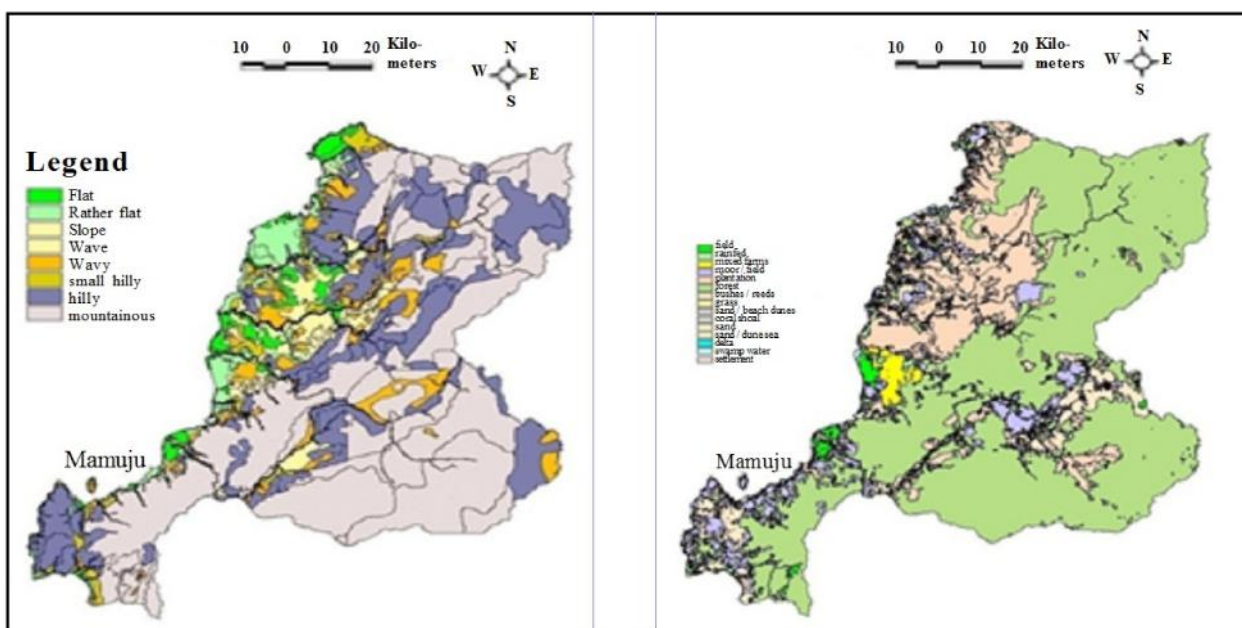

Figure 3. Land form (right) and land use (left) of Mamuju as result of survey data.

overview of the study area. The information would be used as a basis to carry out an initial improvement of land units of analysis and implementation strategy of field operations.

Main Survey- The survey included observations of main land units, and preparation of field maps terrain. Parameters observed included morphological characteristics. For areas that could not be reached, extrapolation based on similarity Landform, lithology, and relief was conducted. The procedure for morphological observation followed the guidelines for Land Observation (ISRI 2004). The composition of the soil units was estimated from observations transect (Steer and Hajeek 1979).

During the observations from the field, delineation improvements and land units map legend were carried out continuously, so that at the end of the field surveys it could already be formed. For land units were spread wide.

Preparation of Concept Maps Land - Concept maps were drawn towards the ground when the field work was completed. This map was the result of the analysis that had been corrected by the observation field. The maps contained legend of land, units Landform, parent material, relief, and slope and description of each unit area of the map (Hardjowigeno *et al.* 1993).

Data Processing

Data processing included interpretation of field data and laboratory data and field evaluation. *Interpretation of data*-data field observations and data analysis interpreted the characteristics and classification of land, land evaluation for agricultural commodities.

Land Evaluation-The evaluation of land, in principle, was done by caramatchingie by comparing the characteristics of the land with the growing requirements of plants (Djaenudin *et al.* 2003). Land suitability assessment methods in principle use the framework of FAO (1976) and CSR/FAO Staff (1983) and the process used the program Automated Land Evaluation System (Roositer and Van Wambeke, 1997). The system was capable of processing large amounts of data in a relatively short time. To support the needs of data which was complete, clean and had been stored in the database.

Preparation Guide Recommendations- Preparation of maps on agricultural development was done by matching the results of the evaluation of land in the overlay with existing maps and landuse maps status regional/spatial planning taking into account existing local commodity.

Evaluation

Evaluation and correlation intended as quality control was to maintain the quality of the mapping to match the rules or standards established soil mapping.

RESULTS AND DISCUSSION

Form Region

Based on the interpretation of radar images / SRTM, Landsat imagery, geological maps, and map

Table 3. Biophysical Parameters.

Parameter	Land Quality	Characteristics of Land
Climate	Temperature regimes, water availability	Air temperature, rainfall annual average, dry months and wet months
Soil	Conditions rooting media, nutrient retention, nutrient availability, toxicity	Soil depth, drainage, texture, coarse material, CEC, Soil pH, organic C, NPK, poisoning / sulfidic materials and salinity
Terrain	Erosion, floods, land preparation	Form regions, floods, Outcrop rock, and the state of the surface rocks

Table 4.Criteria for Assessment.

Symbol	Name	Definition
S1	Very Appropriate	No / little limiting biophysical meaning, which affect soil and crop management
S2	Simply Accordance	Rate limiting biophysical light, which affect soil and crop management. Repairs requiring low input
S3	Corresponding Marginal	Rate limiting can affect the biophysical medium soil and crop management. Repairs needed input was.
N	Not Suitable	Rate limiting biophysical weight, so its use is not possible. Repairs require high inputs that are not comparable.

topographic features Indonesia as well as field observations, the study area could be divided into 6 groups, namely Landform: alluvial group, group fluvio-marine, marine chains, chains karst, tectonics group and volcanic group.

The Land Use

Currently Mamuju land used for: 1) agricultural land, which consisted of rice, dry land farming, mixed farms, plantations and farms, 2) non-agricultural land, including upland forest, mangrove forest, scrub, grassland , sago swamps and neighborhoods (Table 2).

Land Evaluation

Evaluation is the process of land suitability assessments of an area of land for a specific use, in this case agricultural crops and perennial crops cocoa. Biophysical parameters used for land evaluation was the climate, terrain, and soil.

Land suitability assessment was conducted for each soil map unit to the level of class and sub-class. The process of calculation was using a computerized program ALES (Automated Land Evaluation System). Evaluation results were presented in the form of tabular data.

Recommendation of Land Use for Agricultural Development in Mamuju District

The preparation of land use map direction for agricultural development based on evaluation of the suitability of land for food crops and cocoa, taking into account the general plan of the provincial spatial (spatial planning)/forest status, and current land use (existing landuse) using overlay technique

maps. Suitable land which did not enter the protected area and had not been used, it could be used for expansion, while suitable land and had been used could be directed to agricultural intensification.

The land was quite suitable (S2 class) and the corresponding marginal (class S3) could be directed to the development of agriculture, while land that was not suitable (class N) was directed to conservation/ protection. To determine which choice was made priorities that was sorted from the first to crops, namely: (a) crop wetlands/wetland rice,
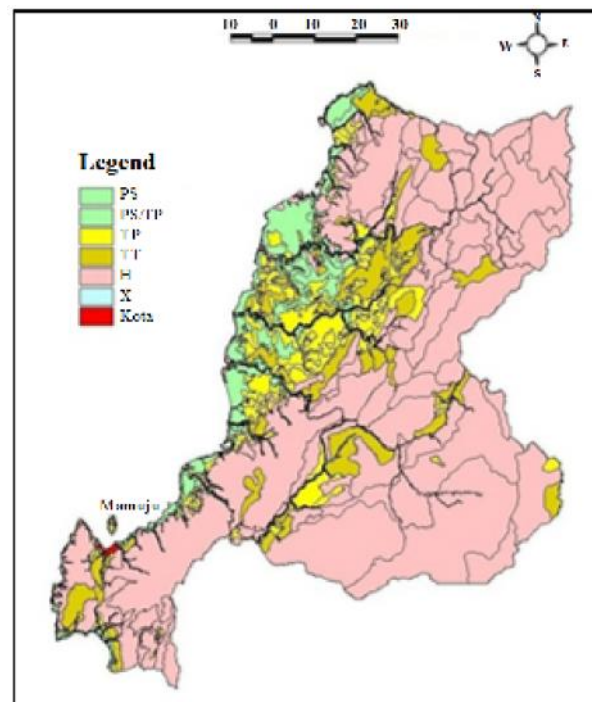

Figure 4. Recommendation of agricultural development of Mamuju District.

Table 5. Referrals land use for food crops and cocoa development in Mamuju.

Symbol	Farming System,CroppingPattern,Alternative Commodities	Area	
		Ha	%
	Wetland Farming System		
PS	Paddy field (sawah)/ com	49,345	6.23
PS/TP	Paddy field-corn/ soybean/sweet potato/ vegetable	10,680	1.35
	DrylandFarmingSystemCrop / Vegetables		
TP	Corn / soybean-sweet potato / vegetable	101,785	12.84
	System Annual Crops / Fruits		
TT	Cocoa, coconut, coffee, palm oil, pepper, cloves, durian, rambutan	90,488	11.42
	Conservation Areas		
H	Conservation Forest / Protected	532,616	67.19
	Other Usage		
X	Other	7,781	0.98
	TOTAL	792,695	100

Table 6. Suitability of land for paddy crop.

Symbol	Commentary	The Limiting Factor	Area Ha	Area %
S2nr	Land is quite appropriate	Nutrient retention	49,442	6.24
S2eh/nr	Land is quite appropriate	Erosion, nutrient retention	18,258	2.30
S2nr/rc	Land is quite appropriate	Nutrient retention, rooting media	34,088	4.30
S2rc/fh	Land is quite appropriate	Rooting media, seasonal flooding	1,580	0.20
S2rc/nr	Land is quite appropriate	Rooting media, nutrient retention	2,294	0.29
S2nr/fh	Land is quite appropriate	Nutrient retention, flood hazard	10,271	1.30
S3eh	Marginal land suitable	Erosion hazard	30,500	3.85
S3xs	Marginal land suitable	Sulfidic material	1,190	0.15
S3xc	Marginal land suitable	Salinity	2,201	0.28
Nrc	Land not suitable	Rooting media	811	0.10
Neh	Land not suitable	Erosion hazard	636,095	80.24
X	Other		5,964	0.75
		TOTAL	792,695	100

Table 7. Suitability of land for dryland crops.

Symbol	Commentary	The Limiting Factor	Area Ha	Area %
S2nr	Land is quite appropriate	Nutrient retention	49,112	6.20
S2nr/fh	Land is quite appropriate	Nutrient retention, seasonal flooding	1,580	0.20
S2eh	Land is quite appropriate	Erosion Hazard	6,587	0.83
S2eh/nr	Land is quite appropriate	Erosion, nutrient retention	23,913	3.02
S3oa/S2nr	Land after marginal / quite fit	Drainage, nutrient retention	8,863	1.12
S3eh	Marginal land suitable	Erosion Hazard	18,862	2.38
S3oa	Marginal land suitable	Drainage	58,578	7.39
Nrc	Land not suitable	Rooting media	811	0.10
Nxs	Land not suitable	Sulfidic material	1,190	0.15
Neh	Land not suitable	Erosion Hazard	617,235	77.87
X	Other		5,964	0.75
		TOTAL	792,695	100

Table 8. Suitability of land for annual crops/ cocoa.

Symbol	Commentary	The Limiting Factor	Area Ha	Area %
S2nr	Land is quite appropriate	Nutrient retention	50.694	6.40
S2eh/nr	Land is quite appropriate	Erosion and nutrient retention	30.500	3.85
S3oa	Marginal land suitable	Availability of oxygen / drainage	68.114	8.59
S3eh	Marginal land suitable	Erosion Hazard	87.105	10.99
Nrc	Land not suitable	Rooting media	811	0.10
Nxs/oa	Land not suitable	Sulfidic materials and drainage	1.190	0.15
Neh	Land not suitable	Erosion Hazard	548.317	69.17
X	Other		5.964	0.75
		TOTAL	792.695	100

(b) dry-land crops (crops, tubers), and (c) annual plant/cocoa. Land suitable for dryland crops generally corresponded well to annual crops/cocoa (Figure 4).

In general, the study area could be grouped into three areas of development, namely: (a) Regions cultivation of food crops and perennial crops, (b) conservation area, and (c) other use. Agricultural

cultivation area has been divided into arable land (existing landuse) for intensification and land for expansion (extensification). Existing landuse from the observations in the field showed that the land was generally flat to gentle sloping potential already cultivated, so that potential land for the purpose of practical agricultural expansion was not available, and if available, its range was narrow and scattered. Referrals/recommendations for the development of land use for food crops and cocoa crops are presented in Table 5 and land suitability and limiting factors for paddy, dry land crops, and annual crops are presented in Table 6 – 8.

CONCLUSIONS

This study results showed land that suitable for food using class S2, 115.934 ha (14.63%) and the corresponding marginal (class S3) 33.891 ha (4.28%). For dryland were S2 class 81.192 ha (10.24%), S3 class 77.440 ha (9.77%), and the class of S3/S2 8.863 ha (1.12%). If assessed only for cocoa trees, the land was quite appropriate that included 81.193 ha (10.24%) and the class of S3 155.219 ha (19.58%). The main limit factors were the seasonal flooding, drainage, nutrient retention, and erosion hazards.

Referrals to the development of agricultural land use were specified as follows: (a) land for paddy crop area of   49.345 ha (6.23%) ; (b) for rice and corn / soy / vegetable 10.680 ha (1.35%); (c) for crops of corn / soybean / sweet potato / vegetable area of   101.785 ha (12.84%), and (d) for the cocoa / coconut area of   90.488 ha (11.42%). Land for conservation area 532.616 ha (67.19%), and the other uses 7.781 ha (0.98%).

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