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A GIS based Land Capability Classification of Guang Watershed, Highlands of Ethiopia

Gizachew Ayalew [1] & Tiringo Yilak [2]

[1] Amhara Design and Supervision Works Enterprise (ADSWE), Bahir Dar, Ethiopia

[2] College of Agriculture, Debre Tabor University, Debre Tabor, Ethiopia

Corresponding author: Gizachew Ayalew, Amhara Design and Supervision Works Enterprise (ADSWE), Bahir Dar, Ethiopia. *E-mail:gizachewayalew75@yahoo.com

Abstract

The main objective of this study was to spatially classify lands of Guang watershed, Ethiopia based on their capability for sustainable use by USDA criteria in 2014. Land use land cover was determined from LANDSAT satellite image by applying supervised classification method in ENVI 5.0 software. "Spatial Analyst Tool Extract by Mask" in GIS environment was used to obtain soil depth and soil texture map of the watershed from Amhara Regional digital soil map. Digital Elevation Model (DEM) data of 30 m resolution was used to derive slope. Intersect overlay analysis method was applied to obtain the spatial and attribute information of all the input parameters using Geographical Information System (GIS) 10.1 soft ware. The study demonstrates that GIS provide advantage to analyze multi-layer of data spatially and classify land based on its capability. The study revealed that 1,540 ha (61.6%), 442.25 ha (17.69%) and 518 ha (20.52%) of the watershed was categorized in the range of land classes I to IV, V to VII and VIII, respectively. It was observed that present land use land cover was not as per the capability of the land.

Keywords: land capability classification, GIS, Guang watershed

1. INTRODUCTION

Natural resources should be managed in a sustainable manner so that the changes proposed to meet the needs of development are brought without diminishing the potential for their future use (Kanwar, 1994). It has been essential in a country like Ethiopia where majority of the population depends on agriculture. The increase in the number of people makes a pressure rate on land resources inevitable that causes an impact on the land degradation and environmental pollution.

United State Department of Agriculture (1973) guidelines have been applied to determine land capability with eight classes designated with Roman number I to VIII. The criteria for placing an area in a particular class involve the landscape location, slope, depth; texture and land use/land cover. The final aim of LCC is to predict the agricultural capability of the land development units in function of the land resources (Sys *et al*, 1991). Agriculture is the mainstay of the Ethiopia's economy where its production is highly dependent on natural resources (Akililu and Graaff, 2007). However, land degradation is a major cause of poverty in country and the farming populations have experienced a decline in real income due to demographic, economic, social, and environmental changes (Mitiku *et al,* 2002).

Sustainable land management is inevitable to minimizing land degradation, rehabilitating degraded areas and ensuring the optimal use of land resources for the benefit of present and future generations (FAO, 1998, 2008). Despite the aggravation of land degradation and its consequences in the country in general and the study watershed in particular, there have been few studies to classify lands based on their capability at watershed level. Therefore, this study was initiated to spatially classify lands of Guang watershed based on their capability for sustainable use.

2. MATERIALS AND METHODS

2.1 Description of the Watershed

Guang watershed is located in Amhara National Regional State at 597 km northwestern of Addis Ababa, Ethiopia. The watershed lies within $11^0 35' 59''$ to $13^0 49' 12''$ latitude and $35^0 09' 45''$ to $37^0 46' 42''$ longitude (Figure

1) in an area of 25000 ha. Agro-ecologically, 51% and 49% of the watershed is found to be warm and hot zone, respectively. Rainfall is ranging from 720 mm to 1253.2 mm and temperature extends from 12.8^0_C to 30.15^0_C in the watershed. Altitude is ranging from 511 to 3,043 m.a.s.l. (DSA and SCI, 2006).

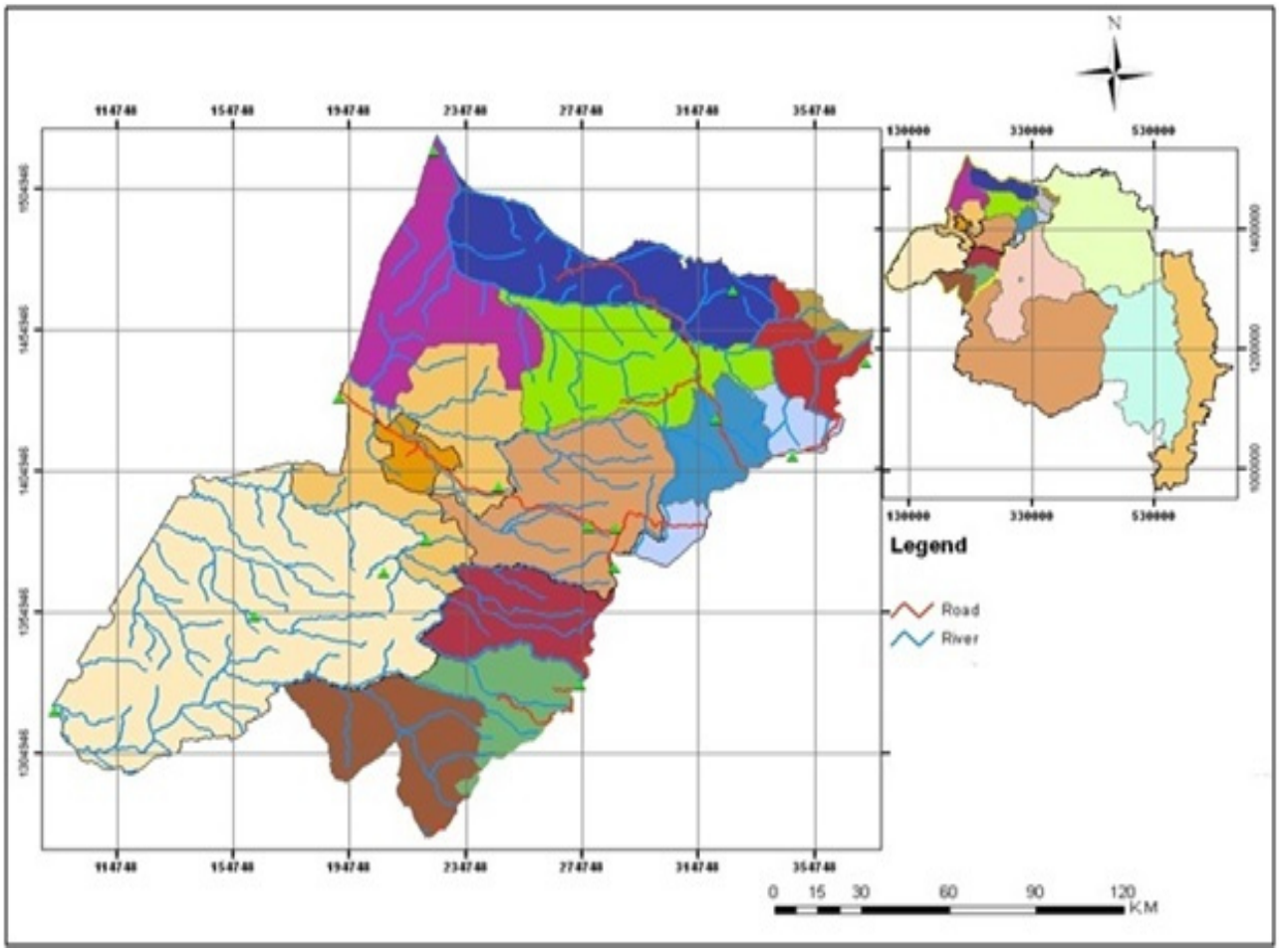

Figure 6: Location map of study watershed

2.2 Materials and Methods

Land use land cover was determined from LANDSAT satellite image by applying supervised classification method in ENVI 5.0 software. The 30 m spatial resolution DEM (digital elevation model) was used to generate slope by using "Spatial Analyst Tool Surface Slope" in ArcGIS environment. "Spatial Analyst Tool Extract by Mask" in GIS environment was used to obtain soil depth and soil texture map of the study watershed from Amhara Regional digital soil map at 1:50, 000 scale developed by DSA and SCI (2006). Finally, "Tools Overlay Intersect" in GIS environment was used to map LCC using USDA (1973) LCC method in ArcGIS at scale of 1:25,000. Ground truth data were used to validate the results.

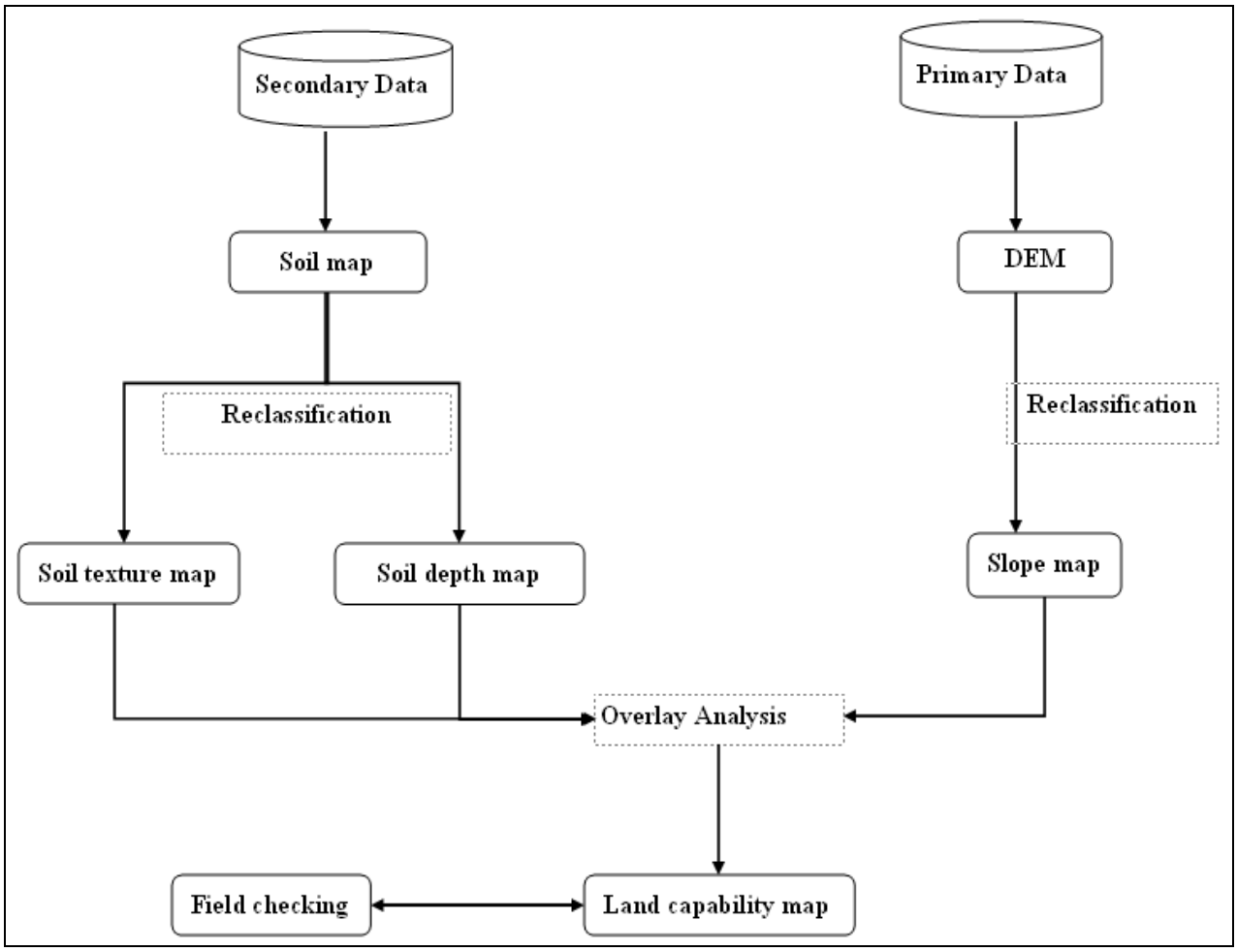

Figure 2: Land capability classification (LCC) method performed in GIS environment

3. RESULTS AND DISCUSSION

LCC I to III occupied 185.5 ha (7.42%) of the watershed can be termed as the land suitable for agriculture. This study indicated 4.78% of the total area falls in LCC I. The soils in LCC I do not have limitations that restrict their use and suitable for a wide range of crops. The soils are deep and the land is flat to gently sloping. Their texture indicates that they have a higher water-holding capacity. LCC II occupied 3 ha of land accounted 0.12% of the watershed. Soils in LCC II have limitations that require moderate conservation practices. LCC III class consists of 63 ha (2.52%) (figure 3 and table 1). Soils in LCC III have combinations of limitations that require special conservation practices. The soils conditions of land capability class IV can be used for cultivation and need conservation measures.

LCC V occupied only 72.5 ha (2.9%) of the study watershed. LCC VI covered about 14.34% and their soils have limitations that restrict their use other than grazing. LCC VII covered about 11.25 ha (0.45%) and their soils have very severe limitations which restrict their use to grazing. LCC VIII occupied 518 ha (20.72%) The soils in LCC VIII should not be used for commercial plantation. Their use should be restricted to recreation purpose. In general, LCC IV to class VIII can be grouped under the group of land not suitable for agriculture. However, the dominant area (1354.5 ha, 54.18%) of the watershed is being cultivated (Figure 3 and Table 1).

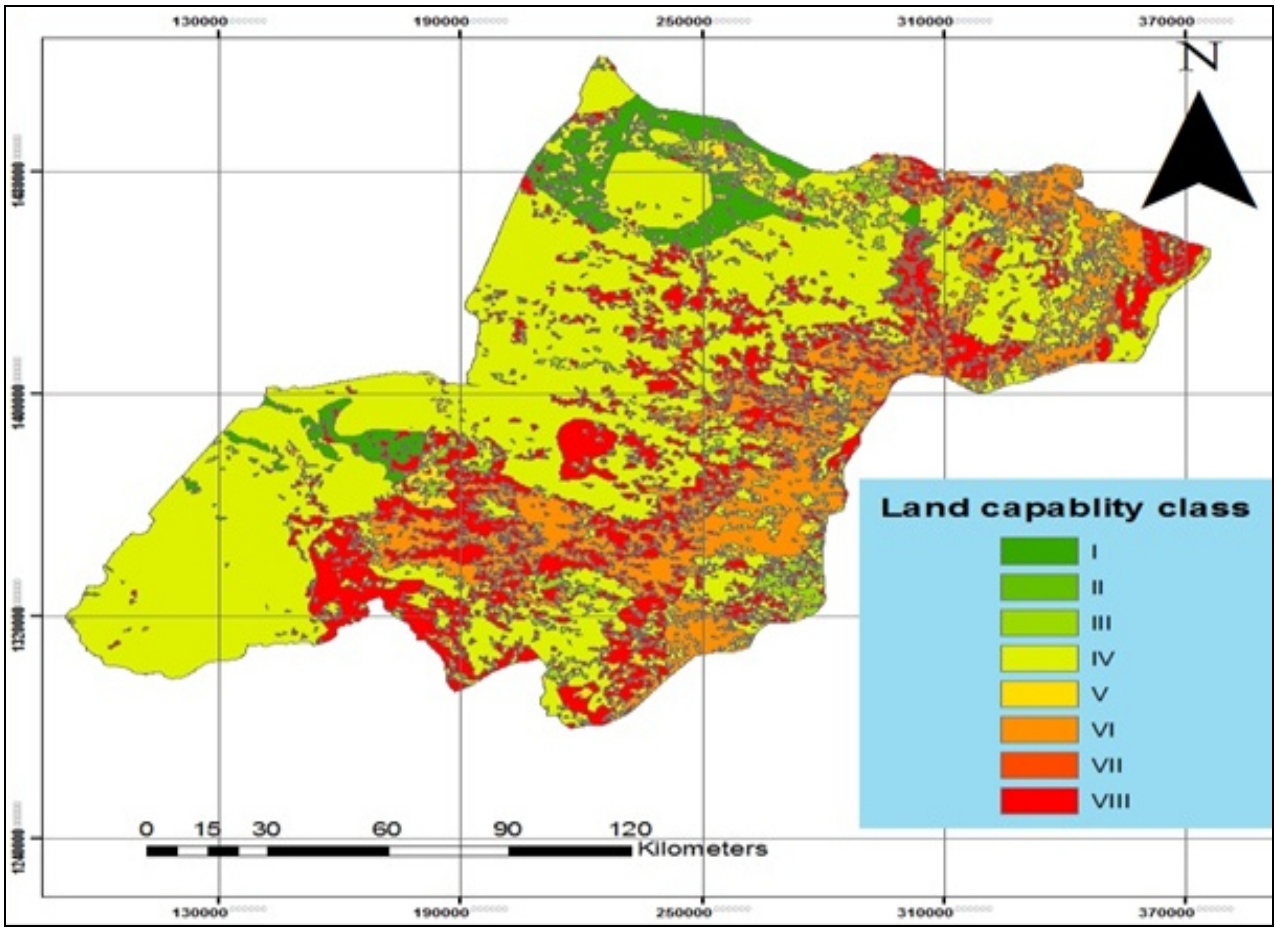

Figure 3: Land capability map of the study watershed

Table 1: Land capability class, land cover and its area

No.	Land capability class	Land cover	Area (ha)	Area (%)
1	I	Cultivation	119.5	4.78
2	II	Cultivation	3	0.12
3	III	Cultivation	63	2.52
Sub-total			185.5	7.42
4	IV	Cultivation	1354.5	54.18
Sub-total			1540	61.6
5	V	Grass land	72.5	2.9
6	VI	Grass land	358.5	14.34
7	VII	Grass land	11.25	0.45
Sub-total			442.25	17.69
8	VIII	Forest	518	20.72

4. CONCLUSIONS

The study demonstrates that GIS provide great advantage to analyze multi-layer of data spatially and classify land based on its capability. The LCC procedure described would be instrumental to identify land capability classes for decision-making process. Land capability classes ranging I to III are suitable for a wide range of uses. However, they require some soil conservation actions. Classes IV and VI are most susceptible to land degradation. Hence, the land use pattern need to be modified according to identified land capability classes to conserve and sustainably use of the land resources of the watershed.

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