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Land capability classification using geographical information system in shinfa watershed, highlands of Ethiopia

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ABSTRACT

The main objective of this study was to spatially classify lands of Shinfa watershed in Ethiopia based on their capability for sustainable agricultural use by United States Department of Agriculture (USDA) criteria. Land use and land cover was determined from LANDSAT satellite image accessed in 2014 by applying the supervised classification method in ENVI 5.0 software. Digital Elevation Model (DEM) data of 30 m resolution was used to derive slope. "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. 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 software. The study demonstrates that GIS software provides 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 was not as per the capability of the land.

Key words: capability, GIS, Shinfa watershed, highlands, Ethiopia.

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). Natural resources management has become important to countries like Ethiopia, where the majority of the population is involved in agrarian activities. Population expansion also increases dependence and pressure on land and its resources. In the absence of pertinent land resources management strategies, this leads to land degradation and ecological pollution in various manners.

United State Department of Agriculture (USDA), (1973) guidelines have been applied to determine Land Capability Classification (LCC) land capability with eight classes designated with Roman numerals I to VIII. The criteria for placing an area in a particular class involve; location, slope, depth; texture and land use. The final aim of Land Capability Classification (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 Ethiopia's economy where its production is highly dependent on natural resources (Akililu and Graaff, 2007). However, land degradation is a major result of rural poverty 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 the areas and ensuring the optimal use of land resources for the benefit of present and future generations (Food and Agricultural Organization (FAO), 1998, 2008). Despite the aggravation of land degradation and its consequences in the country in general and the study of 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 the watershed based on their capability for sustainable use.

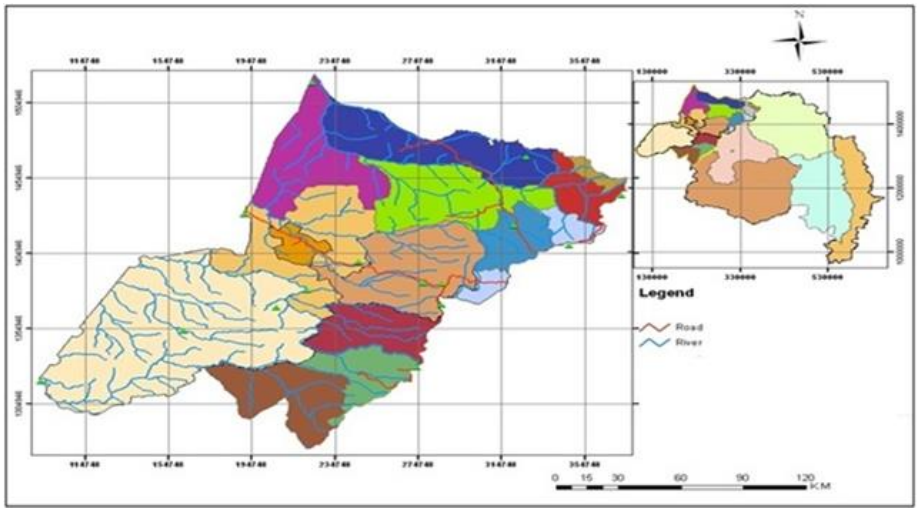

Figure 1. Location map of the watershed. **Source:** Gizachew and Yihenew, 2015).

MATERIALS AND METHODS

Description of the Watershed

Shinfa watershed is located in Amhara national regional state at 597 km north west of Addis Ababa in Ethiopia. Agro-ecologically, 51% and 49% of the watershed is found to be located in warm and hot zones, respectively. Rainfall ranges from 720mm to 1253.2 mm and temperature extends from 12.8 to 30.15^{0}_{C}. Altitude ranges from 511m to 3,043 (m.a.s.l.) (Development Studies Associates and Shawel Consult International, 2006).

Materials and Methods

Land use/land cover was determined from LANDSAT T satellite image by applying the 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 (Figure 1) from Amhara regional digital soil map at 1:50, 000 scale developed by Development Studies Associates (DSA) and Shawel Consult International (SCI), (2006). Finally, “Tools Overlay Intersect” in GIS environment was used to map LCC (Table 1) using USDA (1973) LCC method in ArcGIS (Figure 2) at scale of 1:25,000.

RESULTS AND DISCUSSION

LCC I to III occupy 185.5 ha (7.42%) of the watershed and can be labeled as land suitable for agriculture. This study indicated that 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 and accounts for 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. Class IV lands can are ideal for cultivation if they are given the pertinent conservation measures.

LCC V occupied 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 class 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).

CONCLUSIONS

The study demonstrates that GIS provides 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.

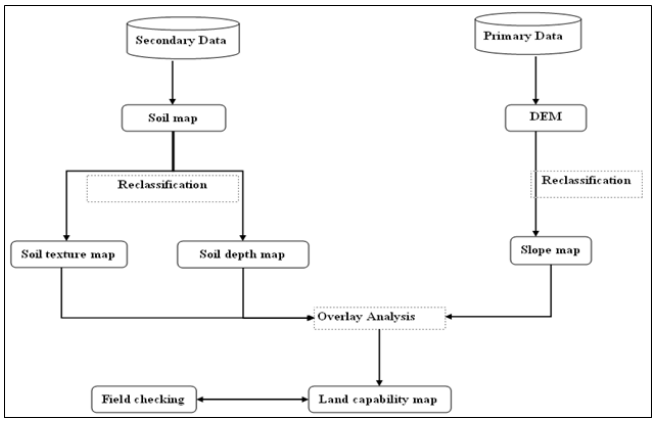

Figure 2. Land capability classification (LCC) method performed in GIS environment.**Source:** Gizachew A,2015.

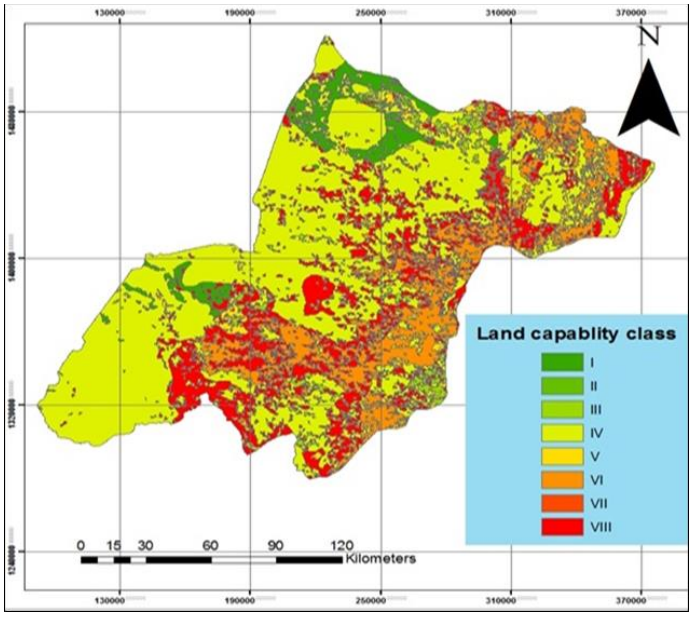

Figure 3. Land capability class map of the study watershed.
Source: Gizachew A,2015

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

No.	Land capability class	Land cover	Area (ha) Cover	Area (%) Cover
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

However, they require some soil conservation actions. Classes IV and VI are most susceptible to land degradation. Hence, the land use pattern needs to be modified according to the identified land capability classes to conserve and sustainably use of the land resources of the watershed.

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