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Assessment of Land Capability Using Remote Sensing and GIS Techniques in Fincha'a Watershed, Western Ethiopia

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Abstract: The main objective of this study was to spatially assess land capability for agriculture in case of Fincha'a watershed. Parameters which assessed to achieve the goal of this study were generated from different sources. Land use and land cover was determined from LANDSAT satellite image by supervised image classification method in Erdas 2010 software. Digital Elevation Model (DEM) data of 30 m resolution was used to derive slope. Soil depth and soil texture parameters were generated from field and assessed in laboratory. "Geospatial Analyst Tool krigging interpolation" method in GIS environment was used to obtain soil depth and soil texture map of the watershed. Intersect overlay analysis method was applied to obtain the spatial and attribute information of all the input parameters using Arc GIS 10.3 software. 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 4758 ha(58.89%) of the watershed was categorized in the range of land capability classes I to IV with increasing of limitation from class I to class IV and 3321.47 ha (41.11%) was categorized in the range of land classes V to VIII which was not suitable for agriculture. For each class which need soil conservations, conservation management practices was proposed and recommended.

Key words: Capability · GIS · Fincha'a Watershed · Highlands · Ethiopia

INTRODUCTION

Land is the most valuable natural resource, which needs to sustain according to its potential. Especially, in developing countries where agricultural activities are backbone for economic value, land needs wisely using with staying on its potential [1]. However, due to over exploitation and mismanagement of natural resources coupled with socio-economic factors, the problem of land degradation is on the rise [2]. Not only have that, over-increasing population, increased competition, for a variety of demands are problem that shrinking land resources [3]. If it continuous without applying appropriate land resources management strategies, it leads to degrading the land and finally put the agricultural activity in question [4]. According to Baja [5], assessing the land based on its capability and putting for proper land use planning is one ways of protecting land from degradation. Guidelines which adopted by Sys, van Ranst and Debaveye [6] and revised soil and land capability classification by Murphy *et al.* [7] applied to determine Land Capability Classification (LCC) with increasing limitation from class I to VIII. The criteria for placing an area in a particular class involve; location, slope, soil depth; soil texture, water logging, infiltration, stoniness [6, 7]. The final aim of Land Capability Classification (LCC) is to predict the Land capability of the land development units in function of the land resources [8]. Even though, Ethiopia's economy depend on agriculture; 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 [9, 10]. Similarly, Fincha'a watershed is one of the highlands of Ethiopia suffered by land degradation from human and natural cause. over population, mismanagement of land resource, overgrazing, continuously cultivation, removal of crops residue and manure, steep slopes farm are main cause which accelerate land degradation in the study area. But, inspire of the problem is highly visible in study area, studies that assess the land capability classes for this specified Fincha'a watershed have been none to date. Therefore, this study was initiated to spatially classify Fincha'a watershed based on its land capability for sustainable use.

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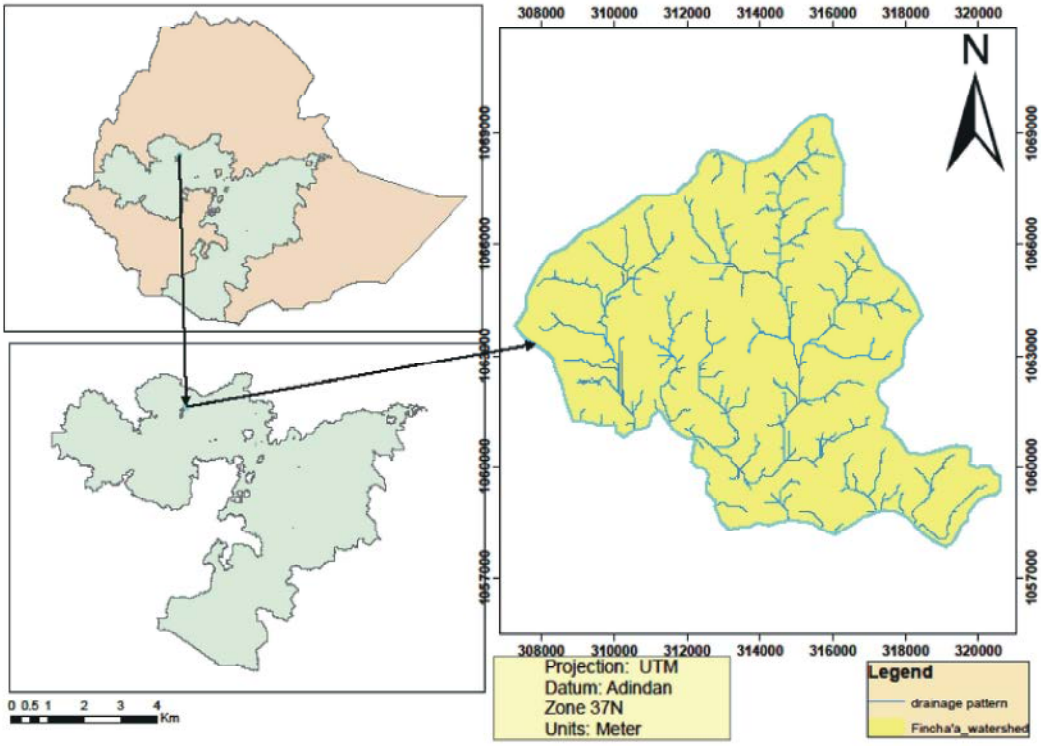

Fig. 1: Study Area Map

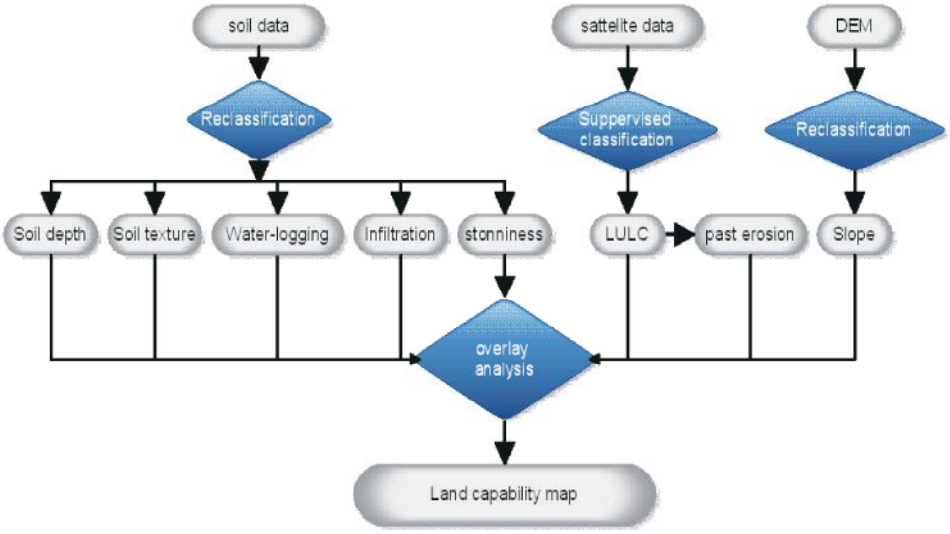

Fig. 2: Flow chart of land capability classification assessment based on GIS application

MATERIALS AND METHODS

Description of Study Area: Fincha'a watershed exist between 9°10'30" and 9°46'45" N and 37°03'00" and 37°28'30" E in Abay Choman, Ethiopia (Fig. 1) with an altitude ranging from 2196 to 2438 m a.s.l. the topographical features of the watershed includes flat to gently sloping, undulating plains, hills and mountains. The average annual rainfall of the study area is 1, 604 mm with mean monthly temperature of the area varies from 14.6 to 17.7°C [11].

Methods: Land use and land cover was determined from LANDSAT satellite image by applying supervised Classification method in Erdas Imagine software. The 30 m spatial resolution DEM (digital elevation Model)

was used to generate slope by using "Spatial Analyst Tool Surface Slope" in Arc GIS Environment. Soil data like soil depth, soil texture, water logging and infiltration of the study area were done by laboratory analysis. A "Krigging interpolation" technique was used to make continuous surface of soil parameters. The past erosion was filled on slope using Arc GIS 10 screen desktop. Finally, "Tools Overlay Intersect" in GIS environment was used to map LCC. Collected GPS points were used to validate the results. The below chart flow (Fig. 2) used to generate land capability of the study site.

RESULTS AND DISCUSSION

Land capability map of selected site was developed in GIS format at a scale1:60, 000 and it represented about six capability classes (Fig. 3). LCC I to III occupied 185.5 ha (7.42%) of the watershed can be termed as the land suitable for agriculture.

The area classified under class I has no limitation that affect crop production. The area classified under class IIL and IIIL have slope limitation that accelerates soil erosion and affect crop production. Moreover, the area classified under IVE has severe limitation of erosion. Unless this capability class supported by soil and water conservation measures, it affects sustainability of crop. The area classified under class V was swampy area that has water logging problem. This area is not suitable for upland plants except rice. The remaining portion of the study site falls under class VIIIE. This area is not suitability for crop production except forestry.

As indicated on Table 1, LCC I to IV cover about 4758 ha or represent 58.89% of the total area of watershed can be labelled as land suitable for agriculture. This study indicated that 1662 ha (20.57%) 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 2880 ha of land and accounts for 35.65% of the watershed. Soils in LCC II have limitations that require moderate conservation practices. LCC III class consists of 216 ha (2.67%) (Fig. 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 796 ha (9.86%) of the study watershed. LCC VIII occupied 888 ha (10.99%).

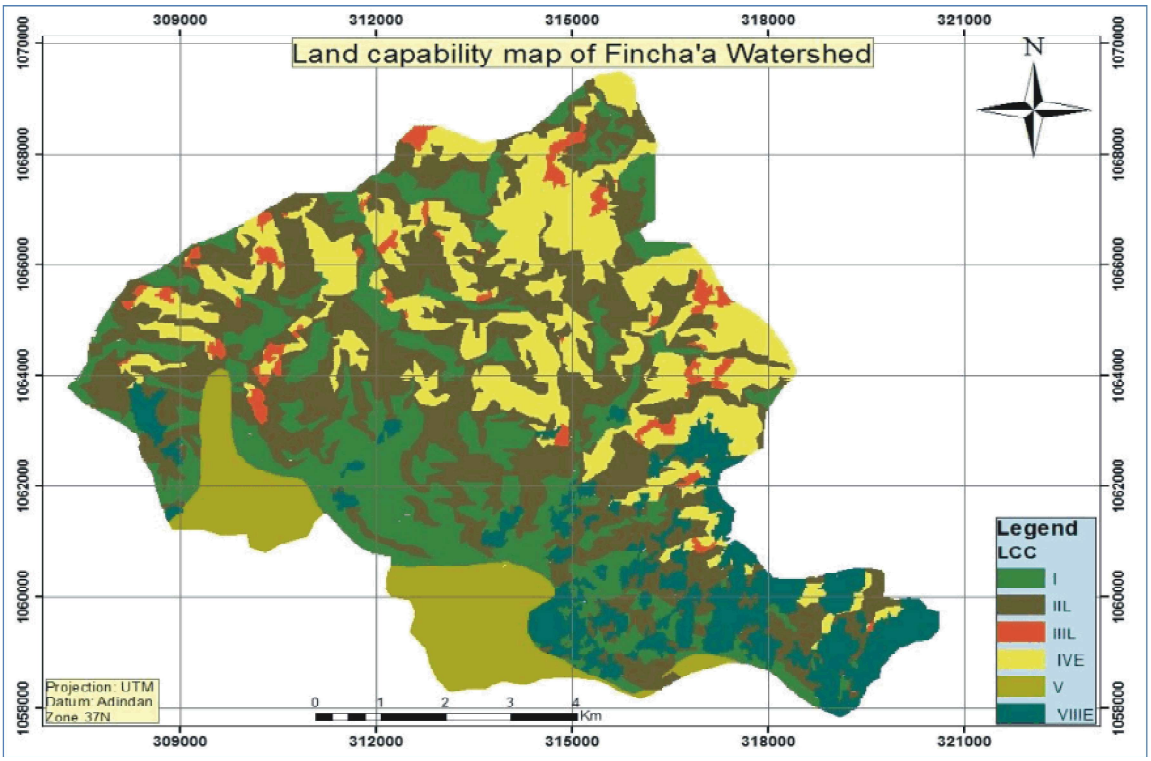

Fig. 3: Land capability map of Fincha'a watershed

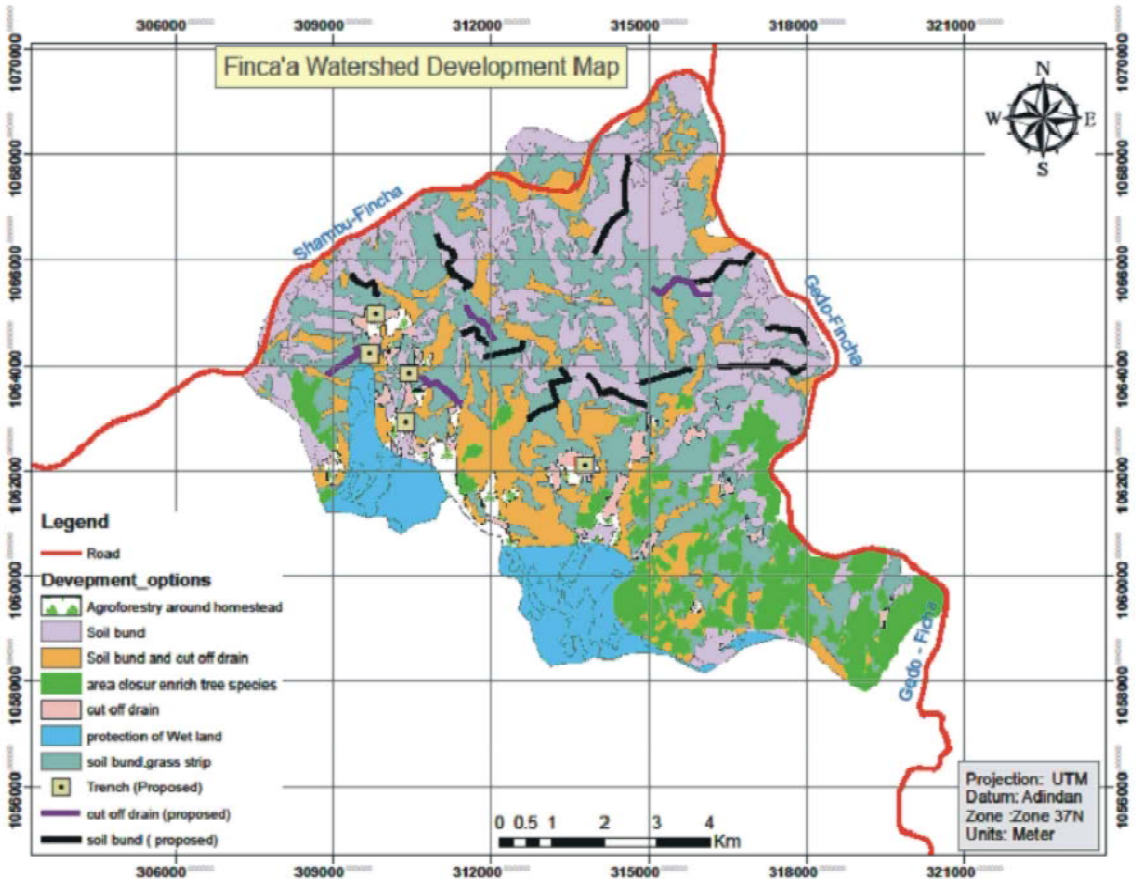

Fig. 4: Development map of study area

Table 1: Land capabilty class and its development options

LULC	LCC	Development option	Area (ha)	Area (%)
Cultivated land	IVE	Soil bund	1636	20.25
Cultivated land	I	Soil bund and cut off drain	1309	16.2
Swampy area	V	protection of Wet land	258	3.19
Cultivated land	IIL	soil bund, grass strip	2453	30.37
Wetland	V	protection of Wet land	371	4.6
open shrub land	IIIL	Soil bund	161	1.99
open shrub land	I	Soil bund	146	1.81
open shrub land	IIL	Soil bund	228	2.82
other land	VIIIE	area closure enrich tree	888	10.99
Grassland	IIIL	soil bund, grass strip	55	0.68
Homestead	I	Agro forestry around homestead	207	2.56
Water	V	protection of Wet land	167	2.07
Grassland	IIL	cut off drain	199	2.46

The soils in LCC VIII Should not used for commercial plantation. Their use should be restricted to recreation purpose. In general, LCC VI to class VIII can be grouped under the class of land not suitable for agriculture (Fig. 3 and Table 1). The large size of study area were covered by highly capable soils (Class II) represent 2880 ha (35.65%) of the total area of watershed with slope limiting factor and mainly suitable for agriculture.

Based on the [6] guideline, the conservation practice for study area land capability classes identified, the developmental option were proposed and shown by map below Fig. 4.

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.

CONCLUSIONS

The study demonstrates that GIS provides great advantage to analyse 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 and IV class also suitability for agriculture with some conservation practices. However and capability classes ranging VI to VIII are not suitable for agriculture purpose. The land which covered under this classification needs immediate action to take lands for wildlife and forests to restore the fertility of it.

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