Land Capability Classification and growing period for Guila Abena Watershed in Sassie Tseda Emba District in Eastern Tigray, Ethiopia

Amir Seid Ahmed[1], Fassil Kebede*, [2] and Mitiku Haile[2]

1- World Vision Ethiopia, Atsibi ADP, 2, Department of Land Resource Management and Environmental Protection, Mekelle University, Ethiopia

fyimamu@gmail.com

Abstract: Land capability classification and defining the growing period are important tools to assess the natural resources for sustainable land management and land use planning. This study was conducted to identify the land capability classes and describe the growing period of Guila Abena watershed, at Sassie Tseda Emba district, in Eastern Tigray. In this study, 13 land units were identified, with an area of 269 ha. The LCC study revealed that land units 1, 2, 3, 4, 5, 7, 8, 9 & 10 were categorized in the range of land classes *II* to *IV* with an area of 146 ha (54.3 %). These land units are mainly used for crop and livestock production. Land units 5 with an area of 18 ha (6.7 %) was grouped under *IIes* class and subclass having limitation of slightly erosion and surface stoniness. Land units 3, 4, 7, 8, 9 and 10 were found as *IIIs* good for cultivated crops and accounts for 28.6 % (77ha). Land units 1 and 2 were categorized as *IVs*, with an area of 51 ha. These land units are best suited for grazing land and the actual farmers practice go with the result. On the other hand, land units 6, 11, 12 and 13 were rated as class *VIIs*, with a total area of 123 ha (45.7 %). Moreover, this study divulged that the length of growing period in the area is 102 days where the growing period begins on June 18 and ends on September 28. Besides, rain ends in the study area around September 5. The humid period begins and ends on June 29 and August 26, respectively, which the humid period extends for about 58 days. Hence the study concludes that 54.3% the study area is suitable for agricultural purposes. Early maturing varieties are recommended to grow so that their crop cycle fits in the short growing period**.** [Nature and Science 2010;8(9):237-243]. (ISSN: 1545-0740).

Keywords: Land, capability classification, growing period

Introduction

Agriculture is the dominant user of environment and natural resources; it has the greatest impact on the sustainability of ecosystems and their services, and accounts directly and indirectly for a major share of employment and livelihoods in rural areas in developing countries (Mahendra *et al,* 2008).It plays a significant and decisive role in the social and economic development of Ethiopia. However, owing to natural and man-made causes the degradation is undermining productivity growth in the agriculture sector and about 2-3 percent of the country's agriculture GDP is lost annually because of land degradation (World Bank, 2008).

The economic development of Ethiopia is dependent on the performance of the agriculture sector, and the contribution of this sector depends on how the natural resources are managed. (Menale *et al*, 2008). However, the natural resources of the country are degrading with different factors. Land degradation is a major cause of poverty in Ethiopia and the farming populations have experienced a decline in real income due to demographic, economic, social, and environmental changes (Mitiku *et al* 2002). The degradation of land resource due to country has not properly benefited from its abundant natural resources conducive to agricultural development, and consequently failed to register the desired economic development that would enable its people pull out of the quagmires of poverty (MoFED, 2006). The country's economy is dominated by agriculture, which accounts for about 50% of GDP, 90% of export value, and a source of employment for more than 85% of the country's population of more than 70 million people. However, land overexploitation and misuse and consequent economic, social and environmental impacts has intensified the pressure on the land resources of the country (EFAP, 1994).

In the recent past, the ill-effect of land use on the environment and environmental sustainability of agricultural production systems have become an issue of concern and inappropriate land use leads to inefficient exploitation of natural resources, destruction of the land resource, poverty and other social problems (Ruiee *et al* 2004). To stop, prevent and reverse further land degradation, sustainable land management (SLM) is crucial to minimizing land degradation, rehabilitating degraded areas and ensuring the optimal use of land resources for the benefit of present and future generations (FAO, 2008). SLM enables smallholders to gradually improve their production capacity and begin generating additional income. In turn, this stimulates local economies and produces a compounding effect which progressively brings the cycle of rural poverty and resource degradation under control (Karl *et al*, 1999).

To get maximum benefit out of a given land, proper land use is inevitable. The land capability is governed by the different land attributes such as the types of soil, which is critical for productivity, underlying geology, topography, hydrology; etc. These attributes limit the extents of land available for various purposes (FAO, 1985). Sustainable agriculture would be achieved if lands were categorized and utilized based up on their different use (FAO, 1993). Society must ensure that land is not degraded and that it is used according to its capacity to satisfy human needs for present and future generations while also maintaining the earth's ecosystems (Rossiter, 1994).

Land capability classification (LCC) can be done at different levels of generalization. In any case, the final aim is to predict the agricultural capability of the land development units in function of the land resources (Sys, et al, 1993). Land capability is a qualitative methodology to classify land resources based on soil, topography and climate parameters without taking into account the yield and social economic conditions. It is not centered on specific crops, kind of recommended practices or economical considerations, but rather considers permanent physical soil parameters, and their effects on vegetation growth (Leonardo *et al*, 2008).

The technique that makes it possible to determine the most suitable use for any area of land is land capability classification (Karl *et al*, 1999). LCC is also useful in the implementation sustainable land management practices because it is a composite assessment of land and soil, which incorporates the key physical characteristics that limit sustainable land management (ISCO, 2004). Therefore, LCC provides a convenient checklist of the natural resource limitations that need to be considered when natural resource planning is undertaken in a given watershed. According to the USDA land capability classification, there are eight classes designated by Roman numerals from I through VIII.

The concept of the growing period is essential to agro-ecological zoning, and provides a way of including seasonality in land resource appraisal and provides a framework for summarizing temporally variable elements of climate, which can then be compared with the requirements and estimated responses of the plant (FAO, 1996). The growing period defines as a continuous period in the year during which the precipitation is greater than half the potential evapo transpiration, calculated by Penman's method, plus a number of days required to evaporate an assumed 100 mm of soil water, stored at the end of the rains (FAO, 1976) . It is also simply the difference between the dates of the beginning and ending of rains and important in determining the length of the growing season in order to reduce the risk of crop failure (Afuakwa, 1991).

The average length of crop growing period in semi-arid region is predicted to shrink to 101 days from 110 days under an average climate change scenario and the growing season of may reduce by more than 20% and crop yield may decline by 50 % 2020 in Africa countries (Terr Africa, 2009).The length of growing period in Ethiopia, Tigray region range from 2.5 month in Wukro to as high as 5 month in shire (Fassil, 2007).Therefore, determination of the length-growing period is important in selecting crop varieties and suitable cropping patterns for research and development in line with sustainable land management practices.

Materials and Methods

Location

The study area, Guila Abena Watershed, is located in Tseda Emba Woreda, in Eastern Tigray at 14^0 15 -14^0 30'N and 39^0 39'E -39^0 45'E (Figure 1). The District is made up of 24 Kebeles with its capital town named Frewioni, which is about 80 km from Mekelle to Adigrat main road. The study area has four sub villages (Kushet) namely Abena, Gula, Geba and Alenta.

Study site description

The climatic data (temperature, rainfall, relative humidity, wind speed) of the study area is taken officially from Ethiopia Metrological Agency, Mekelle Branch (Table 1). This original data taken from Senkata Metrological Station, which is located about 10 km from the study area. The major land use types in the study area are cultivated, grazing, bare land, conserved and bush lands. In these land use types, trees, herbs and grasses are observed .Planted tree species like *Acacia saligna* and *Eucalyptus camaldulensis* are commonly found in conserved land. The production system is mixed farming and the major food crops cultivated are wheat (70 %), maize (15 %), bean (10 %) and others (5 %). The soils of the study area are heavily impacted by topography and high run off during the main rainy season. Soil stoniness and unweathered slates are common in the study area. The major textural class of the soil profiles were categorized as silty clay loam

(SiCL),Clay loam (CL), loam (L), and sandy clay loam (SCL) , which account 23%, 23% , 23% and 15 % respectively. The remaining 16 % are categorized as sandy loam (SL) and silty loam (SiL).Generally, major soil types of the watershed are Fluvisols, Cambisols, Regosols and Leptosols. The study area is mountainous and rugged in topography. Limestone, slates and quartz are commonly observed. The area has slope that ranges from 0 to 37 % and an altitude of 2220 to 2470 meter above sea level. In the lower slope, large gully is observed, which is currently rehabilitated with physical and biological intervention. Besides, flooding and soil erosion are less as compared to the previous years.

Fig 1. Location map of the study area

Table 1: Climatic data for the study area (Source: Ethiopia Metrological Agency Mekelle Branch.)

Month	Rainfall mm	T_{max} ^oC	T_{min} ^oC	RH %	n Hrs	Wind Speed m/s
January	1.3	23.8	9.8	43.3	10.0	1.9
February	7.7	25.8	10.8	37.9	10.1	2.1
March	35.8	25.5	12.1	40.9	9.3	2.3
April	54.8	25.0	13.0	47.5	9.3	2.5
May	21.4	26.0	14.3	41.0	9.0	2.4
June	55.8	25.2	14.1	47.3	7.2	2.0
July	194.5	21.9	12.7	75.5	4.6	1.3
August	171.8	21.9	12.5	77.6	5.5	1.3
September	13.9	24.0	12.5	49.1	7.9	1.7
October	7.4	23.0	11.1	47.7	9.1	2.4
November	8.2	22.8	9.8	48.6	9.8	2.1
December	4.7	23.8	9.6	42.7	10.3	1.4

Methods

Delineation of Watershed and Land Units

To demarcate the watershed and the land uses, different GIS input data such as topographic map, SRTM image and aerial photo were used. The DEM were derived from the SRTM image, it generated slope, flow accumulation, and drainage network by using ArcGIS 9.2. Accordingly, six-land use types were identified. These land uses were bare land, conserved land, bush land, cultivated, grazing and homestead.

The different land units were delineated by taking in to account the study site selection criteria and the identified land use map of the watershed. The grazing and cultivated lands uses were further separated into other land units. This is because, the different land units existing in these land uses are different in terms of slope, management, crop production, position, drainage and soil characteristics. To do this, additional 21 GPS ground points taken and processed with ArcGIS soft ware. Accordingly, 13 land units (Fig 2) identified in the specific study area, which is 269 ha. The grazing, cultivated, village, conserved and bare lands are accounts 84, 78, 6, 62 and 39 ha, respectively.

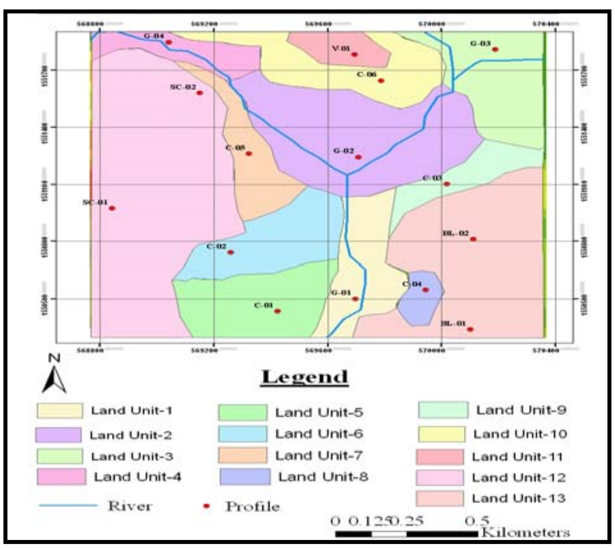

Fig 2. Land units' maps of the study area.

Soil description and physico– chemical determination

Soil profile description was conducted for 13 land units on 15 soil profiles according to the methods given in the Soil Survey Manual (FAO, 2006). The soil samples collected from different diagnostic horizons and soil pH, particle size distribution, EC, organic carbon, available P, calcium carbonate, CEC, exchangeable Ca^{+2}, Mg^{+2}, K^{+} and Na^{+} were determined the Mekelle University Soil Laboratory following the standard procedures.

Determination of growing period

The start of the growing period, end of the rains, start and end of the humid period were determined using a linear interpolation techniques as described in Sys et al (1993).

Land Capability Classification Methods

Land Capability Classification (LCC) method developed by USDA, 1958 was used in the study to estimate different land capability classes of the watershed. In this method, slope, rock outcrops, erosion, soil drainage, soil stoniness, soil depth, surface stoniness, texture, organic matter and pH were considered. For soil texture, soil stoniness, $CaCO_3$, organic carbon and pH, a weighted average have been calculated for the upper 50 cm of each profile.

Results and Discussions

The LCC study reveals that, four major land capability classes found in the study area. As shown in Table 2 and Fig 3 , land units 1, 2, 3, 4, 5, 7, 8, 9 & 10 were categorized in the range of II to IV with an area of 146 ha (54.3 %) .These land units are mainly used for crop and livestock production. Land units 5 with an area of 18 ha (6.7 %) was grouped under IIes class and subclass having limitation of slightly erosion and surface stoniness. Land units 3, 4, 7, 8, 9 and 10 were found as IIIs good for cultivated crops and accounts 28.6 % (77ha). Land units 1 and 2 were categorized as IVs, with an area of 51 ha. These land units are best suited for grazing land and the actual farmers practice go with the result. On the other hand, land units 6, 11, 12 and 13 were found class VIIs, with a total area of 123 ha (45.7 %). The soil depth, erosion, rock out crops and calcium carbonate were major limiting factors in land units 6, 11, 12 and 13. The soils in these land units were observed to have a depth of 8-30cm. Stoniness covering more than 15 % of the surface was seen in land units 6, 7, 9,10,11,12 and 13. The pH, organic matter and texture were not a limitation in this land capability classification and for organic carbon the weighted average for 50 cm, ranges from 1.15 % to 5.16 % in land units 6 and 4, respectively. Based on calculated weighted average, six textural classes were identified. Among the 15 soil profiles , 31% clay loam, 23 % as loam, 15 % silty clay loam and sandy clay, 8% sandy loam and silty loam textural classes.

Table 2 : Land Capability Classification of the Study Area.

S/No	Land capability with subclass	Land units	Total area (ha)	Ratio (%)	Major Limitation
1	IIes	5	18	6.7	Slight - Slope, erosion, surface stoniness and soil texture.
2	IIIs	3, 4,7,8, 9 & 10	77	28.6	Calcium Carbonate
3	IVs	1,2	51	19.0	Soil drainage, erosion and Calcium Carbonate
4	VIIs	6,11,12 & 13	123	45.7	Soil depth, erosion, rock out crops and Calcium Carbonate.
Total Area			269	100	

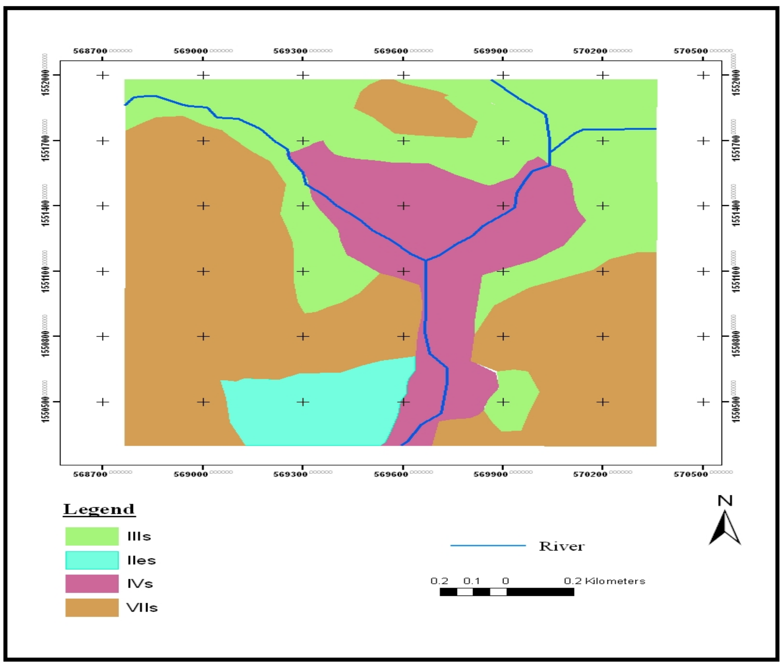

Fig 1 : Land capability classification map.

Growing Period in Guila Abena Watershed

The growing period in the study area began (B) on June 18 and ended (E) on September 28. The end of the rainy period (ER) is September 5. The total growing period is 102 days. The beginning (BH) and end of the humid period (EH) were June 29 and August 26 respectively. This also indicated that, the total number of humid period is 58 days. The end of growing period (E) occurred in the month of September. During this month, the daily evapo-transpiration is 4.44 mm/day. With this daily evaporation rate, 23 days were required to utilize 100 mm water and make the end of growing period September 28. The growing period curve of the study area presented on Fig 4:

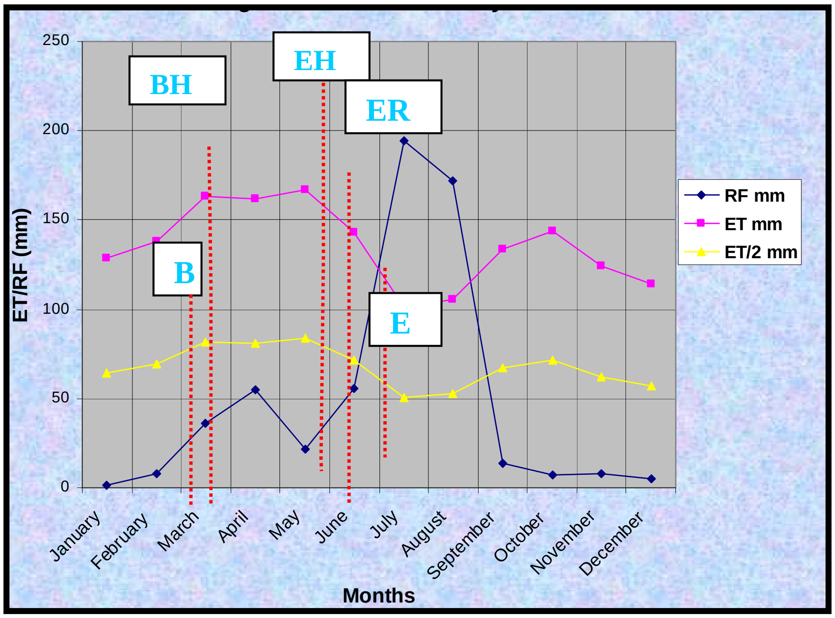

Fig 2: Growing Period Curve of the study area.

Conclusions and recommendations

In this study, four major land capability classes with subclass were identified. Agriculturally important classes for the study area are II to IV, which account for 54.3% of the total watershed. Major limiting factors of these agricultural fields are soil depth, soil stoniness, surface stoniness, erosion, slope, rock outcrops and calcium carbonate content. Besides, this study concluded that the growing period stretches over 102 days, which commences on June 18 and ends September 28. Hence the study duly recommends that reducing the stone cover, introducing of shallow rooted and early maturing varieties will help for using the study site effectively and in a sustainable manner.

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