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Relationship between Vegetation and Topography for an Erosion Management in Ethiopia

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Abstract: Ethiopia has severe problems of soil erosion lead especially by water. The most vulnerable soils are those without a protection plant cover. That' s why, in order to evaluate and predict erosion issues, it is necessary to define the relationship between topographic characteristics and land cover that could explain the vegetation type that occupies the watersheds. We combined classes of elevation, slope and aspect and we obtained a topographic typology that we joined to vegetation distribution through watersheds. We found that there are correlations between the topographic characteristics and vegetation cover, approved by the precipitation map of Ethiopia, in the literature.

Keywords: Digital Elevation Model, Tabulation, Topographic characteristics, Vegetation distribution, Watershed

1. Introduction

Ethiopia is an African mountainous country with highly erodible soils on steeply sloping land and is losing from its topsoil about 1.5 billion tons per year, washed away by rain according to Ademola *et al*. (2008). They reported to be a strong link between vegetation cover and erosion, this explains the necessity to detect and assess the land surface as a first step of erosion evaluation (Woreka, 2004).

That is why, in the present work we try to assess the type, extend of vegetation and the topography over the watersheds -as a primary goal of a land investigation- in order to find out an eventual relationship between topographic characteristics and land cover that could explain the vegetation type that occupies the subwatershed.

2. Materials and Methods

In this analysis, we basically used ArcGIS 9.2 for mapping, tabulating, classifying and joining topographic and vegetative data. In parallel we used Excel to analyze statistically the combinations between topography and vegetation.

At first, to proceed to the vegetation assessment, we used the data of DEM (Digital Elevation Model) and land cover to have information about the land cover with respect to its morphology.

In this study, we used SRTM (Shuttle Radar Topography Mission)-DEM data to define the elevation, while land cover data is based on USGS (United States Geological Survey) legend of GLCC (Global Land Cover Characterization). Furthermore, we created the subwatershed-polygons extending on all Ethiopia surface. In order to evaluate the vegetative potential of the subwatersheds, we calculated the tabulation of the distribution of vegetation through all subwatersheds. In the same way, we calculated the tabulation of elevation and slope using the DEM data as well as the aspects of all the subwatersheds.

We made a classification of the topographic characteristics: elevation, slope and aspect. In order to make a typology that combines all the 3 topographic characteristics. A subjective classification of these topographic characteristics was made. Elevation is classified into 3 categories: Low from: -176 to 1000 m a. s. l, Middle from 1000 to 1900 m a.s.l, and High from 1900 to 4522 m a.s.l. Slope is also classified into 3 categories: Gentle from 0 to 10 degree, Middle from 10 to 30 degree and Steep from 30 to 72 degree.

We obtained 39 combinations that we pulled into 11 combinations following the similarities in elevation and in slope (**Fig. 1**). Then, we joined all these topographic combinations with the dominant land-cover of each subwatershed (**Fig. 2**).

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3. Results and Discussion

We obtained 648 watersheds whose surfaces vary between 5.8 ha and 59900 ha within whole Ethiopia which is covered by 12 types of vegetation defined by USGS data. The major land-covers are Shrubs (40.6% of the area), Savanna (28.8%), Dryland-cropland-pasture (9.74%) and finally Barren or sparsely vegetated (6.51%).

Through watershed assessment and vegetation distribution map, we note that Shrubland occupies the east half of the country facing mostly East and South-east in the aspect. While Savanna and Dryland-cropland-pasture faces the West and South-west, and are concentrated in the west part of Ethiopia. Barren and sparsely vegetation dominated watersheds occupy the north of Ethiopia in the Afar region, the aspect is mainly north.

This could be explained by another topographic characteristic related to the existence of the Great Rift Valley that cross the country as a line of mountains from the South-west to North-east and divides the country on two halves. The east half faces the east and this explains that in this east side we find Shrubland that faces the east too. In the same way, we can explain the fact that savanna and drylands-cropland-pasture, which face the west, are localized in the west half of the country that faces the west too.

As well, according to Mengistu (2003) and Reynolds (2006), the map of precipitation distribution (**Fig. 3**) shows that the rainfall is more important in the west half of Ethiopia than in the east one, which could explain the spread of more vegetation in the west side especially with savanna, cropland and pasture.

As a result of the tabulation of Land-cover versus topographic typology (**Fig. 5**), we find out that Shrubland has as a major topographic characteristics typology: low elevation with gentle slope (68% of the area), followed by middle elevation and gentle slope (19% of the area). Rarely, we find middle slope with low or middle elevation. This could explain that in the east side of the country -occupied mostly by Shrubland- the elevation is not high and has tendency to decrease towards the east, at the Somali region, as shown in the map of elevation (**Fig. 4**).

As for the savanna, 35% of its area has low elevation with gentle slope, 31% has middle elevation with gentle slope. Few percentages only have middle elevation and slope or high elevation with gentle slope and middle slope. So, the area of savanna seems to decrease when the elevation becomes higher and the slope becomes steeper. Drylands-croplands-pasture is found in the area of middle and high

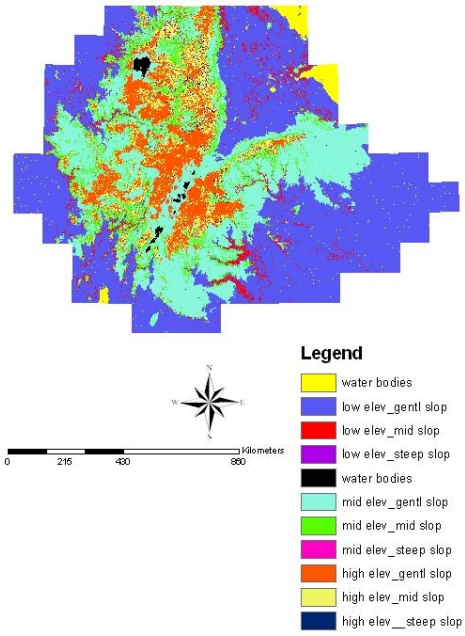

Fig. 1. Distribution of the classified topographic characteristics.

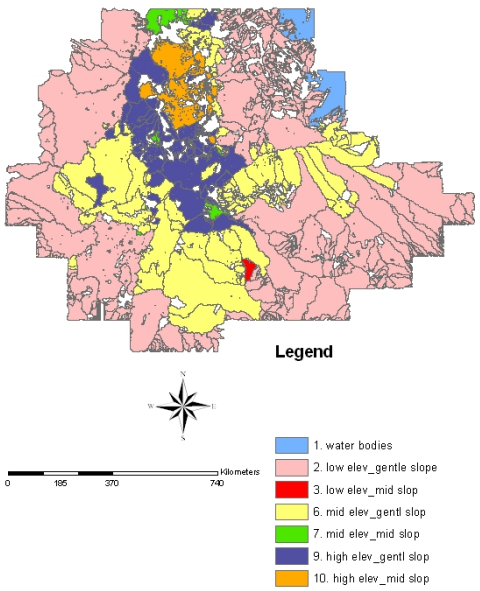

Fig. 2. Topographic typology distributed through watersheds.

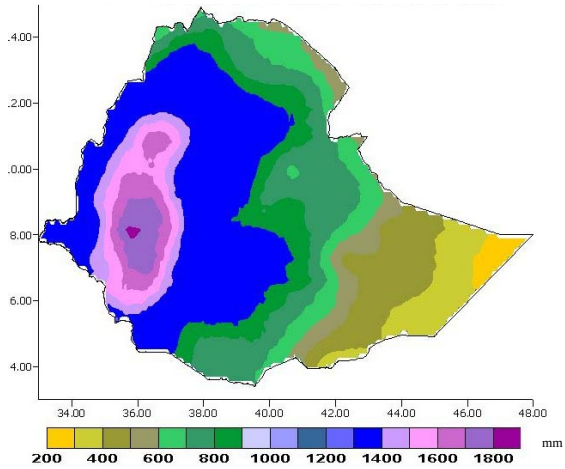

Fig. 3. Precipitation map of Ethiopia (Mengistu, 2003).

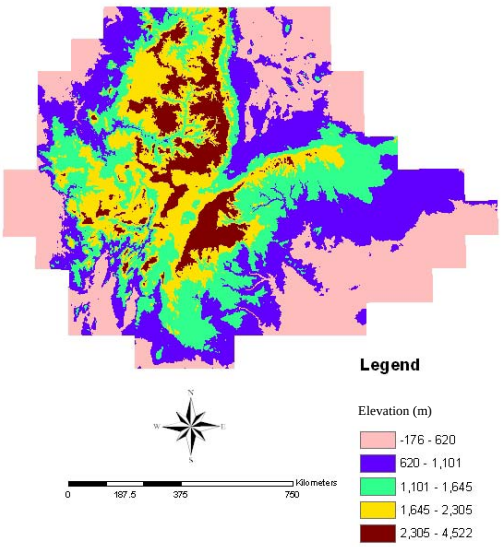

Fig. 4. Elevation map of Ethiopia.

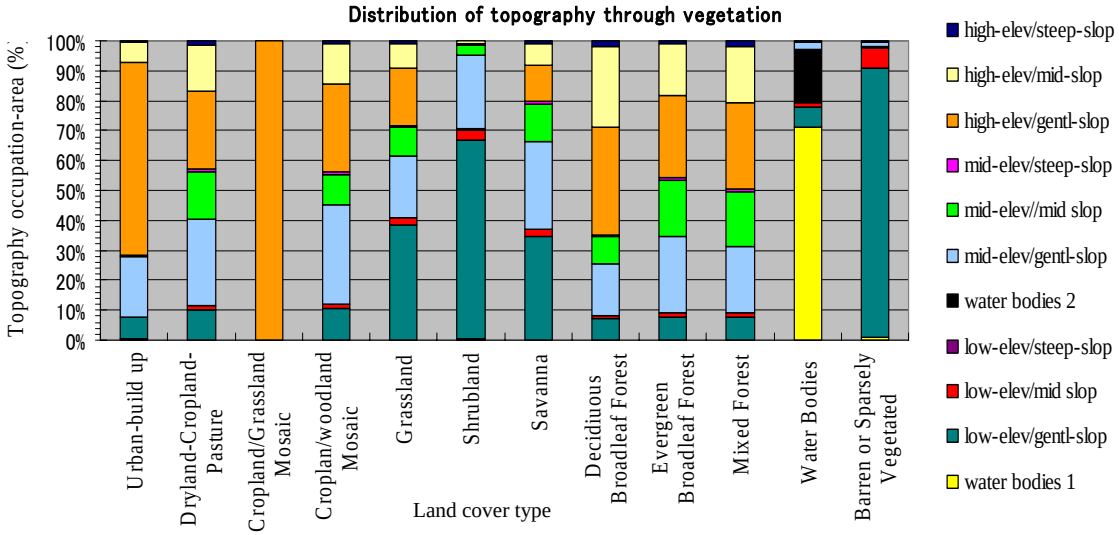

Fig. 5. Distribution of topography through vegetation.

elevation with gentle and middle slope. The area seems to be more important where elevation and slope increase, besides it has an important precipitation. This would explain the spread of erosion in this arid zone, because the crop and pasture management with important elevation and slope erodes the topsoil and makes the land fragile especially when exposed to intense rainfall as it is. Finally, the barren or sparsely vegetated area is mainly spread (90%) in low elevation and gentle slope. Within the sub-watersheds analysis point of view, we assessed and classified the topographic typologies into three categories, i.e. major, second and non-usual for the main vegetative types within each sub-watershed. As a result, we find out this sub-repartition of the topographic characteristics as shown in the **Table 1**.

So, the major topography combinations within the subwatersheds for the most dominant land-cover in Ethiopia are: gentle slope with middle or low elevation, followed by gentle slope with middle or high elevation. Middle slope and high elevation are non-usual. This is confirming with the map of topographic characteristics distribution that shows in the center of the country the two types of topography:

Table 1. Repartition of the topographic characteristics through the four main dominant land cover in the sub-watersheds.

Subwatersheds / Topography	Shrubland dominant L/C	Savanna dominant L/C	Dryland-Cropland -pasture dominant L/C	Barren or sparsely Vegetated dominant L/C
Major	low-elev/gentl-slop	low-elev/gentl-slop	mid-elev/gentl-slop	low-elev/gentl-slop
Second	mid-elev/gentl-slop	high-elev/gentl-slop	high-elev/gentl-slop	
Non-usual	low-elev/midslop high-elev/mid-slop	mid-elev//mid slop	low-elev/gentl-slop high-elev/mid-slop	low-elev/mid slop

gentle slope with middle or high elevation. While in the periphery, we see the low elevation with gentle slope.

4. Conclusion and recommendation

We found a relationship between vegetation and topographic characteristics (elevation, slope, aspect) and precipitation in Ethiopia. This correlation may explain the spread of erosion in this arid zone subjected to erratic and aggressive rainfall especially when agricultural and livestock management are practiced in inappropriate topography and location. Meteorological data will improve our interpretation in later date**.** Moreover, we can deepen this research while assessing the vegetation cover by using NDVI in order to make erosion investigations on the appropriate chosen watershed using a hydrological model.

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