HYPSOMETRICAL CHARACTERISTICS OF SMALL HILLSIDE RESERVOIR CATCHMENTS IN SEMIARID REGION OF TUNISIA

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1. INTRODUCTION

Water shortage is a major concern in Tunisia as well as the most of the Mediterranean countries, which are situated in the arid and semiarid climatic zone where the mean annual rainfall does not exceed 550 mm. The very erratic rainfall pattern with respect to time, duration, intensity and amount, compounded with the lack of hydrological data, have led to the desperate need of a method for understanding the hydrological response in ungauged basins in Tunisia. Forecasting in ungauged basins is made by extrapolation based on the similarity of certain characteristics in basins. Since the hydrologic response of a watershed and its geomorphological characteristics are interrelated, one way to predict the hydrological response in ungauged basins is by (1) analyzing their geomorphological characteristics (2) grouping basins with similar geomorphological behavior and (3) predicting their hydrological response with comparison to gauged basins. One approach to extract more information from the geomorphological characteristics is the use of the hypsometric curve. This curve skillfully shows the percent catchment area above a given percent elevation contour (Harlin, 1978; Luo, 1998).
The aim of this study is the hypsometrical characterization of hillside reservoir catchments in the semiarid region of Tunisia. In this study 24 small hillside catchments were chosen. Their digital elevation models and stream networks were prepared. The hypsometric curves were obtained for all the catchments and hypsometric integrals were computed to compare the watersheds morphology.

2. STUDY AREA

In central Tunisia, in the semiarid dorsal region that extends from the northern east of the country to the Algerian border in the west, 30 small hillslide reservoirs were chosen to make up a network of hydrological observations within the HYDROMED project (Albergel et al., 2004). The catchment areas vary from a few hectares to 100 km^2 and have reliefs ranging from a minimum altitude of 70 m to a maximum altitude of 1309 m. The studied catchments are representative of the rainfall gradient of the semiarid region in Tunisia, which is 250 to 550 mm of annual rainfall. This paper reports on just 24 of these catchments (see Fig.1).

3. METHEDOLOGY

Our 24 watershed DEMs come from the Shuttle Radar Topographic Mission (SRTM) data that is available as 90 m resolution DEMs. Once imported in Arcgis, the DEMs are compiled into a DEM mosaic covering Tunisia area. This mosaic DEM is projected to Carthage-UTM-Zone 32N. The DEMs of the studied sites were clipped out from the mosaic DEM. The hypsometric curves of the catchments were obtained. The hypsometric integrals (area under a hypsometric curve), skewness and kurtosis were computed

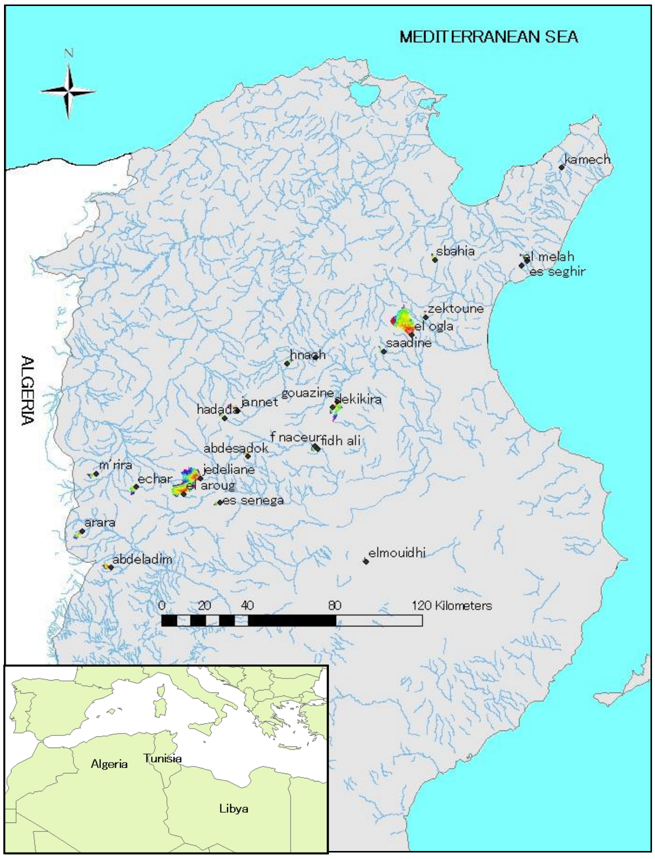

Fig.1 Location of Tunisia and the studied catchments.

(see Table 1).

4. RESULTS AND DISCUSSION

From a simple visual comparison and using the hypsometric attributes (see Fig.3) we divided those curves into five groups. The first group includes the concave hypsometric curves of El Aroug and El Ogla. Their hypsometric integrals are the smallest, 0.234 and 0.242, respectively (see Table 1). Due to their heterogeneous geology, those two watersheds display a rapid drop in the upper reaches of the catchments and then relatively become flat as the area increases. This rapid drop in the upper reaches represents the more erosion resistant geology, whereas in the lower reaches the geology is less erosion resistant (Hancock, 2005). The second group corresponds to the convex hypsometric curves. Their hypsometric integrals are bigger than 0.5 (see Fig.2). In those catchments, the streams are less developed therefore the total amount of mass removed by the river process is less than the other watersheds (Harlin, 1978). The third, fourth and fifth groups include watersheds whose hypsometric curves are S-shaped. Their hypsometric integrals range from 0.3 to 0.47. In the upper reach those curves have the same shape, upward concave and then as the areas increase they

Tab .1: Hypsometric attributes of the 24 studied watersheds.

No	Catchments	Area (Km2)	Hypsometric attributes HI	Skewness	Kurtosis
1	abdeladim	6.42	0.333	0.78	2.27
2	abdessadok	3.07	0.306	1.03	2.93
3	Arara	7.08	0.398	0.43	1.98
4	Dekikira	3.07	0.434	0.21	1.48
5	El Aroug	40.25	0.234	1.27	3.10
6	El Ogla	80.10	0.242	1.26	2.99
7	Echar	9.17	0.450	0.23	1.41
8	Es Segir	4.31	0.444	0.23	1.54
9	Es Senaga	3.63	0.324	0.86	2.44
10	Fidh Ali	4.12	0.409	0.38	1.54
11	Fidh Ben naceur	1.69	0.434	0.31	1.44
12	Gouazine	18.10	0.461	0.10	1.43
13	Hadada	4.69	0.453	0.21	1.50
14	Hanach	3.95	0.411	0.50	1.90
15	Jannet	5.21	0.383	0.58	2.24
16	Jedeliane	47.00	0.505	-0.12	1.46
17	Kamech	2.45	0.525	-0.16	1.54
18	Mouidhi	2.66	0.420	0.46	1.66
19	Mrichet	1.58	0.504	-0.02	1.46
20	Mrira	6.13	0.348	0.73	2.22
21	Saadine	2.72	0.354	0.51	1.97
22	Sadine	6.53	0.550	-0.26	1.96
23	Sbahia	3.24	0.471	0.13	1.38
24	Zectoune	2.05	0.380	0.36	2.20

divide into three groups. For the fifth group, we notice that the hypsometric curves exhibit a higher toe (the lower part of the hypsometric curve) than the group 3 and 4. This is due to a higher branching of the river networks (Willgoose et al. 1998).

Figure 3 shows a linear regression between the hypsometric integral and skewness of the hypsometric curves of the studied watersheds. In Sadine catchment, the fluvial process demonstrates only a little development and the hypsometric curve is slightly skewed, -0.26 and has a high hypsometric integral 0.55. On the contrary, the hypsometric curve becomes more and more positively skewed with the development of the stream network (Harlin, 1978). For example, the hypsometric skewness of El Ogla is 1.27 and his hypsometric integral is 0.242.

Evans (1972) and Harlin (1978) showed that the relationship between the hypsometric skewness and integral is nonlinear. However they were found to be perfectly linear with R^2=0.97 in the case of the studied Tunisian semiarid watersheds.

Concerning the kurtosis values, they range from 1.38 to 3.10 (see Fig.3). Kurtosis increases when an advanced erosion process has occurred in both the upper and lower reaches of a basin (Harlin, 1978). For El Ogla and El Aroug kurtosis are 2.99 and 3.10, respectively. Consequently, they are likely the most eroded in their upper and lower reaches among all studied watersheds.

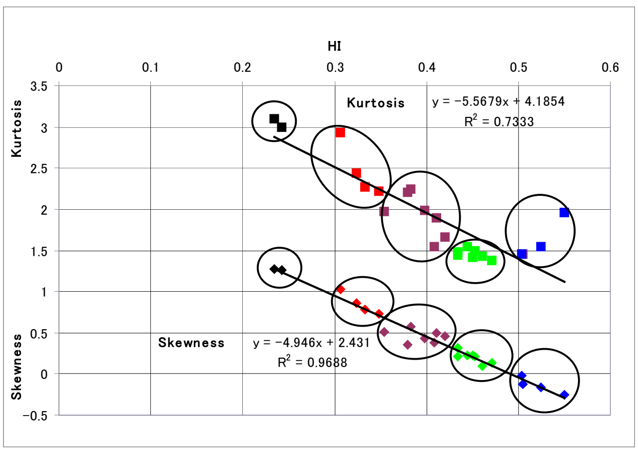

Fig.3 Linear correlations between hypsometric attributes.

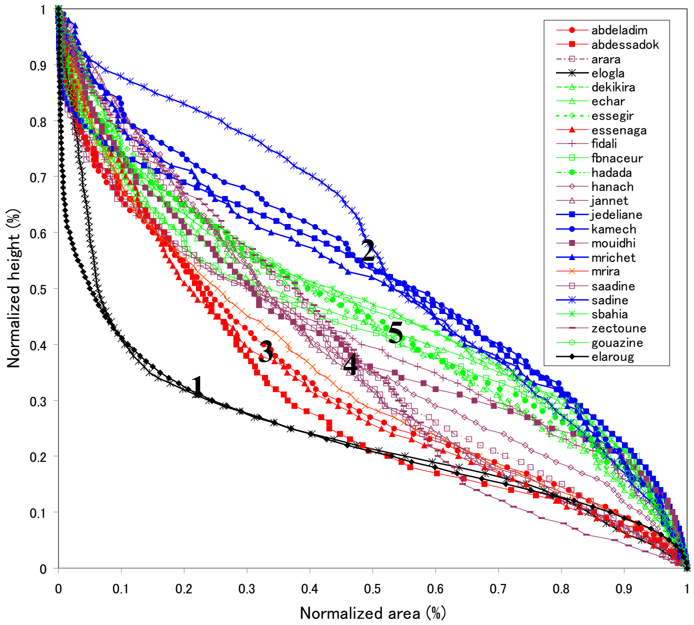

Fig.2 Hypsometric curves of the 24 studied catchments.

5. CONCLUSION

In this paper, we have characterized the geomorphology of small hillside reservoir catchments in the semiarid region of Tunisia by the use of the hypsometric curve as geomorphic indicator.

Findings have shown that hypsometric curves of those watersheds can be classified into five groups. The most eroded watersheds have concave hypsometric curves with small hypsometric integral. At the contrary, the second group of catchments has convex hypsometric curves and higher hypsometric integrals. The third, fourth and fifth group are S-Shaped. However they differ by the shape of their toes (lower parts).

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