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Study of Morphometric And Hydrological Characteristics of Watersheds And Their Impact on The Silting of Small Lakes in the Tunisian Dorsal.

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Abstract: The siltation problem is a problem That Concerns Geomorphologists, hydrologists and Sedimentologists in terms of area dynamics. Indeed, control of silting reserves for Assessment Primarily to Comprehensively the importance of sediment transport. In Tunisia, the processes of erosion, transportation and deposition are Widespread and hold great importance in terms of national interest and in research as They Are Relatively difficulty to model and can cause damage Among --other cut.

The objective of this study is to try to identify the morphological parameters of the watershed or river system HAVING the gold predominant role hand on the siltation of small lakes.

Water erosion as it is Known is a major problem in Tunisia and Neighboring countries Where the extension of eroded land HAS Become increasingly alarming. Our study Focuses on twenty three small lakes Located in semi-arid zones distributed over the Tunisian Dorsal. This area is in a semi-arid climate with rainfall diet characterized by some interannual irregularity and torrential rains and stormy character. The irregularity of rainfall is expressed by seasonal and interannual oscillations both. The dominant lithology is clay and marl watershed and: has a canopy declining in favor of the sloping cereal. This state of the land cover makes the slopes of the basin very vulnerable to the erosive action. This HAS resulted in increased runoff rates and Increased water erosion.

This study has enabled a statistical analysis through principal component analysis to better Understand the impact and contribution of hydrographic and morphometric parameters in the phenomenon of silting of small lakes.

Keywords: water erosion, Hill Lake, watershed runoff model, siltation, Tunisian dorsal.

I. INTRODUCTION

To prevent the influence of morphological parameters and the river system on the phenomenon of silting, we conducted a Principal Component Analysis (Petr Praus 2011). This analysis helped to better approach the phenomenon through research highly significant functional relationships, from the contribution of active variables.

We submitted all morphometric parameters calculated for the different sub-watersheds of the Tunisian Dorsal and Cap Bon in a multivariate analysis to determine the affinities between these sub basins and deduce the key parameters of siltation.

The technique of Principal Component Analysis is a descriptive technique. It allows visualizing the data in point cloud support in a geometric space. The method was applied to 24 individuals (sub watershed) and 18 variables (variables and morphometric data describing the hydrological response) which are: the size (S), the perimeter (P), the index of compactness Gravelius (Kc), length (lr), width (lr) of the equivalent rectangle, drainage density (Dd), the maximum altitude, minimum altitude, the relief of classes, vertical drop, the flow coefficient , the slope index, soil loss, the farmland, the route, the forest, the run-off blade, and finally the volume of silting (Mekki, I., Zante, P., Masmoudi, M. et Ben Mechlia N. 1998).

1. Geographical Setting of the Study Area

The study area is located at the Tunisian dorsal . It extends from the Northeast to the Southwest. It is influenced by two major accidents in NE-SW direction.

Tunisian Dorsal is a set of mountainous alignments. It is the eastern extension of the Saharan Atlas and is moving on to southwest - northeast. It is characterized by generally decreasing altitudes between Mount

Chaanbi (1544 m) to the west, the highest point of Tunisia, Mount Boukornine (576 m) on the eastern end (Mansouri T., 2002).

The back is a succession of mountains more or less aligned, separated by transverse valleys. We can distinguish, on the orographic plan eight divisions including mountainous alignments, uplands and a gap **(Jean Morschel 2010)**:

- Western axis: a line ofhigh Mount Bargou (1266 m), Kesra (1174 m), Serje (1357 m) and Zaghouan (1295 m) between the Wadi Miliane valley to the north and Zaghouan-Bouficha corridor south, with Mount Boukornine end.
- Highlands around Makthar (900 m) and Rebaa (600 m) separated by the valley of Wadi Siliana.
- Eastern axis formed by a more modest mountainous alignment, culminating in Mount Ousselat (895 m), which is in contact with the great plain of Kairouan.
- Mounts Enfidha and Sidi Jedidi who form small mountains along the coastal plain of the Gulf of Hammamet
- Gap Rohia-Merguellil characterized by irregular forms of relief with the watershed of the river Merguellil and the collapse basin Rohia-Sbiba;
- Further south, there are three major parallel alignments:
- AlignmentMounts Essif (1352 m), Bérinou (1419 m) and Umm Jedour (1309m);
- AlignmentMounts Chaanbi, Semmama (1356 m) and Tioucha (1363 m);
- AlignmentMounts Salloum (1373 m) and Mrhila (1376 m).

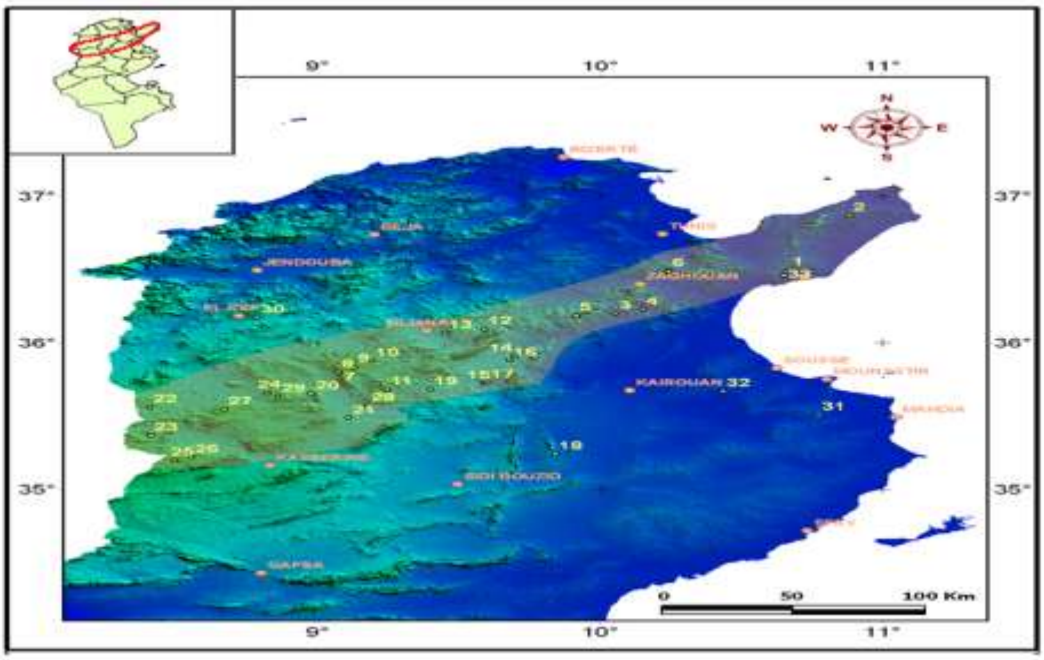

Figure 1: Map of study area

II. STATISTICAL ANALYSIS OF MORPHOMETRIC PARAMETERS

2.1 Specifying PCA settings

2.1.1 Eigenvalues

The eigenvalues serve to measure the percentage of variance explained by each factor axis. In all of the software outputs, the pins are arranged in descending order of inertia. An axis explaining less than 10% of the general inertia wills rarely interesting.

Two empirical criteria to select the number of axes:

Elbow criteria: on the scree plot, the principle is to look if there is an "elbow" followed by a steady decline of values. Keep only the values until the elbow.

Kaiser Criteria: we retain only the axes whose inertia is greater than the average inertia. It then retains the values above their average because only deemed more "informative" than initial variables.

Table 1: Eigenvalues

	F1	F2	F3
Eigenvalues	6,691	3,540	2,330
Variability (%)	37.173	19.668	12.944
cumulative%	37.173	56.841	69.785

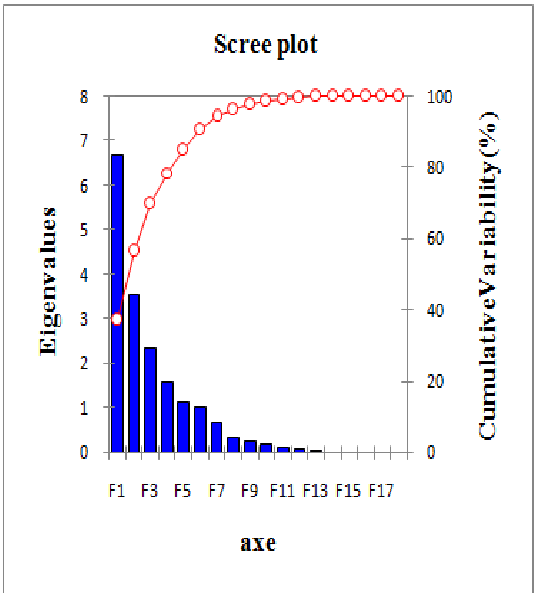

Figure 2: Histogram of values of the correlation matrix

The analysis of the histogram of values (Figure 2) shows that the first three factors can represent as much information. Thus the first three factorial axes express 69.8% of the total variance; with 37.17% for the first factor; 19.7% for the second and 12.9% for the third factor.

Table 1 expresses the eigenvalues of the matrix of correlation coefficients, the percentage of variance explained and accumulated by each axis.

2.1.2 Eigenvectors

The eigenvectors (Table 2) is to visualize the contribution of each parameter to the factorial axis. Individuals can be characterized by their positions in the factor axis. The contribution factor axis parameters facilitate understanding of the source of variability expressed by this axis. For this, we will pay much attention to the parameters with a high positive or negative contribution.

Table 2: eigenvectors

	F1	F2	F3
Area	0.371	-0.123	-0.039
P érimètre in Km	0.375	-0.072	0,003
rectangle length (L) Km	0.373	-0.068	0,028
Width of the rectangle (s) in km	0.317	-0.096	-0.216
É compactness index (C)	0.271	0.116	0.248
Maximum altitude m	0,146	0,429	-0.157
Minimum height in m	0,018	0.396	-0.213
Slope (Ig)	-0.098	0.351	-0.093
Ke	0.016	0,270	0.493
Énivelée D (D) in m	0.311	0,263	0.033
relief of class	0.172	0.403	-0.148
Blade Ruissel ed	0,005	0.161	0.523
Soil loss	0,150	0.053	0.356
volume siltation	0.336	-0.109	0,071
É drainage density	-0.247	-0.012	0.093
Farming lands %	-0.161	0,065	0,278
courses%	-0.063	0.252	-0.232
For and%	0.154	-0.274	0.014

2.1.3 Correlation Matrix

The main interest of this matrix **(Table 3)** is the visualization of all correlations (positive or negative) or the absence of correlation parameters between them. It is important to detect pairs of highly correlated parameters (or highly anti-correlated). Note that each parameter belonging to a set is relatively well correlated with any other parameter of the same set.

The analysis of the correlation matrix shows that the volume of silting is positively correlated well with the surface, the perimeter of the pond and the dimensions of the rectangle equivalent. It is also moderately correlated with Gravelius compactness coefficient and relieves. The compactness index is positively correlated with altitude, the flow rate and volume of siltation.Drainage density is negatively correlated to the dimensions of the pool, the altitude and the volume of silting.

variables	surface (Km2)	Perimeter (Km)	length of the rectangle (L) (Km)	Width of the rectangle (l) in (Km)	Compactness index (C)	maximum altitude (m)	minimum altitude (m)	Slope (m / km)	This %	Altitude difference (D) (m)	Relief of class	Blade (mm)	Loss (m 3 / ha / year)	volume siltation (m3)	Density drainage (Km / km2)	Farming lands %	course %	forest %
area	1																	
Perimeter Km	0,975	1																
rectangle length (L) Km	0.965	0,998	1															
Width of the rectangle (s) in Km	0.862	0,810	0.769	1														
Compactness index (C)	0.587	0.731	0.763	0.303	1													
Maximum altitude m	0.172	0.243	0.233	0.279	0.339	1												
Minimum height in m	-0.136	-0.074	-0.089	0.073	0.053	0.913	1											
Slope (Ig)	-0.364	-0.366	-0.361	-0.325	-0.215	0.334	0.261	1										
Ke	-0.149	-0.045	-0.019	-0.260	0.413	0.276	0.202	0.118	1									
Altitude difference (D) m	0,665	0.714	0.719	0.521	0.702	0.634	0.264	0.297	0,270	1								
Relief of class	0,265	0.317	0.304	0.362	0.322	0.761	0.555	0.509	0.206	0,748	1							
Blade	-0.116	-0.042	-0.026	-0.175	0,288	0.171	0.156	-0.074	0.824	0.109	0,036	1						
Loss	0.322	0.294	0,314	0,050	0.299	-0.054	-0.297	0,076	0.389	0.437	0,212	0.336						
volume siltation	0.902	0.888	0,900	0.596	0.589	0,067	-0.254	-0.255	-0.071	0,640	0.209	-0.079	0.504	1				
Density drainage	-0.599	-0.538	-0.522	-0.566	-0.233	-0.347	-0.191	0.117	0,040	-0.460	-0.244	0.106	-0.294	-0.491	1			
farming lands %	-0.388	-0.357	-0.334	-0.479	-0.071	-0.127	-0.048	0,212	0,165	-0.209	-0.187	0.237	-0.071	-0.269	0.224	1		
course %	-0.231	-0.179	-0.170	-0.221	-0.008	0.252	0.289	0,270	0,004	0,047	0.298	-0.173	-0.038	-0.175	0.206	-0.312	1	
forest %	0.436	0.376	0.353	0.503	0,036	-0.099	-0.143	-0.464	-0.087	0,036	-0.219	0.119	-0.027	0.302	-0.238	-0.485	-0.550	1

Table 3: Correlation Matrix

2.2 Results of the PCA

The correlation matrix of variables and factors of the variance in weight (Table 4) shows that the F1 axis represents 37.17% of variance is positively correlated with the volume of silting, the compactness index, the dimensions and pelvic equivalent rectangle. It is also fine but correlated negatively to the drainage density and agricultural land.

The axis F2 with 19.66% of variance has very good positive correlation with altitude, slope, the flow rate and relief, an average connection with height difference, runoff and rangelands. A negative correlation with the forest is recognized for this axis.

The axis F3 is rather a positive correlation with the run-off blade, the flow coefficient, soil loss and farmland.

Table 4: Correlations between variables and the main axes

	F1	F2	F3
Area	**0.959**	-0.232	-0.060
Perimeter Km	**0,971**	-0.136	0,005
length of the rectangle (L) Km	**0.965**	-0.128	0.043
Width of the rectangle (l) Km	**0.819**	-0.180	-0.330
Compactness index (C)	**0.702**	0.218	0,378
Maximum altitude in m	0.376	**0.807**	-0.239
Minimum height in m	0,045	**0,745**	-0.325
Slope (Ig)	-0.254	**0.660**	-0.142
Ke	0.041	**0.508**	**0.753**
Altitude difference (D) m	**0.805**	0.495	0,050
class of Relief	0.445	**0.759**	-0.225
Runoff	0.014	0.302	**0.799**
Soil loss	0.389	0,100	**0.543**
volume siltation	**0.870**	-0.206	0.108
Drainage Density	**-0.639**	-0.022	0.142
Farmlands %	**-0.417**	0.122	0.424
courses%	-0.163	0,475	-0.354
forest%	0.397	**-0.516**	0,021

The position of the variables on the axes is significant. A variable is even better represented on an axis that is close to the edge of the circle of correlations and the axis, especially misrepresented that it is close to the origin.

A correlation approximation:

- Two variables are correlated positively relatives.
- Two variables that are opposed are negatively correlated.
- Two orthogonal variables are uncorrelated.

The F1-F2 circle representing 56.85% of inertia (Figure 2) indicates that the axis F1 determines the parameters of dimensions and opposes the parameters of drainage. The axis F2 rather a topographical significance.

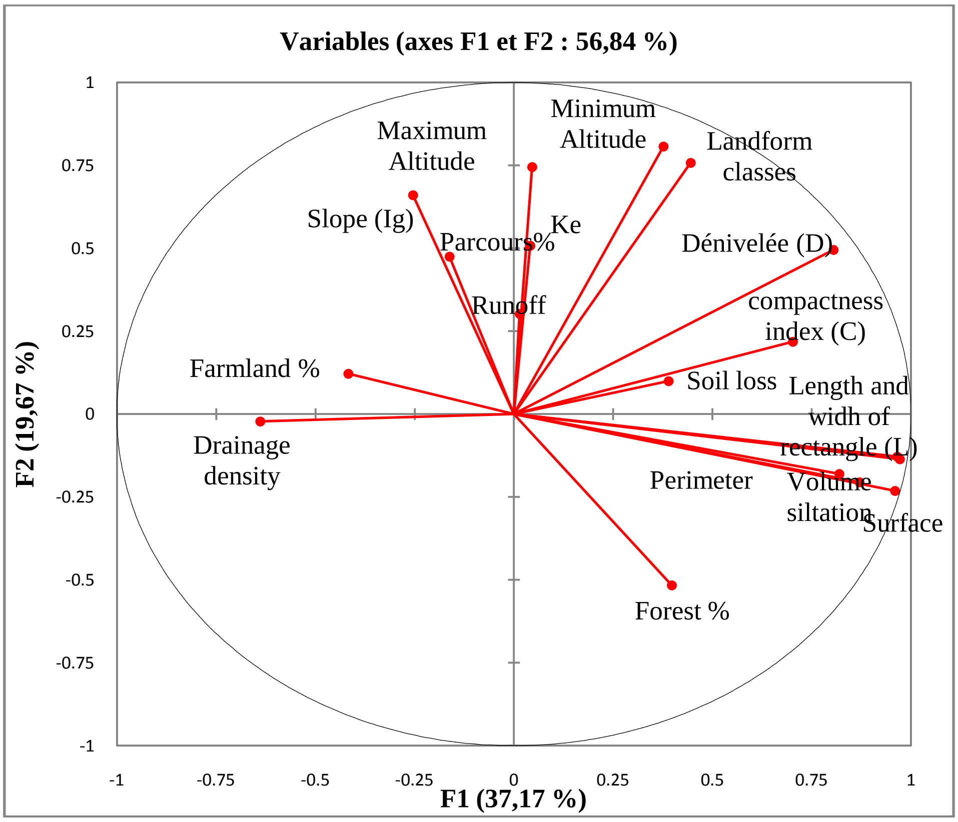

Figure 2: Variables factor map (F1, F2)

The circle F2-F3 represents 32.61% of inertia (3) clarifies the meaning of the F1 axis given above and indicates that the axis F3 can express the interaction between the run-off blade, the flow coefficient , agricultural land, the index of compactness and soil loss.

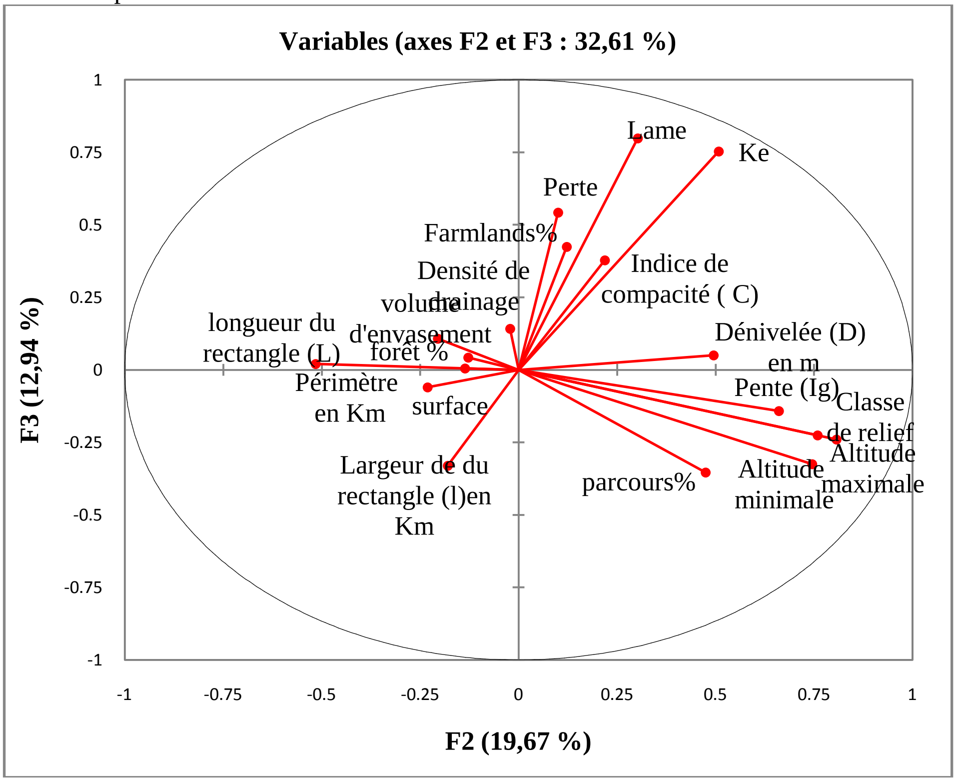

Figure 3: Variables factor map (F2, F3)

Table 5: Contributions variables (%)

	F1	F2	F3
Area	**13,757**	1,516	0.155
Perimeter Km	**14.099**	0.524	0,001
length of the rectangle (L) Km	**13.927**	0.462	0.079
Width of the rectangle (l) Km	**10,031**	0.915	4,669
Compactness index (C)	**7.364**	1,346	**6,133**
Maximum altitude m	2,118	**18.393**	2,460
Minimum height in m	0.031	**15.694**	4,533
Slope (Ig)	0.967	**12.318**	0.862
Ke	0,025	**7,286**	**24.344**
Altitude difference (D) m	**9,680**	**6.927**	0.108
Relief of class	2,964	**16.251**	2,176
Runoff	0,003	2,578	**27.367**
Soil loss	2,260	0.281	**12.639**
volume siltation	**11,314**	1,194	0.499
Density drainage	**6,101**	0.014	0.869
Farming lands %	2,604	0.418	**7,714**
courses%	0.395	**6,372**	**5,371**
forest%	2,359	**7.510**	0,019

After determining the coordinates observations, a factorial map is obtained which represents the observations on the axes (F1 and F2). It is noted that the representation is linear NE-SW (Figure 4). This direction is consistent with that of the Tunisian Dorsal. Note that the small lakes that have positive or negative x-axis and positive ordinates characterize the northern part of the Tunisian Dorsal, while small lakes that have abscissa and negative coordinates, settled in the southern part of the Dorsal. The hill lakes Jédiliane El Ogla El Gouazine and are located in the central part and on the same alignment.

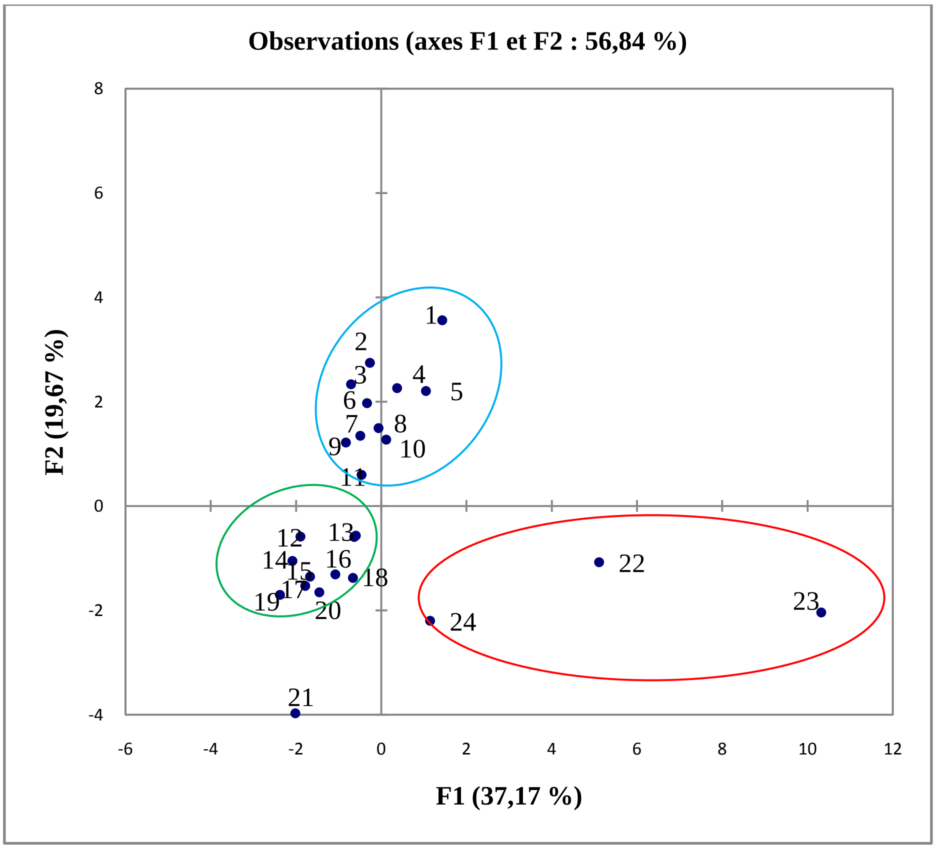

Figure 4. Individual factor Map

Table 6: Lakes list hillside extras on the factorial map

1: 1 Sadine	**14: Fidh Ali bin Ennaceur**
2: 2 Sadine	**15: Kemech**
3: Abdessadok	**17: Dékikira**
4: Jannet	**18: Sbeihia**
5: Arara	**19: Are Séghir**
6: Hadada	**20: Fidh Ali**
7: El Hnach	**21: el maleh**
8: Brahim Zaher	**22: Jédéliane**
9: Es Senega	**23: Elgola**
10: Echar	**24: El Gouazine**
11: Abdeladim	
12: M'Richet El Anese	
13: M'Rira	

The analysis will be done with the individuals and variables contributing most to the axis: if a variable has a strong positive contribution to the axis, individuals with a strong positive contribution to the axis are characterized by high value of the variable.

The screening of individuals (as watersheds) in the factorial plane formed by the axes (F1, F2), highlights three groups of basins (Figure 4): the first consisting Jédiliane basins, El Gouazine is area largely higher than the other pools. The second group is formed by basins dug in consolidated formations (limestones and dolomites) Jurassic and located in high altitudes (altitude> 1000 m), it is mountain basins and occupants southern Dorsal. The third group is formed by basins dug in generally soft formations and whose altitudes are much lower (altitude <300m).

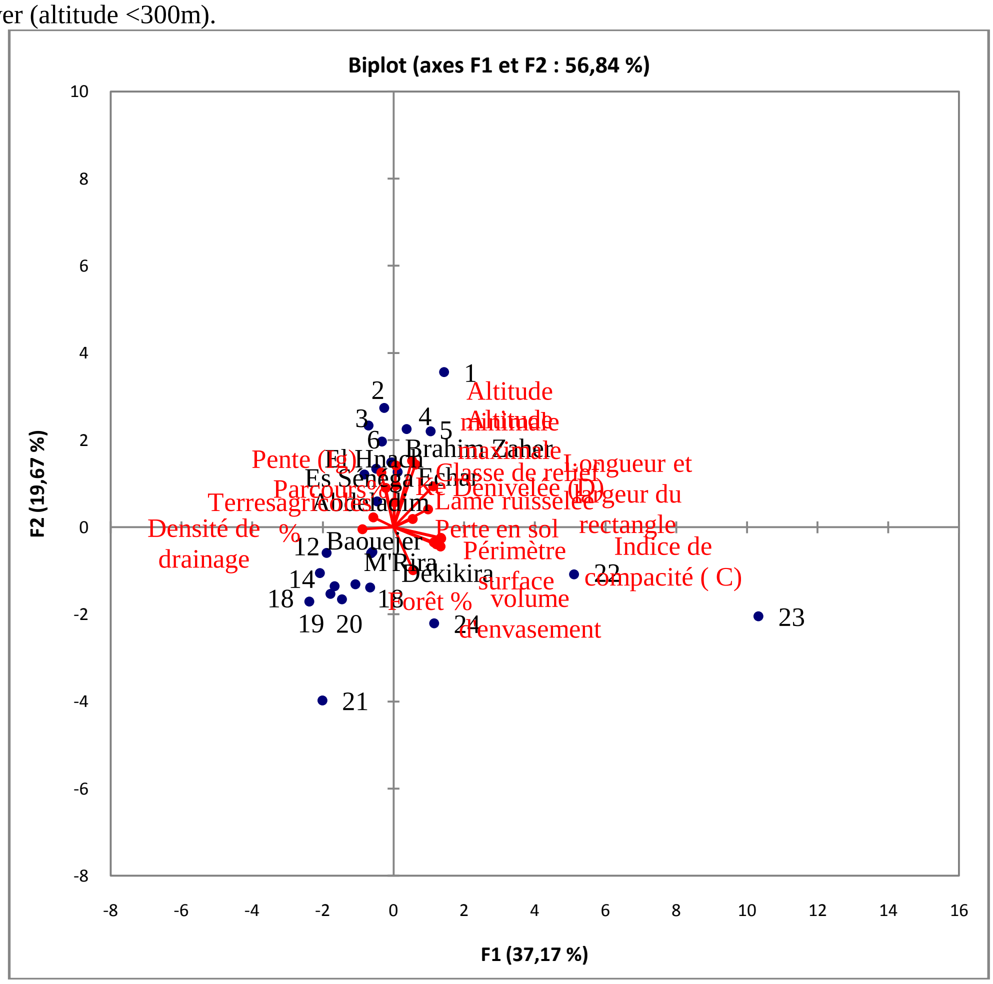

Figure 5: Overlay of variables and individuals on the factor map

III. CONCLUSION

The values of the compactness index show that the watershed built north of the Ridge are the most compact (Kc <1.3), while the more elongated basins correspond to those of southern Dorsal (Kc =

1.52). Besides these extreme data all other values are very close together, the forms of the corresponding basins are therefore more or less similar.

Drainage density values of the sub watersheds vary between 0.37 and 8.87 km / km2. Smaller values are the largest sub-basins. These results indicate that our watersheds are generally well drained. The importance of drainage is mainly due to the nature of the formations that form the basin as well as relatively steep slopes of river on one side and the other climate regime, characterized by its irregular and heavy rains.

The values of drainage density is low in the plains: due firstly to gentle slopes and also to the low abundance of rainfall. For cons, the value of the drainage density is high in the mountain basin which combines a very high relief, abundant rainfall and relative low permeability carbonate outcrops.

We conducted a statistical approach to determine the main influential factors to prevent siltation of some small lakes. The use of principal components analysis, helped to find highly significant functional relationship "the volume of silting" and "the dimensions of the pelvis and equivalent rectangle".

The principal component analysis allowed us to highlight the interrelationship between the various morphometric parameters. The correlation of these parameters indicates the presence of three pools of groups: one formed by the sub-basins El Gouazine El Ogla and Jédiliane widely area larger than the other pools. The second group is formed by the sub-basins which have a high altitude and high compactness index: mountain basins and occupants southern Dorsal. The third group is formed by the basins all descended to the plains as Kemech, Es Séghir (the northern ridge).

Soil loss and run-off blade are highly related to topographic factors as the dimensions of factors. Indeed, the sub-basins of the South Ridge exhibit, overall shape quite collected, favoring a priori, time of concentration runoff.

Soil loss is negatively correlated with drainage density. In Jédiliane and El Ogla Lakes drainage density is respectively 0.4 and 0.37, soil loss of these two lakes and 7.58 respectively and 24.24 t / ha / year.

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