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Research article

The impact of the dimensions of jessour on the destruction of the small hydraulic units (Jessour) in the Mounts of Matmata

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Abstract
Southeast of Tunisia is characterized by an arid Mediterranean climate, where the mean annual rainfall is between 100- 200mm. Rainfalls in this area are torrential and stormy which promotes water erosion.
Agricultural production in the dry lands is generally based on rain fed agriculture, which is in its turn based on rainwater harvesting techniques such as "jessour". Moreover, serious efforts to exploit the runoff water for rain fed agriculture and reduce water erosion in mountainous areas have given a lot more interest to the technique of jessour.
However, despite their significant morphological roles, the jessour known by their fragility that can be easily destroyed in case of an excess water retained behind dams. The risk of destruction has been carefully evaluated at all the small hydraulic structures in the micro watershed (El-Jouabit to Toujène, Mareth) in Matmata Mountains.
The collected data were used to develop different types of maps, which show that in most cases, the disproportion between surface of retention, height of retention and catchment area surface causes overflowing during exceptional rainfall events and after that the destruction of small hydraulic units. The analysis of these parameters show, that there is an advanced disproportion between the surface of retention and the surface of the catchment area, which causes, an important imbalance between, the volume of flowing water and the retention capacity, which is the principal cause of overflow. Therefore, the evolution of the number of the destroyed small hydraulic units, is simulated, by the establishment of many scenarios for different depth of runoff water blade that range between 2 mm and 50 mm. These simulations show, that the units with large dimensions are more resistant to runoff volumes hence a small increase of water blade does not have a marked impact on the number of overflowing units.
Thus, the units located in the upstream are the most risky (steep slope and disproportion between surface of retention, height of retention and surface of the catchment area).
The micro watershed study helped to develop a database for the solution for the risks of water erosion phenomenon that can be applied for the entire chain of Matmata.

Key words: Dry land, Rainwater harvesting, Soil/water conservation system, Typical jessour, Tunisia.

1. Introduction

Tunisia, located on the southern shore of the Mediterranean, remains a semi-arid to arid country on the three quarter of its territory (Boufaroua, 2002). It is characterized by limited and fragile natural resources, subject to intense exploitation (Ounalli and Sghaier, 2009). While the water deficit is quite marked, especially in arid and semi-arid regions. In fact, it is observed from year to another a significant loss of agricultural land because of the intense water erosion (Moussa, 2007, Tounekti, 2002, Moussa et al., 2011).
Physical, geomorphological, hydro climatic and socioeconomic conditions affecting Tunisian lands are particularly favorable to their degradation (Achouri, 1995).

Southeastern Tunisia is characterized by an arid Mediterranean climate, with low rainfall, irregular in time and space. The brittleness of natural environments that have several distinct geomorphological facies that influenced the territorial dynamics through time (Antipolis, 2000).
This area is further characterized by a complex hydrological system, based on a strong complementarity between the surface waters and underground aquifers, which forms the bulk of the available resources. This complementarity is enhanced by various public strategies for water and soil conservation (Romagny and Cudennec, 2006, Boufaroua et al., 2001).

The current situation of water resources, and their uses in the southeast of Tunisia presents, several challenges, that are common to many parts of the Mediterranean basin, limited water resources (Gasmi, 2013), uncertain and random, are widely exploited to meet the growing needs, a situation of competition between sectoral uses, an increasing commodification of resources, restrictive climate conditions, that reinforce the tensions around water (Romagny et al., 2004). Which required the implementation of the right techniques to mobilize, valorize runoff and fight against water erosion (Zammouri and Dababi, 2007). There are many techniques of runoff valorization, but the most important technique in the mountains of Matmata is the technique of "Jessour" which is the oldest and most usable technique of water conservation in the Tunisian arid (Chahbani, 1990; Boufaroua et al., 2001). During exceptional rainfall events, the latter experiencing significant damages (Bonvallot, 1979), which makes necessary to study the status of these small hydraulic units and more specifically the study of the impact of the dimensions of jessour on the phenomenon of overflow and the evolution of the number of destructed units with different scenario of estimated water blade.

2. Material and methods

2.1. Presentation of studied area

Tounine belongs to the delegation of Mareth in the southeast of the province of Gabes. It is limited by: Beni zelten from the north, Toujan from the south,Techin from the west and Tounin from the East.

The study focuses on the micro watershed Jouabit which lies between 33°29' and 33°30' North Latitude and 10°10’ and 10°07 ' East longitude.

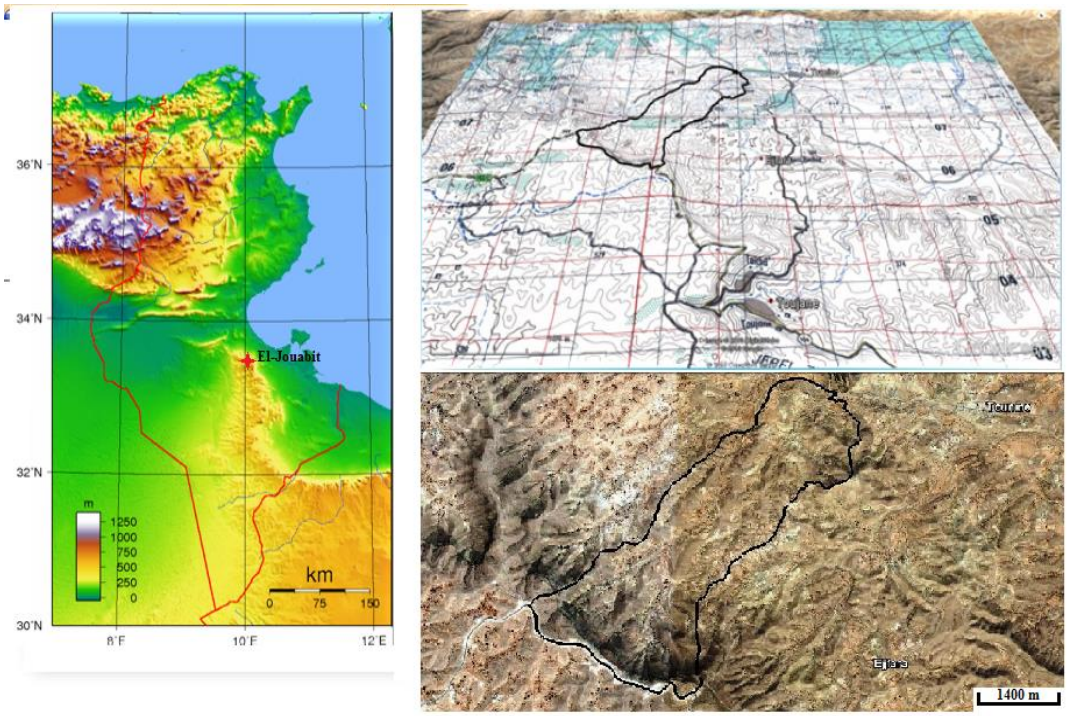

Fig. 1: Location of the study area

This area is a predominantly arid with high rainfall variability, since most part of rainfall is concentrated in the winter season, giving rise to a fragile soil and poor effective vegetation especially during the spring season.

The stormy and violent characteristic of rainfall, that it intensity exceeds 100 mm/h for 5 min, has also contributed to severe and frequent floods, which have accelerated the erosion phenomena and the degradation of the soil in this region.

The relief is very affected by water and wind erosion. The land formed by limestone and marl which are covered by a thick layer of silt, clay and sand, of alluvial and aeolian origin and become thinner going to the south (SEP, 1994).

The vegetation in the micro watershed of El Jouabit is usually with contrasted recovery, the zones oriented towards the East have a denser canopy than facing west, stepping type with diverse grouping with varying recovery rate.

The space of water retention behind the jessour usually planted with trees particularly olive trees, fig trees and cereals (Hilali, 2011). The olive tree always remains the species most cultivated behind the jessour. Different species can be conducted in association in the same Jesr. Thus, we find olive groves, which represent the third of cases, and fig-palm trees association, growing vegetables and cereals are generally practiced in jessour whose production is assured only during wet years.

Surface water are mainly related to rainfall and inflows of the wadis during floods, the exploitation of these waters, has been done by retention works such as jessours.

The study area has been devoided of surface water most of the year. In fact, the amount of water coming from the scarce rainfall is about 30 million m^3/year of which 15 million come from Matmata mountains, but only 0.9 million m^3 are retained by the new dam of Matmata (SEP, 1994).

The river system is composed of a system of hierarchical valleys (SEP, 1994):

- A principal valley of the Wadi;
- A network of secondary valleys where the difference in level may exceed 100m;
- A multitude of valleys usually used for tree crops.

2.2. Methodology

In this paper, we are focusing on the study of the relationship between; surface of the catchment area, surface of retention and height of retention on the destruction of jessour in the scale of the micro-watershed.

To study the relationships between studied parameters and the risk caused by the overflow, we have chosen the following parameters on all units of the micro watershed Jouabit:

- *Height of retention (m):* is the difference of height between the dyke and the surface of the "Jessr";
- *Surface of Retention of the "jessr" (m²):* is the area of the terrace covered by water when the "Jessr" is full;
- *Surface of the catchment area of "Jessr" (m²):* is the micro watershed area, that it outlet is the surface of retention.

To prepare our database of jessours, we have been take for each jessr:

- GPS points at the center of each terrace;
- Length, width of terrace and height of retention of jessr;
- Length and height and the functional status of each dyke (tabia).

The surface of retention and the surface of the catchment area calculated using Arc Gis 9.3.

For mapping, we were used satellite images from Google Earth. These images allow to locate in the field and properly identify the "jessour" by marking the traced of "Tabia" and we are assigning them with a number.

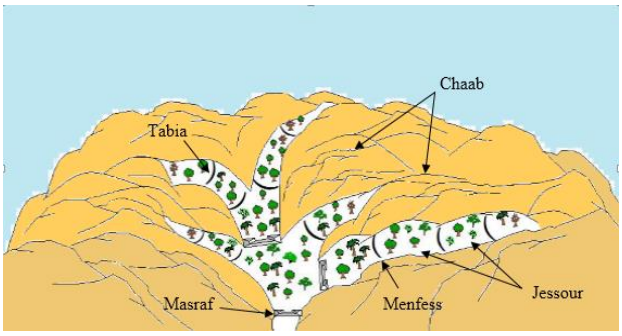

Fig. 2: Components of jessours (Gasmi, 2013)

3. Results and discussions

The surface of the micro-watershed is 304.7719 ha containing 620 jisrs, with a density of 2 jesr/ha, having retention surfaces varied from 3 to 13375 m².

In fact, there are 50 non-functional jesr in the micro watershed, the non-functionality caused, by the destruction of the dykes caused by the runoff. Furthermore, the upstream jessour are the most affected by the destruction (Gasmi, 2013).

To see the relationship between the surface of the catchment area, height of retention and surface of retention and their effects on the destruction and the overflow of small hydraulic units.

The map below shows that there are 4 classes of height of retention and their emplacement in the watershed.

The figure 4 shows that the first class regroups 52.8 % of jessour in the watershed that has a height of retention of between 0 and 0.2 meters, the units located in the upstream are the most representative of this class. The second regroups the height of retention between 0.2 and 0.4 meters includes 42 % of jessour located mainly in the center of the micro-watershed. However, height of retention between 0.4 and 0.8 meters incorporates 4.2 % of all jessour, but possess a significant retention capacity regrouped in the third group. Finally, the last class of height of retention between 0.8 to 2 meters includes the units that hold the major content of runoff water; they exhibit 1% of total number of jessour (6-7 units) which located in the center of the micro watershed represent the fourth group.

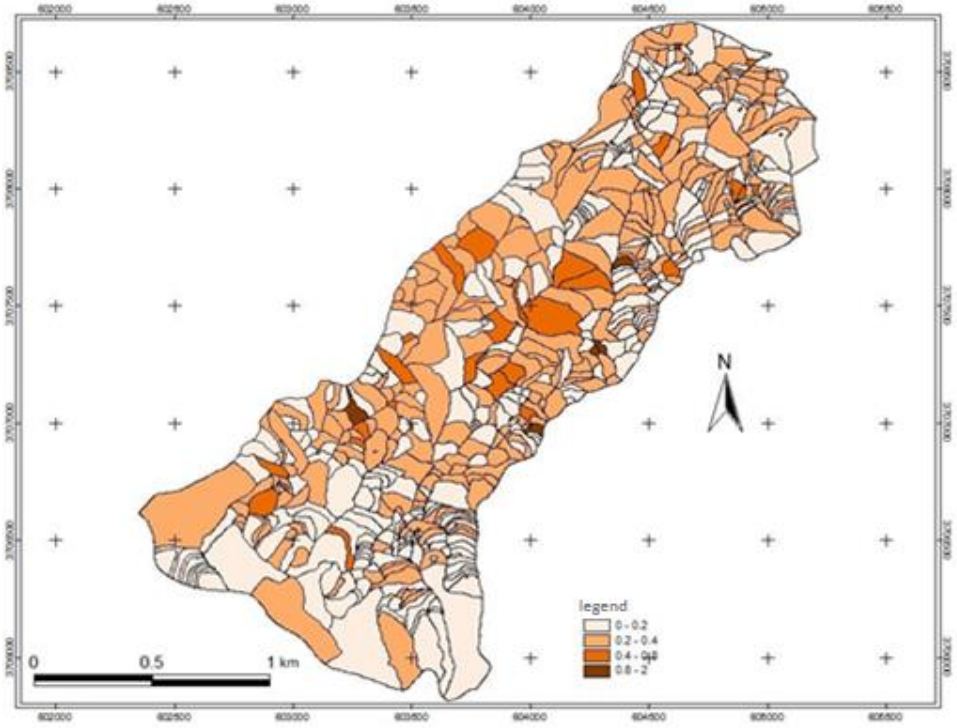

Fig. 3: Classes of heights of retention of jessour

The map below shows that the units located in the upstream have the smallest retentive surface, while the units located in the center and the downstream of the micro watershed have the highest retention surfaces.

The figure 6 shows that the units located in the upstream have the smallest retentive surface, while the units located in the center and the downstream of the micro watershed have the highest retention surfaces.
The retention surfaces are divided into five classes:

- Retention surfaces of less than 500 m^2 include 60.64% of jessour of which are located mainly in the upstream;
- Retention surfaces between 500 and 1000 m^2 comprise 15.96% of small hydraulic units positioned in the upstream, in the far east and the far West of micro watershed;
- Retention surfaces between 1000 and 2000 m^2 comprise 12.9% of all jessours in the micro watershed, which is located in the center and the downstream;
- Retention surfaces between 2000 and 4000 m^2 comprise 7.74% of jessours located in the and the downstream of micro watershed;
- Retention surfaces exceeding 4000 m^2 comprise 2.74% of jessour located largely in the center.

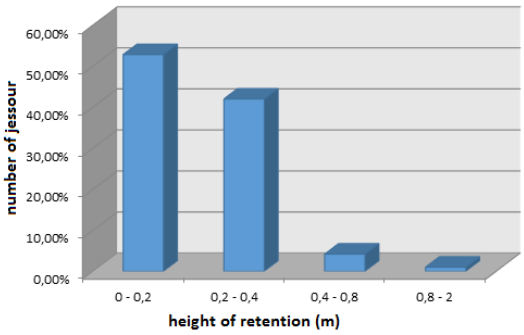

Fig. 4: Variation of the number of jessour with the height of retention

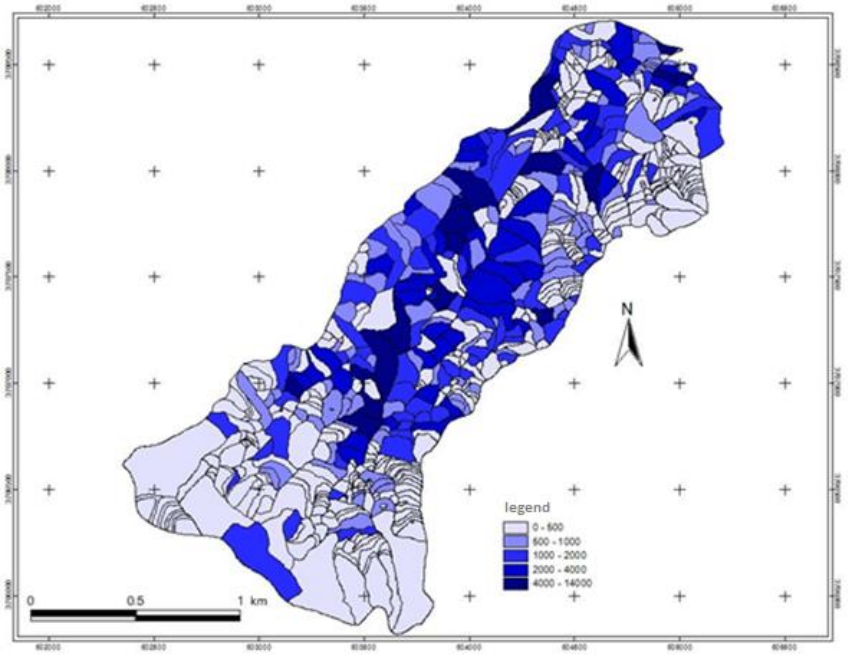

Fig. 5: Classes of surface of retention

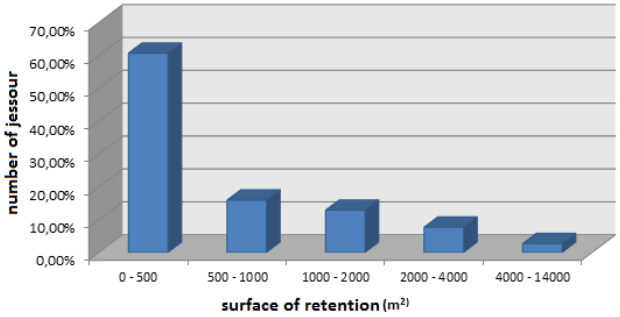

Fig. 6: Classes of surface of retention Variation of the number of jessour with retention surfaces

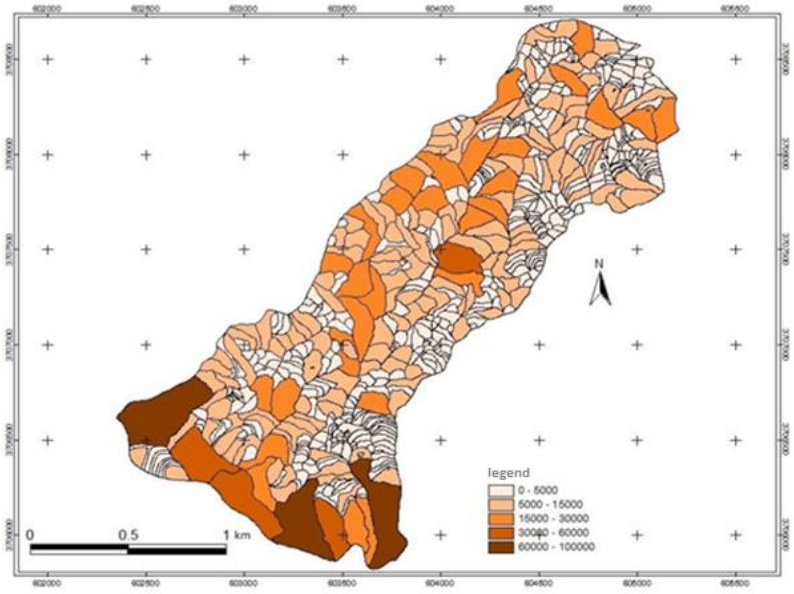

Fig. 7: Classes of catchment areas surfaces

There are 5 classes of surfaces of the catchment area as shown in the map below:

The figure 8 shows that the jessour located in the extreme south of the micro watershed have the largest catchment areas, while the remains have surfaces ranging from medium to small.
We defined five classes of catchment area as follows:
- ***<5000 m²:*** includes 71.29 % of jessour which are located in the south, east and north of micro watershed;
- ***5000 - 15000 m²:*** this class includes 22.74% of jessour, which are distributed over the whole area from the upstream to the downstream;
- ***15,000 - 30,000 m²:*** includes 4.83 % of jessour, which essentially localized in the center and the downstream;
- ***30000-60000 m²:*** includes 0.64 % of the total number of small hydraulic units, which mainly located in the upstream;
-> ***60000 m²:*** includes 0.48 % of jessour, which are located in the upstream of the micro watershed.
The analysis of these parameters shows that in the micro-watershed El-Jouabit, the disproportion is especially marked in the upstream were located the jessour with the most important catchment area but with small retention surfaces. This disproportion between retention surface and surface of the catchment area causes an imbalance between the volume of water flowing into the jesr and the capacity of retention causing the overflowing of the jessour located in the upstream.

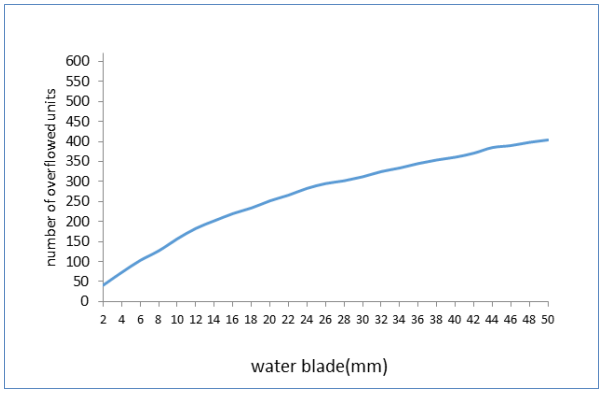

Fig. 8: Variation of the number of overflowing units with water blade

Variation of the number of overflowing units

The figure below shows the variation of the number of overflowing units based on the water run-off blade. In fact, we note that there is a small increase in the number of the overflowing units in the beginning then it becomes faster as long as there is an increase in the value of the water blade. In contrast, the number of overflowing jessour for the low water blades is less important, where the units, which overflow at this level, are on steep slopes where there is a heavy runoff. This is explained by the high sensitivity of some jessour, which are generally small (height of retention and surface of retention) and which are characterized by an improper design (disproportion between the surface of retention and the surface of the catchment area); therefore, these units are more susceptible to overflow. In fact, units with large dimensions are more resistant to runoff volumes hence a small increase in water blade does not have a marked effect on the number of overflowing units.

4. Conlusion

The Jessour in the mountains of Matmata are characterized by their hydro-morphological role, but it is not sufficiently accomplished since the jessour suffer from various problems, particularly climatic (heavy rains) and technical (bad design, sediment accumulation, poor weirs) what causes generally overflow that is causing the destruction of jessours.
There is an advanced disproportion between the surface of retention and the surface of the catchment area, which causes, often an imbalance between the volume of water flowing and retention capacity, which is the principal cause of overflow and therefore the destruction of the small hydraulic units.
To achieve better conservation of soil and water and fight against water erosion. These units must be studied and properly sized to retain runoff water during exceptional events and prevent disasters related to overflow.

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