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# THE STATE ANALYSIS OF THE ANTI-EROSION INSTALLATIONS CARRIED OUT FOR THE PROTECTION OF THE CITY OF HASSI EL GHALA (WILAYA OF AIN TEMOUCHENT, ALGERIA) AGAINST FLOODS

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**ABSTRACT**

Water erosion is an inevitable natural phenomenon that sometimes causes very serious damage to infrastructure (towns, roads, hydraulic dams, etc.). Things' which require anti erosion restorations, in the watersheds of these infrastructures, to protect them. The objective of this research is to perform an is analysis of the state and effectiveness of some anti-erosion restorations, in particular of the thresholds of torrential correction, carried out since 1986 to protect the city of Hassi El Ghalla (region of Ain Temouchent) against floods. The methodology adopted was based on direct observations in the field, taking photos and collecting data at the level of forest conservation in the wilaya of Ain Témouchent. The results obtained revealed a positive assessment of the state of the anti-erosion facilities. The torrential correction weirs and the stepped terraces are mostly in good condition. The vegetation cover is quite dense and the soils are more vulnerable to sheet erosion, qualified as less dangerous compared to linear erosion and mass erosion. The implementation of anti-erosion actions has highly protected the town of Hassi El Ghala against flood. But the forest administration must bring some rehabilitations to these actions and maintain their in sustainability for more efficiency.

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## Introduction.

Water erosion is an inevitable natural phenomenon in the evolution of landscapes and the modification of the land relief. It is defined as the loss of soil due to water which uproots and transports part of the earth to a place of deposit. These land losses have negative consequences on the hydraulic infrastructures installed downstream of the watersheds. Algeria annually loses a total water storage capacity, estimated at 20 million m3 by the deposit of sediments in reservoirs (Remini, 2000). The siltation of dams is rapid, in 30 to 50 years (Roose et al., 2000). The loss of agricultural land only comes second (Laouina, 1998).

A multitude of erosion control methods have been applied worldwide and in Algeria to slow down erosion processes. Some were successful and others presented drawbacks in their implementation and an inadequacy with the socio-economic aspects of the areas treated.

These methods often cost very expensive and sometimes they are a bad choice or a bad installation of the actions to be put in place have negative repercussions on the economic level side. Because their effectiveness which is limited and sometimesis totally non-existent.

The objective of the present work falls within this framework where we tried to make an analysis of the state and the effectiveness of some anti-erosion installations and in particular of the torrential correction thresholds installed since 1986 in a micro watershed located just at the upstream of the town of Hassi El Ghalla (wilaya of Ain Témouchent).

## 2. Materials and methods.

### 2.1 Study area.

The micro watershed chosen for the analysis of anti-erosion facilities is located upstream of the town of Hassi El Ghala and it is under a natural forest of Aleppo pine as shown in figure 1. It is part of the watershed of Oued El Maleh, located in the Oran coastal center in the Northwest of the Algerian territory. The latter is home to the capital of the wilaya of Aïn Témouchent and its neighboring daïras (El Malah, Hassi EL-Ghalla, etc.) and it covers an area of 805.9 km2. It is characterized by a semi-arid Mediterranean climate.


*Figure 1. Location of the study micro watershed in relation to the town of Hassi El Ghala*

*The choice of the study area was based on the presence of anti-erosion facilities at the level of this micro watershed.*

*The area treated by anti-erosion facilities represents only 2,803 hectares, or only 3.48% of the total area of the Oued El Maleh catchment area, estimated with 80,590 hectares (Benselma, 2019).*

All the anti-erosion actions carried out since 1999 in Oued El Maleh watershed are represented in the following table 1:

Table 1. Types of anti-erosion developments carried out in the Oued El Maleh watershed since 1999 (Ain Témouchent Forest Conservation).

| Type of project | Year | Nature of actions | Unit | Volumes achieved |
|---|---|---|---|---|
| PER | 1999 | Reforestation | Ha | 3 |
| PER | 2000 | Wine plantation | Ha | 13 |
| PER | 2000 | Olive plantation | Ha | 10 |
| PER | 2000 | Wine plantation | Ha | 23 |
| PER | 2002 | Torrential Correction | $M^3$ | 500 |
| PER | 2002 | Wine plantation | Ha | 20 |
| PER | 2002 | Wine plantation | Ha | 18 |
| PER | 2002 | Wine plantation | Ha | 20 |
| PSRE | 2002 | Fruit Plantation | Ha | 30 |
| PCSC | 2006 | Forest Band | Ha | 40 |
| PSD | 2007 | Torrential Correction | $M^3$ | 500 |
| PCSC | 2008 | Olive plantation | Ha | 20 |
| PCSC | 2008 | Reforestation | Ha | 6 |
| PCCE | 2010 | Reforestation | Ha | 6 |
| PNE | 2017 | Restocking | Ha | 10 |
| PNE | 2020 | Reforestation | Ha | 10 |
| PNE | 2020 | Reforestation maintenance | Ha | 10 |

The actions carried out according to the various programs were essentially comprised between reforestation and fruit plantations, as biological methods of combating erosion. As well as torrential correction as a mechanical method of protection.

**2.2 Methodological approach.**

To achieve the objective of this study, the methodology adopted was based on field observation, photo shoots and data collection at the level of forest conservation in the wilaya of Ain Témouchent. The collection of data targeted the anti-erosion developments carried out in the study area: their types, their areas and the date of their realization.

The field trips allowed us to visualize the state of the anti-erosion facilities present in the study area and to photograph them. A more detailed analysis was carried out for the torrential correction thresholds by examining their current general state and the main elements of their construction.

**3. Analysis of the state of anti-erosion facilities.**

**3.1. Mechanical processes.**

**3.1.1. Torrential correction.**

In the study area, according to data provided by the Ain Témouchent forest conservation, 1000 m3 of torrential correction works were carried out in 1986, followed by 500 m3 under the

Rural Employment Program (REP) in 2002 and 500 m3 under the Sector Development Program (SDP) in 2007.

The analysis of this type of development was carried out on thresholds installed on the main watercourse only of a micro watershed located just upstream of the town of Hassi El Ghalla.

The latter is threatened by flooding since it is located downstream of a sloping watershed and with a significant water flow at the level of its main watercourse. We noticed that whole trees with their root systems have been uprooted, testifying to the importance of the flood flow that crosses the main watercourse as shown in figure 2.

*Figure 2. Trees carried away by the flow of the flood on the main watercourse.*

At the study station, we also observed outcrops of limestone rocks testifying to significant sheet erosion as shown in figure 3:

*Figure 3. Rocky outcrop symptom of significant sheet erosion.*

At the level of the main watercourse, we observed, analyzed and photographed the state and stability of 17 torrential correction thresholds. The results obtained are reported in the following table:

Table 2. Characteristics of the torrential correction thresholds analyzed.

| Threshold Type | Location | Foundation | Anchoring | Weir | Dissipation basin | Vegetations | Landing % |
|---|---|---|---|---|---|---|---|
| Gabions | MW | +++ | +++ | + | - | +++ | 100 |
| Dry stone | MW | ++ | -+ | - | - | +++ | 100 |
| Gabions | MW | ++ | +- | - | + | +++ | 100 |
| Dry stone | MW | -- | -+ | - | - | +++ | 100 |
| Dry stone | MW | ++ | ++ | - | - | +++ | 100 |
| Dry stone | MW | + | ++ | - | - | +++ | 100 |
| Dry stone | MW | ++ | +- | + | - | +++ | 100 |
| Dry stone | MW | - | ++ | - | - | +++ | 100 |
| Dry stone | MW | +- | ++ | - | - | +++ | 100 |
| Dry stone | MW | - | ++ | - | - | +++ | 100 |
| Dry stone | MW | - | ++ | - | + | +++ | 100 |
| Dry stone | MW | - | ++ | - | - | +++ | 100 |
| Gabions | MW | ++ | ++ | + | + | +++ | 100 |
| Gabions | MW | ++ | + | + | + | +++ | 100 |
| Gabions | MW | + | + | - | + | +++ | 100 |
| Gabions | MW | + | + | - | + | +++ | 100 |
| Dry stone | MW | + | + | - | - | +++ | 100 |

**Table legend:**

Foundation:

+ : good - : poor

MW: Main Watercourse

Anchoring :

+ : good

- : poor

Vegetations :

+ : present

- : absent

Weir :

+ : present

- : absent

Dissipation basin:

+ : present

- : absent

By observing the data mentioned in the table above, we find a more positive than negative assessment of the state of the torrential correction thresholds examined. The foundation and the anchoring of the sills were well carried out in most of the sills. On the other hand, the spillway and the dissipation basin are most often absent. According to Nahal (1975), the foundations are the essential elements of the torrent control works, because they avoid the loosening and the washout of the sills by the waters during peak periods.

These foundations will be opened across the channel and have a dimension of 0.55 to 0.75 m deep and up to 1 meter in scourable terrain. They must also have a width greater than that of the base of the torrent control structure and protrude by a value substantially equal to the upstream and downstream of approximately 0.2 to 0.3 meter in width (Greco, 1966).

We also noted, during the prospecting on the ground, that the mesh of the gabion sills was cut and stolen in all the sills installed as shown in figure 4.

Vegetation cover is significant and the landfall upstream of each sill reached 100% in all sills as shown in figure 5.

*Figure 4. Stable gabion sill with cut and stolen mesh, good foundation and good anchoring.*

*Figure 5. Stable gabion sill with cut and stolen mesh with 100% landing.*

We also found that dry stone sills are less stable than gabion sills. This was due in most cases to poor anchorage either in the left or right side as shown in figure 6.

The fact of anchoring a consolidation dam in the side slopes and the bottom of the ravine considerably reinforces the stability of the structure. The anchorages consist of a trench 0.6 meters deep and wide dug across the channel. In case of excessive instability, it is increased to 1.2 or 1.8 meters (Burchard, 1980).

*Figure 6. Unstable dry stone threshold on its left side due to poor anchoring.*

**3.1.2. Terraces with stepped walls.**

The upstream part of the micro-basin studied was cut into terraces supported by low walls to break the speed of water flow as shown in figures 7 and 8:

*Figures 7 and 8. Terraces with stepped low walls*
*(Some low wall stones were washed away by the force of the water current).*

**3.2. Biological processes.**

**3.2.1. Forests.**

The micro watershed studied is located under a natural state forest, with an area of 69 hectares. Composed of 90% Aleppo Pine and 10% Eucalyptus. With an undergrowth dominated by *Chamaerops humilis* (the Doum) and *Calicotome spinosa* (the thorny Calicotome), indicators of overgrazing due to a heavy pastoral load.

**3.2.2. Fruit plantation.**

We observed in the studied area an olive tree plantation in the upstream part of the catchment area as shown in figure 9:

*Figure 9. Olive growing upstream of the study area.*

**4. Results of analysis and discussion.**

The analysis of the anti-erosion facilities present in the study area has made it possible to identify the following main results:

- The torrential correction works have been carried out since 1986 to fight against water erosion and in particular to protect the town of Hassi El Ghala against floods;
- The installation of torrential correction thresholds has made it possible to break the speed of water flow and minimize the solid and liquid transport which threatens the city of Hassi El Ghala.
- The types of torrential correction weirs used are gabions and dry stone weirs. Most are in good condition and the stones used for their construction were mostly taken on site given their great availability in the region;
- The instability of some gabion sills was mainly due to the total cutting of the fence, where some stones escaped from the sills by the floods;
- The instability of certain dry stone thresholds is due either to poor anchoring or a poor foundation;
- This instability favors the processes of regressive erosion and foxing;
- The weir installation is totally absent in all the sills examined, this makes the sill less resistant to the forces of water currents;
- The landing reached 100% in the majority of thresholds, which is quite normal given the age of their implementation (1986, 2002 and 2007);
- The stepped terraces cover part of the upstream part of the basin and are reinforced by low walls;
- Some low wall stones were washed away by the force of the water currents;
- The plant cover is quite abundant with a natural Aleppo pine forest in good condition and some Eucalyptus trees;
- Some trees were completely uprooted by the force of the floods and others their root system was stripped from the ground by mass erosion;
- The passage of fires also at the level of the forest is clearly observed;
- The undergrowth is quite dense but mainly composed of Doum and Calicotome, indicating overgrazing in the region;
- The fruit plantation is present in the upstream part of the basin composed mainly of olive growing. This type of perennial crop protects the soil better against erosion than cereal crops, for example, often grown in mountainous terrain in the region;
- The problem of isolation does not exist, we have observed two tracks in very good condition in the study area, which will allow more land development and the establishment of crops that are more resistant to erosion;
- The gravel load is very high on the surface of soils with outcrops of limestone rocks. This is a symptom of the dominance of sheet erosion;
- Linear erosion is less important despite a fairly high degree of slope, this is justified by the nature of the soils on site which are not very vulnerable to this type of erosion;

- Apart from the main watercourse and other small huts, the other stages of linear erosion (claws, gullies, ravines, tunnels) are little or not visible;
- Mass erosion, in particular landslides, on the other hand is quite present because of the importance of the degree of the slope and the high flows at the level of the rivers;
- These strong flows are also originating from the very remarkable stony load which covers the ground. Where water from precipitation is directed more towards runoff than infiltration;
- The nature of the land and soils in place makes us predict that the process of water erosion leads more to liquid than solid transport in the study area;

At the end of these analysis results, we estimate a much more positive than negative assessment of the anti-erosion developments in the studied area. Nevertheless, the forest administration must carry out the following rehabilitation works:
- Maintenance of the torrential correction thresholds by replacing the stones carried away and raising them;
- The covering of the gabions again as far as possible by the metal mesh;
- The restoration also of the stones carried away at the level of the low walls;
- More vigilant control of overgrazing and fires;
- Promote the development of land and fruit plantations within the framework of rural development projects.

**5. Conclusion.**

The results obtained through this study, allowed us to note a positive more than negative assessment of the state of the anti-erosion installations. Most of the torrential correction thresholds are in good condition. The instability of some gabion weirs was mainly due to the total cutting of the mesh, where some stones escaped from the weirs by the floods, and not to one of the criteria for their placement. For the dry stone thresholds we have distinguished the instability of some due to either poor anchoring or a poor foundation. Cella favors the processes of regressive erosion and foxing.

The landfall of land transported upstream of each sill reached 100% in most sills. Which is quite normal given the age of their implementation. But the presence of a fairly dense vegetation cover will replace the role of these mechanical thresholds.

The presence of stepped terraces in the upstream part of the study basin also plays an important role in mitigating the speed of water flow and erosion. But their retaining walls currently require maintenance for greater efficiency.

The activity of linear erosion is less significant, this is justified by the nature of the soils on site, which are not very vulnerable to this type of erosion. On the other hand, mass erosion is quite present because of the importance of the degree of the slope and the high flows at the level of the rivers. The gravel load is very high on the surface of soils with outcrops of limestone rocks. This is a symptom of the dominance of sheet erosion.

The nature of the land and soils in place makes us guess that the process of water erosion leads more to liquid transport than solid in the study area.

The installation of anti-erosion actions in the study watershed has certainly protected the town of Hassi El Ghala, located downstream, against flooding. But the forest administration must bring some rehabilitations to these actions and maintain them in a continuous way for more efficiency. Encouraging land reclamation and fruit plantations as part of rural development projects is also highly desirable.

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