*J. Appl. Environ. Biol. Sci.*, 7(3)79-86, 2017
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**ISSN: 2090-4274**
**Journal of Applied Environmental and Biological Sciences**
*www.textroad.com*

# Study of The Durability of Water Resources in the Watershed of Oued El Hammam
# (Case of The Plain of Ghriss, Western Algeria)

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*Received: October 12, 2016*
*Accepted: January 3, 2017*

## ABSTRACT

The zone of study is a plain being part of western Algeria and belonging to the semi-arid bioclimatic floor tempered with annual rainfall less than 350 mm.

The Ghriss plain covers an area of about 957 km$^2$ and is the most important part of the watershed of Oued El Hammam, with high levels of water and agricultural potential.

This area includes a stratigraphic series that ranges from secondary to Quaternary and covering several aquifers, the most important are: groundwater, ground Limestone Lake and upper Jurassic ground.

The piezometric map made allowed us to visualize the hydraulic continuity of the plain, giving the depth of piezometric surface, to locate the zones of food and to determine the direction of the flows as well as the zones of hydrous vulnerability.

The layer deficit is estimated at 30.24 Hm³ / year; it is induced by over-exploitation of aquifers. The deficiency of the climatic contributions, the very important evaporating power and excessive depletion of groundwater resources (Irrigation + AEP) over the past three decades have contributed probably to the low water systems in the region.

This situation leads us to research emergency solutions such as desalination of sea water for water supply and irrigation and irrigated perimeters to create the plain (operations and supply by neighboring dams).

**KEY WORDS:** Durability, watershed of Oued el hammam, plain of Ghriss, piezometric map, climatic contribution, over exploitation, AEP and irrigation.

## I. INTRODUCTION

The operation of the environmental systems is directly related to the existence of water. His state in space and time orders the presence and continuity of plants and biodiversity. Therefore, the protection of the environment is closely linked to the preservation of water resources.

The plain of Ghriss is currently subjected to an overexploitation imposed by uncontrolled irrigation. This situation is worsened by climatic conditions characterized by a weakness of precipitations and rather long periods of drought. More than 70% of the grounds of the plain is irrigated and induce an anarchistic and excessive pumping resulting in a sharp decline of the plain.

The quantitative knowledge of water resources and their evolution in time and space is a key parameter in the management of this resource and environmental protection. It also allows better control of inputs and uses to manage the balance sheet and ensure a balanced operation of the forecast system and management of water resources in the short, medium and long term.

## II. MATERIAL

### II.1. Presentation of the zone of study

Located at the North-West of Algeria, Oued Fekan watershed covers an area of approximately 957 km² and a perimeter of 128 km². The plain is the most important part of this basin; its altitude varies between 400 and 500 m and the slope is between 0 and 6%.

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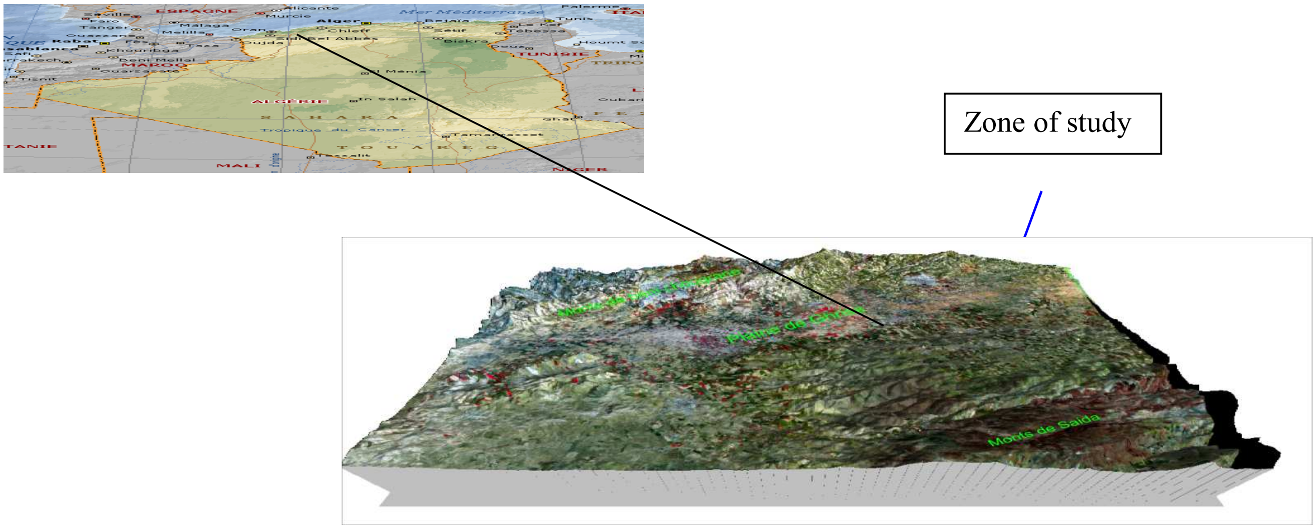

**Fig. 01: Ghriss Plain Location. Own elaboration**

## III. METHOD, RESULT AND DISCUSSION

### III.1. Climate study

To the insufficiency and the irregularity of the rains, the intensity of evaporation is added accentuating the hydric deficit. The Ghriss plain suffers from this phenomenon imposed by a semi-arid regime, a spatio-temporal variability of rainfall and high evapotranspiration (ETP) of about 838.11 mm/year calculated by the method of Thoranthwaite. The average annual average rainfall on the entire area is 330.39 mm, while the excess climate matching infiltration is estimated at 24.54 mm.

The water balance calculated from data of meteorological station of Maoussa is established for the period 1980-2010.

Water supplies are carried by rainfall while losses are mainly due to evapotranspiration. The two sizes are evaluated in quantity of water per unit of area, but they are usually translated in water depth. They are physically homogeneous, and it is possible to compare them by calculating either their difference (Precipitations sub evapotranspiration), or their report (precipitations div evapotranspiration). The assessment is obviously positive when the difference is positive or that the report is higher than one. We choose one or the other expression according to conveniences or of various constraints [2].

It is current in the study of water balances to compare the precipitation ***P*** and potential evapotranspiration ***ETP*** which allow us to distinguish the different situations according to thresholds that are directly significant for a place or a given period:

***Table 01 : water balance***

| **Month** | **Sep.** | **Oct.** | **Nov.** | **Dec.** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May.** | **Jun.** | **Jul.** | **Aou.** | **Annuel** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **P** | 15.72 | 27.4 | 48.35 | 40.15 | 37.91 | 38.27 | 37.53 | 29.76 | 25.48 | 3.35 | 2.02 | 5.68 | 311.6 |
| **ETP** | 70.2 | 56 | 37 | 17.1 | 16.9 | 35.1 | 33.2 | 80.9 | 102.6 | 104.7 | 150 | 148.8 | 838.1 |
| **P-ETP** | -54.4 | -28.6 | 11.35 | 23.05 | 21.01 | 3.17 | 4.33 | -51.14 | -77.12 | -101.3 | -147.9 | -143.1 | -526.4 |
| **Useful reserve** | 0 | 0 | 11.35 | 34.4 | 55.41 | 58.58 | 62.91 | 11.77 | 0 | 0 | 0 | 0 | 0 |
| **ETR** | 15.72 | 27.4 | 37 | 17.1 | 16.9 | 35.1 | 33.2 | 80.9 | 37.25 | 3.35 | 2.02 | 5.68 | 311.6 |
| **Agricultural deficit** | 54.48 | 28.6 | / | / | / | / | / | / | 65.35 | 101.3 | 147.9 | 143.1 | 540.8 |

If P < ETP, real evapotranspiration ***ETR*** is equal to P; the period will be known as deficit.
If P > ETP, real evapotranspiration is equal to the ETP; the period will be known as surplus.

The importance of the ETP on the water balance is represented by the dependence that connects the monthly change of rainfall and evapotranspiration [7]. We observe weak ETP values for the rainy months (October to April), i.e. there is an excess of water in the ground. On the other hand the deficit period is from May to September.

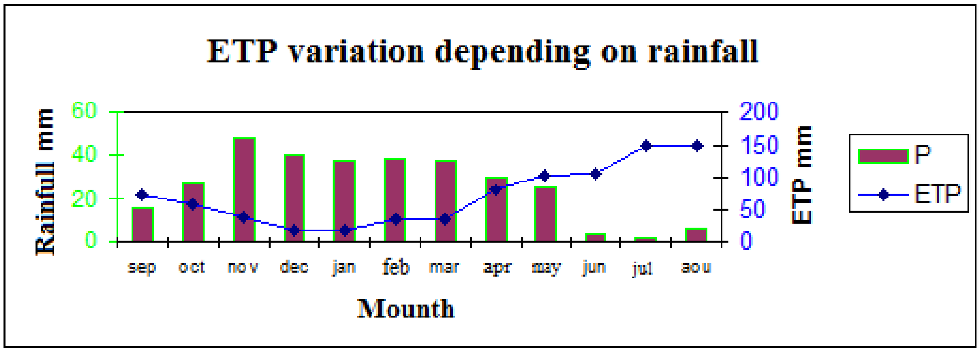

**Fig. 02: Variation of evapotranspiration depending on rainfall. (Personal elaboration)**

### III.2. Use of the water resources

The unprecedented orientation to irrigated agriculture by groundwater leads to overexploitation of aquifers [9]. To meet the hydrous needs of the region, a desalination station put moving lately (at the end of 2014) located at Macta near from Arzew, a project of routing treated water for several regions of the West east is in an execution state. The irrigated area in the plain of Ghriss in 2013 is approximately 12379 ha according to data from the Directorate of Agricultural Services in 2014, representing 0.13% of the plain.
To produce one hectare of potatos it is necessary between 1000 and 3200 m3, this fluctuation depends on the soil type, farming control and the type of irrigation.
In the study area this speculation is dominant and occupies an average area of 5270 ha [5].
The 70% practiced irrigation system is sprinkler irrigation (5270 ha of potato need about 10540 HM3/ development cycle that lasts 120 days.

### III.3. Study of underground resources

From the Hydrogeology viewpoint, the main aquifers characterizing the plain of Ghriss are [6]:

- The *surface layer* ( alluvial ) which is fed by rainfall .
- The *lacustrine limestone layer*: fueled by his outcrops in Beni Chougrane mountains.
- The *Upper Jurassic aquifer.*

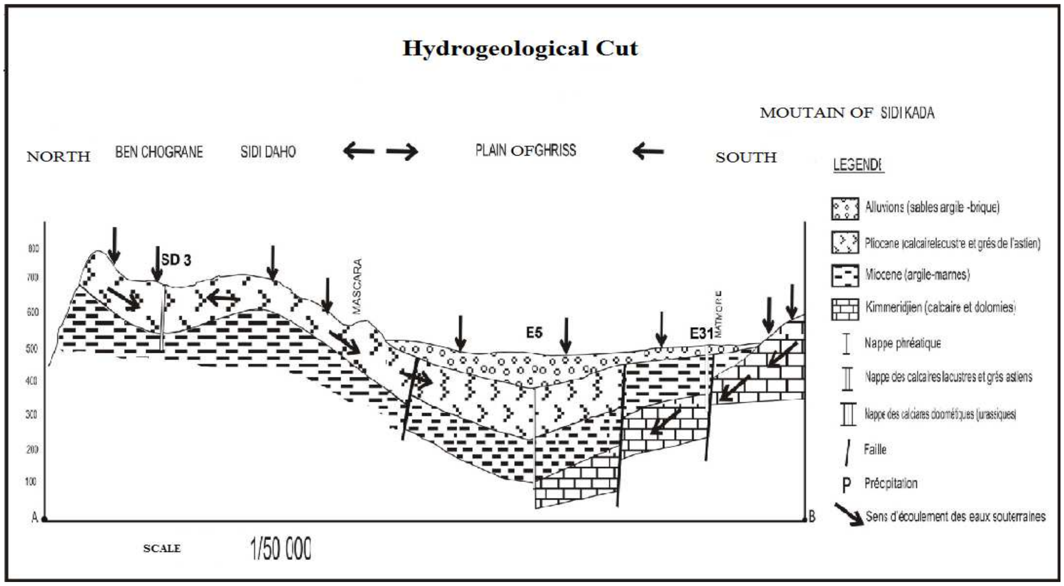

**Fig.03: Hydrological Cut of plain of Ghriss [1].**

The alimentation deficit of the main aquifers is estimated at 30.24 Hm³ (Table 02).

*Table 02: Comparison of alimentation fraction depending on the rainfall*

| Plain of Ghriss layer | Impluvium (km²) | Rainfall (mm) | | Alimentation rate (HM$^3$/year) | Alimentation déficit (HM$^3$/year) |
|---|---|---|---|---|---|
| | | year | P | | |
| **surface layer (alluvial)** | 605 | 1972 | 410 | 50 | 16. 02 |
| | | 2010 | 319.3 | 33.98 | |
| **lacustrine limestone layer** | 125 | 1972 | 520 | 7.7 | 2.42 |
| | | 2010 | 352 | 5.28 | |
| **Upper Jurassic aquifer** | 376 | 1972 | 550 | 31 | 11.8 |
| | | 2010 | 371.8 | 19.2 | |

The plain presents a Piezometric peak located around Elkouair due to the refeeding by the water of Mascara city. Underground flows are carried out in general From the North East to the South West.

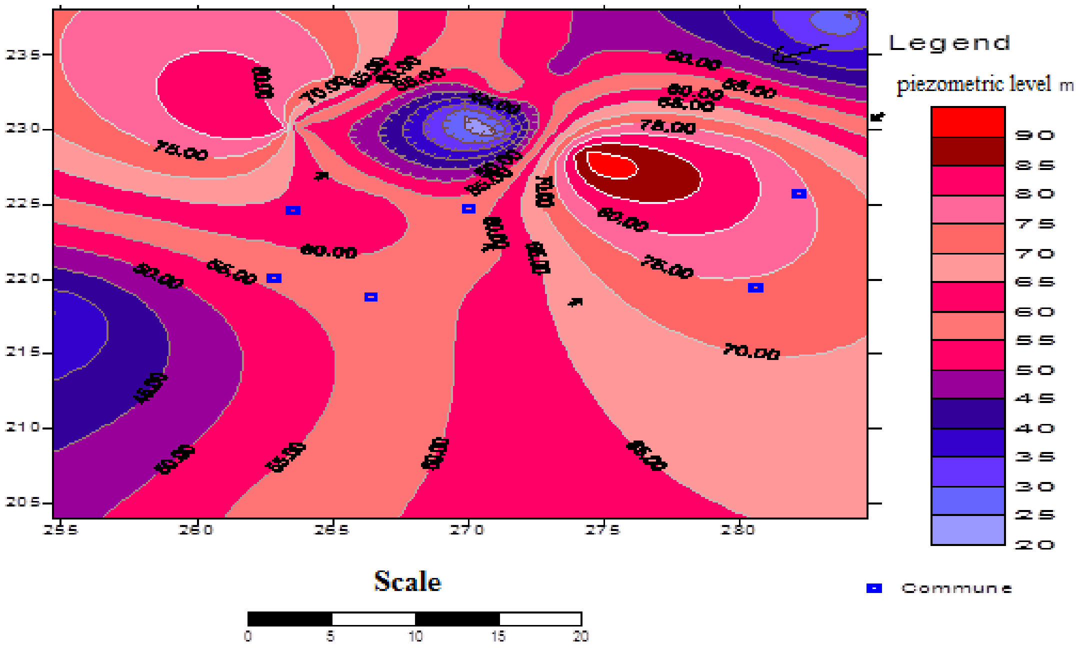

**Fig. 04: Piezométric map of the plain of Ghriss. (Own elaboration)**

Excessive and continuous exploitation of the aquifer, the deficiency of the climatic contributions and the very important power evaporation have contributed to the increase of the influence zone and threat in the near future the final extinction of the first aquifer.

A considerable reduction in the static levels of the cities of Mascara, Tighennif, Ghriss, Matemore, Maoussa and Tizi, due essentially to the large number of wells and borehole exploited for agricultural use (irrigation of crops grown during drought) and climatic conditions (reduced precipitation and increased evapotranspiration).

For example, in 1985 the average static level of the commune of Maoussa was about 17m whereas in 2014 it was about 49m according to my own researches because I live in the area of Ghriss.

In terms of drinking water supply, illicit borehole compromised severely and without ambiguity, the alimentation of Mascara city [4].

The lack of strict control and unawareness to protect water resources by the local authorities (direction of water resources of Mascara), encourage farmers in Tizi region to dig unauthorized borehole (depth estimated 400m). This situation weakens the flow of the aquifer which represents the primary source of alimentation in Mascara city. To illustrate, the case of Tizi is very significant, since in 1980 only one artesian drilling borehole retailed 180 l/s, whereas at present the total flow rate of 5 drillings boreholes hardly exceed 140 l/s with consequent folding backs [4].

According to the ANRH services [6], illicit borehole counted on the plain of Ghriss until June 2012 are about 800 (including deep borehole not-authorized) with an output rate equal to 4 l/s.

If it is estimated that the average duration of exploitation is around 15 hours/day [3], the annual review of the water deficit by illegal irrigation pumping of drilling borehole (Dii) is equal to:

15*365*60*60 *4
Dii = 78840000 l/year =78840 $m^3$/year .

Illicit borehole costs a deficit of 78 840 $m^3$/year.
Thus, 800 drillings boreholes weighs a burden equivalent to:
V0 = 63072000 $m^3$/year.

Part of this amount returns to the aquifer by infiltration, it is close to 15% [11]. Therefore, the volume of the net outputs by illicit drillings boreholes is:
Vnet = 53611.2 $Hm^3$ / year.
On the other side of the balance the hydrous entries (natural) of the aquifer are represented by the rain infiltration which is equal to 14 mm only.

The balance sheet of infiltration at the plain is estimated at 13398 * 10 ^ 4 $m^3$/year.

The final assessment which takes into account only the outputs of illicit drilling borehole results in the following:

$$80368800 \text{ m}^3 = 80368.8 \text{ Hm}^3$$

This value reflects the accentuated folding backs of static levels of the aquifer.
The impact of climate changes on the fluctuation of the aquifer is represented by the following graph:

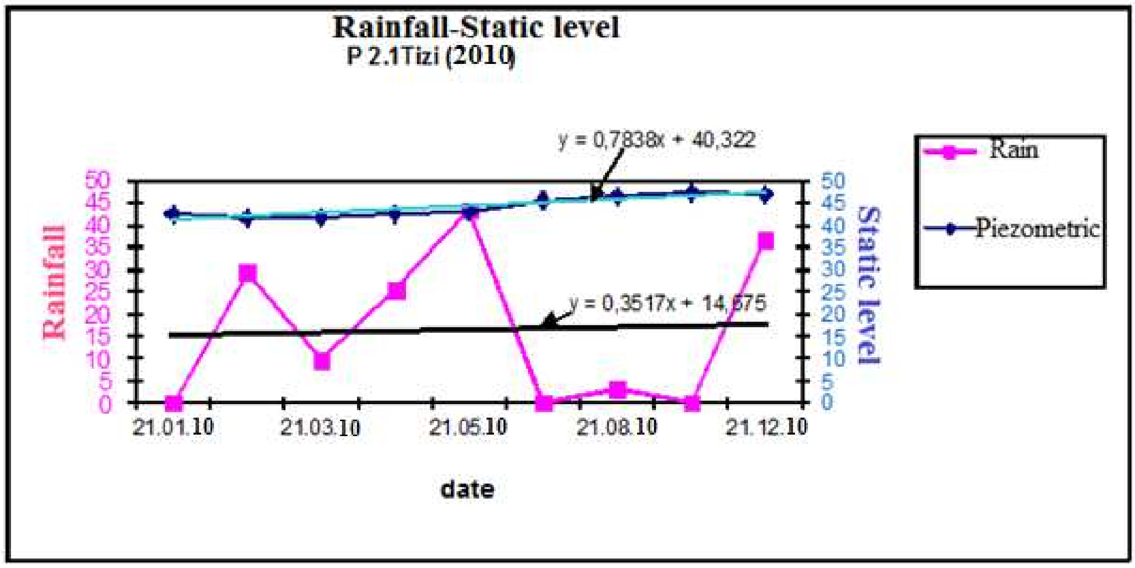

**Fig. 05: Impact of climate changes on the fluctuation of the aquifer P 2.1Tizi.**

The analysis of the piezometric evolution allows us to distinguish a variability of the levels in correlation with time; it follows two directions:

- A *seasonal fluctuation* characterized by rain alimentation and a "rest" of the aquifer during the winter season (no irrigation), we note that there is a rise in the static level, against, the piezometric folding backs takes a significant trend during the summer season. This change is due primarily to the rainfall deficit and excessive pumping
- A *progressive inter-annual fluctuation* is manifested by the continuous lowering of the static level, which clearly appears on the graph with a positive linear trend given by the following line:
-

$$\boxed{Y = 0.2444*X+42.24}$$

## III.4. Use of Water for Irrigation

Usually the irrigation water salinity is a key parameter reflecting its quality; it is expressed as the total quantity of the dissolved solids ***tds*** in milligrams per liter (mg / l). This ***tds*** is measured by evaporation, between 100 ° and 200 °C of a volume of water and by weighing of the residues. This value can be compared to the calculated value by adding the contents of different ions after chemical analysis. Generally, salinity is equivalent to the electrical conductivity (EC) measured at 25°C in millimhos.

The accumulation of sodium (sodication) on the adsorbing complex of soils may degrade their physical properties. Their drainage capacity, so their permeability, conditions the productivity of irrigated land. A sodium excess compared to alkaline-earth (calcium, magnesium, etc) in the absorbing complex causes a flocculation of clays, a destructuring of the soil which results in a reduction of the permeability and porosity of the surface layers of the soil.
The quality of water can be classified with a SAR (sodium absorption rate) relating to the sodium content and is expressed by the following formula:

$$\mathrm{SAR} = \frac{\mathrm{NA}}{\sqrt{(\mathrm{CA}+\mathrm{MG})/2}}$$

Some cultures, such as vine, the citrus fruits, the walnut trees, the avocado tree and the bean, the strawberry plants and, generally, the pip fruits and with cores, are sensitive with relatively weak concentrations of NA [10].

***Table 04: Calculation of the S.A.R module of water samples of the Ghriss plain***

| **Samples** | **NA Mg/l** | **CA Mg/l** | **MG Mg/l** | **S.A.R** | **Electric conductivity C25 µscm** | **Water quality** |
|---|---|---|---|---|---|---|
| **P21.Tizi** | 65 | 76 | 85 | 7.24 | 1200 | Risk of high salinity and low danger of alkalinity. |
| **PO3.ONM** | 18 | 84 | 64 | 2.09 | 1400 | Risk of high salinity and low danger of alkalinity. |
| **PO4. Matemore** | 89 | 106 | 179 | 7.45 | 740 | Risk of average salinity and alkalinity. |
| **Po5. Sidikada** | 51 | 60 | 77 | 6.16 | 2400 | Risk of high salinity and low danger of alkalinity. |
| **Po6. Tighenif** | 18 | 48 | 106 | 2.05 | 1000 | Risk of high salinity and low danger of alkalinity. |
| **Po7. Tighenif** | 59 | 74 | 86 | 6.59 | 900 | Risk of high salinity and low danger of alkalinity. |
| **E2. Mascara** | 78 | 192 | 131 | 6.13 | 1400 | Risk of high salinity and low danger of alkalinity. |
| **E44. ElKouair** | 76 | 140 | 61 | 7.58 | 2700 | Risk of high salinity and low danger of alkalinity. |
| **E29. Tizi** | 58 | 130 | 87 | 5.56 | 720 | Risk of average salinity and alkalinity. |
| **Froha** | 39 | 126 | 66 | 3.98 | 700 | Risk of average salinity and alkalinity. |
| **Se.Tighenif** | 110 | 80 | 56 | 13.33 | 1800 | Risk of high salinity and average alkalinity. |
| **E43. Maoussa** | 59 | 56 | 178 | 5.45 | 860 | Risk of average salinity and high alkalinity. |
| **E31. Matemore** | 38 | 110 | 242 | 2.86 | 700 | Risk of average salinity and alkalinity. |
| **E21. Fekan** | 59 | 56 | 107 | 6.53 | 2050 | Risk of high salinity and low danger of alkalinity. |
| **E13. Ghris** | 71 | 36 | 108 | 8.36 | 700 | Risk of average salinity and alkalinity. |

The water of irrigation presents a danger of salinity which varies from average to high and a risk of alkalinity varying from weak to average.

## IV. Conclusion

From a quantitative point of view, the realized diagnosis shows that the aquifers reserves of the plain of Ghriss are threatened both by the climatic fluctuations (frequent periods of drought) resulting in a regression of the rainfall and the increase of the evapotranspiration. The overexploitation of the plain to meet the needs of agricultures during more than 7 months constitutes a determining parameter of the water resource situation.
Qualitatively, water of the Ghriss plain for the agricultural use is of average quality and does not present any risk of salinity or sodication except for SE. Tighennif borehole.

Of this analysis it is possible to make some agro-environmental orientations to better manage the resource; the principal ones are:

- Any management and development program must be subjected to specific ecological rules of space (choice of the cultures according to the privileges of the site).
- Genetic improvement to obtain varieties adapted to the drought and the diseases.
- Introduction of cultivation techniques allowing the soil to preserve water during the deficit months and to stop the groundwater losses by capillarity (dry cultivation) [9].
- Popularization of economic systems of water irrigation (sprinkling, pivots center, drops by drops).
- The creation of an irrigated perimeter in the plain (introduction of large scale hydraulics) to improve groundwater recharge.
- The popularization of use organic fertilizer and integrated lutes instead of chemical products which threaten human health and environment.
- Establishment of a permanent observation system which ensures regular monitoring over a long period [1].
- To develop an approach of participative governance of the water resources where decision making is done by the representatives of all actors of water in a given territory [8].
- Preserve the environmental balance of the region by proceeding to a reasonable control of groundwater by reducing the overexploitation by closing illicit boreholes.
- Using modern techniques for the plain of Ghris recharge.
- Reinforcement of rain water storage capacity and reduction of the outputs except basin during the rainy season by the realization of collinear reserve and dams.

## V. REFERENCES

[1]Agence de Bassin Hydrographique Oranie - Chott Chergui, 2012, Rapport De Synthese Du Plan Directeur D'amenagement Des Ressources En Eau Amelioration De L'outil Pdare Suivi De La Nappe De Ghriss. Avril.

[2] André Durbec, 1990. Modélisation de la nappe Alluviale de l'Hérault, CEMAGREF

[3] Benkaddour B, 2006 Diagnostic des ressources hydriques et leurs utilisations dans l'agrosystème de la Plaine de Ghriss (Bassin versant de Oued Fekan région de Mascara).Thèse de Magister, C.U. Mascara.

[4] Cabinet Wilaya de Mascara, 1997. Rapport sur la protection du domaine public hydraulique et lutte contre les forages illicites.

[5] Direction des services agricoles (DSA). 2014. Service statistique.

[6] Direction des ressources hydriques, 2010.

[7] Elaine M. Barrow, Rick J. Lee, 2000. Changement climatique et évaluation environnementale. Institut canadien d'études climatologiques.

[8] Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs (2012). Gestion intégrée des ressources en eau : cadre de référence, Québec. Québec : Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, 36 p.

[9] Quarouch H., 2014, Eaux souterraines, sources de dignité et ressources sociales : cas d'agriculteurs dans la plaine du Saïss au Maroc. Revue Cahiers d'agricultures.

[10] Sakr I, 1982. Les Principes de l'hydrogéologie, FELLEH.

[11] Sourisseau, 1970, 1976. Etude hydrogéologique de la nappe de Mascara.