academicJournals

Vol. 10(7), pp. 248-262, 16 April, 2015
DOI: 10.5897/IJPS2015.4267
Article Number: 375C2EE52063
ISSN 1992 - 1950

http://www.academicjournals.org/IJPS

International Journal of Physical Sciences

*Full Length Research Paper*

# Development of an approach for Mapping of features thermal and hydric of watersheds. Case of the watershed of Brezina (Algeria)

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Received 27January, 2015; Accepted 4 March, 2015

**The objective of the present study is to present the parameters of the hydrological assessment of a steppe area from the data of remote sensing. Adopted methodology rests on the cartography of the various parameters of the hydric and energy balance on one year scale. Several methods are used. Thus, for cartography of precipitations, one uses in a combined way the relief, the distance of the sea and the exposure. The second method is used for the cartography of the streaming on an each pixel scale. This method utilizes a matrix which calls upon the information contained in space variability and information resulting from the first method. The combination of information of precipitation and the streaming allow the development of the chart of infiltration. The third method consists with the estimate of the evapotranspiration on broad scale. This last method uses images AVHRR and the model of assessment of energy Surface Energy Balance Algorithm for Land (SEBAL). The quality and the space precision of these cartographies using imagery NOAA AVHRR open a broad hydrological field of application and can be extended for the exploration of all the Algerian steppe area.**

**Key words:** Balance of water, Brézina, mapping, surface energy balance algorithm for land (SEBAL), energy balance.

## INTRODUCTION

The arid regions cover approximately 40% of the surface of the grounds world (Dregne et al., 1991; Standish-Lee et al., 2005; Bridget et al., 2006) and accommodate 2 billion people, of which 90% live in the developing countries. These zones receive small and irregular quantities (in space and time) of precipitations (Goudie, 1987; Thornes, 1994â; Unganai and Mason, 2002; Lange and Leinbundgut, 2003). They are characterized in particular by frequent, drying winds and violent ones which accelerate the evaporation of water and activate the perspiration of the plants (FAO, 2008). The arid regions correspond to territories characterized by the

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presence of a cover degraded vegetable (Le Houerou, 1995) and by an imbalance marked between the quantity of water available and the evaporating capacity of the climate (CNULD, 2009). These zones are the object of significant environmental tensions, because of their great ecological brittleness and of the scarcity of the water resources (Qadir et al., 2007). The growth and the transformation of the needs for the populations accentuate the pressure on the natural resources and can generate phenomenon of degradation of the medium, often amplified by the climatic changes (Simonneaux et al., 2009).

Algeria is classified as being a semi arid zone to arid because of importance of the evapotranspiration compared to precipitations. According to Halitim (1988) and Haddouche (2009) the arid region covers nearly 95% of the own territory, including 80% of which the hyper arid field (Saharan) (Nedjraoui, 2003). In Algeria, the arid areas are characterized in particular by steppe zones. These last represent a space and privileged course of the extensive ovine breeding (Hirche et al., 2007). They play a fundamental role in the agricultural economics of the country. However, these areas are subjected to recurring drynesses and an increasing anthropic pressure: overgrazing, exploitation of unsuitable grounds to the cultures (Nedjraoui and Bedrani, 2008). Since more than one about thirty years, they know an increasingly accentuated degradation of all the components of the ecosystem (flora, vegetable cover, ground and its elements, fauna and its habitat). This degradation, result of a hydrological imbalance, is due in particular to the turning into a desert. This tendency to the degradation of the steppe vegetation is attested by a whole of research tasks on these mediums (Le Houerou, 1993, 1995, 2005; Bouchetata and Bouchetata, 2005; Haddouche et al., 2007; Hirche et al., 2007; Haddouche, 2009). This appeared by a deterioration of the grounds and hydrous resources. What led to a reduction in the potentialities of the ecological systems, socio-economic and by the reduction of the biological potential (Le Houérou, 1995; Aidoud, 1993; Bedrani, 1996; Senoussi and Bensemaoune, 2009).

The problems of the availability of water in this part of Algeria were treated by several work (Bessaoud, 2008; Lambs and Labiod, 2009; Benblidia and Thivet, 2010). The need for bringing up to date and for following regularly its evolution, remains paramount. The country underwent one period of very severe drynesses with increases in the annual average temperature varying from 0,65 with 1.45°C between 1970 and 2004, an average comparable with the planetary average rise observed over the period 1906-2005 (Bessaoud, 2008).

Thus, Algeria has passed for the 30 last years to a severe and persistent hydrous deficit over several years, resulting from an evaluated pluviometric deficit with 30%. Another factor comes in its turn to accentuate the imbalance of the water resource: it is about the increase in the Algerian population which knows rates varying of 1.5%/year in 2003 (Kaci and Sassi, 2003) and 1.2% in 2011 according to world statistics' (http://www.statistiques-mondiales.com/algerie.htm). The total renewable water resource of the country was estimated at 11 300 × 106 $m^3$ whose 7900 × 106 $m^3$ are exploitable. The total taking away in 2000 were evaluated with 6074 × 106 $m^3$ of which 65% were intended for agriculture, 22% with the domestic use and 13% with the industrial sector (Bakreti et al., 2013). The two combined factors, rate/rhythm of exploitation and climatic change, were negatively reflected on the water resource in Algeria. The impact was very quickly noted on the mode of the flows, in particular that of the surface waters which underwent progressive reductions, become increasingly permanent and thus threatening the aptitude to meet the requirements of water of all the sectors (industrial, agriculture, AEP, etc.) (Kettab, 2001; Benblidia and Thivet, 2010). For the assumption of responsibility of this problem, Algeria granted a particular interest to the valorization of the hydrous potential, these last years (Kettab, 2001).The purpose of this vision is to adapt to the changes born of the climatic upheavals (Kettab et al., 2008). In addition to the dryness which touches in particular the steppe areas, the problem of failing management of these resources worsens the situation, (Kadi, 1997; Benterki et al., 2009; Mebarki, 2009; Ciheam, 2010). The characterization and the quantification of the various contributions out of water thus remain a concern of foreground. Annual volumes of the rains which the slopes basins receive must be well considered and mobilized.

The engineering methods of characterization and quantification of the various contributions of water, requires multicriteria assessment of information on the geomorphology, lithology, climatology, the hydrology of the various slopes basins (Terra, 2006).

The modern techniques of investigation and exploration such as the remote sensing and the satellite imagery give the access to this information in several layers (Haddouche, 2009). Taking into account of the various sources of information requires a combination of these various layers. Several hydrological techniques founded on the GIS were reported to improve space modeling of water (Schumann and Geyer, 2000; Jain et al., 2004; Zhan and Huang, 2004; Li and Zhang, 2008; Van Dijkn and Renzullo, 2010). Thus, the coupling GIS-remote sensing allows the quantification of incoming and outgoing volumes of water and the number of parameters which intervene (Saleh and Christopher, 2011). The methodology used is founded on the analysis of the satellite imagery, the integration and the analysis of the data of the physical environment. The evaluation of the various parameters of the assessments of water and energy give charts of identifications of the zones presenting sensitive conditions to the degradation of ground and desertification (Nejraoui, 2008). For the estimate of the assessment mass and energy, various

**Table 1.** Somme **studies** scientific related to the question of GIS and remote sensing.

| References | Study area | Climate Type | parameter mapping | GIS or remote sensing |
|---|---|---|---|---|
| Seguin (1980) | plain of Crau, north of Marseille | dry zone | Real evaporation in the water balances | remote sensing in infrared thermography |
| Ottlé (2001) | three sub-basins of the Seine | very wetlands | water balances | Remote Sensing |
| Khaldi (2005) | the West Algerian Macta and Tafna | Mediterranean to the north and the South continental | precipitations | GIS |
| Mebarki (2007) | Eastern Algerian | Saharan arid- wet Mediterranean | Precipitation, flow, shortfall | GIS |
| Bensaid (2006) | wilaya of Naama (West Algeria). | arid area | the study of the silting up | GIS and Remote Sensing |
| Simonneaux et al. (2009). | Marrakech, Morocco | semi-arid | management of irrigation | Remote Sensing |
| Haddouche (2009) | Nâama, Algeria | semi-arid to arid | landscape dynamics in arid mid | Remote Sensing |
| Souidi et al. (2010) | Mountains of Béni Chougrane, Algéria | semi-arid | evapotranspiration | Remote Sensing |

methodological approaches were applied (Jacob, 1999; Bastiaanssen, 2000). These applications concern in their majority of particular cases (Seguin, 1980; Servat and Mahé, 2009). Thus, the direct methods of the estimation of the various parameters of water assessment take much time and in materials and are not very representative on the scale of the area (Souidi et al., 2010) (Table 1).

This present work concerns the application of the Remote Sensing coupled with the Geographical Information System (GIS) for the cartography of the components of the hydrological assessment. One is interested in the area of *Brézina* (*Wilaya of' El Bayadh*) which belongs to steppe space. It is characterized by a weak pluviometry (ANRH, 2003). The rainy events are at limited duration and of strong intensity. What gives a weak a cover vegetable. The abrasion of the ground is remarkable (Remini et al., 2009). The area shelters a significant dam called Brézina dam. However, failures in the quantity of stored water were raised on the level of this dam (ANB, 1999). Importance of the dam on the level of the area of Brézina, its localization in the steppe zone, the influence of the steppe aspect on the water resources, the significant solid contribution, the significant annual evapotranspiration, the considerable infiltration justify the choice of the site.

Thus we propose to evaluate the possibilities offered by satellite data AVHRR of NOAA and the multi-source data for the quantification of the quantity of the incoming and outgoing water on the scale of the slope basin of Brézina. Also, it is a question of understanding the behavior of its hydrological mode with respect to the physical constraints. It is thus a question of a contribution to a strongly multi-field gasoline approach in order to provide an aid tool to decision.

The method used appears likely to provide satisfactory information to a space scale of and time. It can be compatible with the models of the water assessments. The followed step seeks to make the combination between two methodological options which are an associated specific study that has a total space-time vision which utilizes the multispectral Remote Sensing and the techniques of GIS. It calls upon various methods of measurement of flows, models (SEBAL, SPLIT WINDOW) and with an approach of spatialization of the results based on the concept of layers of information.

## GENERAL CHARACTERISTICS OF THE ZONE OF STUDY

The territory of El Bayadh framework in a space delimited by longitude by 0°(méridien de Greenwich) à 2°E and latitude by 31°à 34°N. (El Zerey et al., 2009). It is divided into three geographical bands parallel to the Mediterranean Sea, is successively from the North to the South: the High Plains steppe area, the area of the Saharan Atlas and the pre-Saharan area. The site retained for this study is localised in steppe space extending from synclinal of El Bayadh located at western part of Algeria (Figure 1). It forms the side in the north,

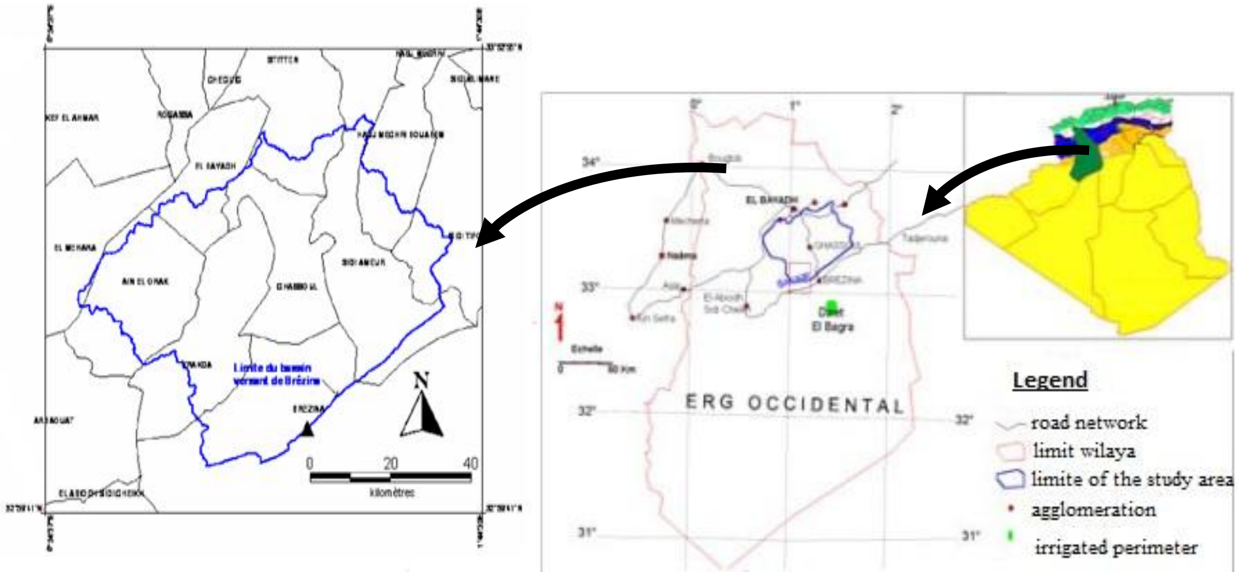


**Figure 1.** Location of the zone of study.

Kheneg Larouia and the Southern side. The site which is a genuine physical barrier in extreme of the Sahara represents a hydrological unit upstream dam Kheneg Larouia. This last is with ten km in the North of the "oasis city" of Brézina. It is characterized by, a broken relief, a varied lithological mosaic (Regagba et al., 2006). The geodesic coordinates system used for the elaboration of the different maps used in this work is UTM Nord Sahara.

The relief is notched by a hydrographic network which is strongly arranged hierarchically with rivers and gullies (Figure 2). The hydrographic network map has been established by using the DEM of the region by using the software MAPINFO, Vertical Mapper.

The zone of study is very little sprinkled. Precipitation is weak and irregular (El Zerey et al., 2009). The variations in temperatures are very marked. The area is characterized by one cold winter and a very hot summer. 30 years the maximum average temperature recorded (1965-1995) in August is of 31°C, whereas the weakest is recorded in January with 9°C (Figure 3). The bioclimat is of the semi arid type to arid, alternative fresh with cold (*sensu* Emberger) with an average annual pluviometry varying from 250 with less than 100 mm/an (Southern) (ANRH, 2003). The zone of study is classified as a very sensitive zone to desertification because of the importance of the climatic aridity, the unequal distribution of water, a strong sensitivity of the grounds to hydrous and wind erosion. These last decades knew a notable reduction in the annual rainfall, with sometimes several consecutive years of persistent dryness. The reduction in precipitations is about 18 to 27% and the dry season increased 2 months during last century. The ork of Hirche in 2007 (Nedjraoui, 2008) bearing on a statistical analysis of the evolution of the rainfall of several steppe stations. Among these stations those of El Bayadh. The ork shows that this steppe zone is characterized by an increasing aridity. The climatic disturbances are a significant cause of the brittleness of these mediums, already very significant and causing ecological crises reflecting itself on the whole of the ecosystem.

The Map of the slope has been developed from the DEM of the of the study area by using the software MAPINFO. The slopes of the basin are classified in four classes. One notes that the strong slope is remarkable in the North of the basin where altitudes can go to 1200 m (more than 10%). This slope becomes weak in Southern extreme of the basin area (lower than 0.5%). An average slope characterizes the remained basin (from 5 to 10%) (Figure 4).

The ground of the area of study breaks up into five classes. Hard limestones which outcrop in the shape of directed furrows from West to East. These formations are thus in the interface with the South where the stopping rests. The gypseous marly formations drowned in the calcareous solid mass are overflowing along the hydrographic network. The filling sedimentary covering the other formed surface is of argilo-gypseous nature, it is remarkable in the center of the basin. The limestone grounds are condensed in the North of the basin and the area of El Ghassoul (Figure 5).

## DATA USED

The data used are those of the ONM (National office of Meteorology) and of the ANRH (National Agency of the Hydrous Resources).They are a weather data which were

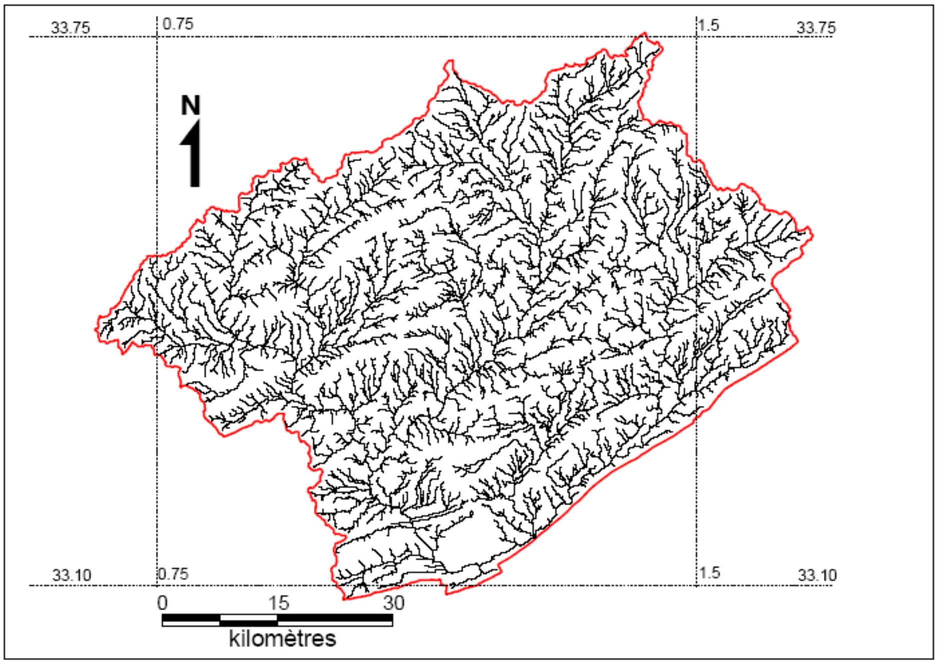


**Figure 2.** Hydrographic network of the zone of study.

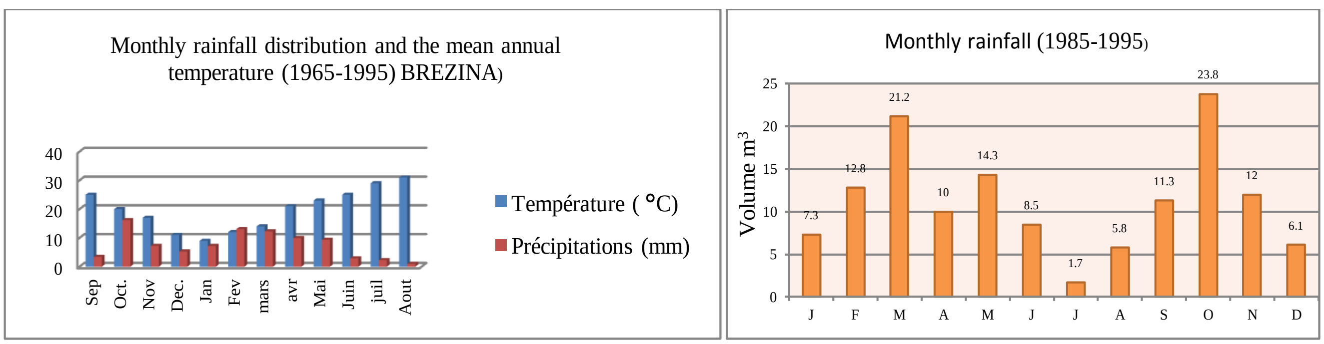


**Figure 3.** Representation of volumes precipitated and temperatures of catchment of Brézina (ANRH, 2003).

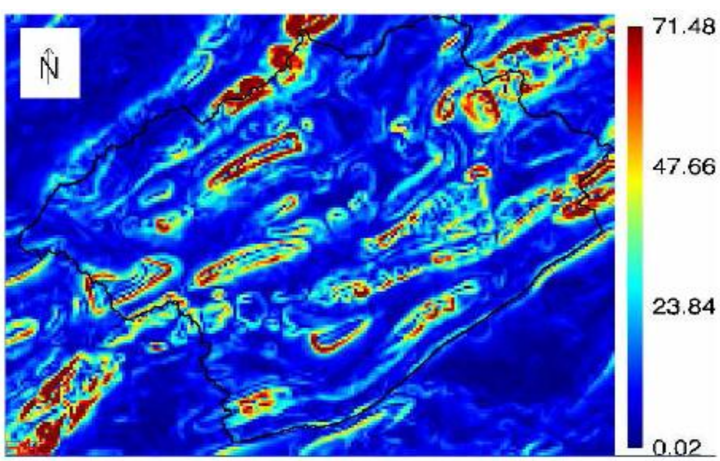


**Figure 4.** The slope classes of the zone of study.

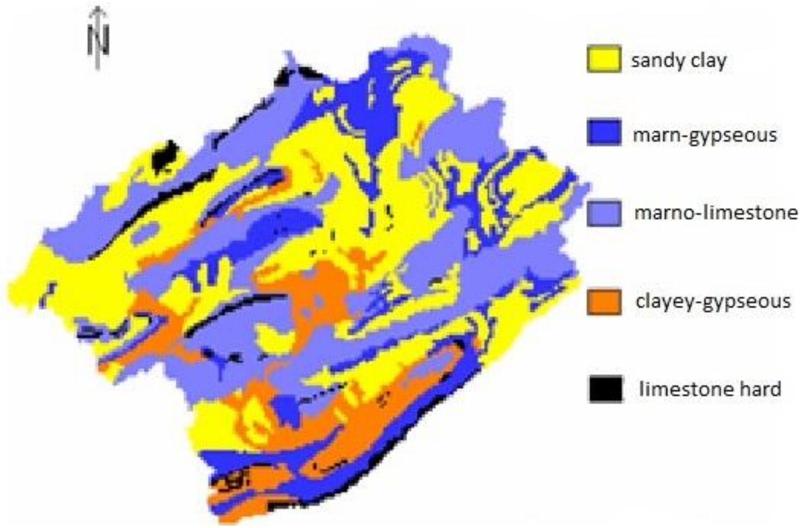


**Figure 5.** Different classes of sol of the study area.

**Table 2.** Reference weather stations.

| Stations | ALT | EXP | LONG | LAT |
|---|---|---|---|---|
| EL BAYADH | 1209.34 | 283.53 | 869.97 | 3748.51 |
| STITTEN | 1347.61 | 338.18 | 890.25 | 3751.66 |
| AIN EL -ORAK | 1312.20 | 74.03 | 347.41 | 3702.34 |
| GHASSOUL | 1139.61 | 212.55 | 890.68 | 3701.06 |
| S-A-BEL ABBES | 1243.82 | 182.14 | 918.95 | 3717.17 |
| BREZINA | 849.71 | 184.69 | 899.36 | 3669.37 |
| ARBA-TAHTANI | 1038.91 | 294.09 | 834.42 | 3665.95 |

collected from the localized stations in the basin considered (Table 2). These data relate in particular the measurements temperature of the air (minimal, maximum and average), the temperature in the ground (0.5 and 1 m), monthly precipitations , the moisture of the air and the speed of the wind. The satellite data are collected using the AVHRR (improved radiometer with very high resolution) which equips the satellite 14 with the National Oceanic and Atmospheric Administration (NOAA). These data illustrate measurements which concern the average of three images per week taken in the middle of the days between 13 and 15 h from January 1 to December 31 of the year 1998 (Table 3).

## MATERIALS AND METHODS

### Cartography of the properties in the Vis-PIR and the IRT

The sizes of the energy balance make it possible to extract the sizes from the hydrological assessment (Makhlouf and Michel, 1994; Allen et al., 2007). These sizes are: albedo, the index of vegetation [Normalised Difference Vegetation Index (NDVI)], and the temperature of surface (Vidal and Durand, 1993; Bastiaanssen et al., 1998; Jacob, 1999). The planetary albedo is the integration on the solar spectral field (0.3 - 3 µm) of planetary hemispherical reflectance. The NDVI is calculated starting from the planetary reflectance in the red and the infra-red close relation. For the extraction of the surface temperature starting from the satellite images we use the Split window method. The latter is largely used for cartography of the surface temperature under the arid conditions (Hamimed et al., 2001; Balaji and Raghavan, 2000).

### Méthode of cartography of the annual evapotranspiration on the scale of the watershed

To cartografy the evapotranspiration, the equation of the assessment of energy on the surface is applied. The latter is solved in this case by the means of model Surface Energy Balance Algorithm for Land (SEBAL). Several researchers confirmed the reliability of the use of this model (Bastiaanssen, 2000; Teixeira et al., 2009, Souidi et al., 2010; Yan et al., 2012). The extraction of the latent heat flow (the energy equivalent of the real evapotranspiration) is given by residual equation of the assessment of energy. This step leads to the cartography of the density flux of latent heat on the scale of the pixel. The office plurality gives thereafter the annual evapotranspiration on the scale of the studied basin.

**Table 3.** Data used of NOAA-AVHRR during the year 1998.

| | | | | | |
|---|---|---|---|---|---|
| 01 January | 22 February | 14 April | 17 June | 30 July | 14 October |
| 09 January | 02 March | 16 April | 19 June | 02 August | 15 October |
| 15 January | 03 March | 25 April | 29 June | 05 August | 21 October |
| 19 January | 04 March | 29 April | 05 July | 29 August | 26 October |
| 23 January | 06 March | 05 May | 09 July | 05 September | 30 October |
| 13 February | 10 March | 15 May | 16 July | 09 September | 18 November |
| 14 February | 20 March | 31 May | 17 July | 14 September | 25 November |
| 15 February | 21 March | 01 June | 19 July | 15 September | 09 Décember |
| 16 February | 31 March | 03 June | 25 July | 30 September | 13 Décember |
| 20 February | 01 April | 04 June | 26 July | 02 October | 19 Décember |
| 21 February | 05 April | 10 June | 29 July | 12 October | 24 Décember |

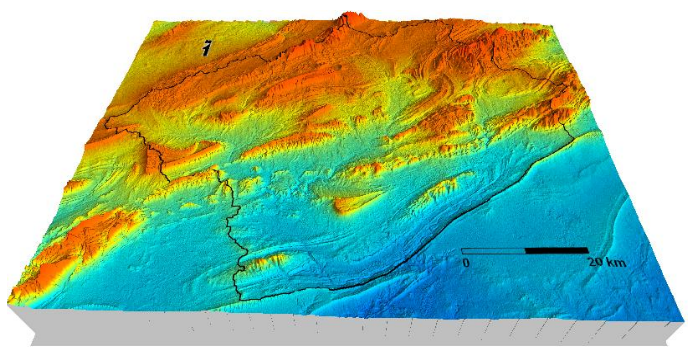


**Figure 6.** Representation in 3D of the study site.

**Cartography method of the rainfall map**

The space estimation of the rain rests on two approaches. First is called geostatistic approach. It is applied after having to identify the space structure starting from the values measured at the pluviometric stations (Hevesi et al., 1992). Second is based on the relations between precipitations and the characteristics of relief (altitude, smoothed altitude, the exposure, effects of site, the distance to the sea), (Mebarki, 2007; Meddi and Meddi, 2009; Mariam, 2010). In Algeria, Seltzer (1946) showed that the distribution of the rains evolves according to three configurations: It notes that the height of rain increases with altitude. It is higher on the slopes exposed to the wet winds than on the slopes under the winds. Of another dimension, the author notes that pluviometry increases from west to the east and decreases as one moves away from the littoral (Bouanani, 2004). The cartography of the precipitation of the zone of study is obtained by a mathematical model worked out by the combination of the sizes of relief (altitude, longitude, altitude and the exposure).

$$P = 0{,}19045.ALT + 0{,}20079.EXP + 0{,}0539.LOG + 0{,}9613.LAT - 3636{,}4604$$

**Method of cartography of the streaming and the contribution of water**

The coefficient of streaming is a function of the slope (Figure 4), of the vegetable cover and the classes of the ground of the zone study (Figure 5). Maps of synthesis of the type "evaluation of the coefficient of streaming" are elaborated starting from the MNT (Figure 6) (Bonn, 2005). Thus, the combination of the maps of the slope and the ground gives the values of the coefficient of streaming of the zone of Brézina (Table 4). The latter are calculated starting from the indications given by Mallants and Feyen (1990) and Bonn (2005).

For the calculation of the drained areas we utilize in entry the hydrographic network map (Figure 2). Each pixel is affected by number of pixels located upstream according to directions' of flow. For a pixel given, the blade of stream water equal to the rain fallen on the considered pixel by the coefficient from streaming of the considered pixel. A calculation matrix of the streamed strip water is used for all the pixels composing the basin of Brézina (Figure 7). For the development of the map of the liquid contribution of the catchment area, a combination of the layers of information is used. This combination is established by multiplying each pixel of water strip obtained by its surface. That is done by using a program in C++ which utilizes in entry the image of the streamed water strip. This program was created by the author to facilitate the calculation which involves precipitation and evapotranspiration data as input as to indicate the figures (Figures 7and 8). The calculation is repeated over the entire surface of the watershed which is composed of 5934 pixels.

**Cartography of the infiltration**

The quantity of water infiltrated on the level of the basin is calculated starting from a calculation program. This program utilizes two images in entry, that of the rain and that of the streamed water strip. A matrix of calculation of the quantity infiltrated for each pixel is thus worked out (Figure 8).

**Table 4.** Runoff coefficient for different geographical conditions of the study area established from methodology of BONN.

| Soil classification | Slope | Clay- | MARN- | Marno- | Clayey | Limestone |
|---|---|---|---|---|---|---|
| | % | sandy | gypseous | limestone | gypseous | hard |
| | <0.5 | 0.215 | 0.6 | 0..685 | 0.7 | 1 |
| Dense canopy | 0.5-5 | 0.285 | 0.61 | 0.7 | 0.725 | 1 |
| | 5-10 | 0.365 | 0.635 | 0.72 | 0.75 | 1 |
| | >10 | 0.44 | 0.7 | 0.785 | 0.8 | 1 |
| | <0.5 | 0.215 | 0.6 | 0.685 | 0.7 | 1 |
| Cover little dense (herb) | 0.5-5 | 0.26 | 0.605 | 0.7 | 0.725 | 1 |
| | 5-10 | 0.35 | 0.615 | 0.74 | 0.775 | 1 |
| | >10 | 0.4 | 0.615 | 0.765 | 0.8 | 1 |
| | <0.5 | 0.515 | 0.75 | 0.835 | 0.85 | 1 |
| Bare soil | 0.5-5 | 0.555 | 0.77 | 0.855 | 0.87 | 1 |
| | 5-10 | 0.615 | 0.8 | 0.885 | 0.9 | 1 |
| | >10 | 0.735 | 0.86 | 0.945 | 096 | 1 |

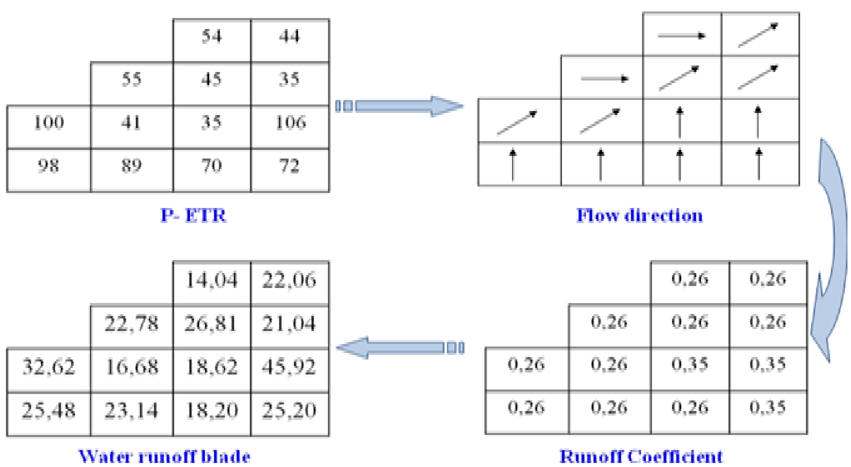


**Figure 7.** Extract of the matrix of calculation of the blade of runoff water of the watershed of brézina on the basis on images NOAA-AVHRR (1998).

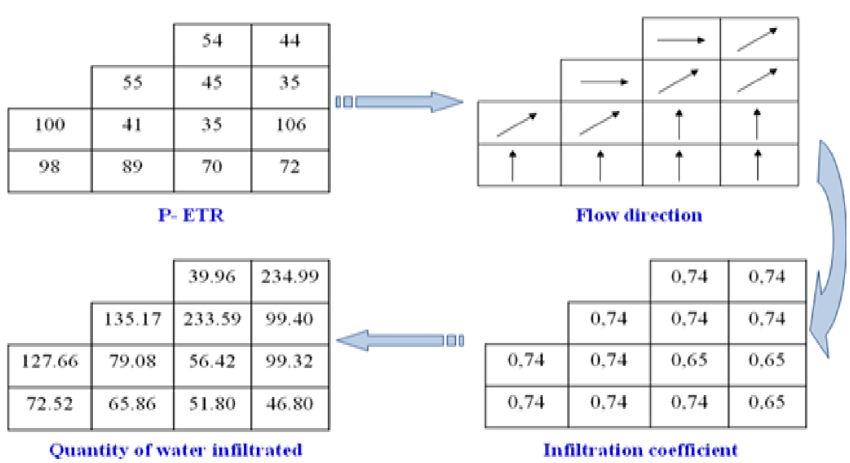


**Figure 8.** Extract of the matrix of calculation of lthe infiltration using the images NOAA-AVHRR (1998).

**Table 5.** NDVI of the basin studied.

| The values of NDVI | Type of Cover | Positions |
|---|---|---|
| NDVI> 0.25 | Coverage relatively dense | North of Basin |
| 0.15-NDVI-0.25 | Medium coverage | The center of the basin |
| NDVI< 0.15 | Low coverage | South of Basin |

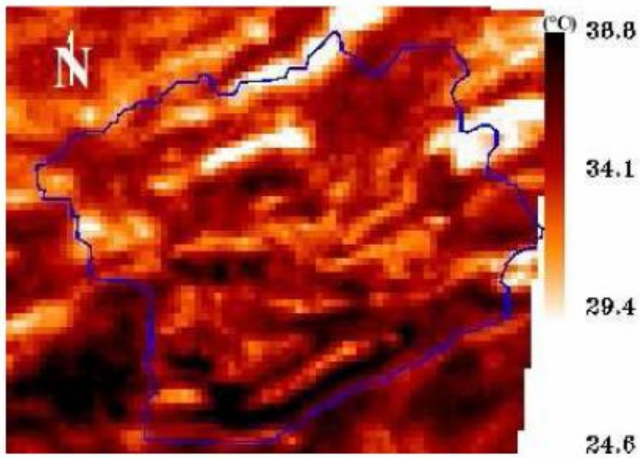


**Figure 9.** Average annual temperature of area by using the Split Window method.

## RESULTS AND DISCUSSION

While being based on the various data in the visible, the infrared close relation several maps are elaborated: The maps of the index of vegetation show that the vegetable cover of the catchment area of Brézina is relatively weak. This much degraded cover present bad quality of density of covering and generation. Three types of cover thus characterize the catchment area as shown in Table 5.

The weakness of vegetable cover in this steppe zone is confirmed per M (Benslimane et al., 2008). The image of temperature of average surface of the basin of Brezina is illustrated in the Figure 9. Compared to the little covered grounds, the average temperature is more significant on the naked ground. This temperature also varies according to altitude; it is weak in the mountains that on flat surfaces. Validation of the Split Window method for the estimate of the temperature of surface is given by several researchers.

The application of model SEBAL to the level of the site of the study makes it possible to note that the evapotranspiration is a function of the vegetable cover and the geographical position (Figure 10). A strong evapotranspiration is observed in the dense zones and reached 68 mm / year. However, it decreases by North to the South (South-western of the basin) where are the naked zones, where it does not exceed 10 mm / year. As for the influence of the geographical position, the data point out that the evapotranspiration increases in the North-western part of the basin to reach the 40 mm / year value. However it decreases in the South-eastern zones, and does not exceed 20 mm / year. The average value of the evapotranspiration thus deduced (68 mm/year) approaches with that founded by the Turc model (72 mm/year). The validity of model SEBAL is thus confirmed.

This model gives similar results found to those for the ground of experimentation (Bolle et al., 1993; Goutorbe et al., 1994; Van den Hurk et al., 1997; Bastiaanssen et al., 2000, 2005; Souidi et al., 2010; Yan et al., 2012).

The approach based on the relations between precipitations and the characteristics of relief gives the pluviometric map of the area of Brézina (Figure 11). This map shows that the three laws of Seltzer are respected. The height of the rain increases with altitude. The pluviometric gradient of altitude is significant in the majority of the basin. The zones in relief are sprinkled than the plane zones. Moreover, one clear pluviometric degradation from North to the South is remarkable. The station of El bayadh located at the North of the catchment area and of which altitude is 1209 m, receives more than 150 mm, whereas to 47 km in the South, the station of El Ghassoul receives just 110 mm .The difference becomes more significant as one approaches the southern areas of

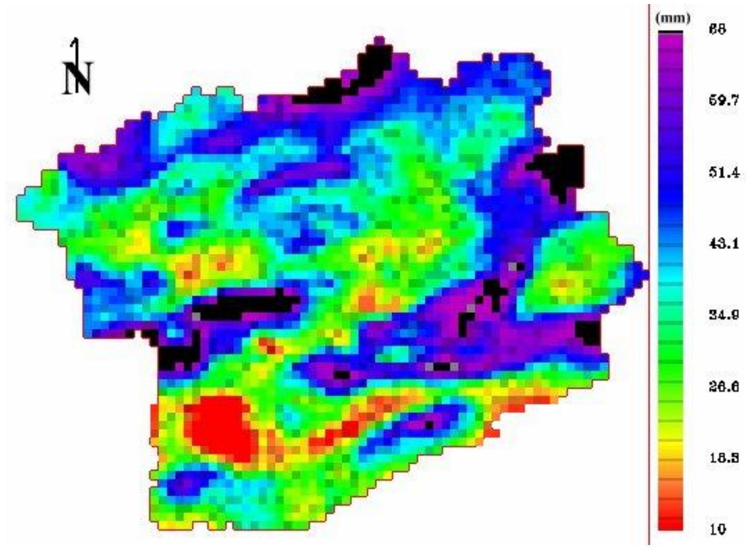


**Figure 10.** Map of evapotranspiration of Brézina after application of the model SEBAL.

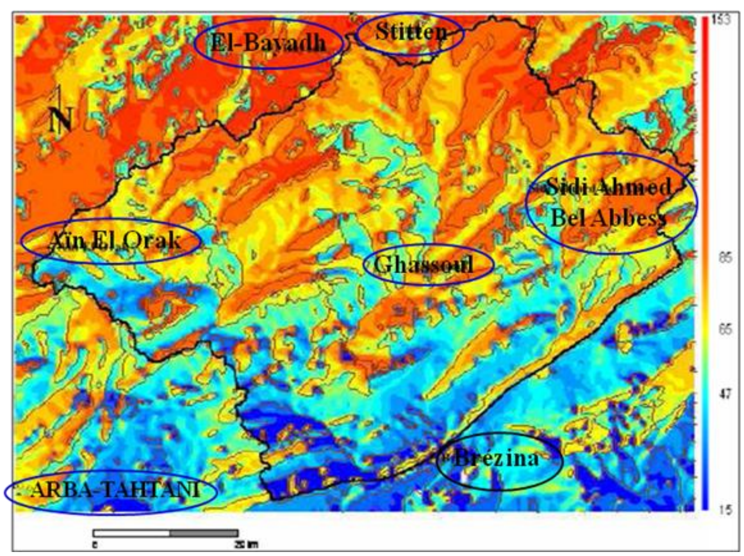


**Figure 11.** Map of rainfall in the study area of the year (1998).

the basin. The station of Brézina which is in Southern extreme of the basin, the records just 30 mm. One also notes a sensitive degradation of rain from the West to the East. The station of Aïn Orak receives an average height of 100 mm, whereas in extreme east of the basin, the station of Sidi Ahmed Bel-Abbes records only 80 m for the same altitude. The quantity of rain precipitated on the West side is thus more significant than on East side .The basin of Brézina thus presents various quite distinct pluviometric zones.This is with the diversity of the relief just like that of the conditions of the organization of the hydrographic network and valley and orographical provision. For the year of study, the results are consistent with data of ANRH (ANRH, 2003). On the other hand, the work of Hirche in 2007, (Nedjraoui, 2008) relating to the same region gave similar results. The character of drought during the year study is indicated by ANB (1999) and (El Zerey et al., 2009).

The map of the coefficient of runoff (Figure 12) makes it possible to note that this parameter is very high on the level of the calcareous bar in the North and the Southern interface of the basin. The permeability of the ground where is the dam is reduced. The value of the coefficient of streaming is very low for the sandy grounds (about 0.26).

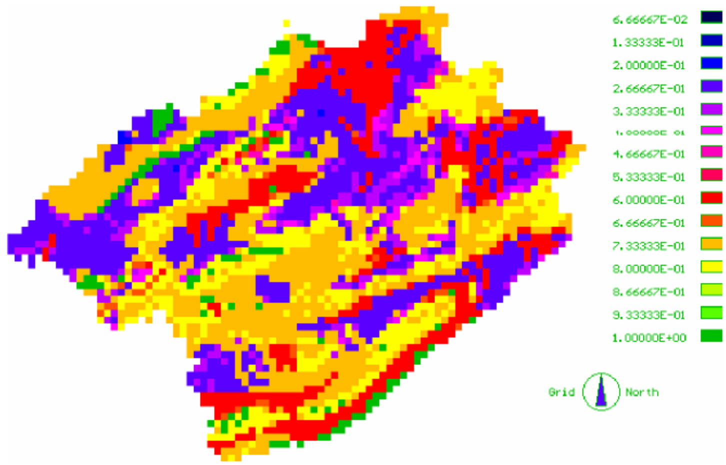


**Figure 12.** Runoff coefficient of the study area.

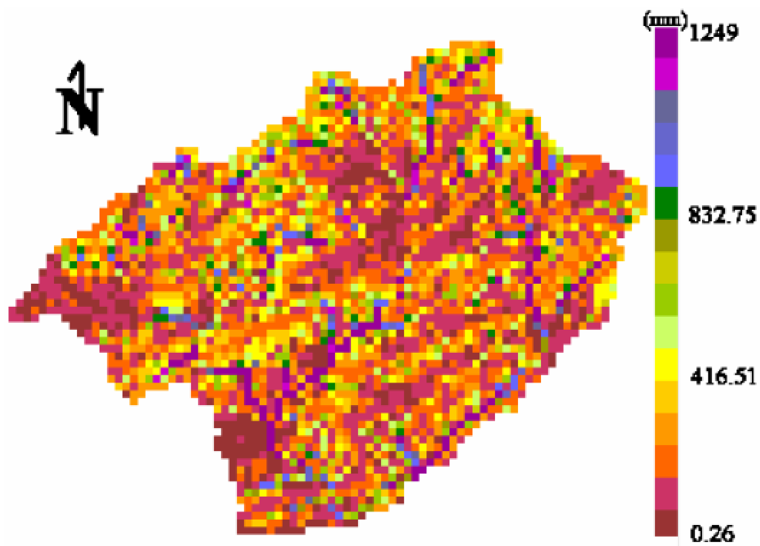


**Figure 13.** Map blade of runoff during the year.

What generates thereafter a strong infiltration on these grounds. In the rest of the basin the value of the coefficient of streaming is moderate (from 0.3 to 0.6).

The irregularities of precipitation, the diversity of the types of ground, the strong slopes, disturb the distribution of the streamed water strip on the catchment area (Figure 13). This disturbance is remarkable on the pixels having a stronger precipitation and a coefficient of higher streaming. The water strip decreases by North to the South and by the West to the East where precipitations are higher. With the discharge system, the cumulated value of the received water strip reached 784 mm / year. It is about a small quantity compared to the surface of the basin. What explains the importance of the infiltration in the basin. The volume of water stored in the dam is thus systematically weak.

During the year 1998, the calculated contribution, by extraction of the parameters of surface starting from the satellite images, has the scale of the catchment area of Brézina is of 0.05 $m^3$ / S. the same value was recorded during year 1982/1983 (ANRH, 2003). The average of the flows measured by the services of the ANB, during a series of observation of 30 years , being spread out between 1948 and 1986, gives an average of 0.91 $m^3$ / year (ANB, 1999). The year of study (1998) seems thus an overdrawn year. Indeed, Nejrauoi (2008) confirms the tendency of dryness during these last decades.

Regularized volume by the dam Brézina, with the downstream, is evaluated at 6.5 $mm^3$ / year (ANB, 1999) distributed between the water needs for the AEP for

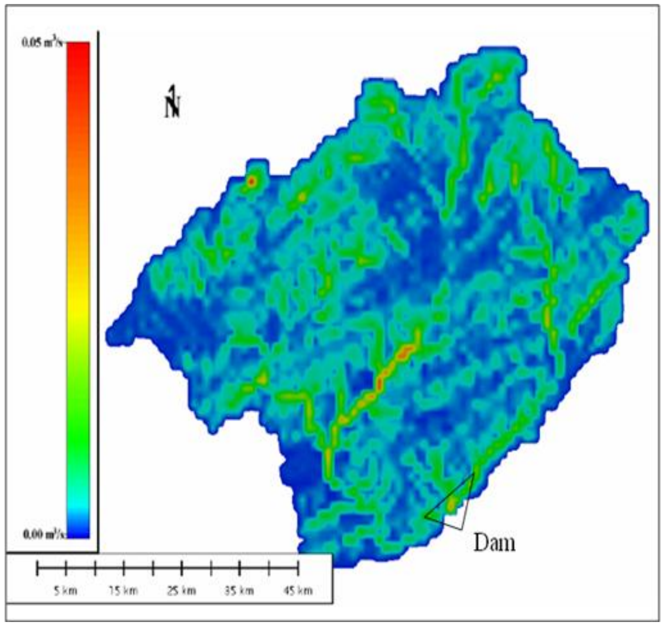


**Figure 14.** Map of liquid supply in the study area.

Brézina: 0.62 Million $m^3$/year, for 9 429 inhabitants; the requirements of water for palm grove:1.47 Million $m^3$ / year (174 ha); and the needs for the new perimeter of Daiet El Bagra:4.41 year/$m^3$ Million (330 ha).

In addition, it is to be announced that the data relating to the solid contributions, quantified by the services of the ANB, are estimated at 1.2 tonnes/$m^3$ (ANB, 1999). Brittleness of the lithological context of the catchment area of Brézina thus the strong socio-economic pressure of this area with agropastoral vocation is the principal factors of the impoverishment of the soil. With these constraints, the irregularities of the exceptional climatic parameters are added (Figure 14).

The crossing of the various maps (type of ground, vegetable cover and relief) of the zone of study gives the map of infiltration (Figure 15). The map obtained makes it possible to note that the infiltrability is related to the permeability of the ground. A strong infiltration characterizes the majority of the pixels of the catchment area going to 300 mm. This quantity of water is considerable compared to the quantity of stored water each year. This report is directly related to the type of the ground, which can be fissured, and to the presence of the caves to a low depth.

The phenomenon of the infiltration is thus posed like a major concern for the managers of the dam of Brézina. One finds oneself in front of a critical situation, where the management of surface waters in steppe medium by this type of work, is little adapted compared to the hydrological assessment recorded with the discharge system of the catchment area. Such a situation challenges a priori on the utility of such an investment in a similar site.

## ANALYZE OF SENSITIVITY AND CONCLUSION

At the end of this work, the various parameters of the hydrological assessment are cartographies. Infact, rain, streaming, the infiltration and the evapotranspiration. For the analysis of the sensitivity one based on the average values of the various values on the scale of the catchment area. With regard to pluviometry, a good correlation between the latter and the characteristics of the stations are observed and this in spite of a low density of the pluviometric network (coefficient of correlation reaches 95%). This justifies the validity of the selected method.

In what concerns the evapotranspiration, the value deduced starting from model SEBAL (68 mm) approaches with that found by the model Turc (72 mm) (TURC, 1954). The recourse to the application of this model is justified by the fact of nonavailability of measurements on the ground of the evapotranspiration. The choice of the Turc model is justified by the fact that in keeping a hydrological approach, it adapts to slopes basins to calculate the ETR. Evaporation is calculated starting from this equation utilizing the average value of the annual rain and the annual temperature of the average air estimated starting from the satellite data. The error is 5%.The error value is low. That what justified the validity of the choice of model SEBAL for the cartography of the evapotranspiration on the scale of the catchment area.

The method of estimation of the two key parameters of the hydrological assessment the evapotranspiration and pluviometry is validated. This validity extends to the values from the infiltration and the streaming. These last

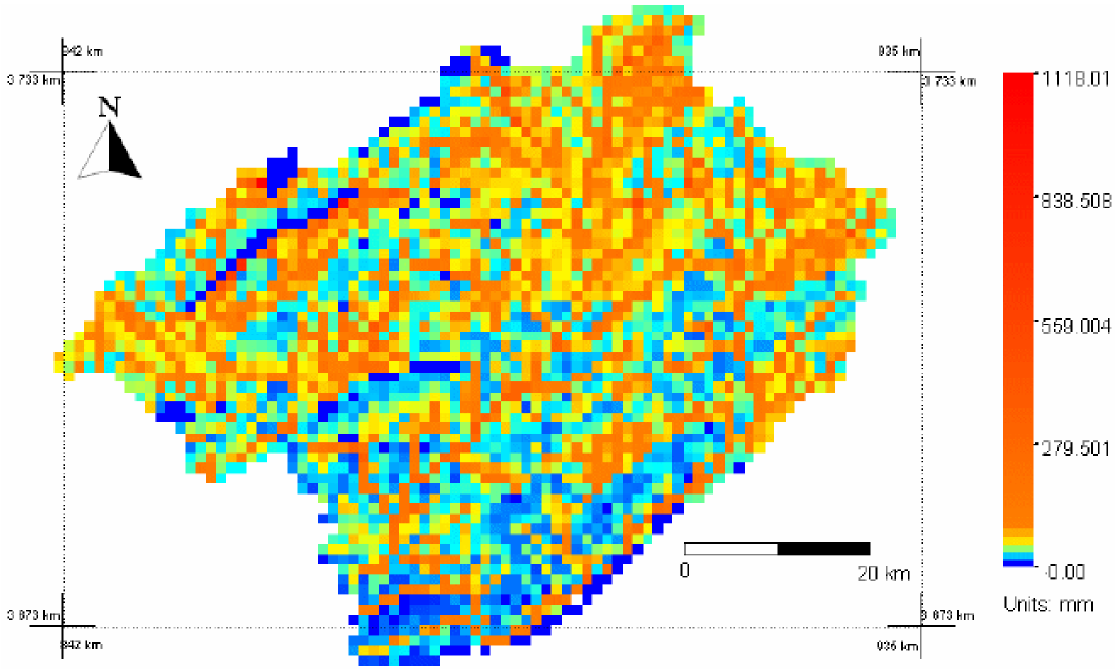


**Figure 15.** Map of infiltration of study area.

are deduced starting from pluviometry and from the evapotranspiration. The cumulated value of streaming on the scale of the pixel exceeds the value (600 mm). Whereas that cumulated relating to the infiltration on the scale of the pixel reaches (500 mm).

The same remark can be associated with the methodology of estimation of the liquid contribution. The value of this last is of 0.05 $m^3$ / S. This value is comparable with the data collected by ANB (1999) whose average over the period 1974-1984 is equal 0.05 $m^3$ / S. The catchment area belongs to an area slightly sprinkled, located between the zones at desert tendency. The occasional appearance of violent downpours cause significant streamings where the major part of water is concentrated in the first twenty hours. The risings have place in autumn and in spring but there are also those appeared in summer.

The purpose of this contribution was to contribute to a development of methodologies making it possible to integrate the remote sensing and the GIS into the approaches used to improve the estimates of flows of energy and mass on a regional scale. Consequently, to estimate the evolution of a steppe area in terms of resources water. The data resulting from NOAA-AVHRR allow the follow-up of the annual variations of the hydrological assessment. The satellite observations convey rich information. It is starting from this study relating to a simple and paramount interrogation "How this potential of information can it be used for the evaluation of the water resources of a steppe area?".

In prospect, it is considered to have a continuous follow-up of the hydrological assessment. That by approaching the quantification of solid transport in the area catchment of dam of Brézina which reveals an extremely worrying aspect. The managers of the dam and consequently safeguards the water resources which become more in rarer in this steppe area and oasis of the Algerian south west.

## Conflict of Interest

The authors have not declared any conflict of interest.

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