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Water Between Scarcity and Floods, and the Impact of Natural and Human Factors: The Case of the City of Tebessa - Algeria

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Abstract

Human and natural factors play a decisive role in the water problem in the Algerian city, especially in light of global climate changes. Our study of the city of Tebessa, located in the high semi-arid eastern plains, on the Algerian-Tunisian border, comes to shed light on the impact of these factors, the human factor (population growth, the doubling of the urban environment in 2020, over-exploitation of groundwater), and the climatic (climatic characteristics of thermal changes and changes In the amounts of precipitation, and the water balance) on the water problem (water scarcity, floods) and its implications for the future of the city's population: the risk of displacement due to scarcity on the one hand, and the risk of exposing the urban fabric to floods, which causes material and human losses and a future social challenge for its residents.

This work relied on collecting and revising climatic data from the weather station in the city, and then analyzing it according to a descriptive analytical approach by adopting statistical laws from one side and the other, with regard to climate science, and the use of GIS software (Geographical Information System) to prepare some maps. The study showed the seriousness of the problem of water scarcity, the low groundwater level, and the large deficit in the water balance. It also showed the reality of the future social challenge that the city suffers from, represented in the repercussions of the excessive exploitation of groundwater by the city's residents, which is what we mean by the recorded deficit in drinking water. Thus, the study represents a work base for the city authorities to mitigate the repercussions of water scarcity on the one hand and the danger of floods on its residents on the other hand.

Key words: Human and natural factors; water scarcity; floods; water balance; SIG.

INTRODUCTION

The city of Tebessa [1] has known a great urban expansion in response to the city's growing population, especially during the seventies, which represents the stage of the demographic explosion for Algerian cities, where the population size of the city moved from 62639 to 198281[2] people (its population doubled by more than twice) between 1977 and 2008, The human impact on water resources is nowadays one of the main challenges global in urban areas [3],consequently, their need for drinking water increased, which is now recording a deficit of nearly 50% [4] (Human factor), As for the urban perimeter, its area has increased to reach 3200 hectares[5] in 2019 after it was 1637 hectares in 1988, and it was not more than 165,35 hectares in 1972. The urban expansion has taken an orthogonal position with The many temporary valleys paths that penetrate this urban perimeter [6].

In addition to the extension of urbanization in the aforementioned direction, it extended north at the expense of the "Marjah" plain and south towards the Tebessa Mountains. In (the absence of appropriate urban planning), the urban surroundings of the city became subject to periodic floods, and the impact of these floods increased under the influence of the increasing slopes and heights north-south (topographical factor) As well as the absence of vegetation cover [7] .

The evolution of cities is going to happen with climate itself rapidly changing [8].One of the decisive factors in the matter is the nature of the climate of Tebessa (Semi-aride à hiver frais) [9] which made it vulnerable to sudden cyclonic rains that cause material and human losses annually, as happened on September 12, 2018. The semi-arid climate (increased latent evaporation, water balance deficit) also contributed to the water deficit that the city suffers from. What distinguishes this work is its reliance on carefully revised data collected from the meteorological station for the period (1972-2008), The work aims to highlight the impact of the human factor represented in (population growth, doubling of the urban environment in 2020, excessive exploitation of groundwater), and the natural climatic factor represented in (climatic characteristics, thermal changes, as well as changes in precipitation amounts, and water balance) on the water problem in the city (Water scarcity, floods) and their implications for the future of its inhabitants.

Study Area

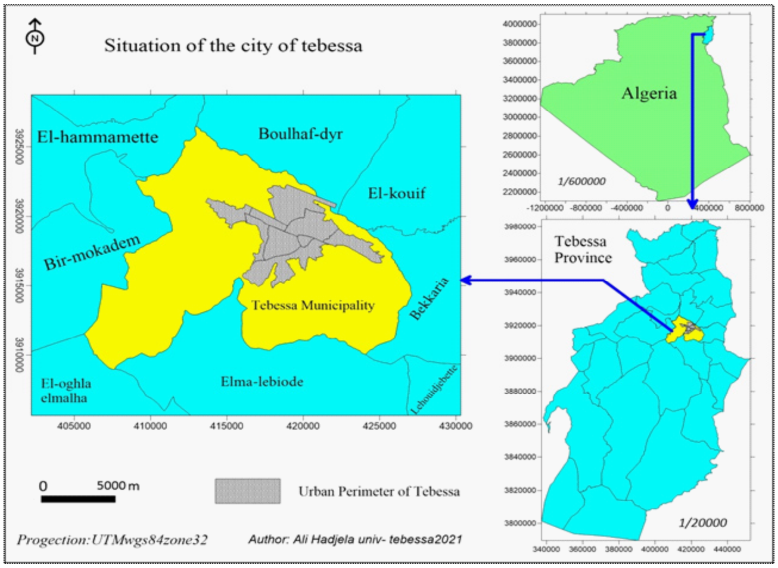

Figure 1. Situation of the study Area

Administratively Tebessa City is the agglomeration capital of the wilaya, border since the administrative division of 1974, in the same time the agglomeration capital forms the Daira of one municipality. The latter, located in the northeastern part of Tebessa wilaya is bordered by the municipalities: Boulhaf Dir to the north, at the north-east El-Kouif, to the northwest by Hammamet, in the south by Elma-labiode and Eloghla_elmalha, to the east by Bekkaria and to the west by Birmokadem municipality. The municipality of Tebessa sits on an estimated area of 184 km^2 and is one of the municipalities of the province (wilaya). This latter is 39 km distant from the Tunisia border. It includes 28 municipalities and 12 Department or Dairat, The wilaya border extends to more than300 km, shared with the Republic of Tunisia. For the latitude and longitude Tébessa city is Located on the longitude 8,11 E and latitude 35,4 N. It is what makes the city in the warm temperate zone most affected by climate change[10] in the world, belonging to the southern bank of the Mediterranean Sea with the most continental climate as will be seen from the study. Regarding the extension of the urban perimeter within the hydrologic basin (Sub watersheds of Elouedelkebir+ bouakous), We note that the city as part of the basin of the el Oued el Kebir and the Valley of Chabro.

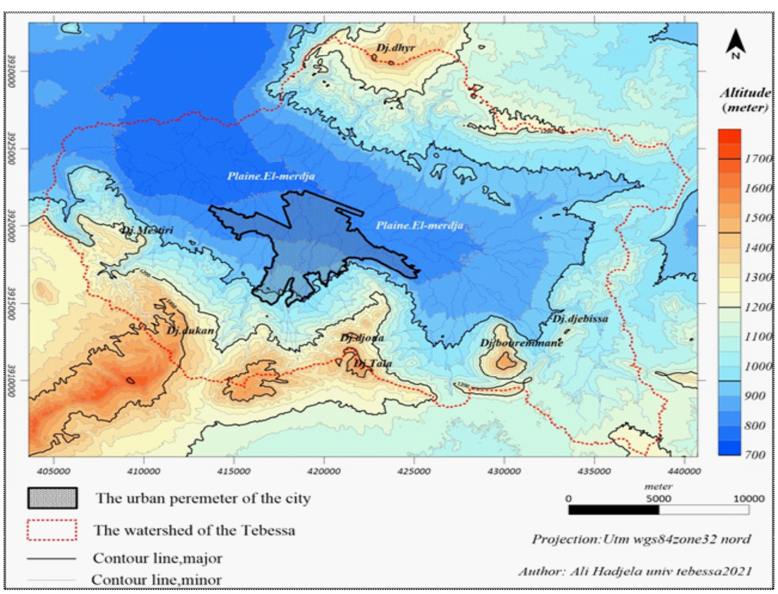

Figure 2. Tebessa city in the watershed of Oued-elkebir

which covers an area of approximately 570 km2 , extending from Djebissa Mount (1100m), Bouremane Mount (1520m) in the east, Tazebent plateau (1330m) in the west, Guenifda Mount (1420m) at the north until the mountains of Thala (1591m), djoua (1400m) and Aldukan (1718m) in the South, strikethrough the plain of Marjah .The urban perimeter occupies 3206 hectares between the airport district in the north area (Ali Hadjela, 2021), (805 meters above sea level), and (1000 m) in the south (Aldukan district) (Fig. 2).

METHODS

In our study We adopted the analytical descriptive approach for data obtained from the city's meteorological station and then revised, extending over a period of time estimated at 36 years (1972-2008), which is related to changes in precipitation amounts and average minimum and maximum temperatures, and we also adopted laws related to climatology such as Gossen's law, Emberger, and those of water balance, and the laws of central tendency and dispersion

We also used population data to highlight the shortage of drinking water in the city in the medium and long term, and we also used some tools such as geographic information systems and remote sensing to draw some maps such as the geographical location map and the location of the field of study in the watershed of Oued-elkebir (Figures 1 and 2).

ANALYZE

The Problem of Drought, Floods and Natural Factors

If it is natural for the problem of water scarcity on the one hand and floods on the other hand, how do human and natural factors affect the issue? We must analyze the problem to answer the question, starting with the influence of natural factors (climate analysis and water balance).

The Evolution of the Precipitation and Temperature in Tebessa

The urban environment is characterized by high temperature [11] and lack of evaporation and increase the proportion of greenhouse gases, would see climate change elements of the city's heat loss and exploring the future climate events and thus environmentally sustainable urban planning them. The study is based as indicated above on a series of data covering 36 years, See Table 1: Below:

Table 1. Evolution of temperature and precipitation rates (1972-2008) in Tebessa.

Year	T(c°)	P(mm)	Year	T(c°)	P(mm)	Year	T(c°)	P(mm)	Year	T(c°)	P(mm)
1972	13,92	561,6	1982	16,51	391,5	1992	14,95	451,7	2002	16,57	438,8
1973	14,60	467,75	1983	15,53	217,9	1993	15,94	199	2003	16,54	691,3
1974	14,39	270,31	1984	14,84	307,2	1994	16,94	221,07	2004	16,42	520,7
1975	14,72	352,61	1985	15,91	311,3	1995	15,92	390,3	2005	16,04	424,5
1976	13,82	493,9	1986	15,44	364,4	1996	15,57	348,9	2006	16,64	282,3
1977	15,58	253,6	1987	16,39	258,6	1997	16,41	377,9	2007	16,25	400,5
1978	14,78	317,4	1988	16,18	340	1998	15,93	314,56	2008	16,34	376,2
1979	15,20	404,3	1989	15,86	310,6	1999	17,15	432,2	Source: meteorological station of Tebessa.		
1980	14,31	357,2	1990	16,13	635,8	2000	16,46	263,5			
1981	15,40	260,2	1991	14,73	463,6	2001	17,25	217,5			

The Annual Distribution of the Amounts of Precipitation

(Precipitation between volatility and decreasing) From the chart (Fig. 3) to change the amount of precipitation in the town of Tebessa and depending on the data of meteorological station of the city for the time period extending between (1972-2008) , notes the lack of amounts of precipitation and Irregularity clearly from year to year, it turns out that the average amount of precipitation for this period is estimated at 370,03 mm , and that the largest amount was recorded in

2003 by about 691,3 mm, the least amount was registered during the year 1993 by about 199 mm as estimated standard deviation of these values at about 112,91 mm , and from it we find the coefficient of variation which is estimated at 30,51 % (Table), confirming the existence of fluctuations in rainfall over the length of the time series Extended for a period of 36 years , but the precipitation values of contrast and irregular seem clear during phase (1990 to 2008) compared with the previous period have (1972-1989) assured us that what is the coefficient of variation for the periods (32,73 % , 25,40 %) on arrangement, despite the fact that the average amount of precipitation has increased from 346,69 to 392,12 mm annually mm per year for the two periods .

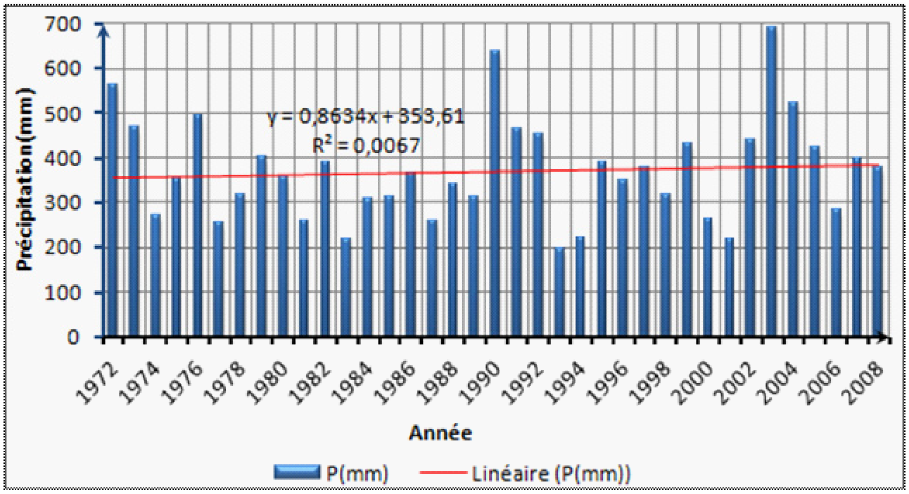

Figure 3. The annual distribution of the amounts of precipitation (72-2008)

Table 2. Some indicators relating to quantities of precipitation (city-station)

Periods	**1972-2008**	**1972-1989**	**1990-2008**
average	370,02	346,69	392,12
Standard deviation	112,91	88,08	128,34
Coefficient of determination	0,01	0,24	0,000031
Coefficient of correlation	0,08	-0,49	-0,0055
Coefficient of variation	30,51	25,40	32,73

Source: Researcher's account based on Table 01

The evolution of the amount of annual precipitation according to statistical data series (1972 - 2008) during 36 years is subject to a linear equation take the following form (y = 0,8634x – 1348,2) and the coefficient of determination (R2 = 0,0067) look at (Fig. 3). This confirms that the climatic changes in the city and the region of Tebessa during the past four decades are characterized by an increase in the amount of precipitation from year to year and the changes appear over the past two decades.

The Evolution of the Annual Temperature (Thermal continuous growth is a major risk)

With a fluctuation in the average temperature from year to year, it is known to have a continuous rise in the city Where it recorded its lowest value (13.82 degrees Celsius) in 1976, and the highest value in 2001 (17.25 degrees Celsius), and this increase is observed at the level of cities in the region in general, and the latter increasing is subject to a linear relationship (Yi = 0,0627Xi-109,11): where Yi: express the temperature in a given year , Xi expresses the year and the coefficient of determination of two variables (temperature, year) R2 = 0,5793 and from this correlation coefficient between them is R = 0.76, expresses the positive relationship between temperature and time (Fig. 4), It is a sign of an increase in the intensity of drought in the region in the future and threatens human stability there, as the average recorded in the city is 15.70 degrees Celsius, which is higher than the global average of 15 degrees Celsius. [12] (Michele béguin-Denise pumain, 2003) and this city average is expected to rise by about 3.8 degrees Celsius in the middle of this century.

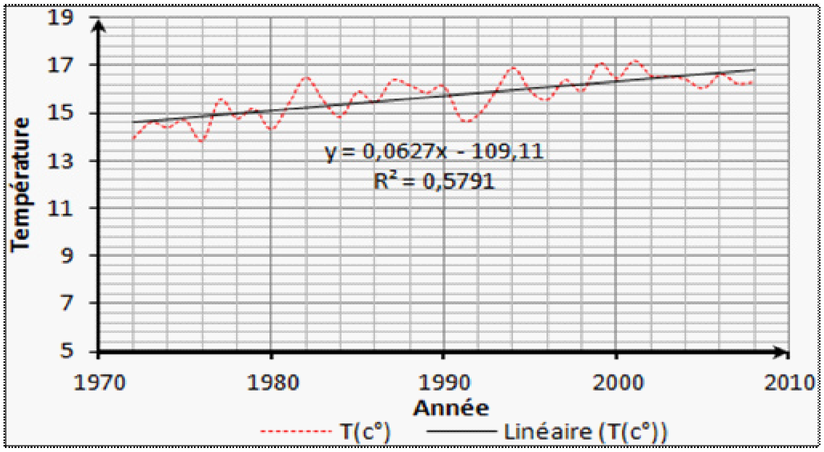

Figure 4. Changing the temperature average (1972-2008)

Monthly and Seasonal Distribution of Temperature and Rainfall Amounts

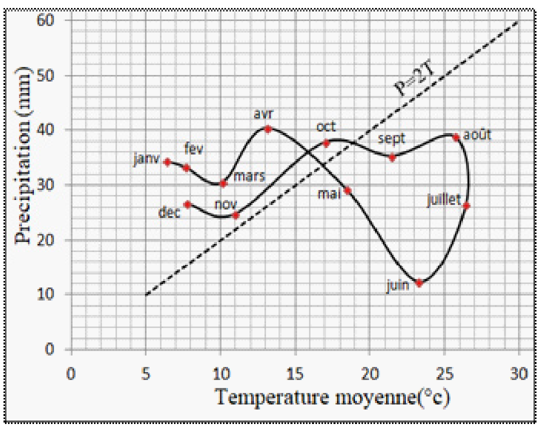

Figure5. Climagram « Tebessa »

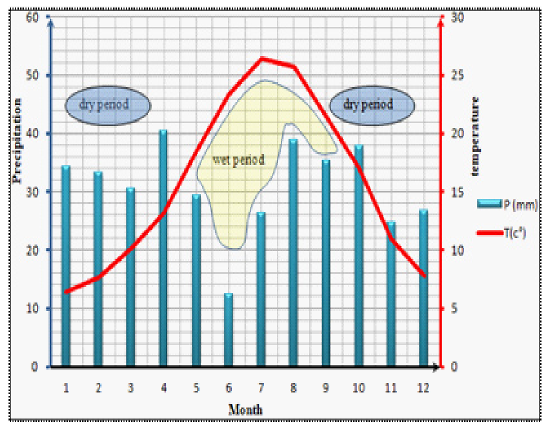

Figure 6. Ombrothermic diagram of Tebessa city « Gaussen » (P=2T)

From the graph (Fig. 6) we find that the Tebessa city climate is characterized by high temperatures in summer and low in winter, with thermal extent up to 20,04 °c, and the oscillation in rainfall seems clear during the months of the year, We note that the precipitation average monthly rates is 30,84 mm, the standard deviation is 7,41 coefficient of variation of the months of the year 24,04%, With an annual precipitation of 370.02 mm. The largest amount falls in September (40,37 mm), as well as during March and May (spring 37,81, 38,86 mm, respectively), while the lowest score the amount of the loss in the month of July to 12,38 mm , as shown in the curve of the rainy thermal "Gaussen" founder on the relationship P = 2T and climagram "Tebessa" in determining the humid periods of dry During the year, also noted that the dry period extends between June and October, which for five months, where we find that (P <2T) , more than half of the days of the year is a drought in the region and note that the rain that falls in the region limited to the number of days of the year and in the form of rain a flood.

The Nature of the Climate

Tebessa Within the Range (Half-Arid With Cool Winter)

Depending on the data Seltzer (1913 - 1938)[13], the minimum temperature of the coldest month of the year for the city of Tebessa is 1,9°c the maximum for the hottest month of The year 34,8 °c, the amount of annual precipitation is 338 mm, and so we find "Emberger Coefficient[14] is equal to 35,26 [15], after recalculating "Emberger coefficient" for the period (1972-2008) turned out to be equal to 43,04 with (M,m)(31,04°C 1,31°C) respectively, and thus making this city belongs to the "Semi aride à hiver frais" look at (Fig . 7) Which shows the change in the status of the city within "Emberger" classification to near-scale (sub-Humide), with the increase Tarry due to lower average Minimum temperature of the coldest month of the year that reflect the specifications winter, The affiliation of Tebessa City to climate scale half dry "Using the data (2009-2018), we get a similar result (M=30.21 m = 7,13 P= 390,30 →Q=39,12)" and assured us through the Aridity index of De Martonne [16] who I=P/(T+10) , T : la température moyenne annuelle, P : précipitations totales annuelles [Hyperaride (5>I≥0) ; Aride (10>I≥5) Semi-aride (20>I≥10) ; Subhumide (30>I≥20) Humide (55>I≥30)], pour P = 370,02 et T = 15,70 Application I =14,40.

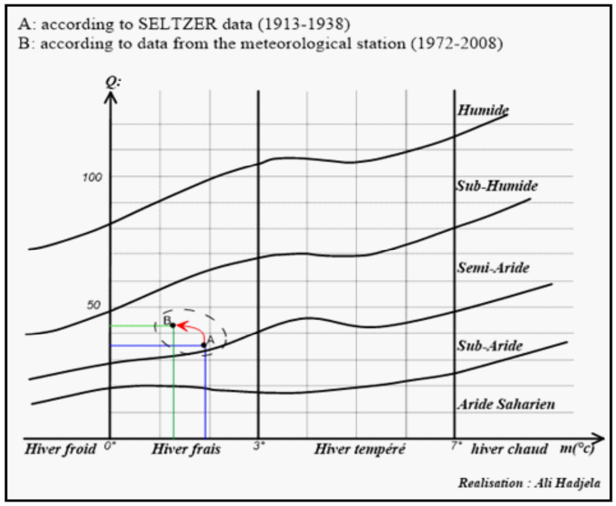

Figure 7. changing the position of Tebessa city in Bioclimatic climagram "Emberger"

Aridity problems and floods: the city belongs to the (semiarid with cool winter), characterized by the period of drought almost seven months of the year in which "potential Evapotranspiration" may be greater than precipitation. Rain as a flood fall during short periods and caused material and human damage sometimes. The situation has become serious because the extensions of the city were on land near the rivers and land of low slope, where there is underground water that supplies the city with drinking water , Water as a vital resource must be protected from pollution "Filthy water cannot be washed" (Proverb from West Africa) [17], and rationally exploited, while at the same time avoiding the dangers of floods, See (Fig. 8). The topographical characteristics of Tebessa watershed, which houses the city, make water moving toward the Great Valley (Oued Elkebir), El-Merdja in the north of the city and towards the north-west, which will bring the future risk of groundwater contamination, through domestic and non-domestic wastewater, where we find the future extensions of the city area in the short, medium and long term (Révision du PDAU Intercommunal Phase C).See (Fig. 8), and table.

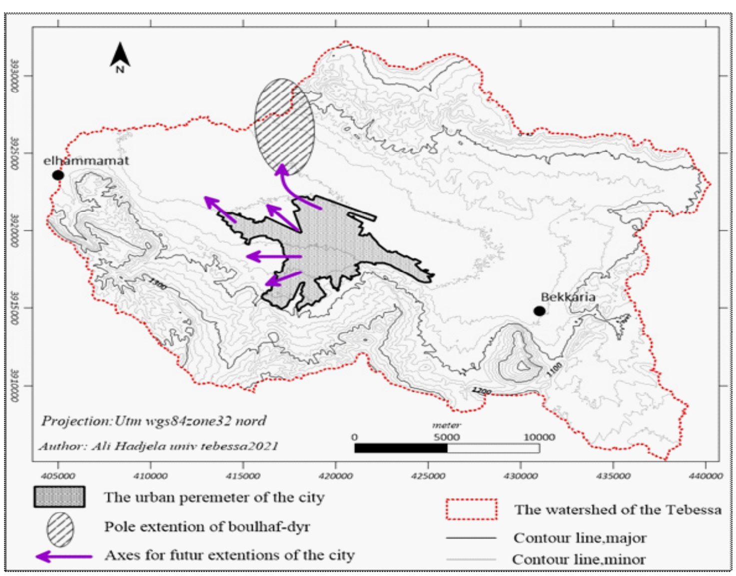

Figure 8. The axes of the city extensions

Table 3. The future extensions areas of the town.

Urbani Areas (SU) The year 2012	Future Extensions*	
	SAU(2018)	SUF(2028)
2594,99 ha	1590,68 ha	710,12 ha

Source : révision du PDAU Intercommunal

Water Balance

According to the United Nations Water Programme, water scarcity affects all continents and more than 40 percent of the people on our planet. By 2025. 1,8 billion people will live in countries and regions that suffer from water scarcity, and two thirds of the world's population will face deteriorating living conditions due to the lack of fresh water resources[18].

"Evapotranspiration" may be greater than "precipitation"; Rain is also characterized as a flood fall during short periods and caused material and human damage sometimes. The water balance (Seghir K,2008) makes it possible to calculate : Precipitation (P), "Evapotranspiration-reel (ETR)", Runoff (R), Infiltration (I), Potential evapotranspiration , For more information see the site (http://hmf.enseeiht.fr/travaux/bei/beiere/content/formules-destimation.) (ETP)

Table 4. Water balance by Thornthwaite method for the Tebessa station (72-2008).

Mois	janvier	Février	mars	avril	mai	juin	juillet	Août	septembre	octobre	novembre	décembre	Somme
P (mm)	34,37	33,3	30,47	40,37	29,29	12,38	26,39	38,86	35,33	37,81	24,78	26,68	370,03
ETPc (mm)	11,13	14,65	28,38	46,56	90,7	133,97	168,33	151,5	99,55	63,53	27,19	14,94	850,43
P-ETPc (mm)	23,24	18,65	2,09	-6,19	-61,41	-121,59	-141,94	-112,64	-64,22	-25,72	-2,41	11,74	-480,4
RFU (mm)	29	29	29	22,81	0	0	0	0	0	0	0	11,74	121,55
EX (mm)	5,98	18,65	2,09	0	0	0	0	0	0	0	0	0	26,72
Da (mm)	0	0	0	0	38,6	121,59	141,94	112,64	64,22	25,72	2,41	0	507,12

$ETP = 16(10T/I)^a K$, T: average monthly temperature(C°), I: annual heat coefficient equals the sum of the monthly coefficients for the year. a: function of the thermal coefficient where : $a=1,6(I/100)+0.5$ and K: a variable correction factor with changing day lengths and latitude.

For the Tebessa station, 35,428 degrees latitude. Evapotranspiration combines two physical processes, the first represented by evaporation, and the second is biological, which is the process of transpiration in plants. The process of evaporation - transpiration is linked to factors: moisture, heat, solar radiation and vegetation cover.

Estimation Of Actual Evapotranspiration (ETR)

According to the Thornthwaite method, we have the following cases

1) P > ETP → ETR = ETP, So we have a surplus of water.

2) P <ETP → ETR = P + RFU (all or part of the RFU), If → ETR = P , RFU = 0 and therefore there is no water surplus.

Calculation of the "Easy-To-Use Soil Water Stock"

Mean's the effective water stock or Soil water stock RFU equal to 0.029 m or equivalent to 29 mm maximum that the soil can store before it reaches the point of saturation [19].

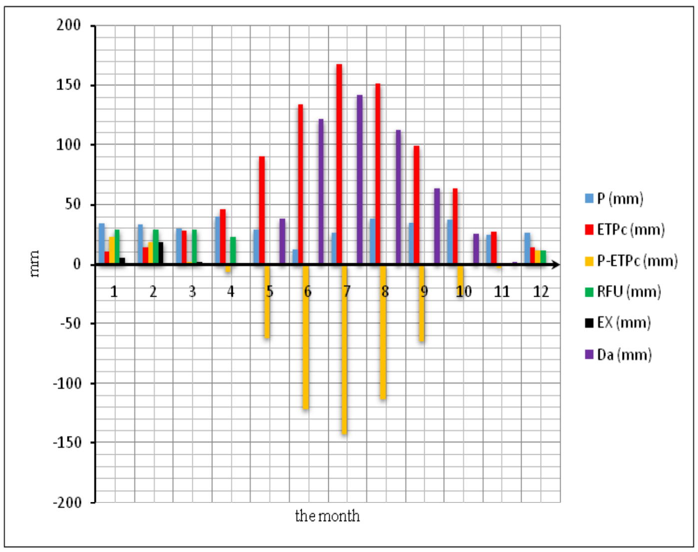

Figure 9. The water balance in the city station (1972-2008)

Precipitation distribution: Precipitation (P) is divided into, 1) Surface runoff of water (Le ruissellement: R), 2) Internal infiltrates (L'infiltration : I), 3) (ETR), where the relationship is: P= R + I + ETR, from which I = P- (R + ETR) where: R = P3/(3(ETP)2), precipitation, run-off and latent evapotranspiration As annual averages, and according to the city station, (P=370,03mm), (ETP = 850,43) We find that the coefficient of runoff is (R = 23,35 mm), which represents 6.22% of the total amount Annual precipitation (P) , as for the internal leakage is calculated from the previous relationship representing the water balance I=P-(R + ETR), for the study area and the collecting basin of the city of Tebessa, we find (I = 3.37 mm), the table:4 and (Fig.9.) Shows us the various elements of the water balance of the Tebessa station according to the method of Thornthwaite, (Gabriel Teteka Mutondo et al, 2018), this allows us to estimate the water surplus (ex) or water deficit (Da) of soil moisture per month.

The Increasing Overexploitation of Water as a Challenge Facing the City Community

The water wealth in the city of Tebessa is threatened by other human factors related to the increasing human activity with the increasing number of the city's population, and on the basis that the city, with its estimated population size in 2015 at 232196 people, depends on groundwater obtained by wells spread at the level of the watershed (Tebessa-Hammamet) in the plain (Al-Marjah), whose number in 2016 is 26 wells, three of which have been exhausted, and therefore the real number is 23[[20]], can secure about 33000 m^3 of drinking water per day, but other uses prevent the availability of this quantity, such as water destined to serve the university and the industrial zone, in addition to military uses and lost water Through leakage, this amount is estimated at about 11000 m^3 per day, and from it, the daily drinking water destined for the city's residents does not exceed 22000 m^3. We consider that water is not overexploited when there is a match between the population's demand for water, And what is available on the water table (ground water), without recording a decrease in the yield of wells or a decrease in their level.

The Problem of Supplying Drinking Water to the City's Residents

The city's need for water includes drinking water and other uses for its calculation we use a scale of 200 liters / person / day, and thus we find that the city needs16, 95 million m^3 in 2015, or 46439, 2 m^3 per day, which is more than double the available quantity in 2015 and reflects the large deficit recorded in drinking water. As for the maximum quantity required, it is estimated by 53405, 08 m^3 per day, which amplifies the city's water deficit.

Table 5. Estimated population needs (2015-2030) of drinking water

Year	2015	2020	2030
Population	232196	258932	318999
Needs (million m^3/year)	12,71	14,18	17,47
Daily need (thousand m^3)	34829,4	38839,8	47849,85
Recorded daily deficit (thousand m^3)	12829,4	16839,8	25849,85

*Source: researcher's calculation based on a scale (150 litters/person)

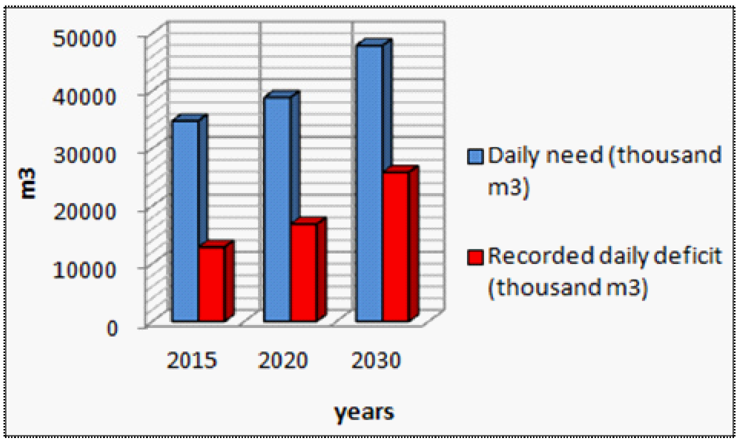

Figure 10. Daily needs and deficit in drinking water (2015-2030)

Renewable Underground Water at the "Oued-Elkebir"Sub Watershed

The volume of leaking water (m3/year) = the area of subwatershed (km2) x the effective seepage (mm), effective seepage (I) is estimated at 6% of the annual precipitation value (P) according to the National Agency for Water Resources ANRH Tébessa.

Table 6. estimation of the amount of renewable water in the sub-watershed of (Tebessa – Hammamet)

Year	Annual Precipitation (mm)	Leakage (mm/year)	Renewable Water (m^3)
2012	236,4	14,184	14510232
2013	368,3	22,098	22606254
2014	443,3	26,598	27209754
Average	/	/	21442080

From the table it is clear that the average amount of renewable water in the catchment basin (Tebessa - Hammamet) is 21,44 million m3 during three years, The area of the sub-watershed is about 1023 km2.

The Irrational Large Exploitation of the Underground Water and its Low Level

By making a comparison between the groundwater level in the catchment basin under study for the years 1994 and 2014 [21] a decrease was estimated at 55,27 meters in the Hammamet area, and about 71,78 meters in the Ain Chabro region, which is the main source of drinking water supply for the city of Tebessa, and about 14 meters in Bekkaria . and this is what tells us once again the reality of the problem experienced by the city of Tebessa and the neighbouring towns, in which natural factors and human factors participated in the same.

RESULTS AND DISCUSSION

After the analysis, the vital role represented by natural and human factors was revealed at the same time, Among the natural factors we find: The temperature knows a steady increase that threatens a big climate change and it is expected that the average temperature will increase by about 3,8 degrees by the year 2050, Which confirms to us the reality of the problem related to global warming, This thermal increase foreshadowed a future increase in the continental intensity of the city. As for the change in the amounts of precipitation, it turns out that it is between fluctuation and decrease.The average amount of precipitation is estimated at 370,03 mm, the coefficient of variation is estimated at 30,51%, which confirms its fluctuation. The amount of annual precipitation for the period (1972 - 2008), that is, during 36 years, is subject to a linear equation (y = 0,8634x – 1348,2), coefficient of determination (R^2 = 0,0067), which assures us that climatic changes at the level of the city and the region of Tebessa During the past four decades, it is characterized by an increase in the differences in the amounts of precipitation from one year to another (the sharpness of the discrepancies is highlighted especially during the last two decades). In addition to this, we noticed a decrease in the amount of precipitation during the period 1972-1989 with a relative stability in the period 1990-2008 between 250 and 500 mm, which is the right of the semi-arid climate (Anne- marie Gérin-Grataloup,1995).

According to the "Gussen" heat rain curve and "Brest" climagram, based mainly on the relationship (P=2T).We are assured of the low amount of rain that the city receives throughout the months of the year, as we mentioned earlier. The largest amount of rain falls in September (the beginning of the autumn season is 40,37 mm), as well as during the months of March and May (the spring season with 37,81 and 38,86 mm, respectively) While we record the lowest amount in July with 12,38 mm, meaning that the rainy seasons in the city of Tebessa are the spring and autumn seasons. It is also noted that the dry period extends between June and October for a period of five months, where we find that (P<2T). In fact, the month of May is also almost dry, and therefore more than half of the days of the year are dry in the region, knowing that the rains that fall in the region It is limited to a number of days of the year and in the form of torrential rain.

Regarding the nature of the climate, the city belongs to the "semi-aride a hiver frais" zone, based on the data of Seltzer (1913 - 1938), as well as the data of the meteorological station of the city (1972-2008) by calculating the Omberger coefficient (35,26 and 43, 04) respectively, and the calculation of the (Indice d'aridité demartonne 1923), which equals 14,40 confirmed that the city belongs to the same region, which once again confirms the nature of the city's climate, "semi arid à hiver frais" mentioned above.

The water balance suffers from an agricultural water deficit estimated at 512,05 mm. This deficit is distributed over six months of the year from May to October, The agricultural surplus is limited to three months, which is January - February - March, and is estimated at about 31,65 mm. Also, the easily usable reserve (RFU) does not exceed 136,41 mm and is limited to the months between November and April. The corrected effective evapotranspiration values appear to us to be large compared to the amounts of precipitation and even the amounts of actual evapotranspiration, which confirms the nature of drought that dominates the region. Therefore, it is necessary to sense the danger threatening its inhabitant's future. With regard to the excessive exploitation of water, it was found that the increase in the population as a human factor causes a deficit in meeting the needs of drinking water in the city, as this deficit ranged between 36,83% in 2015 and will reach 54,02% in 2030. It also resulted in a decrease in the groundwater level in the city's wells during twenty years (1994, 2014) (the piezometry) this decrease ranged between 55,27 meters in the "Hammamet" and about 68,78 meters in the "Ain Chabro", which is the main source of drinking water supply for the city of Tebessa, and about 14 meters in the "Bekkaria". As a human factor, the population increase in the city (its population doubled by more than three times, moving from 62639 in 1977 to 194461 in 2008) and will reach, according to our estimates, 318999 in 2030, will increase its water needs as previously mentioned, as well as increase the area of its urban surroundings, which It moved from 165 hectares in 1972 to 3200hectares in 2020 (as we calculated it with arc-gis 10.3), at the expense of flat lands that embrace groundwater, which leads to its leaching on the one hand and exacerbated the problem of floods on the other.

CONCLUSION

Through this work, we have shown the role that natural factors play in increasing the severity of the water problem in the city of Tebessa, which is characterized by water scarcity on the one hand, and consequently the lack of drinking water. The precipitation is characterized by irregularity and the restriction of rainfall to short periods of time, which leads to the occurrence of floods that usually cause material and human losses, as happened on September 12, 2018.

As for the temperature, it is eligible for an increase of more than 3°c by 2050, knowing that the average temperature of the city is 15.70°c, which will lead to an increase in continentality in the region in general. The nature of the city's climate, "semi-dry to cold winter"(semi-aride à hiver frais), was confirmed to us, which negatively affects the amount of precipitation and the abundance of water, which was also confirmed by the water deficit recorded throughout the year and the dry period in the region, which was shown by the study of the water balance with its various components.

Similar to the natural factors, it shows us the vital role of human factors in complicating the water crisis. In both cases, when abundance produces floods, and when scarcity produces drought and a crisis of drinking water shortage, and among human factors ,Increasing the population of the city and thus increasing their need for water, as well as increasing the area of the urban perimeter and its extension in a way that did not take into account the topography and extensions of the valleys. The limited water intrusion (renewed by the underground recharge of groundwater) was confirmed to us, and on the other hand, the irrational exploitation of groundwater, which led to a decrease in its level.

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