Impact of Climate Changes on Water Resources in Algeria

Chapter · May 2014

DOI: 10.1007/978-94-017-8962-2_12

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Chapter 12
Impact of Climate Changes on Water Resources in Algeria

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Abstract This work outlines the methodology followed in the study of climate change impact on water resources in North Algeria and presents the results on the vulnerability of the water resources. It focuses on research efforts of old data and homogenization of long series of climate data since 1926 at stations in the watersheds of North Algeria. We were able to establish a database homogenized precipitation and temperatures. Recent trends show mixed but generally increasing, except in the south basin that reflects a sharpening of the drought. We then conducted a study of impact of climate change on the hydrological behavior of watersheds. Of all the simulation models used in the world, only two global models UKHI-EQ and ECHAM3TR give an acceptable results. Throughout this paper, it clear that uncertainty surrounds our understanding of future climate change and its impacts.

Keywords Climate change • Modeling • Water resources • Climate scenarios • Algeria

1 Introduction

An analysis on a worldwide scale of the annual and seasonal changes of precipitation suggest that the two most outstanding features of the second half of the twentieth century would be the increase in precipitations, up to 20 % in Northern Russia, and especially the reduction of rains in West Africa (D'Orgeval 2006) and East Africa

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M. Behnassi et al. (eds.), *Vulnerability of Agriculture, Water and Fisheries to Climate Change: Toward Sustainable Adaptation Strategies*,
DOI 10.1007/978-94-017-8962-2_12,

(sahel) (Hulme 1992, 1994; Hulme et al. 1992, 1998, 2001; Viner & Hulme 1994) ranging between 20 and 50 % (Bradley et al. 1987). Regarding Algeria, with a total area of approximately 2.4 million km^2, the pluviometry concerns only 10 % of this area, which is divided into three zones: The Northern one (500 mm/year), the High plateaus zone (300 mm/year) and the Southern Atlas zone (250 mm/year) (ANRH and ONM); in average, the country receives 100 billion m^3 of rain per annum, of which 85 % evaporate and the remaining 15 % runs on the surface to rivers and the sea, or infiltrates inside the underground layers (Sari 2009). The economically mobilizable quantities of water for the various uses of the population are evaluated to 5.7 billion m^3 of surface water, 1.8 billion m^3 of subterranean water in the North, 4.9 billion m^3 in the South, which makes a total of 12.4 billion m^3 (Sari 2009). Because of the limited water resources, and the need to meet the demands for the desired quantity and quality of water by the planners must develop reasonable alternatives that take into account multiple purposes and objectives (Boudjadja et al. 2003) Algeria, though very little emitting of greenhouse gases (1.5–3.5 TE CO^2/Inhabitant/year), is vulnerable to climate change because of its geographical location in a semi-arid to arid zone (Viner and Hulme 1993a, b). The aim of work is highlighting of the impact of climate change on water resources in North Algeria and presents the results on the vulnerability of the water resources.

2 Study Area

The Northern Algeria was the subject of this study. It covers the basins slopes of Oranie, Algiers and Constantine. This zone presents climatic characteristics. It extends from the west to the east over a length of more than 1,000 km, whereas it extends to 450 km between north and south (Fig. 12.1)

3 Methodology

3.1 The Climate Changes and the Simulation Models in Algeria

In Algeria, studies based on analysis of experimental data have quantified the relationship between cause and effect between climate disruption and the recent availability of water resources. In relation to future climate change, an attempt of calculating a shortfall of water supplies due to climate change in 2020 was conducted as part of developing the national strategy and national action plan for climate change (IPCC 2001). This study is based on the exploitation of two global climate models: the model UKHI – EQ, designed in 1989 by the British Meteorological Service, and ECHAM3TR model, developed in Germany in 1995 by the Max Planck Institute. In a first step, climate projections were developed at a seasonal scale (temperature and precipitation) in the form of cards. In a second step,

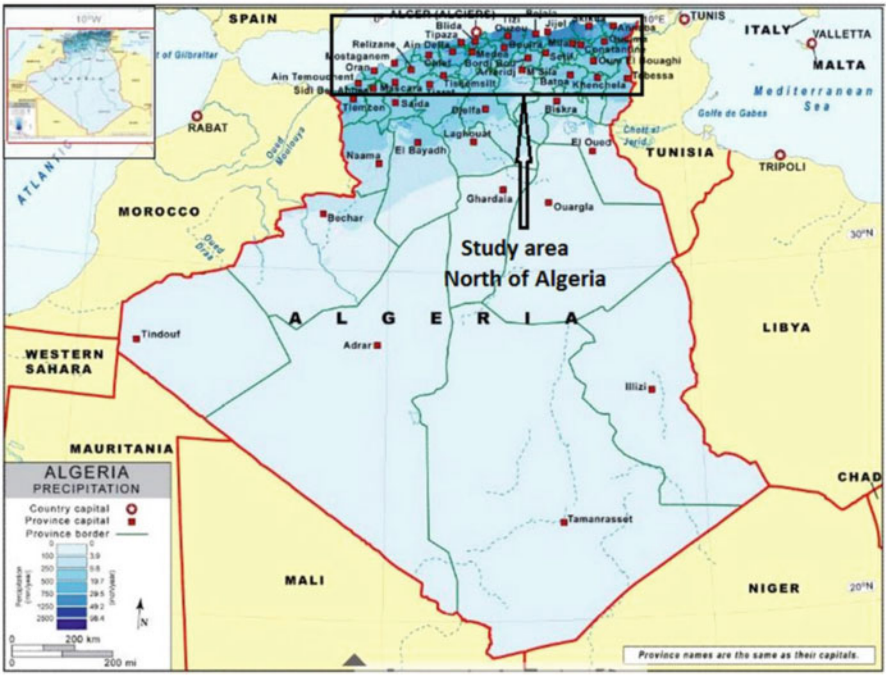

Fig. 12.1 Location of study area

and from a statistical analysis on the relationship Rainfall – runoff and climate scenarios, an estimate of the deficit in water supplies, based on total amount of surface water mobilized was made.

4 Results and Discussion

4.1 Climatic Projections

These are not forecasts but estimates of the possible evolution of the climate. For Algeria, the results give, by 2020, temperature risings of 0.5–1.5 °C and precipitation decrease of 5–20 %, and by 2050, temperature risings of 1.5–2.5 °C and a precipitation decrease of 10–50 %. An increase of 1–2 °C in temperatures can induce a reduction of 10 % in precipitations (Table 12.1). This will have important effects on the mobilization of dam waters up to 0.64 billion m^3 (Table 12.2).

4.2 Disturbances of Seasons

This disturbance will be expressed as a rising in temperatures and a concentration of precipitations over one short period increasing thus risks of flooding and an elevation in the frequency of droughts.

Table 12.1 Seasonal climate projections of temperature and rainfall in Algeria by 2020 for two GIEC models (IPCC 1990), (UKHI and ECHAM3TR) (Ministry of Regional Planning and Environment, 2001)

		Autumn	Winter	Spring	Summer
UKHI Model	Temperature (°C)	0.8–1.1	0.65–0.8	0.85–0.95	0.85–1.05
	Precipitation (%)	−6 à −8	−10	−5 à −9	−8 à −13
ECHAM3TR Model	Temperature (°C)	0.8–1.3	0.9–1	0.95–1.1	0.95–1.45
	Precipitation (%)	No change	−5	−7 à −10	−5

Table 12.2 Projection by 2020 of mobilizable surface water quantities in Algeria (ANRH 1993) according to UKHI (1989) and ECHAM3TR (1995) models**

	Quantity of mobilizable surface water (billion m^3)	
Type of projection	Optimal scenario (−10 %)	Optimal scenario (−20 %)
Projection without climate changes	6.4	6.4
Projection with climate changes	5.76	5.12
Incidences of climate changes	0.64	1.26

* Model UKHI-EQ, designed in 1989 by the British Meteorological Service
* Model ECHAM3TR, developed in Germany in 1995 by Max Planck Institute

4.3 Evolution and Trends of Pluviometry

4.3.1 Temporal Evolution of Pluviometry (1923–2006)

The tendency from 1923 through 1938 is to an overflow in rainfalls. This surplus is of 9 % in the West (Station of Oran: station 1), 17.6 % in the East (Station of Constantine: station 3) and 12.3 % in the Center (Station of Algiers: station 2). In 1939, started a dry period that stretched until 1946 to reach deficits of 14.5 % in the West and 10.2 % in the Center. In the East a surplus of 6.7 % was recorded. The period 1947 to 1973 was characterized by a wet period with an excess of 13.1 % in the Center. The driest periods were observed during 1949–1956 and 1960. Whereas in the West, the surplus is of 17.9 %. For the East of the country, the pluviometric surplus is a little lesser (4.5 %). Starting from 1974, the tendency is clearly to the dryness. The difference between the East and the other parts of the Country lies mainly in the intensity of this dryness. The rainfall deficit is of about 13 % in the East, 13.6 % in the Center and 16.1 % in the West. Since 2000, the pluviometry remained deficient for all the areas except in the East and the Center where, afterwards (2002), the tendency was to wetness with 0.4–2.7 % average deviation. In the Center and the East, this deviation is of 0–51.1 %. For the West, the deficits are of 3.2–17.7 % in comparison to the mean values. From 2002 until now, the pluviometry approaches the normal level for the Western and Central areas. On the other hand, in the East the pluviometry tends to increase. The general tendency in the North of the Country is to a decrease of pluviometry to become more marked since the middle of the 1970s (Béthoux and Gentili 1996, 1999).

The examination of the maps established by Chaumont for the period 1913–1963 (Fig. 12.1) and those of ANRH for the periods 1922–1989 (Fig. 12.2) and 1965–2004

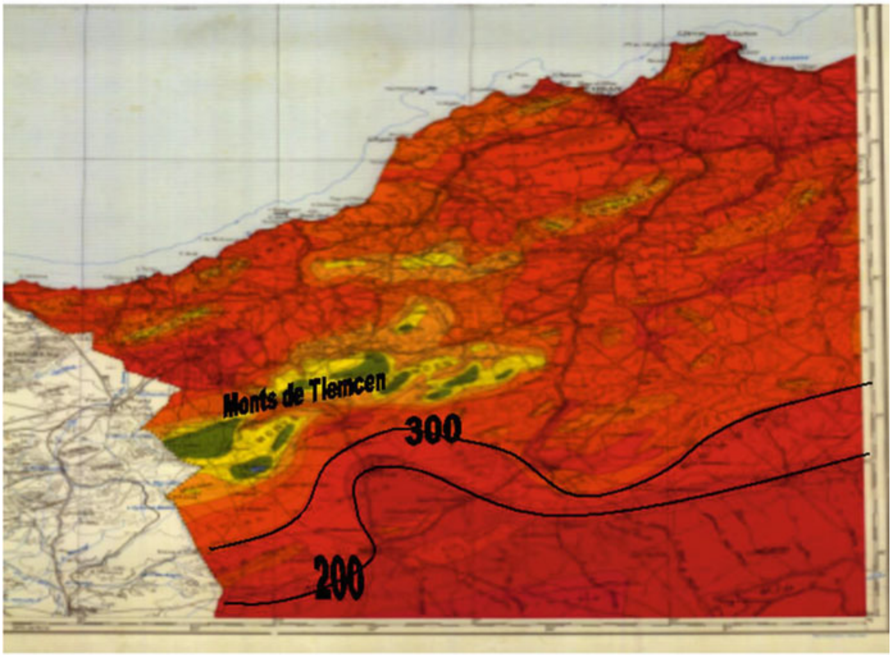

Fig. 12.2 Map according to Chaumont for the period 1913–1963

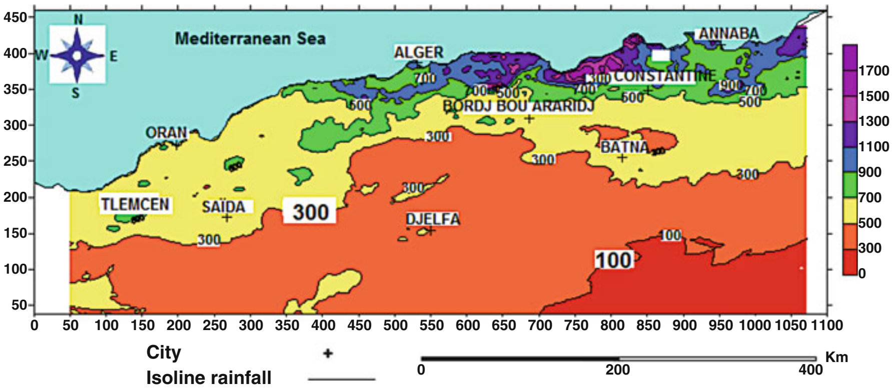

Fig. 12.3 Map according to ANRH for the period 1922–1989 (ANRH)

(Fig. 12.3), show that the isolines evolve in a significant way towards the North. This evolution is an indicator of climate change in Algeria. Indeed, the examination of the isolines 100, 200 and 300 mm shows that displacement towards the North can reach distances of more than 100 km.

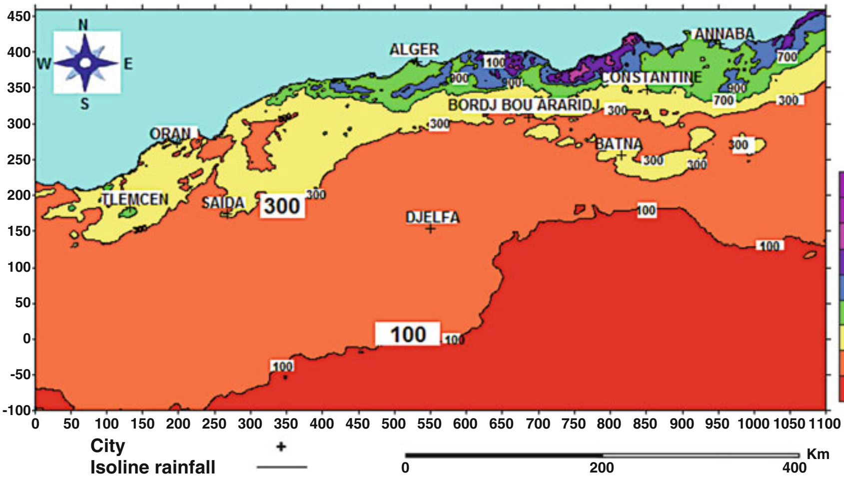

Fig. 12.4 Map according to ANRH for the period 1965–2004 (ANRH)

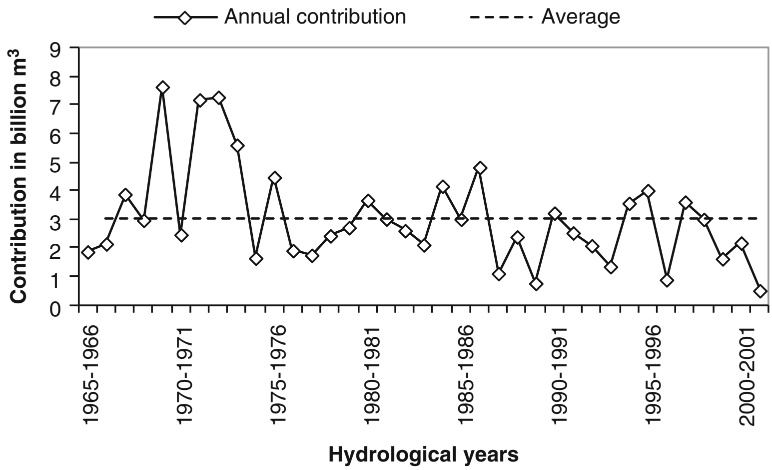

Fig. 12.5 Evolution of liquid contributions of catchment areas around Algiers (*Center*) (1965–2003) (ANRH)

4.4 *Impact on Overland Flows*

The climate is characterized by an important recurrence of phases of dryness and floodings. It influences directly the overland flows marked by the extreme seasonal and inter-annual irregularity of the liquid contributions characterized by the violence and the speed of rising waters and the severity of the low water levels. The impact on water flows is very significant since 1974, particularly in the west (Figs. 12.4, 12.5, 12.6, and 12.7). For this purpose, the surface

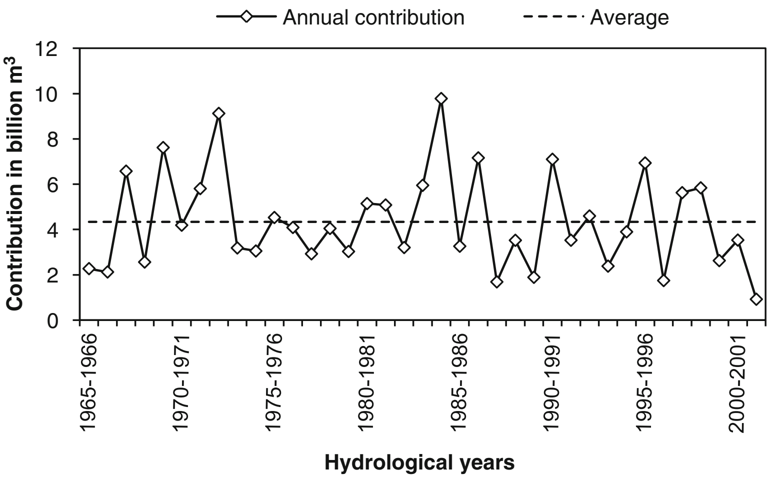

Fig. 12.6 Evolution of liquid contributions of catchment areas around Constantine (East) (1965–2003) (ANRH)

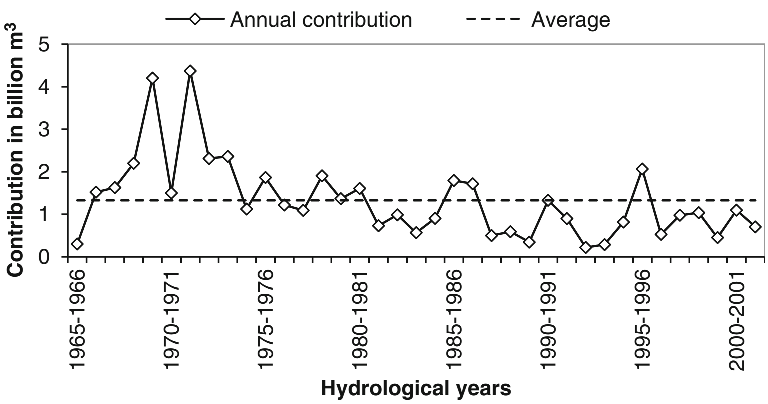

Fig. 12.7 Evolution of liquid contributions of catchment areas around Cheliff (Center-West) (1965–2003) (ANRH)

water resource, at the end of the 1970s, was evaluated to 13.5 billion m^3. From 1980 to 1990, it was estimated at 12.4 billion m^3. Currently, it is of 9.7 billion m^3 (Sari 2009).

4.5 Impact on Liquid Contributions to Dams

The impact of climatic change in Algeria during the last 25 years is expressed by a diminution of dam levels. Overflow volumes decreased in certain cases by more than 50 % (Dam of Ksob in M'sila: Fig. 12.8 – Cheffia in El Tarf Fig. 12.9 – Algeria).

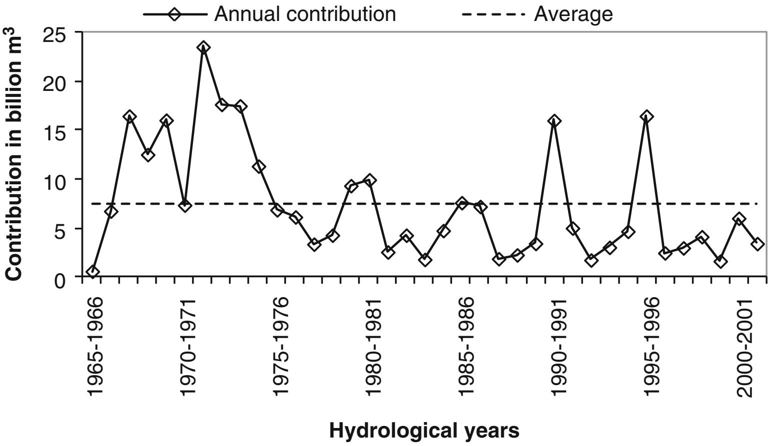

Fig. 12.8 Evolution of liquid contributions of catchment areas around Oran (West) (1965–2003) (ANRH)

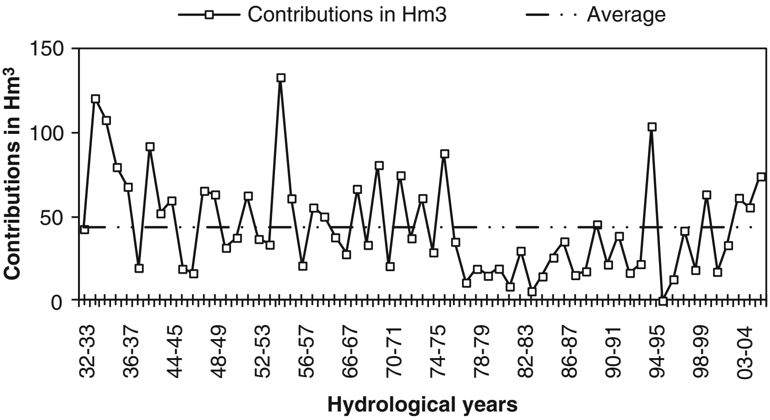

Fig. 12.9 Decreased volume in the dam of Ksob: area of M'sila (South-East of Algeria) (1932–2006) (ANRH)

Both dams, as an example, are located in a region with semiarid climate. The evapotranspiration estimated by the following formula of M. Coutagne, giving a mean value of 314 mm. The annual means rains are 341 mm. 92 % of this rain is which returned to the atmosphere (Gouaidia 2008).

4.6 Impact on Erosion and Sedimentation

The climate changes have significant consequences on erosion on height slopes and wadi beds (Achite 1999, 2002; Achite and Meddi 2004). This is expressed by a

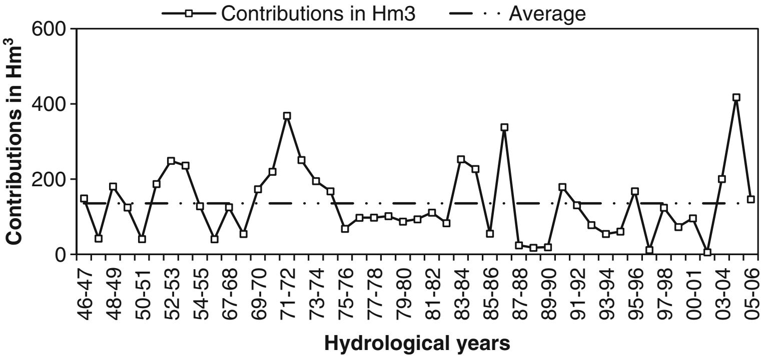

Fig. 12.10 Decreased volume in the dam of Cheffia: area of Tarf (East of Algeria) (1946–2006) (ANRH)

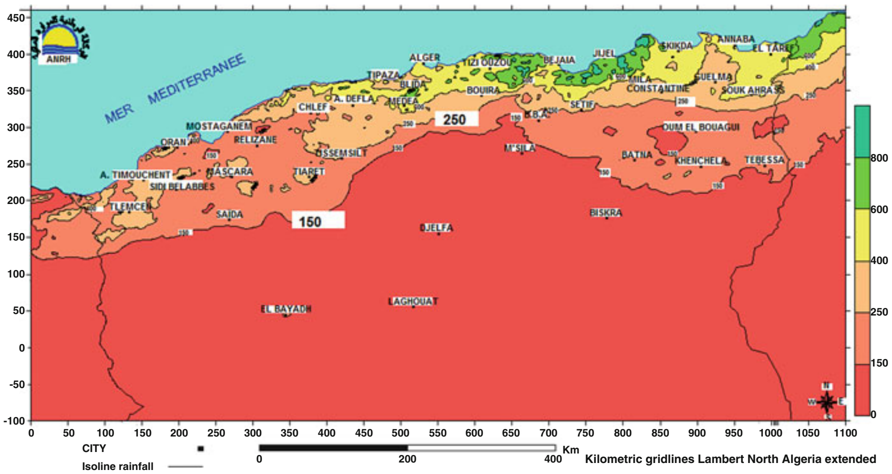

Fig. 12.11 Map of average annual rainfall in Northern Algeria – Decennial frequency **dry** (1965–**2001**) (ANRH)

tendency to an increase in the erosion phenomenon. Specific erosion reached 2,000 t/km^2/year in our basins (Tellian areas representing 45 % of the farming grounds (12 M – ha)). Also, it is estimated about 120 million tons of sediments rejected into the sea each year (Touaibia 2010).

4.7 *Impact on the Extreme Phenomena*

The climate changes are accompanied by extreme phenomena like brutal and devastating floodings (Figs. 12.12 and 12.13). In order to highlight the importance of these phenomena, the maps of decennial average rains over the dry and wet

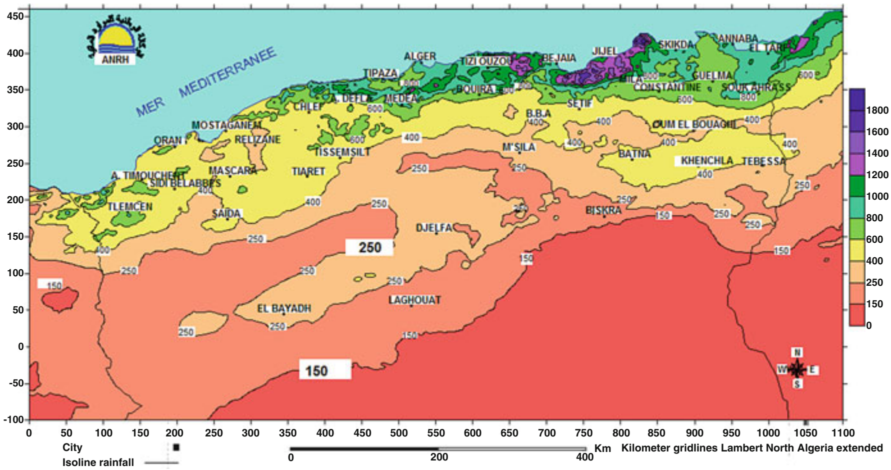

Fig. 12.12 Map of average annual rainfall in Northern Algeria – Decennial frequency **wet** (1965–**2004**) (ANRH)

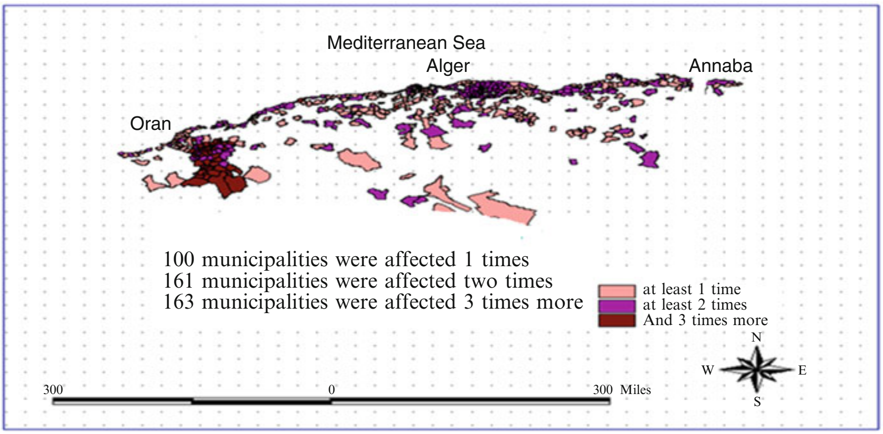

Fig. 12.13 Municipalities victim of floodings during the 3 last years (2003–2005) (ANRH)

periods were taken into account. The examination of these maps (Figs. 12.10 and 12.11) reveals a great fluctuation and a significant difference (decrease) between the dry and wet periods (shift of some isolines by more than 200 km). This instability implies that the phenomena of dryness and floodings have a severe impact on some areas of Algeria. These extreme variations translate extreme climatic conditions compared to the average deviation of the climatic system, which often provoke natural disasters (Figs. 12.12, 12.13, and 12.14).

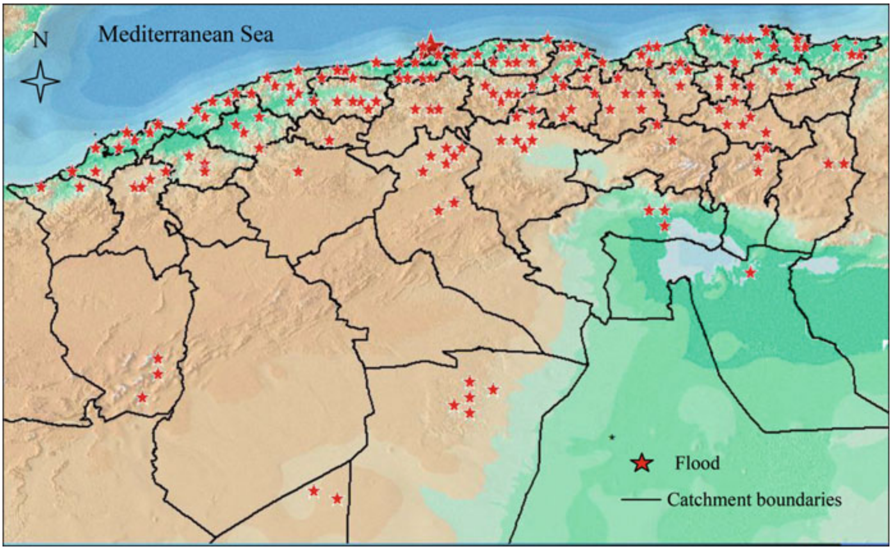

Fig. 12.14 Localization of the most important floodings during 10 last years (1973–2005) (ANRH) Behlouli (2009)

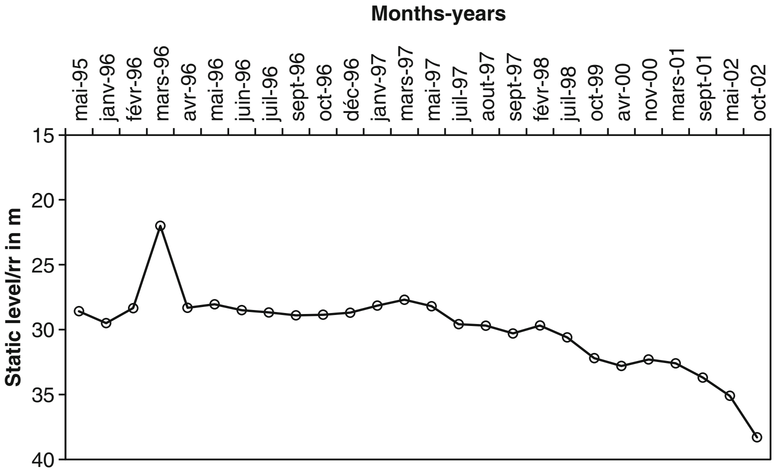

Fig. 12.15 Evolution of the groundwater depth of Mitidja – Area of Algiers (1995–2002) – Piezometer PZ N°1 Hamiz/21 (ANRH 2004)

4.8 Impacts on Underground Water Resources

The reduction in pluviometry and the increase in temperatures were directly influence the groundwater recharge and generate a significant decrease of water contributions leading to a folding back of groundwater levels (Fig. 12.15).

5 Conclusion

The water, now considered as a rare and invaluable food product, constitutes an essential element for the life and the balance of the individual. It represents a determining factor for the economic and social development of a country. Because of its precariousness, vulnerability and, even its irregularity, this resource requires in particular a special attention regarding its mobilization and with its management. The climate changes represent, for Algeria, a major risk if adaptation measures are not taken right now through the optimal use of the water resources, by the economy, the efficient use and the recycling of wastewater and the mobilization of new water resources.

Acknowledgments The authors warmly thank Mr Sahnoune for translation assistance, Mr Ould mara Arezki from the Climatology Office of the Agence Nationale des Ressources Hydrauliques (ANRH) in Alger, and reviewer whose comments and suggestions were highly appreciated.

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