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Climate change and water resources in Algeria: vulnerability, impact and adaptation strategy

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Abstract: The climate changes going on for a long time now have ceased to be a scientific curiosity. They constitute the major environmental question which dominates our time and pose the major challenge to environmental organizations of control. Water is one of the most important raw materials in Algeria. Because of its importance, it is essential to know its vulnerability with the climate changes. In Algeria, the vulnerability due to the climate changes is expressed through several aspects: demographic explosion, probable reduction in the water run-offs, scarcity of the resources, the degradation of the hydraulic infrastructures, threats to wetlands, etc. In the face of this situation, Algeria has taken quantitative and qualitative adaptive measures within the framework of durable management of this invaluable resource for the future.

Keywords: climate changes, water, vulnerability, strategy of adaptation, Algeria

JEL codes: Q54 , Q25

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1. Introduction

Freshwater systems are part of larger ecosystems, which sustain life and all social and economic processes. The provision of freshwater is therefore an ecosystem service which,

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when disrupted, threatens both the health of ecological systems and human wellbeing, which are in complex interaction (Millennium, 2005). Through the primary medium of water, climate change influences the Earth's ecosystems, people's livelihoods, and general human wellbeing (UN-Water, 2012). Scientists within the Intergovernmental Panel on Climate Change (IPCC) expect that the present increase in greenhouse gas concentrations will have direct first-order effects on the global hydrological cycle, with impacts on water availability and demand (Bates et al 2008). These changes will in turn create other higher order effects (Chalecki et al, 1999). Overall at the global level, a net negative impact on water availability and on the health of freshwater ecosystems is foreseen (Kundzewicz et al, 2007), and thus a cascade of negative consequences is expected to affect social and ecological systems and their processes.

Besides climate, there are other drivers of change, such as increased population pressure, economic development and urbanization trends. These drivers of change are closely linked to each other and pose complex management problems for land and water resources. As populations grow and move to cities and as their income levels increase or decrease – their demand for water resources changes both spatially and temporally. Taken together, the net effects of these supply and demand changes in areas of increasing population, can translate into increases in the vulnerability of water resources systems, which can create major challenges for future management of water resources for human and ecosystem needs. As stated above, climate change can contribute further to exacerbation of problems, in particular when considering medium to long-term projected impacts. There is therefore a need to assess the vulnerability of water resources systems for enhanced management strategies, also including robust adaptation measures for future sustainable water use.

Vulnerability assessment is not straightforward, in particular because there is no universally accepted concept for vulnerability. For example, Thywissen (2006) lists 35 definitions of the term. The plurality of the definitions leads, as expected, to very diverse assessment frameworks and methods (Cutter, 2001; Brooks et all., 2005; Turner et all., 2003; Luers, 2005; Füssel et all., 2006; Füssel, 2007). Some authors even argue that by principle, vulnerability cannot be measured, as it does not denote observable phenomena (Moss, 2001; Patt, 2008) while, according to Hinkel (2011), the opportunity arises to make this theoretical concept operational. Indicators can provide the means for doing so and, in particular, make the assessment of vulnerability possible, as we propose herein with the methodological framework for the assessment of the vulnerability of water resources, within the broader context of climate

change adaptation, and with a specific emphasis on operational implementation in developing countries.

Water resources systems are complex in nature and consist of four inter-linked sub-systems: individuals, organizations, society and environment (Simonovic, 2009). As a consequence, management issues should generally consider multiple decisional criteria and large numbers of possible alternatives, usually characterized by high uncertainty, complex interactions, and conflicting interests of multiple stakeholders, but also of a multiplicity of compartments, such as river, land or coastal ecosystems, or different economic sectors (Hyde et al., 2004). Due to this dual complexity (*i.e.*, complexity in vulnerability assessment itself and complexity of water resources management), not many studies of vulnerability assessment of water resources systems have been available to date. The issue of vulnerability was first brought to the attention of policy makers in an international context in the field of water resources management in 1992 at the Dublin Conference (Tessendorff, 1992) (Dublin Principle 1 states that fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment). Later, several studies on the vulnerability assessment of water resources systems were carried out at various geographical scales, e.g., global scale (Vörösmarty et al., 2000), large scale trans-boundary river basin (Babel et al., 2009; Hamouda et al., 2009), regional scale (Hurd et al., 1999; Sullivan, 2011) and also in small scale watersheds (Pandey et al., 2009; Gober et al., 2010; Pandey et al., 2010; Pandey et al., 2011). A few studies, e.g. (Balica et al., 2009), also include the variation of vulnerability value across different spatial scales, ranging from river basins to urban areas. In some of these studies (Vörösmarty et al., 2000; Hurd et al., 1999; Gober et al., 2010), vulnerability is considered only as a physical component of water resources and these studies focus on water resources availability rather than how society and the ecosystem deal with water (Pandey et al., 2011). Global and large-scale studies usually cannot provide the detailed information that is required for appropriate adaptation and management actions (Pandey et al., 2010). Other studies (Hamouda et al., 2009; Pandey et al., 2009; Pandey et al., 2010; Pandey et al., 2011) incorporate important components (i.e. exposure, sensitivity, adaptive capacity) of vulnerability in their assessment, but limited stakeholders' involvement can produce subjective biases and limited credibility. Typically, a dichotomy exists between engineering science approaches and those focused on the human dimension, with the first commonly lacking adequate consideration of stakeholders' involvement as required by the most relevant international references in the field, such as the Dublin Principles (Tessendorff, 1992). (Dublin Principle 2 states that water development and

management should be based on a participatory approach, involving users, planners and policy makers at all levels.) Similarly, a society cannot improve without the support of innovative scientific ideas and technical knowledge.

Since the 1990s, the concept of climate change puts debate of water resources and the risks related to them by placing them at the heart of the problem. According to experts, on the horizon of 2020, Algeria will experience rainfall law of reduction of 5 to 13% and a temperature increase of 0.6 to 1.1°C. In this non-distant horizon, Algeria, arid country, will suffer droughts and recursive flooding and water needs will double in volume under pressure from population growth and continued urbanization. The country already knows an accentuation of droughts and thus worsening of desertification, soil salinization, and pollution of surface water and therefore progressive degradation of water resources. Similarly, floods that continue to serve north and south would be greater in frequency especially in spring and autumn (Anonyme, 2009).

Urban issues facing these hydro-climatic risks come in terms of water availability and sanitation, ecological balances and safety of people and property. Thus, in the future, natural phenomena, probably more frequent and stronger will make a more serious impact on both the current socio-economic activities of operating and development in times of crisis can cause real disasters, (Kettab, 2001).

Algeria is Africa's second most water scarce country, after Libya. There are no large rivers in Algeria. The Chéliff River in the coastal plain is the only significant stream, providing some water for irrigation. Water is unevenly spread over the country. While most regions suffer from water shortage, yearly floods can also occur after heavy rains. A challenge to managing Algeria's water resources is the large fluctuations in supply from year to year and in regions. Large efforts have been made by the state to mobilize water resources by building dams. The problems related to water can be summarized as follows (INRAA pers comm, 2011): - Scarcity and uneven distribution; - Low mobilization; - Low-productivity; - Insufficient management. Algeria, with its arid and semi-arid climate, is highly vulnerable to climate change with desertification as a major concern. Overall, temperature and evaporative demand is expected to increase for Algeria. The change in future rainfall is however more debated. A small decrease is expected up to 2025, but exact values are unknown. Knowledge about climate change is restricted by a lack of information in general for the region. A recent study by Laborde et al. (2010), however, has shown that even a small decrease in rainfall will have a disproportional large reduction in water availability (runoff) for (northern) Algeria.

This paper presents the evolution of CO_2 emissions and an analysis of the current situation in terms of support for sustainable development and the issue of climate change. We discuss the vulnerability and adaptation strategy of water resources sector to climate changes, as well as the national climate plan and the challenges the country faces.

2. Evolution of GHG and climate in Algeria

2.1. Evolution of GHG

Since 1950, the emissions of CO_2 has been on the increase. In the Global Atmosphere Watch (GAW) Program of the World that helps to improve the understanding of interactions between the atmosphere, the oceans and the biosphere, the amount of CO_2 measured at the GAW station of Assekrem (altitude: 2710 m), Tamanrasset, Algeria, has been growing steadily from 360 ppm in 1995 through 385 ppm in 2008, representing an annual increase of about 2 ppm / year (Figure 1) to that of no less than 392 ppm as we measure it today.

Algeria has conducted two national emission inventories of greenhouse gas (GHG) emissions for the years 1994 and 2000. The inventory covered the direct six greenhouse gases (CO_2, CH_4, N_2O, SF6 and CFCs) and indirect greenhouse gas precursors (NOx, CO, NMVOC and SO_2). The share of emissions of each greenhouse gas is illustrated in Figure 2. In 2008, the overall GHG emissions totalling 121.31 MT eq.CO2 per capita were 4.1 T eq. CO2/inhab/an. It was 3.1 in the year 1990.

By comparing the emission per inhabitant, Algeria is among important emitters from developing countries (Figure 3). In comparison, the average annual global emission of CO_2 is 4.7 T/inhab., Qatar 55.4 T inhab., UAE 31.1 T/inhab., U.S. 19.8 T/inhab., France 6.1 T/inhab., Lebanon 20.3 T/inhab, Tunisia 2.4 T/inhab., Morocco 1.5 T/inhab. and India 1.4 T/inhab.

Due to the nature of its activity, the energy sector (production and consumption) – the source of highest emissions (about ¾ of the total) (Figure 4) – has the most important potential for mitigation measures. The annual average growth of 2.0% seems to be in line with the increase of the average annual consumption of energy during this period. Thus, with this growth, emissions will increase by 2020 by 40% over the year 2000. In these emissions, the production of electricity increased since 1997 by about 6% / year, accounting for 40% of CO_2 emissions.

In 2008, for one $ PPP (purchasing power parity) of GDP, Algeria emitted 0.41 Kg CO_2 (Kerbachi, 2011).There is generally a good correlation between living standards and CO_2

emissions. This rate shows that the Algerian economy use fossil energies in the process of production and consumption. For example, France uses nuclear energy, the rate rises to 0.2. It also follows that for a tonne of CO2, the wealth generated is two to three times lower than in developed countries. It is also a result of the delocalization of heavy polluting industries to developing countries (Kerbachi, 2011).

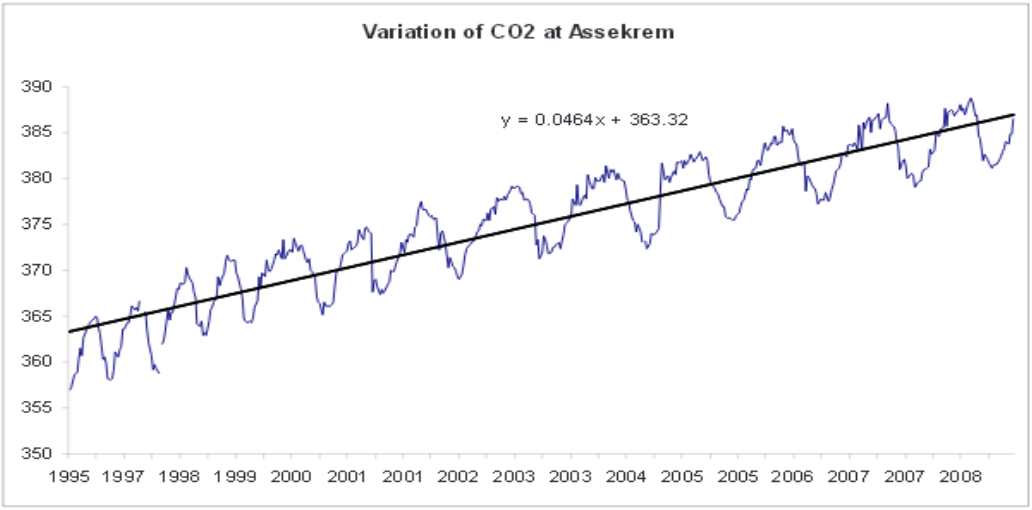

Figure 1. Evolution of CO_2 at the Assekrem Station
Source: Author's own elaboration based on [ONM, 2009]

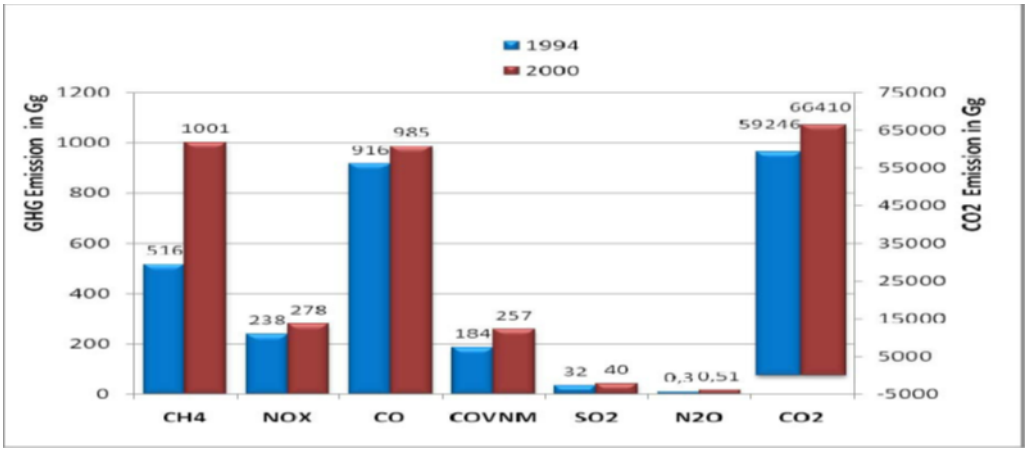

Figure 2. GHG emissions from the energy sector in 1994 and 2000
Source: Author's own elaboration based on [MATE, 2010]

In all sectors, energy use in 2008 amounted to 23.2 million Toe. Taking into account the current socio-economic trends and without mitigation actions, the estimates we conducted show that Algeria will have consumed 50.02 million Toe until 2030 (average annual growth rate of 4% energy) which corresponds to emissions in the order of 180 MT CO2 per year by the energy sector (power plants to natural gas).

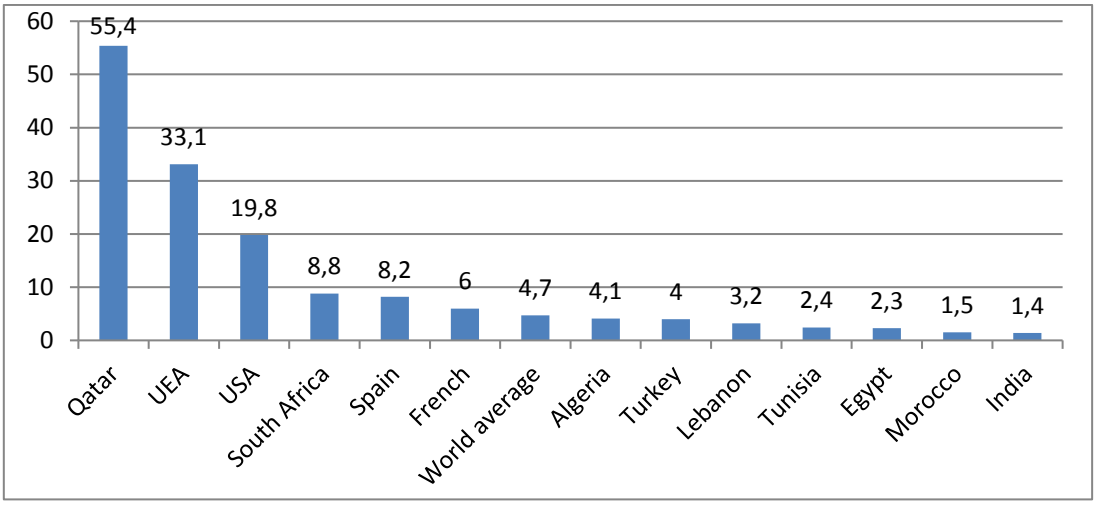

Figure 3. Comparison of CO_2 emissions per capita among other countries

Source: Author's own elaboration based on World Bank data [WB]

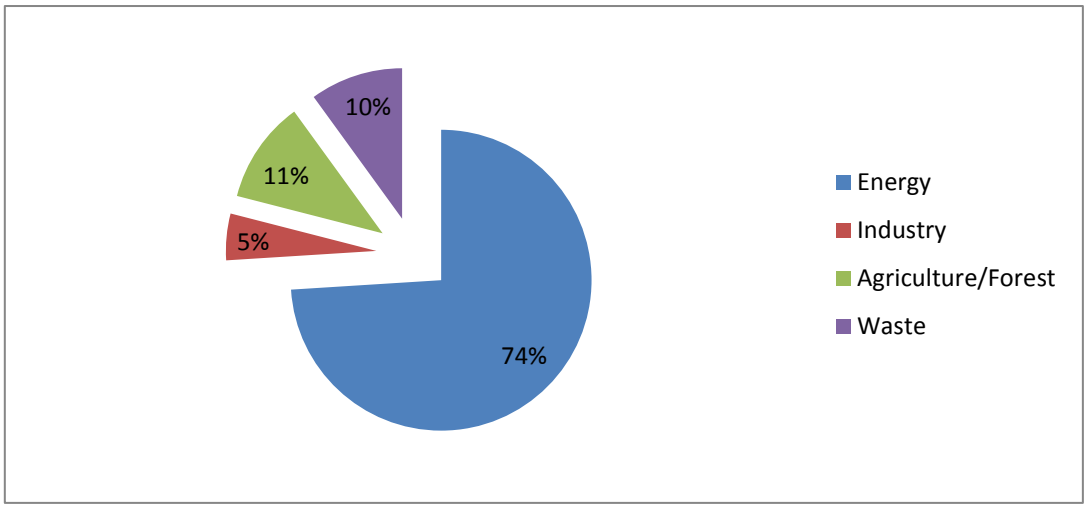

Figure 4. Total GHG emissions by sector in Algeria

Source: Author's own elaboration based on [MATE, 2010]

2.2. Climate change

In its 2007 report, the IPCC combined 25 global climate models to assess the impacts of climate change in 2050 and 2100. In the Mediterranean region, there is forecast a temperature rise by 2-3°C by 2050 and by 3-5°C by 2100. The incidence of rainfall will be less frequent but more intense, while droughts more common and longer. The spatial and temporal distribution of precipitation would change, which will directly affect agriculture and water resources. Regional models with the IPCC scenarios applied to Algeria for the period 1990-2020 forecast growth in the average temperature by 0.6°C to 1.1°C and reduced precipitation by 10% (Figures 4, 5) with an increase in the sea level of 5 to 10 cm. Increased evaporation and decreased

precipitation will accentuate the decrease in the level of water mobilized in dams and groundwater.

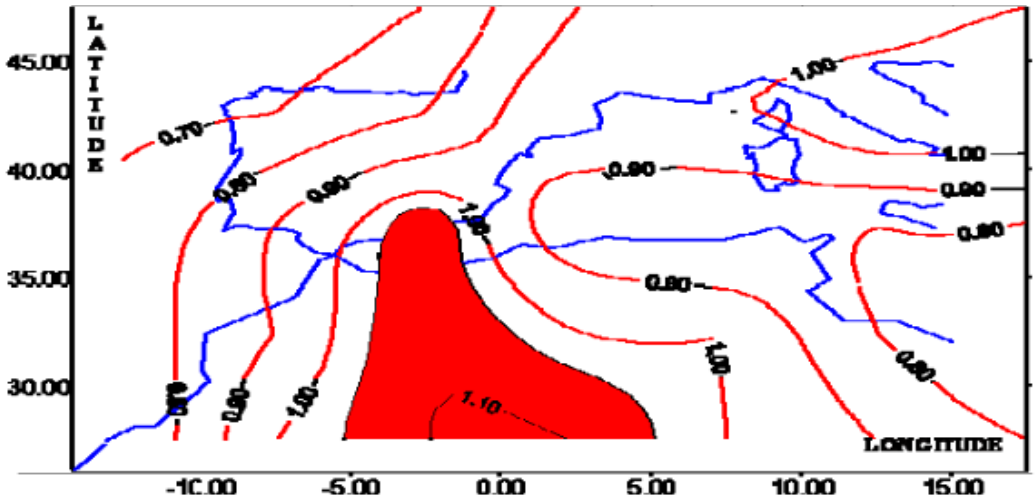

Figure 5. Projected Temperature (°C) to 2020 (winter)

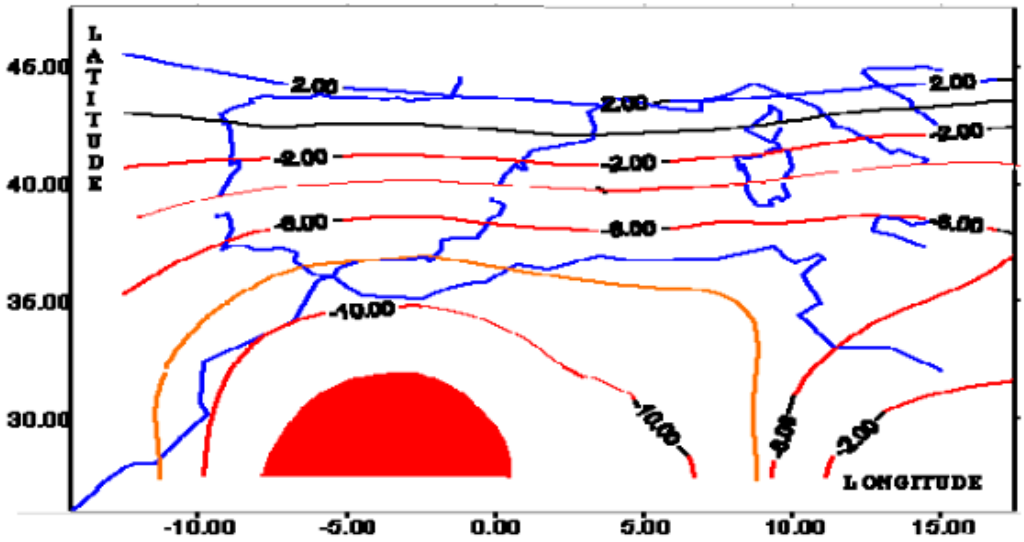

Figure 6. Change in precipitation (%) to 2020

3. Vulnerability to climate change in Algeria

The major vulnerability of the country is observed in the areas of water and agriculture. Algeria is a semi-arid to arid north to south. Water availability per capita is 600 m3/inhab./an., placing Algeria in the category of countries poor in water resources under the shortage threshold set by the UNDP or the scarcity set by the World Bank in 1000 m3/inhab./an. With 71 dams of a capacity of 7.1 billion m3, Algeria has almost reached the mobilizable water potential. The rate of groundwater exploitation in the north of the country reached about 90%,

nearly 2 billion m3/year. Some aquifers are already overexploited. On the other hand, in recent years, in order to satisfy the consumption needs, the country has successfully applied desalination of sea water with a production capacity of about 2 million m3/day.

Land used by agriculture, which occupies nearly 21% of the total land area, is estimated at 49 million ha distributed as follows: 8.4 million ha of agricultural area, 33 million ha used as routes, 6.6 million ha of forests and steppes of Alfa. Irrigated land accounts for 11% of the agricultural area, an area of 929.000 ha. Algeria therefore has only 3.5% of the total area of the country as arable and irrigated land. The ratio "availability / capita" agricultural land rose from 0.75 ha / cap in 1962 to 0.24 ha / cap in 2008. This enormous loss of farmland is not only the result of human pressures (industrial, construction, pollution), but also the result of desertification, soil erosion or vegetation cover loss. Climate change will degrade biodiversity and contribute to the weakening of the soil and reduced vegetation cover resulting in gradual desertification. In the steppe, the effect of climate change is reflected by the change in the cyclical nature of drought from one year to three years in the 1960s to two years out of five in the 1970s and the 1980s and to seven out of ten years now.

Vulnerability to climate change is a vital issue for the protection of natural resources and human health and the environment protection, developing the strategic development of the country.

4. Vulnerability of water resources to climate change in Algeria

The climate changes which have been going on for a long time now have ceased to be a scientific curiosity. They make a major environmental issue that has dominated our era and pose a major challenge that environmental control agencies must meet nowadays.

Water, one of the most important raw materials in Algeria, including its importance for human consumption, food production, industry, transport, recreation and ecosystems has become the focal point. Because of its importance, it is essential to know its vulnerability to climate change in Algeria (Bouziani, 2006).

However, climate variations are not the only factors defining vulnerability of this resource to climate change; the economic, demographic and environmental factors are also criteria to consider. The reaction of water users as well as the management mechanisms of this resource are determining the vulnerability of the resource in Algeria to a large extent (Bouziani, 2006). In Algeria, the vulnerability to climate change is expressed through several aspects:

Resource scarcity

Algeria is qualified, like the other 17 African countries affected by water stress, in the category of the poorest countries in terms of water potential, as water is below the theoretical scarcity threshold set by the World Bank in 1000 m3 per capita per year. If in 1962, the theoretical availability of water per capita per year was 1500 m3, it was only 720 m3 in 1990, 680 m3 in 1995, 630 m3 in 1998, 500 m3 now and it will be only 430 m3 in 2020, i.e. the availability of drinking water in Algeria in m³ / inhabitant / year will slightly exceed the threshold of 400 m3 / ha.

Demand for permanent growth

The demand for drinking water, agricultural water and industrial water is growing, generated by a demographic and industrial development ever increasing.

The likely reduction in water flows

Given the highlands and the Saharan regions that occupy a large part of the national territory (93%), it receives only 10% of the total flow in Algeria, valued at 12.4 billion m3.

Evaporation of surface water

Due to evaporation of the surface water, there is an increased demand in groundwater. The vulnerability of surface water can also result in an increase in temperature to their warming thereby reducing their ability to biodegrade certain pollutants resulting in a decrease in quality.

The deterioration of water infrastructure

This deterioration is due to the frequent lack of vegetative cover of watersheds. Rapid deterioration of water infrastructure seen releases of original urban industrial pollution and poor quality technical management of the works causes huge losses of water.

Floods and other extreme events

These phenomena have already affected several parts of the country; it is the example of Bab El Oued in Algiers in May 2001, and others in the south, in the case of Tamanrasset, Ain Guezzam and Ghardaia.

Threats to wetlands

Despite their importance in vital processes and the fosterling of fish and birds, there are many threats to these areas, in consequence of excessive pumping and thoughtless dams that drain the benefit of agriculture. The drying up of two large wetlands, which took a little over a century, in this case Fetzara Lake in Annaba and Halloula Lake in Tipaza has led to the disappearance of 7 or 8 species of birds nested there.

5. Impact of climate change on water resources in Algeria

Climate Change, an aggravating factor

Data relating to the climate, collected in the Maghreb region during the 20th century, indicate a warming during this century estimated at more than 1°C with a pronounced trend in the last thirty years, general circulation models converge to estimate a probable warming of the region by about 2 to 4°C during the 21st century. By its geographical location within the arid and semi-arid area, Algeria is subject to physical conditions and unfavourable hydro weather, accentuated by periods of chronic drought. Algeria is highly sensitive to climate, especially in the highlands and the steppes that cover approximately 60% of viable land in the North. The climate changing is inevitable and it will result in significant impacts, including those related to increased temperatures and rainfall, to water resource scarcity and increased frequency of storms. Other impacts are studied: the loss of biodiversity and degradation of ecosystems, the increased risk of famine, population movements and the effects on health, (Bolin, 1980).

The impacts on surface runoff

The Intense drought and persistent observed in Algeria during the last 30 years is characterized by a rainfall deficit estimated at 30% (50% during the year 2001- 2002), had a negative impact on flow regimes watercourses, causing serious consequences for all socio-economic activities of the country.

Changes affecting the dam waters

Changes affecting the retention of surface water are due to due to siltation and reduced runoff (Kadi, 1997). Siltation is connected with the nature and morphology of the steep terrain, fragile vegetation cover, lack of afforestation and urbanization upstream dams which generate

strong erosion that reduces the dam storage capacity of 2 to 3% each year, due to siltation transport and deposition of sediments by rainwater. Currently, there are 14 dams affected by siltation. Similarly, reduced runoff contributes to the worsening of the state as runoff contribution to surface water has consistently decreased. Too low a flow does not allow filling the existing dams.

Changes affecting groundwater

Reduced rainfall due to drought raging since the early 1970s led to a steady decline in groundwater reserves of major aquifers in the north. In many plains of the country, the groundwater level has dropped at an alarming rate (> 20 m.). Worsening droughts coupled with the overexploitation of groundwater has resulted in mineralization of unsaturated zones of deep aquifers in semi-arid regions such as the plateau of Oran and the high western plains. The average rate of use of groundwater is 79% in the Northern region; it can sometimes reach and exceed 90% in some areas. In coastal areas, the decrease in hydrostatic pressure levels has already resulted in the penetration of sea water into fresh water supplies of coastal aquifers regions of Mitidja, Oran, Terga and Annaba.

The Impact of climate change on irrigation

Recent climatic fluctuations and drought, more frequent over the past three decades have accentuated the phenomenon of soil degradation, thus causing desertification in vulnerable areas, such as steppes and high plains. The current trend to more intense floods could lead to erosion and degradation of a larger portion of land. These lands are real agricultural potential and must ensure the country's food security and protection of the coastal strip (Arrus, 2006). Water resources are essential to food production. Of the 150 000 ha of irrigated area, 43,000 ha of it was actually not irrigated until in 2007, due to drought and the re-allocation of irrigation water to the drinking water supply for people, especially in the west of the country.

The Impact of climate change on sanitation

Climate change has implications for public health, which is the reason for the efforts made in sanitation. The invoice outbreaks of MTH (water-borne disease) are heavy for the Algerian state. The cost of these outbreaks has been estimated at the equivalent of the construction budget of more than a dozen water treatment stations. The main factor of these diseases lies in the lack of water resources combined with the absence of treatment of certain

water sources. The sanitation specialists are trying to better understand the links between climate change and sanitation, including health issues and hygiene.

Flood risk

Based on scientific studies, experts estimate that torrential rain and storms like those that have ravaged parts of Bab El Oued, Ghardaia and Bechar will become more frequent. We must expect the accentuation of these weather events, which will be increasingly violent and dangerous.

6. Strategy of Adaptation

In Algeria, adaptation practices are already used as increases in drought events, flood and abnormal air temperature occur continuously. These actions must be integrated into an overall adaptation policy of the country because of the fact that adaptation initiatives taken in this area will have important implications in many other sectors (Agoumi, 2003).

The main quantitative, qualitative and management measures have been taken by Algeria and those being developed can be described as follows:

Quantitative measures

- Recourse of water saving techniques, especially in agriculture, such as irrigation drip and controlled suction and choosing crops that consume less water;
- Mobilization of non-conventional water mobilized nowadays;
- Valuation of treated wastewater through mastering its use for irrigation of certain crops and the development of industrial activities;
- Acceleration of dams construction;
- Launching additional drilling programs and rehabilitation of some abandoned wells;
- Taking Water Regulation of the groundwater level;
- Rehabilitation of water distribution networks;
- Improvement of the industrial water management methods (recycling, reuse);
- Construction of desalination plants and wastewater treatment;
- Reduction of evaporation on the lakes of dams;
- Tanks or small lakes (several experiments were conducted but have not were not successful).

- Resumption of the technique of "rain caused" end to increase the water yield precipitated from the clouds;
- Application of artificial recharge techniques aquifers in the southern regions. These techniques, were applied in the Netherlands, California and Florida and require technology transfer in Algeria, making it possible to store groundwater in winter and river water for use in the summer to be pumped for irrigation and urban consumption.

Qualitative measures

- Clean-up of water systems and wastewater treatment before discharge;
- Protection of water against pollution (agricultural, industrial and human);
- Strengthening of water resource monitoring systems;
- Improving the quality of human consumption water by desalination and removal of contamination in transport, storage and distribution;
- Protection of wetlands as places of habitat for local and migrant wildlife species. In Algeria, preventive measures to fight against the harmful effects of extreme events, have also been in the centre of attention since the adoption of the law on major natural and technological risks (04-20 law of 25 December 2004 on the prevention of major risks and disaster management in the context of sustainable development) (Meddi, 2002).

To satisfy the growing water demand, Algeria's policies are directed towards an increase in water supply by increasing the number of water infrastructures. There are a number of 68 dams operational now in the country, mostly in the north. The dams supply around 65% of the water that is used for agriculture (Source: DHA, 2011, pers comm).

The National Agency of Dams and Transfers (Agence Nationale des Barrages, ANBT) is in charge of the construction and maintenance of dams. Silting of dams is becoming a problem; now, in Algeria reservoirs have lost one quarter of the original capacity already due to silting (Plan Blue 2007).

To mitigate water shortages in different parts of the country, several large water transfer projects have been realized. One of the mega projects is the south-south transfer "Water Mega Project In-Saleh-Tamanrasset", operational since March 2011. It supplies water from In Salah Albien to the regions in the far south of Algeria (Tamnarasset) over a distance of 750 km. The project provides up to 100 million m3/year, with water coming from underground sources.

The use of non-conventional water resources such as treated wastewater and desalinization is not widespread yet in Algeria. The country launched major desalination

projects on the Mediterranean shore (14 stations in 2010, production of 2.39 million m3/day); (EMWIS country profile). Desalinized water is estimated at 140 million m3/year, and treated waste water amounts to 270 m3 (MWR, 2008).

Algeria owns the largest desalinization unit in Africa. More than 10 desalinization plants are operational, and the intention is to have a number of 43 plants running by 2019. The Hamm site is the largest converter of seawater into drinking water (200,000 m3/day) in Algeria.

Until now, the water supply side has received a lot of attention in the country. The Ministry of water resources make strong efforts to mobilize water resources to increase water supply, by constructing new dams and installing new wells. The environment has not been high on the political agenda of the Ministry. Now, with the commitment to reach the Millennium Goals and the land and water degradation the country is facing, the need for a sustainable development is acknowledged. The demand side, i.e. the reduction of water use, is now increasingly receiving attention. This process has been started by implementing more efficient irrigation methods, the use of treated waste water in agriculture, and more progressive water pricing.

7. The National Climate Plan

The National Climate Plan (NCP), which is in final discussion before being finally adopted by the authorities, outlines the various vulnerabilities of Algeria. The NCP is part of the vision of Rio + 20 and contributes to the global effort against climate change and sustainable development of the country. It defines the outlines of the overall strategy to be adopted taking into account the reality of the country and its priorities. The NCP offers among others:

- To identify the impacts of climate change on the economy and society;
- To propose a strategy to address against the CC and decline this strategy into a coherent set of actions and measures for adaptation and mitigation priority will be translated at operational level, indicators, achievements, and that into action plans for fields and periods;
- To identify the terms and conditions of their implementation as well as of monitoring and evaluation;
- To improve access to public and private international finance and promote technological and financial foreign partnership.

In the operational part, NCP offers a coherent set of actions in the short, medium and long term that are based on existing sectorial policies and on international best practices and ensure the integration of the problem of climate change in the Algerian economy and society.

The following are the key actions, whose implementation is inexpensive and can be executed without much delay:

- Reuse of treated wastewater for agricultural adaptation to climate;
- Water Economy;
- Adaptation of agricultural calendars to climate change;
- Selection of varieties and seeds adapted to the arid climate;
- Strengthening local participation in planning, implementation and monitoring of actions relating to mitigation and adaptation to climate;
- Implementation of the monitoring mechanism and early warning about extreme weather;
- Strengthening the capacity of institutions involved in climate change;
- Adaptation of the institutional and regulatory framework and implementation program of fight against climate-sensitive diseases;
- Promotion of renewable energy and energy efficiency in buildings;
- Integration of climate change in development studies and impact hazards and environmental audits and energy;
- Adaptation of climate change in the fight against desertification and land degradation;
- Enhanced protection against extreme rainfall events;
- Adaptation of urban and interurban public transport.

The NCP will be revised periodically in response to the changing climate.

Apart from the National Plan of Action and Adaptation to Climate Change (2003), adaptation measures have largely focused on sustainably meeting the growing demand for a secure water supply, particularly in cities and coastal towns. Algeria has invested around USD20bn in dams, water treatment plants, drinking water sanitation and desalination facilitates. The most recent 5-year infrastructure plan (2010-2014), included the construction of 35 dams, 35 supply treatment plants, over 3,000 upgrades to drinking water facilities, and eight new desalination plants, in addition to the 21 small-capacity plants built in 2002-2003. The Second National Communication to the UNFCCC identified a number of potential adaptation measures for the water sector, as well as irrigation goals for agriculture.

8. Conclusion

The strategic dimension and vital role of water characterized by scarcity and shortage imposes a maximum mobilization policy and the rational exploitation of this resource. The

challenges in this area are related to security of the population and economy of the country, which is important to provide as it is true that water security is closely linked to economic security, health and environmental and, in particular, food security. The ongoing changes in the climate and the unforeseeable future in this respect will make water management more difficult. Taking immediate actions to adapt the sector to climate change will be much less costly than the damage resulting from this phenomenon. Regarding the effects for which projections are reliable enough, adaptation must therefore start now. Algeria has a good chance of a successful struggle against the change climate provided that certain conditions are met, such as formation of qualified human capabilities, integration of all the possibilities existing today, good coordination and good governance.

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ZMIANY KLIMATYCZNE I ZASOBY WODNE W ALGIERII: PODATNOŚĆ, WPŁYW I STRATEGIA ADAPTACYJNA

Streszczenie

Zmiany klimatu przez długi czas przestały być ciekawostką naukową. Stanowią one główne zagadnienie ekologiczne, które dominuje nad naszym czasem i główne wyzwanie, na które muszą odpowiedzieć organizacje ochrony środowiska. Woda jest jednym z najważniejszych surowców w Algierii. Ze względu na jego znaczenie niezbędne jest poznanie jego wrażliwości na zmiany klimatu. W Algierii wrażliwość na zmiany klimatyczne wyraża się w kilku aspektach: eksplozja demograficzna, prawdopodobna redukcja spływów wody, niedobór zasobów, degradacja infrastruktury hydraulicznej, zagrożenia na mokradłach ... itd. Staw czoła tej sytuacji, Algieria dostosował środki ilościowe i jakościowe w ramach trwałego zarządzania tym nieocenionym zasobem na przyszłość.

Słowa kluczowe: zmiany klimatyczne, woda, podatność, strategia adaptacyjna, Algieria

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