

## Chapter 2

# Climate Change Impacts in the Maghreb Region: Status and Prospects of the Water Resources

L. Oualkacha, L. Stour, A. Agoumi and A. Kettab

**Abstract** The fifth report of the Intergovernmental Panel on Climate Change reiterates that the Maghreb region is severely threatened by climate change and seems to be one of the most vulnerable regions in the world regarding its water resources responses to the changing climate conditions. The effects of climate change could significantly increase the relevance of water development policies, given that economic growth of the majority of Maghreb countries is closely related to water resources and contributes strongly to the socioeconomic balance and gross domestic product. In the Maghreb region, the need to mainstream climate change into development plans is already recognized and highlighted; the new constitutions have already adopted the sustainable development concept, which opens opportunities for improvement and protection of natural resources. Over the last decades, countries have tried to overcome water stress and scarcity by improving water policy and strategy, infrastructure development, economy of water use, wastewater, and desalinization, among others. However, the great challenge within the Maghreb region is mainstreaming climate change issues into development planning in the contextual framework of the water–energy–food security nexus, whose components are strongly interdependent. The aim of this paper is to analyze the impact of climate change on the water sector in the Maghreb region (Algeria, Morocco, and Tunisia) by means of a SWOT analysis (SWOT standing for Strengths,

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Weaknesses, Opportunities, and Threats) and to make recommendations on how to improve climate change mainstreaming into water development plans within the region.

**Keywords** Climate Change • Water resources • Adaptation • Orientations • Maghreb

## Introduction

In the Maghreb region, water resources are characterized by irregular distribution in space and time. Climate data indicated that during the twentieth century a temperature increase of 1 °C occurred (Stour and Agoumi 2007), with a pronounced warming trend during the last 40 years and a net increase in the frequency of droughts and floods (Moujahid et al. 2014).

Based on the results of the fifth report of the Intergovernmental Panel on climate change, the Maghreb region is threatened by climate change and seems to be one of the most vulnerable regions in the world regarding water resource responses to climate change. The effects of climate change could influence the viability and relevance of water development policies, given that economic growth and development of the majority of Maghreb countries are closely related to water resources that contribute strongly to the socioeconomic balance and gross domestic product.

Models available for the Maghreb region project that droughts will be more frequent, more intense and longer lasting (Elrafy 2009). Model simulations also announce a drop of 4–27% in annual rainfall with more frequent torrential rain (UNEP 2008); this will increase the competition for water within the Region, carrying the risk of conflicts and can represent strong push-factors for migration.

The World Bank and United Nations experts in 1995, estimates water availability at about 605 m<sup>3</sup> per capita per year in Algeria, 758 m<sup>3</sup> per capita per year in Morocco and 418 m<sup>3</sup> per capita per year in Tunisia (Abdessamad 2005). Therefore, the Maghreb countries (Algeria, Morocco, and Tunisia) have per capita water availability of less than 1000 m<sup>3</sup>, the threshold for the water-poverty level.

Hydraulic infrastructure development was a priority for the Maghreb governments to cope with droughts and floods in the last decades, hence, today available water resources are already mobilized at a rate exceeding 75% in Morocco (in 2007) and 80% in Tunisia (in 2000) (Desjardins 2010). Agricultural water consumption absorbs more than 80% of the total water demands in Morocco (88%) and Tunisia (90%), and about 59% in Algeria (Abdessamad 2005).

Droughts in rural areas associated with water scarcity enhance push-factors for migration into cities where today more than 60% of the total population are living (Agoumi 2003); this will increase the trend of urbanization and aggravate the socioeconomic conditions.

The Maghreb countries have undertaken numerous efforts to respond to water scarcity and improve groundwater management by adopting water economy use

strategies and plans (Green Plan in Morocco). In Tunisia, wastewater reuse for irrigation was already initiated in 1960 in the Plain of the Soukra, and 800 million cubic meters of water sewage are currently treated and reused for irrigation in Algeria (Lachkar 2015). Many countries in the region have adopted sea water desalinization to secure water supply in the coastal cities (Algeria's production of sea water desalinization is about 825 m<sup>3</sup>/day in 2015 (Taibi 2012).

The objective of this paper is to analyze the impact of climate change on the water sector in the Maghreb countries. Analysis is focused on the countries that have already adopted a water adaptation strategy and plan to combat climate change impacts namely: Algeria, Morocco, and Tunisia. The SWOT method is used to undertake this analysis and make recommendations on how to improve climate change mainstreaming into water development plans within the region.

## Methodology

The SWOT analysis is focused on the current state of the water resources in the region with a view of climate change impacts; it is used to identify internal strengths and weaknesses, as well as external opportunities and threats within the region with regard to strategic tools and measures for mainstreaming climate change adaptation. The analysis also identifies progress made in institutional, regulatory, technical, and governance aspects. This will permit to make recommendations for promoting and improving business adaptation within the region.

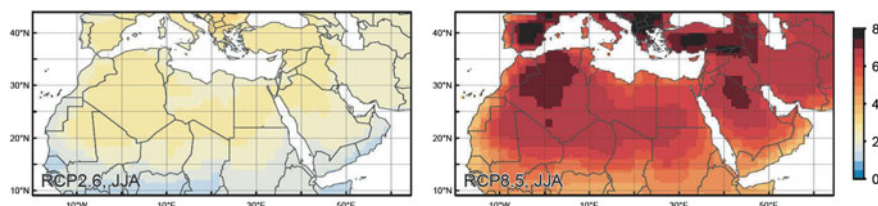
SWOT analysis is based on the following components:

- Collection of official strategic documents (National Strategy and Plan for mainstreaming adaptation, National Communications to the United Nations Framework Convention on Climate Change, etc.),
- Identification of SWOT aspects with a view to institutional, regulatory, technical, and governance issues related to water management.
- Consultation with a group of national and regional experts to validate the results of SWOT analyses.

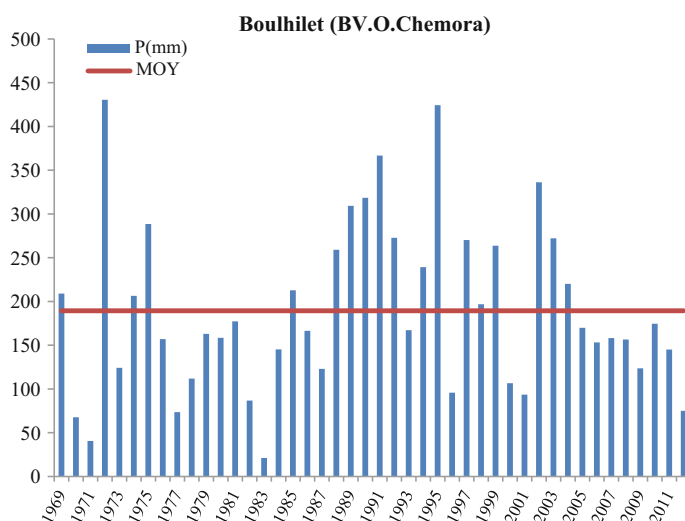
## Climate Change Impacts on Water Resources in the Maghreb Region

Climate change is likely to result in less rainfall, increasing temperature and frequency of droughts and floods. These effects increase water stress through reduced water availability quality groundwater management.

Projections developed for the Maghreb region (national communications of Algeria, Morocco, and Tunisia) depict trends of a decrease in rainfall and a gradual



**Fig. 2.1** Evolution of the average temperature (°C) of June–July and August during the period 2071–2099 relative to the 1951–1980 period, results of the models RCP2.6 (2 °C world, *left*) and RC8.5 (4 °C world, *right*) (World Bank Group 2014)

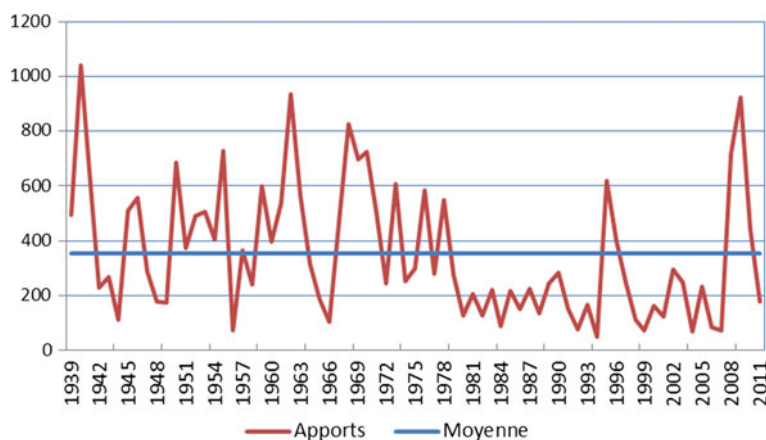


**Fig. 2.2** Evolution of annual rainfall of Boulhilet station (Chemora basin) in Algeria (Tatar 2014)

increase in the monthly average temperature in the Maghreb area. The results in Fig. 2.1 of the models RCP2.6 (2 °C world, *left*) and RC8.5 (4 °C world, *right*) show the evolution of average Temperature (°C) for June–July and August during the period 2071–2099 relative to the 1951–1980 period. These results show that average temperature will increase by 2–8 °C during 2071–2099 within the region (World Bank Group 2014).

In Algeria, the study of rainfall recorded in hundreds of weather stations (period 1951–1980 and 1961–1990), shows a succession of episodes of excessive and deficient rainfall compared to normal documenting great variability (Hassini et al. 2011). The analysis of rainfall data in Fig. 2.2 demonstrates annual variability and irregular rainfall with excessive and deficit episodes recorded in the Boulhilet station, Chemora basin (Tatar 2014).

In Morocco, the analyses carried out under the “National Water Strategy” show that most basins will experience more water stress by 2030 and water flow at dams



**Fig. 2.3** Evolution of water flow at El Kansera dam during 1939–2011 (Secrétariat d’Etat chargé de l’Eau au MAROC 2009)

will continue to decrease (SEE 2009). Figure 2.3 shows a decrease of the water flow at El Kansera dam, especially during 1980–2011 (SEE 2009).

Tunisia also faces the effects of accelerated sea level rise; in fact, Tunisia is among the top 10 impacted countries in terms of population affected and GDP losses due to the accelerated sea level rise (Dasgupta et al. 2007). Hence, Tunisia will have to absorb and compensate for multiple climate change effects. Changes will be noticed in the productivity of fisheries and fishing areas. The most exposed sites are: the Bizerta lagoon, GaraetIchkeul, the Ghar el Melh lagoon, the Kalaat el Andaloussebkhas, the wetlands and lagoons in the Gulf of Gabès, the archipelagos and islands of Kuriat, Kneiss, Kerkennah, and Jerba and the entire sandy beach.

## Water Strategies and Plans in the Maghreb Countries

During the last decades, the water sector was prioritized in the National strategies and plans; however, the great challenge within the Maghreb region is mainstreaming climate issues into development plans, especially in water policy and the water–energy–food security alliances. The Maghreb countries have tried to carry out transitions to adaptive management; focusing on some specific aspects as highlighted in Table 2.1.

**Table 2.1** Measures for water adaptive management

Aspects	Measures for water adaptive management
Governance	Water management decentralization (River Basin Agency)
Legal and institutional	Creation of planning and coordination structures at national and territorial levels
	Adoption of water laws
	Institutional reforms
	Tariff reforms
Infrastructure	Infrastructure for conventional and unconventional water resource development and management (dams, wastewater reuse, water desalination, rainwater management)
Integrated Water Resources Management (IWRM)	IWRM included in development plans at national and territorial levels
	Flood and drought plan management (Morocco)
	Strategic plan for groundwater management
	Transboundary water cooperation (North-Western Sahara Aquifer System shared between Algeria and Tunisia)
Information management	Economy of water use (Morocco's Green Plan)
	Climate data, observations and forecasting networks
	Early warning systems
Financing	Public–Private Partnership (Partnership model for water desalination in Algeria)

## SWOT Analysis

The SWOT analysis results are given in Table 2.2.

**Table 2.2** SWOT analysis of climate change adaptation in the Maghreb region: Focus on the water resources

Factors that contribute to achieving adaptation goals	Factors that inhibit climate change mainstreaming in water development policies
Strengthens	Weakness
Adoption of the sustainable development concept through the new constitutions in Algeria, Morocco, and Tunisia	Difficulties to operationalize the National Strategies and Plans for Water to adapt to climate change
Development of the water national strategies and plans to adapt to climate change (National Plan against Global Warming adopted on 2009 in Morocco; National Strategy on climate change adopted on 2012 in Tunisia)	Lack of institutional coordination
Targeted research programs	Lack of engagement and involvement of stakeholders and partners
Integrating Water Resources Management process	Lack of mainstreaming climate change into water legislation and regulations
	Lack of structured Monitoring and Evaluation systems
	Weak local and territorial institutions and structures

(continued)

**Table 2.2** (continued)

Factors that contribute to achieving adaptation goals	Factors that inhibit climate change mainstreaming in water development policies
Structures for consultation and coordination (Water and Climate Council in Morocco; National Water Council in Tunisia) Decentralization of institutional, regulatory and administrative water management (River Basin Agency in Algeria and Morocco) Hydrological and climatological data and information (National Meteorology Direction in Morocco and National Institute of Meteorology in Tunisia)	Difficulties in implementing regulatory and institutional reforms; especially for water tariffs and taxes Gaps in financing mechanisms and instruments Low human resource capacity building and trained staff Difficulties in integrating drought and flood plans into territorial development plans Short-term planning (2020 or 2030) in contrast to the climate change long-term impacts (2050, 2090)
Opportunities	Threats
International Cooperation and Climate Funds Ratification of the United Nation Framework of Climate Change Convention and the Kyoto Protocol by Algeria, Morocco, and Tunisia Global and rapidly increased exchange of climate change knowledge and information Lessons learned from the Integrating Water Resources Management process at national, regional and international levels	Conflicts for water use at transboundary level (Madjerda shared basin and the shared Aquifer) Diversion of political attention and will toward other immediate concerns and business influenced by international and regional factors

## Recommendations

Guidance and recommendations to consider in response to climate change, climate risk, and their impacts on water resources in the Maghreb region are summarized as follows:

- Mainstreaming climate change into water development plans with a view of integrating the “green economy” process and the Post 2015 sustainable development water agenda;
- Develop a long-term vision and operational strategy and planning to mainstream climate change into national and regional water development agenda, ensuring the readjustment of climate change adaptation measures, approaches, and no regret investments that allow to adjust gradually and gain a better understanding of the new climate change realities based on the new and improved data from climate projections;
- Create or strengthen expertise and discussion on uncertainty management (communication and consultation on the risks and uncertainties and promote training of water managers in these new approaches);

- Create or strengthen the climate change center of researches with a view to improve institutional coordination, climate observations (qualitatively and quantitatively), climate projections; research on modeling, sharing experiences, and dissemination of information and data both at the national and local levels;
- Promoting lessons learned from the past experiences of integrating water resources management into development planning and initiate adequate large-scale programs of awareness, communication, training, and education with a focus to climate change;
- Consider, the benefit of international support and opportunities through international negotiations and climate funds;
- Integrate the costs of climate change adaptation into financial mechanisms within the national and territorial plans and promote the public–private partnership;
- Integrate flood and drought plans into development planning processes at national and territorial levels;
- Continue to mobilize unconventional water, ensure efficient water use and institutionalize water quality and groundwater management;
- Create a Maghreb platform to share information, lessons and experiences, and monitoring of water vulnerability with a view to create and institutionalize a climate change water champion within the region;
- Set up a Monitoring and Evaluation system for tracking progress in mainstreaming climate change in water development plans.

## Conclusion

The entity of water resources in the Maghreb region requires sustainable management, especially in a future context marked by climate change. National Water Strategies and Plans will contribute to improve this sustainability. However, the implementation of the strategies and plans requires a number of governance and institutional reforms, economic and financial mechanisms, monitoring and evaluation tools, and communication and capacity-building measures.

Sustainable development and climate change mainstreaming require a continuous readjustment of strategies and measures that consider regional and local climate conditions. The success of this readjustment depends on a better coordination and a good understanding of the water–energy–food security nexus in the context of climate change.

The developed strategies are focused on the short and middle terms (2020–2030); however, climate change mainstreaming should consider short, middle but also long-term planning and interventions including necessary investments for adaptation.



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