Algerian Journal of Environmental Science and Technology
Avril edition. Vol.3. N°1. (2017)
ISSN : 2437-1114
www.aljest.webs.com

An Integrated Development of the Water and Energy Sectors to face Climate Change in the Maghreb Countries: Situation and Prospects

L. Oualkacha[1], L. Stour [1], A. Agoumi [2], A. Kettab [3]
[1]Department of Process and Environment Engineering: Faculty of Sciences and Technologies of Mohammedia, Hassan II University of Casablanca, Casablanca, Morocco.
[2]Department of Hydraulic, Environment and Climate: Hassania School of Public Works, Casablanca, Morocco.
[3] Laboratory Research in Water Science: LRW-Water/ENP National, Polytechnic School El Harrach, Avenue Hassen Badi, Algiers, Algeria

Corresponding author: Email: lailaoualkacha@gmail.com; Tel: +212 6 62 05 93 27.

ARTICLE INFO

Article History:

Received ***: 01/01/2017***
Accepted ***:03/03/2017***

***Key Words*:**

Water;
Energy;
Climate Change;
Nexus;
Maghreb.

ABSTRACT/RESUME

Abstract: *The results of the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) show that the Maghreb region is threatened by climate change, which 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. To face this threat, the Maghreb countries (Morocco, Algeria and Tunisia) have adopted climate change adaptation strategies that highlighted many alternatives to resolve water scarcity and the threat of climate change.*

However, the adopted alternatives and solutions include economic irrigation options and non-conventional resources with high energy consumption such as water desalination and water reuse. Therefore, developing these alternatives will increase the energy consumption in the water sector.

The aim of this paper is to analyze the strategic issues of the integrated development of the water and energy sectors, as well as the level of interactions and nexus between water and energy that are considered in the sectors policy management and planning in the Maghreb countries. The analysis is focused on the case of Algeria, Morocco and Tunisia and aims to identify some strategic recommendations and orientations to promote an integrated development of the water and energy system. The SWOT analysis (SWOT standing for Strengths, Weaknesses, Opportunities and Threat) is used to undertake this analysis.

I. Introduction

In the Maghreb countries water availability is significantly below the "scarcity threshold" of 1,000 m^3 per year adopted by the United Nations. This alarming status is compounded by the climate change threat. Indeed based on the results of the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), the Maghreb region is threatened by climate change, which 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.

To face water scarcity, countries have built diverse infrastructures and created water institutions. In addition, the Maghreb countries (Morocco, Algeria, and Tunisia) have adopted climate change adaptation strategies that highlighted many

alternatives to resolve water scarcity and the threat of climate change.
The adopted alternatives and solutions include economic irrigation options and non-conventional resources with high energy consumption such as water desalination and water reuse. In addition, switching towards efficient technological options and modern irrigation systems increase the energy needs in the agricultural sector.
Therefore, developing non-conventional resources and modern irrigation systems will increase the energy consumption in the water sector and the development of the water sector will be strongly related to the energy sector development. Furthermore, the interactions and synergies between the water and energy sectors require an integrated planning policy and more collaborative mechanisms between these sectors.
In this context, the Maghreb countries (Morocco, Algeria, and Tunisia) have choose a new options for the development of the renewable energy, especially in Morocco with the adoption of the new strategy that aims to secure the energy supply, ensuring accessibility of energy at the lowest possible cost and promoting energy efficiency in all economic and social activities.
The aim of this paper is to analyze the strategic issues of the integrated development of the water and energy sectors, as well as the level of interactions and nexus between water and energy that are considered in the sectors policy management and planning in the Maghreb countries. The analysis is focused on the case of Algeria, Morocco and Tunisia. It proposes ways to improve the interactions and synergies of this system. In addition, the analysis will permit to identify some strategic recommendations and orientations to promote an integrated development of the water and energy system considering interactions and synergies between these sectors. The SWOT method is used to undertake this analysis and make recommendations on how to improve the water–energy synergies under climate change threat in the Maghreb region.

Methodology

The SWOT analysis is focused on the current state of interaction between water and energy under climate change threat; 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 energy - water synergies into development plans.
SWOT analysis is based on the following components:

- Collection of official strategic documents (National Strategy of water, National Strategy of energy and National Communication to the United Nations Framework Convention on Climate Change (UNFCC), National strategy for adaptation to climate change, etc...),
- Identification of SWOT aspects with a view to institutional, regulatory, technical and governance issues related to water and energy sectors.

II. Impact of the climate change on the water-energy system in the Maghreb countries

The Maghreb countries are facing many challenges related to a decrease in renewable water resources. Moreover, water resources are characterized by irregular distribution in space and time. Historical data confirm that during the 20th century a temperature increase of 1°C occurred [9], with a pronounced warming trend during the last 40 years and a net increase in the frequency of droughts and floods [6].
Projections developed by the World Bank [10], show that average temperature will increase by 2-8°C during 2071-2099 within the region. These increased temperature will affects water stress and reduce water availability. In addition, the limitations and problems due to the impact of climate change in the Maghreb countries are related primarily to decreased water resources. The previsions adopted in the national communication of Morocco and Tunisia show that rainfall will be decreased in average of -5% to -40% in 2070 for Morocco [8] and from -10% to -30% in 2050 for Tunisia [5].

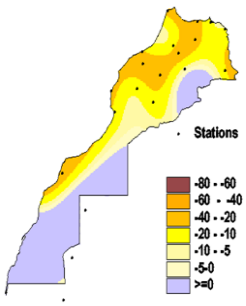

Figure 1. *Decreased of the average rainfall during 2041-2070, Compared to 1961-1990 in Morocco [8]*

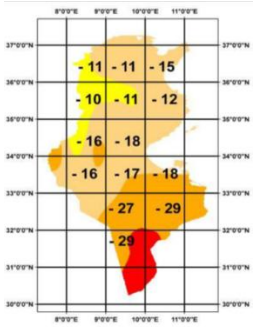

Figure 2*. Decreased of the average rainfall for -10% to -30% on 2050 in Tunisia [5].*

Case study of Chéllif river basin in Algeria shows that climate change will affect water flow which will be decreased by - 34% to -40% by 2020 and the decreased flow will attend -60% to -78% by 2050 respectively for the low and high scenario [7].
Furthermore, climate change has an impact on the hydro-energy production, reflected in decreased water storage and energy production across dams. Indeed, in Morocco, climate change impact leads to

an energy production shortfall of almost 1,200 KWh (50% of the objective established in the historical studies) and limited intensification of agriculture, hence low returns on the capital invested in water infrastructure [3].

III. Energy needs for water production and water needs for energy production

III.1. Energy needs for water production

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 the study countries. Agricultural water consumption absorbs about 59% of the total water demands in Algeria, about 88% in Morocco and about 90% in Tunisia [1].

Furthermore, in the tree study countries, National Strategy for Development of Water Resources gives a significant place to the exploitation of non-conventional water resources.

In Algeria National Water Resources Strategy estimates the volume of water that could be exploited from non-conventional water resources at over 2 billion cubic meters including sea water desalination which is already producing 2260000 m3 per day [2]. Furthermore, the national strategy estimates the contribution of the seawater desalination at approximately 1000 Mm3 by 2030 in Algeria [7]. The contribution of the sea water desalination is estimated at approximately 400 Million m3 by 2030 in Morocco [3].

The exploitation of non-conventional water resources will depend on energy production, indeed electrical energy is used mainly for the operation of pump and injection stations for drinking, industrial and irrigation water, drinking water treatment plants and activated sludge wastewater treatment plants. It is also used for lighting and for pumping in marine outfalls. The table 1 below shows the energy needs to produce water in the Maghreb countries.

The table 1 shows that the predicted consumption of energy in the water sector will be increased in the coming years. Thus the study countries have to face this increased consumption that will affect economic and business development.

III.2. Energy consumption and water needs for energy production

Hydropower has been a key component in the design of water infrastructure, particularly in Morocco (Dam of El Makhazine and dam of Bin El Ouidane) and Tunisia (Dam of Barabra and dam of Sidi El Barrak).

The total energy consumption of Algeria in 2012 was about 50.9 million tons of oil equivalents (TOE) and will increase to 91.54 million TOE in 2030 [2]. The energy system in Algeria is still relying mainly on natural gas and fossil fuel resources. However, the national energy policy calls for increasing the contribution of renewable energy in the national energy balance [7]. National policy in Algeria, proposed a gradual rise of renewable energy with a target of achieving the contribution of renewable energy at around 6% by 2020 and 30% by 2050 [7].

Morocco currently imports over 95% of its energy supplies due to its own minimal resources. By 2030, primary energy demand will be between 35 and 40 Million TOE [3]. Moreover, between 1995 and 2008, electricity demand increased from 10,711 GWh to 24,004 GWh, reflecting an average annual growth rate of approximately 6.4%. To meet these multiple challenges, a new energy strategy was developed with the aims to set up an achievable energy efficiency potential of 12%, to be reached by 2020 and the share of solar, wind and hydroelectric power will represent about 42% of installed capacity (14,580 MW) compared to 26% in 2008 (5,292 MW) [3].

In Tunisia, currently, renewable energy plays a minor role in the energy supply; Tunisian energy supply is still dominated by fossil fuels like oil (35%) and gaz (63%) which partly have to be imported [4]. Renewable energies account for only 2 %. In order to increase the renewable energy, the Tunisian Government issued a strategic plan "Plan Solaire Tunisian" in 2009, which envisages the installation of 4.7 GW renewable power plant capacities and a 40% renewable share by 2030 [4].

Water is used in the energy sector mainly for cooling thermal power plants, turning turbines at hydroelectric plants, operating and maintaining energy generation facilities. In Morocco, the water abstraction for cooling thermal power plants is estimated to be about 1,200 Million m³ in 2030 compared to the current volume of 172 Million m³ [3].

IV. Measures adopted to improve water –energy synergies in the Maghreb region

During the last decades, the water and energy sectors were prioritized in the National Strategies and Plans; however, the great challenge within the Maghreb region was improving the synergies of the water–energy system under climate change threat. The Maghreb countries have tried to carry out transitions to adaptive management, focusing on some specific aspects as highlighted in the Table 2 below.

V. SWOT Analysis

The table 3 below highlights the features of the SWOT analysis focusing on factors that can improve the integration of the water-energy system or inhibit this integration.

Table 1. *Energy needs to produce water in the Maghreb countries*

Countries	Energy needs to produce water in the Maghreb countries
Algeria	Water sector in 2011 consumed around 4983 GWh. This consumption is set to rise to 16 090 GWh by 2030 (0.7-0.8 kWh/m3), more than three times the consumption of 2011 [2].
Morocco	Water sector currently consumes around 1450 GWh. This consumption is set to rise to 6150 GWh by 2030, more than four times current consumption [3].
Tunisia	Water sector consumed 3826 Gwh/year on 2010. The energy balance is in deficit since 2000, since the government subsidizes the energy sector and the energy subsidies have increased from 600 Million of Tunisian Dinar (MTD) in 2010 to 3500 MTD in 2012 (6 times) [4].

Table 2. *Measures for improving Water - Energy Interactions in the Maghreb Region.*

Aspects	Measures for improving water - energy interactions in the Maghreb Region
Governance	- New energy strategy based on sustainable development approach (New renewable strategy in Morocco and Solar Plan of Tunisia).
Legal and Institutional	- Creation of planning and coordination structures at national levels (National Office for Water and Energy -ONEE - in Morocco and the Tunisian Company of Electricity and Gas - STEG renewable Energy in Tunisia). - Adoption of energy laws (Energy law in Algeria, Morocco and Tunisia). - Institutional reforms that combine water and energy institution: ONEE in Morocco. - Adoption of Tax: The Government of Algeria has introduced a tax on water consumption at the oil and gas plants that required fresh water for production. The revenue from this tax is available on the national fund to finance protected aquifers projects. - Creation of special structure: The Moroccan Renewable Energy Centre.
Infrastructure	- Building dams with hydro-power production design: In Morocco, the plants associated with dams have a hydro-power capacity of 1729 MW [3].

Table 3. *SWOT Analyses*

Factors that contribute to improving the integration of water- energy system	**Factors that inhibit the integration of water-energy system**
Strengthens	**Weakness**
- The new constitutions have already adopted the sustainable development concept, which opens opportunities for the water-energy sustainable integration. - Political will for switching to renewable energy: especially in the case of Morocco and Tunisia. - New energy strategy switching on renewable energy (Morocco and Tunisia). - Targeted research programs, especially on the issues of the reduction of the cost of desalinization (Algeria and Morocco). - Creation of structures for consultation and coordination (Moroccan Renewable Energy Centre).	- Lack of research that could lead to innovation. - Difficulties to operationalize the new water and energy strategies. - Lack of institutional coordination. - Lack of engagement and involvement of stakeholders and partners. - Lack of structured Monitoring and Evaluation systems; - Difficulties in implementing regulatory and institutional reforms; especially for water and energy tariffs and taxes. - Gaps in innovative financing mechanisms. - Lack of capacities for implementing water-energy nexus approach. - Poor integration of energy and water efficiency in key sectors of the national economy. - Lack of good visibility for potential investors or deployment of adequate financial mechanisms. - Limited technology transfer and lack of exchanging good practices at regional level.
Opportunities	**Threats**
- Potential world market for: wind, solar thermal and photovoltaic technologies. - Global and rapidly increased exchange of expertise and technologies for improving the water-energy synergies. - Environmental awareness for fighting global warming. - Global financing process to support green growth.	- Conflicts for water use at transboundary level (the shared basin of Madjerda and the shared aquifer of the North Western Sahara -SASS). - Limited government incentives and political will towards other emergency problems and business influenced by international and regional factors (Fuel crises and its impact on Algeria economy). - Uncertainty and extreme volatility of fossil fuels. - Marginal contribution of foreign funds.

VI. Conclusion

The strong interaction between energy and water will demand an equally strong policy that considers all aspects of this interaction were water use is a pillar of overall sustainability of a particular energy system. This interaction need to be implemented at all levels including policy makers, researches, stakeholders, academic, civil society and private sector. The nexus approach presents an opportunity for Maghreb countries to set up effective governance of the water and energy sectors, considering natural, social and environmental aspects. This will lead to making strides towards economic growth.

VII. Recommendations

After the above analyses, the recommendations to improve the interaction between water and energy in the Maghreb region can be as follows:

- Integrate water-energy nexus approach into national water and energy policies with defined and targeted contributions and programs.
- Implementing water and energy national strategy considering nexus approach to promote coordination and collaboration across sectors, based on national information systems and a high level ministerial coordination.
- Improve the integration of the nexus approach by the adoption of a nexus knowledge platform to enable information sharing.
- The implementation of water -energy nexus can be done through a national nexus steering committee comprised of policy makers, researchers, private sector, civil society and non-Governmental organizations.
- Promote energy efficiency and the improved wastewater management.
- Strengthen relevant national institutions.
- Promote capacity building and public awareness programs.
- Initiate new financial mechanisms and increase private sector investments in renewable energy and non-conventional water re-use.
- Provide needed support for research and technology transfer of renewable energy and non-conventional water re-use.
- Reduce the large amount of government subsidies given to natural gas and oil.
- Set up regional technology platforms for exchanging innovative technologies and good practices dedicated to energy efficiency, renewable energy and water- energy nexus.
- Improve the integration into the Euro-Mediterranean market.
- Adopt international standards for solid, liquid and gas emissions in energy production with the objective to protect the environment and citizens' health.

VIII. References

1. Abdessamad, D. L'eau matière stratégique et enjeu de sécurité au 21èmesiècle. (2005).
2. Boudghene Stambouli, A.; Ait Mimoune, H.; Flazi S. A Review on the Water and Energy Sectors in Algeria: Current, Forecasts, Scenario and Sustainability Issues, University of Sciences and Technology of Oran, Algeria. (2016).
3. El Badraoui, M.; Berdai, M. Adaptation of the water-energy system to climate change: National Study-Morocco», Plan Bleu, UNEP/MAP Regional Activity Center. (2011).
4. IBFMER, "International Bureau of the Federal Ministry of Education and Research at the Project Management Agency". Tunisia summarizing report on the Determination of the Tunisian Innovation System with Special Focus on the Water and Energy Sector. (2013).
5. MET, "Ministère de l'Environnement de la Tunisie ". Stratégie Nationale sur le Changement Climatique, projet élaboré avec l'appui de la GIZ. (2012).
6. Moudjahid, M.; Stour, L.; Agoumi, A. Drainage urbain et changements climatiques: Limites de la modélisation. Article en cours de publication dans la revue internationale de l'eau «La Houille Blanche». (2014).
7. MSPE, "Ministry of Spatial Planning, Environment and Tourism". National Second Communication of Algeria. (2010).
8. SEE "Secrétariat d'Etat chargé de l'Eau au Maroc ". Stratégie Nationale de l'Eau. (2009).
9. Stour, L.; Agoumi, A. Sécheresse climatique au Maroc durant les dernières décennies. Revue Hydroécologie Appliquée, tome 16, p 215-232. (2007).
10. World Bank Group.Turn Down the Heat Confronting the New Climate Normal. p 113-159. (2014).

Please cite this Article as:
Oualkacha L., Stour L., Agoumi A., Kettab A., *An Integrated Development of the Water and Energy Sectors to face Climate Change in the Maghreb Countries:Situation and Prospects*, ***Algerian J. Env. Sc. Technology***, **3:1 (2017) 70-75**