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Water resources and their management under impact of climate change and users pressures in Kebir-West River basin (North-Eastern Algeria), using the WEAP model

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Abstract

Water is the factor of the humanity development, this resource of life threatened by human pressure and the effects of the nature to know the future climate change put the man in face of challenges for a rational management. The objective of this paper is to examine the likely impacts of a climate change on the water supply and demand and the resulting socioeconomic implications in the watershed of El Kebir West located in the north-east of Algeria under different scenarios applying the WEAP model. or an optimistic scenario of reference, the water resources of the basin could perfectly cover the requirements of different users. To that taking into account the impacts of climate change on these reserves, and the augment in the demand induced by the increase of populations and their activities, the region will suffer from water stress from the Horizon 2030, when demand exceeds 80 MCM of water and reach more than 136 MCM in 2050. Whereas, the supply will decrease from 70.8 actually to 66 MCM (million cubic meter) in 2050. This could be caused by a possible decrease in the storage of water. This stress could be avoided if we decide to a policy for the demand management, or may establish a state of balance of supply and demand by various tools of water management.

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Introduction

Water conflicts arise when the demand exceeds the available supply and its water allocation fails to meet the demand. This would be aggravated further by the intensified demands from the users and the increase in the frequency of these demands (Babel *et al*., 2005). Drinking water requirement will be multiplied by three around twenty five years and especially as they will represent practically 40 % of the mobilize resources at about 2025 (UNDP, 2009). The 21th century announces under the sign of a worsening of the water shortages, particularly in the western regions of the country in spite of the recourse to other forms of water mobilization (UNDP, 2009).

Thus, in order to avoid the present as well as future water conflicts between the competing demands, researchers and scientist have given increased emphasis in developing tools and techniques for improved management of the water resources (Gleick *et al*, 2009). The development of various models, which provide a good insight into the intricacies related to water allocations and balancing mismatch between supply and demand through integrated water management is therefore necessary (Nurul Nadiah *et al*, 2016).

It exists a set of software infrastructures of which we can consider that can allow services such as software of mathematical modeling (Math Lab1, Maple, Mathematica, etc.), platforms of simulation by discreet events (Any Logic, Simulink, DEVS), graphic environments of software development by components (Rational Rose, Win Dev), platforms multi-agents (Swarm, Repast among whom Sim Builder, Cormas, DIASFACET, MadKit), dynamics of equation++6nels systems (Ven Sim, Stella, ICMS, WEAP21). However, and for criteria of availability, expressiveness and presentation WEAP was chosen. The WEAP is already used in diverse country, including Germany, the United States, Mexico, Brazil, Morocco, Tunisia, Ghana, Burkina Faso, Kenya, South Africa, Mozambique, Egypt, Oman, Central Asia, Sri Lanka, India, Nepal, China, South Korea, and the Thailand (SEI, 2008).

Algeria undergoes at present an acute water stress. The World Bank considers that the current subsidy (lower than 1000 CM/inhabitant/year) will be only 430 CM/inhabitant/year in 2020. In Algeria, this model was applied in different regions: i.e. the east of the country to Souk-Ahras in Ouled Zaoui *et al* (2010), and the West to Chelif in APRM (2008) and Hamlat *et al*. (2013).

In the present paper we will aim to compare between the existing water resources and the current demands and their future tendency according to a reference scenario and others scenarios which take into account the quantitative effect of the climate change and uses growth on the future water supply in the El Kébir West River basin, using Water Evaluation And Planning WEAP model.

Material and methods

Study area

El Kébir West River basin is a part of the (Constantinois) central coastal, Northeastern Algeria. It situated between 36°30 N to 37°05 N latitude and 7°E to 7°45E. It covers a surface of 1865 sq km (Titi Benrabah *et al*., 2013).

This vast surface drained by the two rivers Emchekel and El Hammam in its upstream part, and El Aneb River and El Kébir-West River in downstream of basin (Fig.1).

The basin case of study is surrounded by the mounts of Djebel Edough in the Northeast, Djebel Alia (659 m of height) in the Northwest, the Djebel Taya (on 1208 m) in the Southeast and the mounts of Djebel Debegh (1060 m) in the Southwest. With a population density of 120 living by sq kilometer, characterized by its agricultural vocation with a total agricultural surface about 61000 hectare in 2014. And a mean growth rate of population for ten communes of study area around 1%, the region is subject to quite important demand for irrigation water (Titi Benrabah *et al*., 2013).

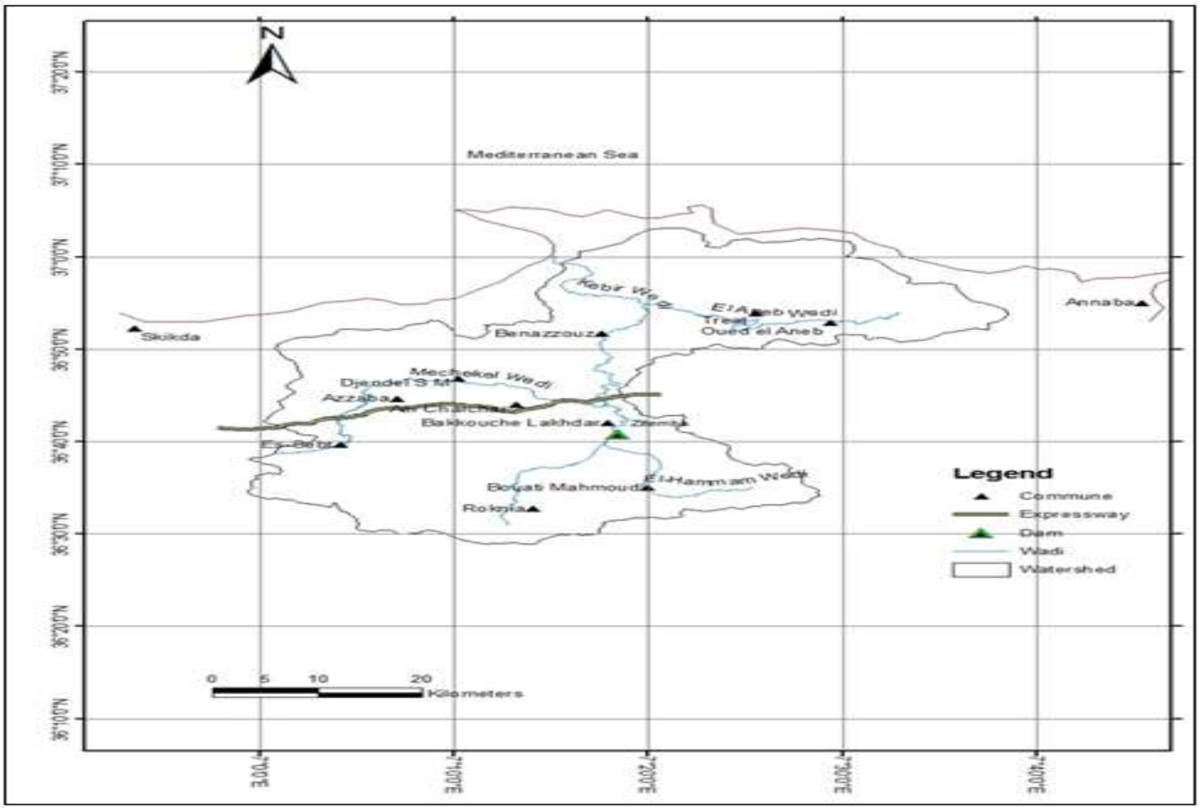

Fig. 1. Study area.

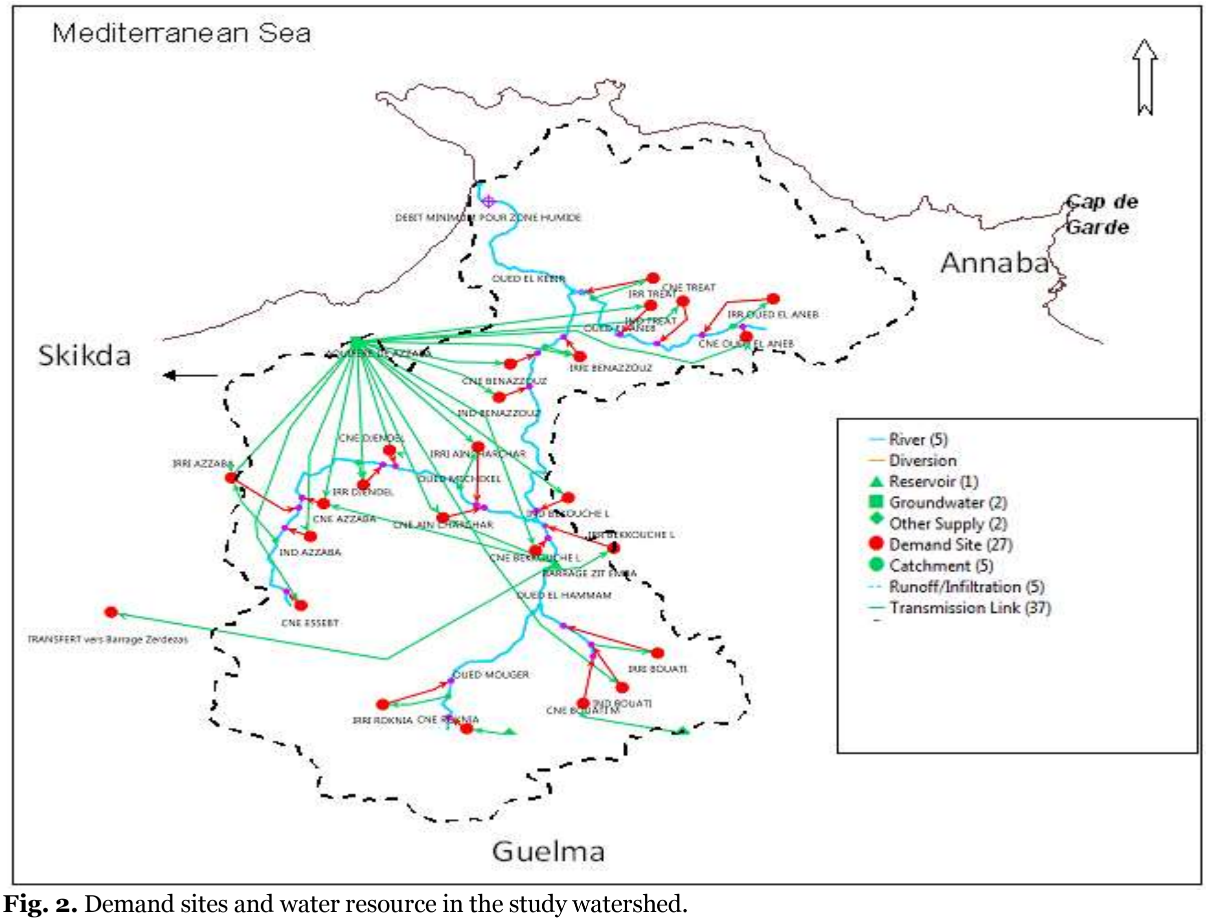

Fig. 2. Demand sites and water resource in the study watershed.

Materials

WEAP model was developed by the Stockholm Environment Institute (SEI), is software of evaluation of the specific water problems in a global frame. WEAP conducts a water mass balance of flow sequentially from upstream to downstream in a river system, considering water abstractions and water inflows. As part of the model setup, the parameters of water supply and demand systems, and their spatiotemporal variations and priority of access, are characterized. The model then optimizes water use in the basin using a linear programming algorithm to allocate water to the various demand sites, as for the demand priorities that range from one to 99, with one being the highest priority (Pennan *et al.*, 2015). At the same time, other data related to the study area in a current year: ie population, irrigated area and industries demand for water demand and groundwater, surface water supply. The obtained results by applying the WEAP 21 model in the El Kébir-West Wade basin are presented by cartographic and graphic forms by considering various scenarios.

Data input

Demand sites: it's about the three traditional users, the drinkable water demand, the agricultural water demand and the industrial water demand is shown in Fig.2. Domestic water Demand it was found that a number of inhabitant of 166822 and 187480listed respectively in 1998and2008 census (ONS, 2011), and a theoretical water usage per person about 150 liters per capita and per day.

Irrigated water demand: the agricultural activity represents the first consumer sector of the water in the basin, in particular in its low water period. The total agricultural area in 2014 is about 60922 hectares, among which only 8.59 % is irrigated, 66.86 % of this area is fed by intakes of water from the streams and the small dams restraints. The rest was supplied by wells and drillings in groundwater, table 2 present an irrigated area distribution in the study basin. The main irrigated cultures are the market gardening which occupies more than 85 % of the irrigated lands.

For the demand in water irrigation, we introduced the irrigated areas and the theoretical annual subsidy according to zones, which is 5000 CM by hectare by year (Mouhouche *et al*, 2004; Babel *et al*, 2005).

Industrially water demand: we arrange data of some industries situated in the basin, but there are no important industrial unities, the total water demand was found about 526800.

Surface water: The contrasted topography, the aggressiveness of the climate and the soft lithology allowed the installation of a dense river system, unfortunately only an old series of monthly flow registered in Ain Charchar hydrometric station covering the period going from 1985 to 1999 is available, with a mean flow of 3.71 CM/s. The average flow of streams is simulated by the WEAP model; it's estimated using the climatic data (precipitation, temperature, humidity …) of the study region. The Zit-Emba dam is realized on the El Hammam River. It presents a total capacity of 120 MCM and a volume settled by 43 MCM/y (million cubic meters per year). It allows converse the agricultural and domestic demand. Ten MCM of the water is transferred towards the Zerdezas dam, situated in the Saf-Saf adjacent watershed.

Groundwater: from a hydrogeological view, the region contains two aquifers; the shallow one is hosted in alluvial deposits and the deep one in the underlying alluvial formation. Both will be confused in the west side. The average capacity of the alluvial aquifer of the Wadi El Kébir West is 11.08 MCM. During dry period, the reserves decrease to 6.84 MCM (MRE, 2010), while it reaches 15.32 MCM at the end of the high tides period.

Scenarios simulation

Assumptions

Actual tendency: water resources are considered as constant and only the various demands increase in the future horizons according to the actual demographic growth. Temperature increase and precipitations decreases:

According to the results of the national project ALG/ 98/G31 (MAT, 2001), the Northeast Algeria did not escape the consequences of the global warming. According to both digital models UKHI and ECHAM 3 TR, we registered an increase of temperature ranging between 0,8 and 1,1°C and a decrease of the precipitation between 6,75 and 6,50 % before 2020, respectively. In 2050, the discharge of the streams of the catchment of the Constantinois-Seybouse-Melègue will decrease with 17 % because of the increase of the average temperature which will achieve 3°C. Also, water retention in the dams will significantly decrease (UNDP, 2009).

Uses pressure: In order to foresee the impact of possible population and its activities rate growth on the model, high growth was added to the model with a population growth rate of 3%, increase in irrigated lands of 2% and increase of the water demand in industry of 3%.

Demand management: According to the national report for water sector problematic related a climate impact on Algeria of UNPD in 2009, the better water management and the use of modern irrigation techniques would reduce these requests 20 to 30%. In addition, for drinking water sector, the loss rate can be reduced between 40 and 30% by the rehabilitation of disturbing water drinking network program. Water savings initiatives were taken into the calculation of the model (25% from municipals and industrial water and 30% from agricultural water at 2050) and the amount of water demand that can be reduced was translated in this scenarios. From precedents assumptions, five scenarios were simulated, Table 1 summarizes the hypotheses and resulted scenarios.

Results and discussion

Water storage

A sharp decrease in water reserves in the Zit el Amba dam (Fig.3), for climate change and uses pressure scenarios we arrive at the top inactive zone (20 MCM) on 2035, on 2040 for climate change scenario and on 2050 for uses pressure scenario. With an application demand management scenario, we can maintain the water level in the dam especially at medium-term, but, we observe a slight decrease on reserves at long – term.

Table 1. Assumptions used by scenario

Scenario	Hypotheses			
	Actual tendency	Temperature increase Precipitation decrease	Uses pressure	Demand reduce
Reference	X			
Climate change		X		
Uses pressure			X	
Climate change and uses pressure		X	X	
Demand management		X	X	X

For groundwater storage, a decrease is simulated by the model to 25 MCM for reference and climate change scenarios, for the scenarios found that user pressure the storage reach 22 MCM in dry period after 2049 (Fig. 4).

For demand management scenario losses storage was not exceed 2 MCM from 2015 at 2050.

Water demand

The annual water demand of three water users for the whole study area summed up over all scenarios are viewed in Fig.5, It can be seen from figure 5 that the annual total water requirement in the basin will be gradually increasing with the extension of planning period, from 78 MCM in 2015 to 85,6 MCM in 2050 for climate change scenario and reference scenarios, while the water demand for two scenarios ticking into account the uses pressure are projected to significantly increase to 136.78 MCM in 2050 resulted from living condition improvement, population growth and dramatically socio-economic development. On the contrary, the water demand is reduced slowly, partially because of promotion of water saving consciousness and improvement of water usage efficiency in all uses.

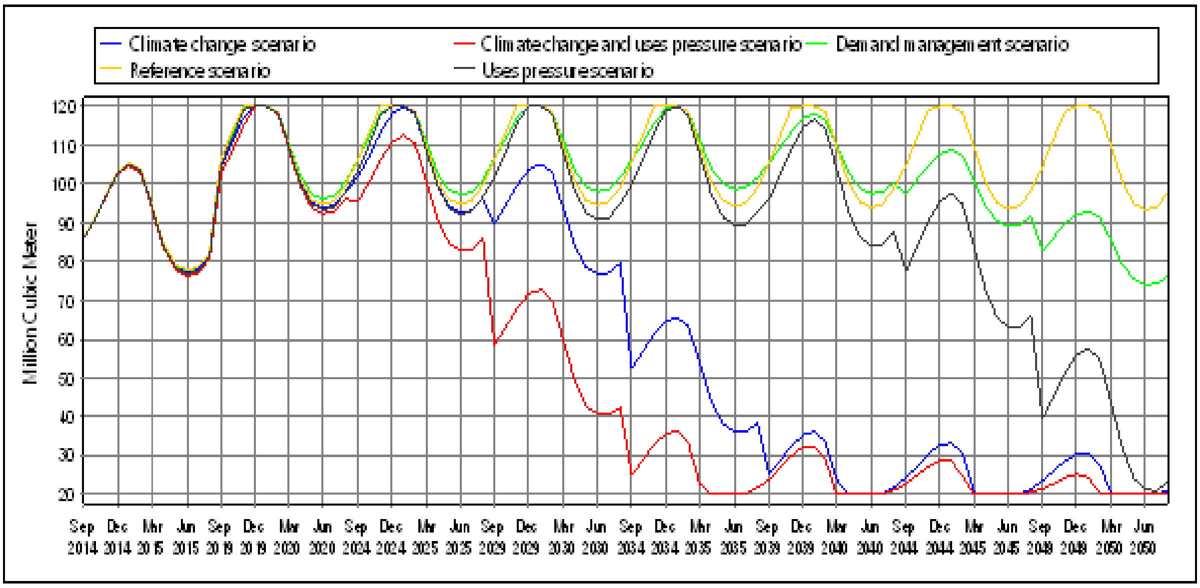

Fig. 3. Decrease in reservoir storage simulated by WEAP model.

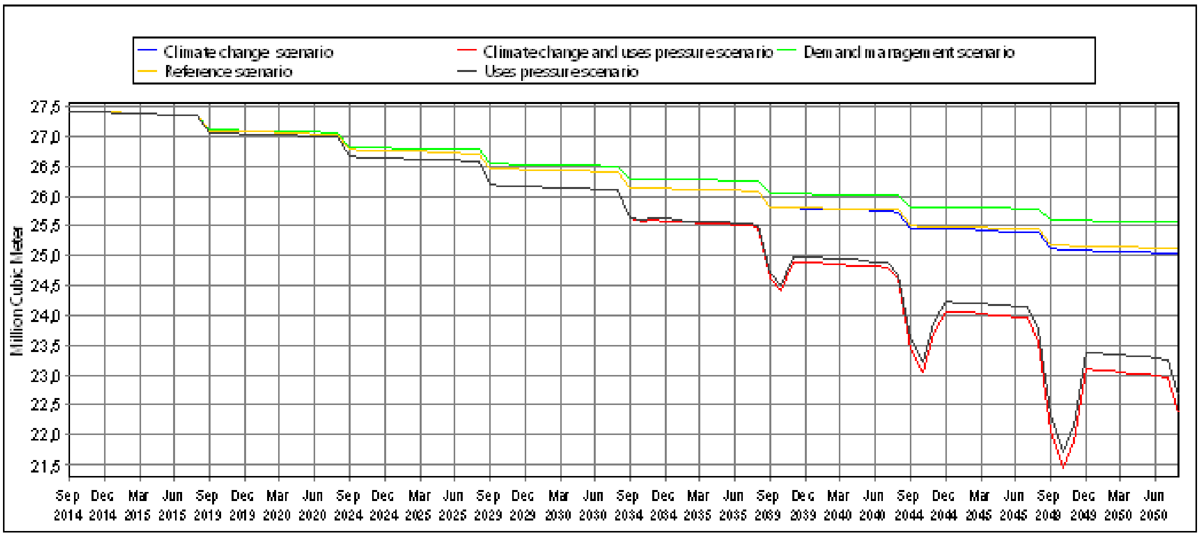

Fig. 4. Decrease on groundwater storage simulated by WEAP model

The climate change impacts on supply delivered are shown in Figure 6.Results indicated an increase of supply delivered from 70.85 MCM to 113.5 MCM under uses pressure scenario.

Whereas, they shows a decrease after 2030 from 84 to 70 MCM on 2035 and 66 on 2050 under climate change and uses pressure scenario.

For climate change, a small increase before 2035 then, this decreases due to due to a changing climate in any given year. So, under demand management policy, we can reduce the supply demand and consequently the supply delivered to 50.4 MCM.

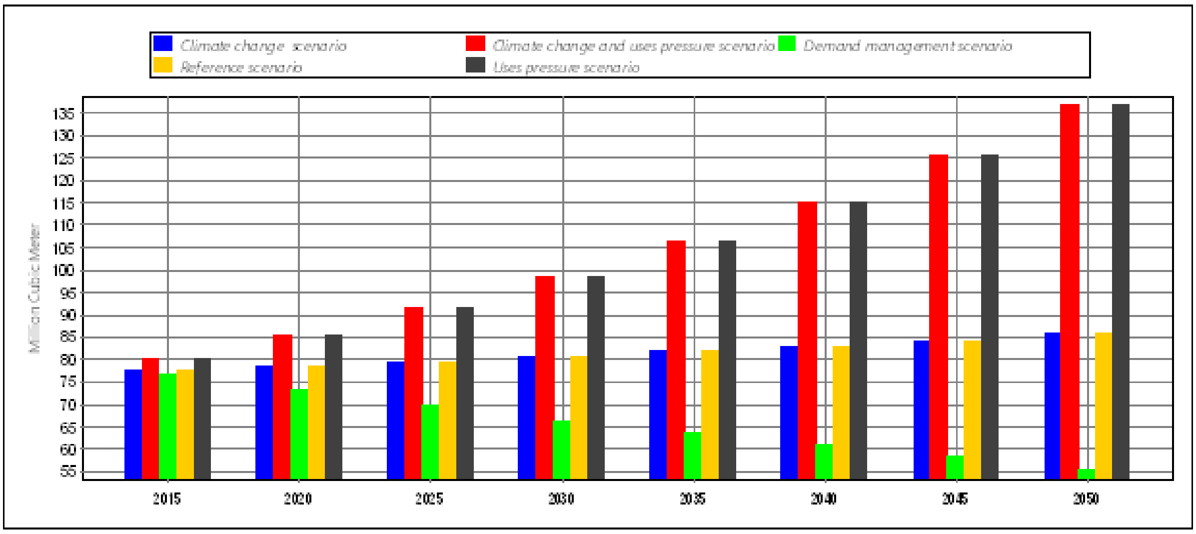

Fig. 5. Supply requirement in the basin simulated by WEAP model

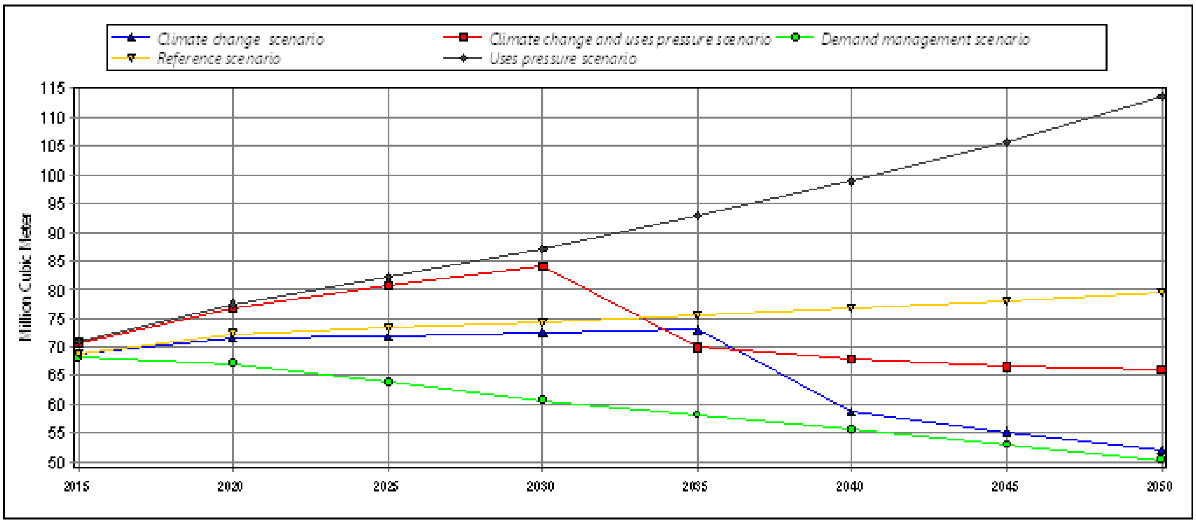

Fig. 6. Supply delivered for all users simulated by WEAP model

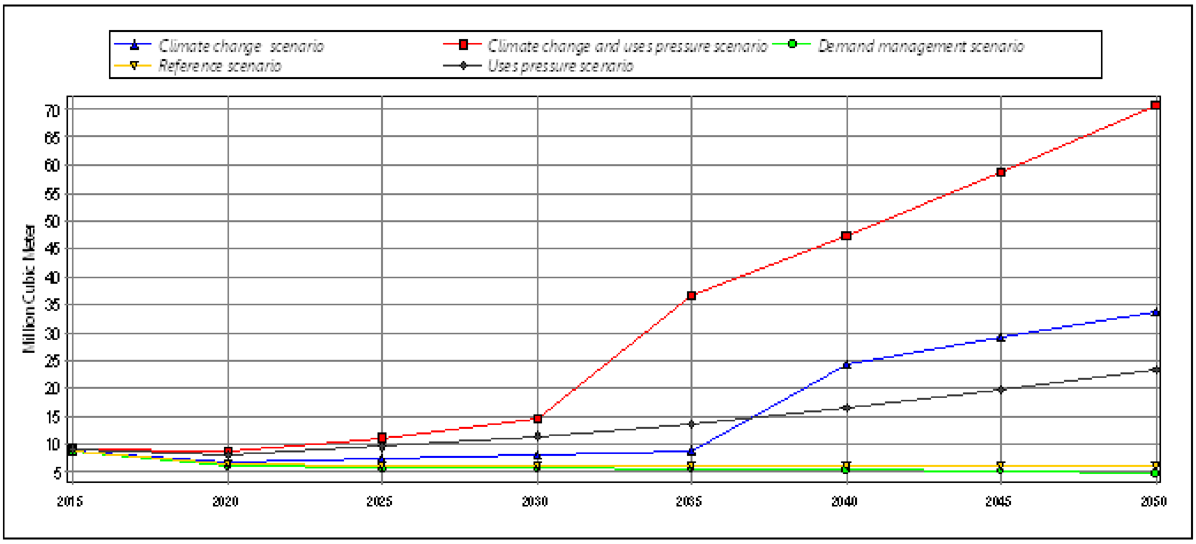

Fig. 7. Unmet water demand for all users, simulated by WEAP model

Unmet demand

Fig. 7 shows temporal (annual) occurrence of total unmet demand under the five development scenarios. For reference scenario, it is only 6 MCM, with climate change and uses pressure scenarios run together for the 2050, the unmet demand increases from 9.23 to 70.77 MCM.

As compared with demand management scenario, annual unmet demand for each water use is considerably reduces and become about 5 MCM.

Conclusion

WEAP simulated an impact for climate change and population increase on water supply. Five scenarios were developed in the present study. Under a reference scenario, a low increase in supply demand about 8 MCM from 2015 to 2050 can be covered by mobilizing more resources. Combining the two hypotheses (climate change and uses pressure scenario) we get the most pessimistic scenario or we will observe a considerable deficit which exceeds 70 MCM. Finally, a demand management scenario can reduce the deficit to less than 5 MCM per year.

References

Babel MS, Das Gupta A, Nayak DK. 2005. A Model for Optimal Allocation of Water to Competing Demands. Water Resource Management **19,** 693-712.

UNDP. 2009. Problématique du secteur de l'eau et impacts liés au climat en Algérie. 19 p.

Gleick HP, Cooley H, Cohen M, Morikawa M, Morrison J, Palaniappan M. 2009. The World's Water 2008-2009: The Biennial Report on Freshwater Resources. Washington DC: Island Press.

Nurul Nadiah MFH, Suhaimi AT. 2016.Modeling water supply and demand for effective water management allocation in Selangor, Jurnal Teknologi **78,** 15-20.

Stockholm Environment Institute (SEI). 2008. WEAP Tutorial website: www.weap21.org

Ouled Zaoui S, Snani S, Djebbar Y. 2010. Management of water resources at Souk-ahras region (Algeria) Fourteenth International Water Technology Conference, IWTC 14 2010, Cairo, Egypt.

APRM/National Focal Point Algeria. 2008. Report on the implementation of the national action programme on governance. APRM/National Focal Point Algeria (available at: http://www.algerianembassy.org.my/PDF/Rapport%20Gouvernance/rapport_gouvernance_an.pdf

Hamlat A, Errih M,GuidoumA. 2013.Simulation of water resources management scenarios in Western Algeria Watersheds using WEAP Model, Arabian Journal of Geosciences **6,** 2225-2236. http://dx.doi.org/10.1007/s12517-012-0539-0

Titi Benrabah S, Bousnoubra H, Kherici N, Cote M. 2013. Assessment and management of water resources in Northeastern Algeria: case of watersheds Kebir West Safsaf and Guebli rivers, Skikda. Applied Water Science **3,** 351–357. http://dx.doi.org/10.1007/s13201-013-0085-2

Pennan C, Luna B, Utsav B, Ambika K, Vaskar D, **Shahriar.** 2015.Impact of planned water resource development on current and future water demand in the Koshi River basin, Nepal, Water International **40,** 7,1004-1020. http://dx.doi.org/10.1080/02508060.2015.1099192

National Office Of Statistics Algria (ONS). 2011. Website: www.ons.dz

Mouhouche B, Guemraoui M. 2004. Réhabilitation des grands périmètres d'irrigation en Algérie. Ali Hammani, Marcel Kuper, Abdelha d Debbarh. Séminaire sur la modernisation de l'agriculture irriguée, Rabat, Maroc. IAV Hassan II, 13 p. cirad-00189190.

Ministry Of Water Resources Algeria (MRE). 2010. Website: www.mre.dz

Ministère de l'aménagement du territoire (MAT). 2001. Elaboration de la stratégie et du plan d'action national des changements climatiques. et de l'environnement. Projet national alg/98/g31.