ALLOCATING WATER BASED ON EC IN EXISTING AND MIDDLE TERM DEVELOPMENT CONDITIONS CASE STUDY: SEFIDROUD IRRIGATION NETWORK, IRAN

REPARTITION DE L'EAU COMPTE TENU DE LA CONDUCTIVITE ELECTRIQUE DANS LES CONDITIONS ACTUELLES ET A MOYEN TERME DU DEVELOPPEMENT ETUDE DE CAS : RESEAU D'IRRIGATION DE SEFIDROUD, IRAN

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ABSTRACT

In the current research, the Water Evaluation and Planning System software (WEAP) was used to assess salinity of the water of the Sefidroud River, north of IRAN, under the existing and middle term development conditions, using electrical conductivity (EC) as the main criterion to formulate and assess the water allocation options. Three scenarios were simulated representing; low, average and high discharge conditions in the river, using 3, 5 and 7-years moving averages. The water allocations and EC values along the river in different location were estimated for the two development conditions and under three different scenarios including; drought, normal and wet hydrologic conditions. Results indicate that, the reliability of water supply for the Tarik and Sangar diversion dams under drought, normal and wet hydrologic conditions are 66.7%, 75% and 87.5%, respectively. However, the water supply reliability for the Galeroud dam in all three hydrologic conditions is equal to 100 percent and there will be no shortage in water supply. However, shortages of water for Tarik and Sangar dams in normal condition occur through April, May and August, in contrast to the drought condition when it occurs in April through August. Also, results show that the largest water demand in Sefidroud irrigation network would be during April through August. The simulated EC values for this period, under wet and normal situations are less than 2000 µmhos/cm, which represent low to moderate degrees of restriction. On the other hand, the EC values are

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more than 3000 µmhos/cm under drought condition implying severe limitation of water use in agriculture. In conclusion, in the existing and middle term development and under drought situations, Sefidroud irrigation network strongly face water shortages and critical conditions of EC criterion. In contrast, in the existing and middle term development normal conditions, the EC values are near critical.

Key words: *Water allocation, water quality, WEAP model, Sefidrood irrigation network (Iran).*

RESUME ET CONCLUSIONS

Dans l'étude actuelle de l'évaluation de l'eau et de la planification du système logiciel (WEAP) a été utilisé pour intégrer les questions mentionnées ci-dessus en un outil pratique pour évaluer la rivière Sefidroud, au nord de l'Iran, sous conditions existantes et moyen terme de développement. Comme l'eau de conductivité électrique, CE, est l'un des paramètres les plus importants qui affectent directement le rendement agricole, dans l'étude actuelle, il a été choisi comme le critère principal d'élaborer et d'évaluer les possibilités d'attribution de l'eau dans les conditions actuelles et à moyen terme de développement. Selon les dossiers de la rivière hydrologique, trois scénarios ont été simulés représentant;, les conditions de débit faible, moyen et élevé, impliquant 3, 5 et 7 ans en mouvement technique moyennes. L'attribution de l'eau et les valeurs CE, le long du fleuve, à l'emplacement du ci-dessus mentionné trois barrages de dérivation ont été estimées dans les conditions existantes et moyen terme et le développement selon trois scénarios différents, y compris, la sécheresse, normal et les conditions hydrologiques humides. Les résultats indiquent que, de la fiabilité de l'approvisionnement en eau pour les barrages de dérivation et de Tarik Sangar en vertu de la sécheresse, les conditions hydrologiques normales et humide sont égales à 66,7%, 75% et 87,5%, respectivement. Toutefois, la fiabilité d'approvisionnement en eau du barrage Galeroud dans les trois conditions hydrologiques est égal à 100 pour cent. Selon les résultats, les besoins en eau du barrage de Galeroud sont fournis avec pas de pénurie. Toutefois, les pénuries d'eau pour les barrages de Tarik et Sangar se produire dans des conditions normales en avril, mai et août, en revanche dans un état de sécheresse qui se produisent en avril, Mai, Juin, Juillet et Août. En outre, les résultats montrent que la plus forte demande du réseau d'irrigation Sefidroud pourrait être enregistrée par l'intermédiaire de avril à août et les valeurs simulées pertinentes de la CE pour cette période, dans des situations normales et humides sont moins 2000µmhos/cm, dont les valeurs selon les normes agricoles de qualité de l'eau représentent environ faible à modérée degrés de restriction. D'autre part, les valeurs CE sont plus 3000µmhos/cm dans des conditions de sécheresse qui montre sévère limitation de l'utilisation de l'eau dans l'agriculture. En conclusion, dans le développement actuel et à moyen terme et dans des situations de sécheresse, réseau d'irrigation Sefidroud fortement face aux pénuries d'eau et les conditions critiques du critère CE. En revanche, dans le développement actuel et à moyen terme des conditions normales, les valeurs CE sont sur le point de la valeur critique.

Mots clés : *Répartition d'eau, qualité de l'eau, modèle WEAP, réseau d'irrigation de Sefidrood (Iran).*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

Many regions in the world are facing formidable freshwater management challenges. Allocation of limited water resources, maintaining environmental quality and policies for sustainable water use have become issues of increasing concern. High population growth and rapid growth in industrial and agricultural activities in the river basins, without regard to environmental issues, have caused pollution of water and soil in many countries.

The Sefidroud River basin is located in the northwest part of Iran and travels through 8 provinces with the total area of 59,000 km2 harbouring population of about 4.7 million. Two main tributaries in the Sefidroud river basin, namely, Qezel Ozan River and Shahrud River are merged into the reservoir of Sefidroud dam and then Sefidroud River flows 110 km from the Sefidroud dam to the river mouth. The study area consists of Sefidroud River located in the area between Caspian Sea and the Sefidroud dam. Sefidroud dam provides Sefidroud irrigation network demand and has a crucial role in the regional economy. The water is supplied from three diversion dams namely, Tarik, Galeroud and Sangar. About 80% of the water needed by 230,000 ha of paddy in Gilan province is provided through Sefidrood irrigation network. Agriculture is the main foundation of the regional economy. Generally, field visits and evaluations conducted in this area show that the Sefidroud river is facing many problems such as: discharge of municipal and industrial wastewater, inflow of agricultural drainage water, quarrying river materials, erosion and pollution of natural resources. Since surface water is mostly used for agricultural use, providing high quality water is very important. Figure 1 depicts the Sefidroud River.

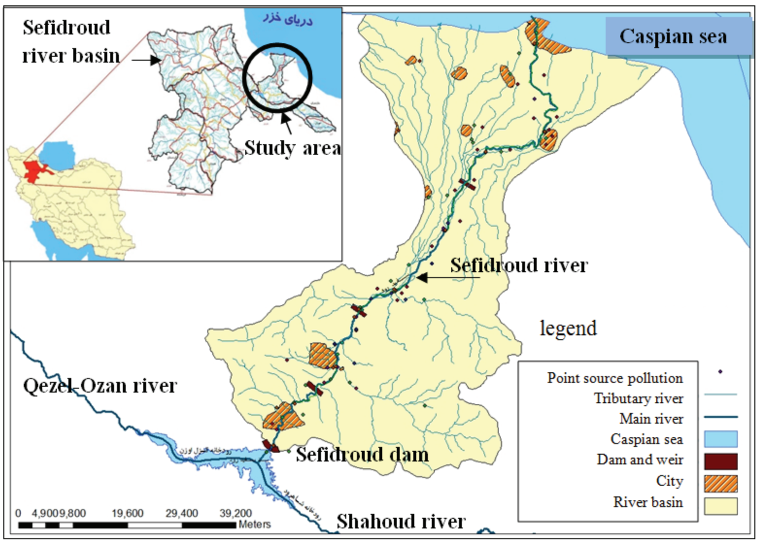

Fig. 1 Sefidroud River Basin (Bassin de la rivière Sefidroud)

According to the WEAP software user manual, its applications generally include the following steps: the study definition sets up the spatial boundary, time frame, system components and configuration of the problem. The Current Accounts provide a snapshot of actual water demand, pollution loads, resources and supplies for the system. Alternative sets of future assumptions are based on policies, technological development and other factors that affect demand, pollution, supply and hydrology. Scenarios are constructed consisting of alternative sets of assumptions or policies. Finally, the scenarios are evaluated with regard to water sufficiency, compatibility with environmental targets, and sensitivity to key variables' uncertainty.

Built on the basic principle of mass balance, the WEAP program can be used for municipal and agricultural systems, in a single basin or in complex basin systems. In addition, this program can simulate a wide range of the natural and man-modified components of river basin systems, including rainfall runoff, base flows, aquifer recharge, analysis of demand for water by sectors, water conservation policies, water rights and priority outlines for assigning of water, reservoir operations, hydroelectric power generation, contamination processes and water quality monitoring, vulnerability assessments, and the hydrological requirements of ecosystems. Furthermore, a financial analysis model in the WEAP program facilitates cost-benefit comparisons of several projects (Lee et al., 2005; Sieber and Purkey, 2007).

In the previous research studies WEAP has been used widely to incorporate irrigation related issues. Varela-Ortega et al. (2007) used WEAP software to develop public policies for groundwater conservation using a vulnerability analysis in irrigated agriculture. Yazdan panah et al. (2009) reviewed the effect of irrigation efficiency in Azghand basin, Northern IRAN, on Groundwater storages by WEAP model. Rycroft and Wegerich (2009) discussed the three blind spots of northern Afghanistan: water flow, irrigation development, and the impact of climate change. They considered the different data sets for the current irrigated areas, water resources, and future potentials according to identified projects in northern Afghanistan. They also used WEAP model to estimate the current demands for water as well as the increased demands resulting from climate change. Sánchez et al. (2011) Used WEAP to describe the vulnerability of the water resources in the case Guayalejo-Tamesí River Basin in Tamaulipas, México, taking into account the effects that climate change can have on water availability in the municipal, industrial, and agricultural sectors.

In the current research study, the Water Evaluation and Planning System software (WEAP) has been used to incorporate the above mentioned issues into a practical tool for assessing Sefidroud River discharge, under existing and middle term development conditions. As the water Electrical Conductivity, EC, is one of the most important parameters which affect directly the agricultural yield, in the current study it has been selected as the main criterion to formulate and assess the water allocation options in the existing and middle term development conditions.

2. MATERIAL AND METHODS

The middle term development of the irrigation network has been established on the basis of national development plan for IRAN's water resources. The existing and middle term development (year 2016) irrigation demands of the irrigation network have been estimated by the maximum water demand which is primarily dependent on the following considerations: (1) the area to be irrigated, (2) crops to be grown, and (3) anticipated efficiency of water application to the crops. Also in this study attempts have been made to evaluate the effects of Sefidroud River discharge and the relevant water quality changes on the water allocation options. To achieve this aim, according to the river hydrological records, three scenarios have been simulated representing; low, average and high discharge conditions, involving 3, 5 and 7-years moving averages technique. It should be noted that the required data have been collected and recorded by the Iranian Water Resources Management Company. The water allocations and EC values, along the river, in the location of earlier mentioned three diversion dams were estimated in the existing and middle term development conditions and under three different scenarios including; drought, normal and wet hydrologic conditions.

WEAP model is able to allocate water according to the pre-defined demands, priority associated with each demand area. In this study it has been assumed that all demand areas have equal priority of water supply and therefore have the same share of demand coverage in shortages periods. As the network case study is managed by only one organization, therefore, any proposed water allocation scenario can be performed and operated. WEAP strives to maximize supply to demands sites, subject to all constraints and priorities. Demand sites are allocated water depending on demand priorities and supply preferences. In cases where there is not enough water to satisfy all demands with the same priority, WEAP tries to satisfy all demands to the same percentage of their demand (Sieber and Purkey, 2007).
Water quality parameters that can be considered in WEAP include conservative substances, constituents that decay according to an exponential decay function, dissolved oxygen (DO) and biological oxygen demand (BOD) from point sources, and in-stream water temperature. These parameters are not modeled in reservoirs, though; all reservoir outflow concentrations must be entered as data. The river network is the same for the water resources and water quality simulations and assumes complete mixing. Starting with the simplest assumptions, that the effects of diffusion and dispersion are negligible relative to the effects of advection, the stream may be represented as a plug-flow system. The initial concentration of a pollutant at the point of injection into the stream is calculated from a mass balance equation (Sieber and Purkey, 2007):

Equation 1: $$c = \frac{Q_w c_w + Q_r c_r}{Q_w + Q_r}$$

Where c is the new concentration (mg/l), Q_w is the flow of wastewater discharged (m^3/time) c_w is the concentration of pollutant in the wastewater (mg/l), Q_r is the flow of receiving water (m^3/time) and C_r is the concentration of pollutant in the receiving water (mg/l). This is the simplest case of representing the spatial and temporal variation of pollution in a system. One possible candidate that could be modeled as a conservative pollutant would be salinity or EC.

3. RESULTS

Results indicate that, the reliability of water supply for the Tarik and Sangar diversion dams under drought, normal and wet hydrologic conditions are equal to 66.7%, 75% and 87.5%, respectively. However, the water supply reliability for the Galeroud dam in all the three hydrologic conditions is equal to 100 percent. That is because of two stream branches called Tarik and Toot-kabn, which are discharging into Sefidroud River right downstream of Tarik dam and upstream of the Galeroud dam. Moreover, the demand values of the network which supplied from the Galeroud dam are small relatively to the Sangar and Tarik dams. In addition, the monthly variation of demands for Tarik and Sangar dams are very different from the Galeroud dam. In other words, the most demands of the Galeroud dam are in months when the demands are low for Tarik and Sangar dams.

According to the results, the water demands of Galeroud dam are supplied with no shortages. However, shortages of water for Tarik and Sangar dams in normal condition occur through April, May and August, in contrast in drought condition that occur in April, May, June, July and August (Fig. 2).

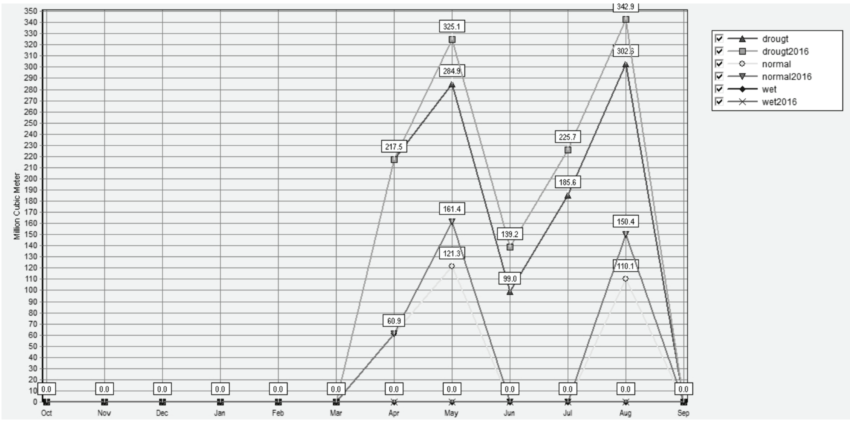

Fig. 2 unmet demands (MCM) (besoins non satisfaits (MCM))

Also, results show that the largest demand of Sefidroud irrigation network could be recorded through April to August and the relevant simulated EC values for this period, under wet and normal situations are less than 2000 μmhos/cm, which according to the agricultural water quality standards represent low to moderate degrees of restriction. But, the EC values are more than 3000 μmhos/cm under drought condition implying severe limitation of water use in agriculture. For example Figure 3 depicts EC values for all scenarios in August.

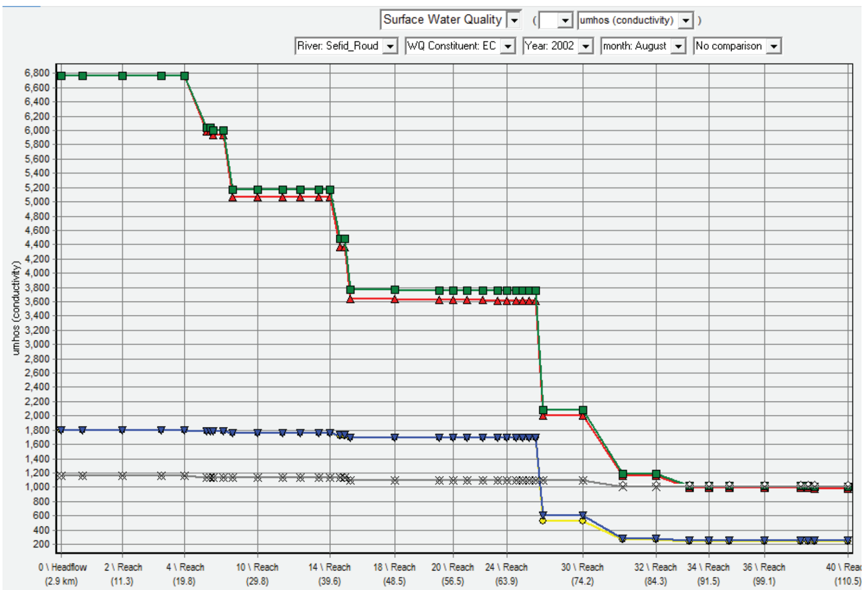

Fig. 3 EC values in Sefidroud River for all scenarios in August (CE valeurs Sefidroud rivière pour tous les scénarios en août)

In conclusion, in the existing and middle term development and under drought situations, Sefidroud irrigation network strongly face with water shortages and critical conditions of EC criterion. In contrast, in the existing and middle term development normal conditions, the EC values are about to the critical values. Therefore, in order to improve the relevant irrigation water quality, considering the potential of groundwater resources in the study region the combination surface and groundwater supplying, for a sustainable irrigation plan, is highly recommended.

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