Article

Agricultural activities impacts on water resources of Masouleh river basin with WEAP model

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Abstract
The Masouleh river basin is in south of Iran. Different water user such as urban, rural, agriculture and industry are presented in the catchment. Municipal, rural, agricultural, industry and environmental need are going exacerbate future water resources management. The agricultural activities are related to a range of environmental factors such as conservation of the natural resources, water and biodiversity. WEAP capabilities are extensive related to water resources for municipal and agricultural sector including water conservation, ware allocation priorities, water demand and ecosystem requirements. In this study, three scenarios (Reference, Change of priority and Agriculture reuse Scenario) were selected in order to assess the impact of water demands on the water resources of the Masouleh River catchment in 2035. Scenario made in the current situation and the model enabled analyses of unmet water demand for each scenario for 25 years (from 2011 to 2035). The results of the study showed that Change of priority scenarios water supply is not insufficient to completely meet the demands of all sectors therefore, reuse scenario is the next priority. Application of Water Conservation and Demand Management practices and improvement water distribution can reduce the unmet demand.

Keywords Water Evaluation and Planning System WEAP; water resources management; Masouleh river basin; agricultural activity.

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1 Introduction

Regarding to unsuitable local rain distribution and not its suitable time according irrigation season, water crisis is a serious problem in almost country. Certainly in a near future, many countries would encounter to lack of renewable water resources for continuation of agricultural activities and providing its necessities. Consequently, in order to counter with this crisis, water resources must be managed through the most executable and economized methods (Shamsaei, 2013). WEAP has been developed to integrate information about water supply, water demand and the costs and benefits of water management in the Upper Tana catchment, Kenya (Droogers et al., 2011). Construction of hydraulic structures such as diversion channels, dams and factors related to the management system must also be considered (Yates et al., 2005). Maximizing net returns according to the available water resources is important. It is so complex problem due to the many factors that affect it such as production costs, irrigation system configuration and climatic variability (Mahamadou Mounir et al., 2011).

Using WEAP software and Masouleh River information and data can provide suggestion on water resource management and agricultural sector. The water evaluation and planning tool (WEAP) has been used in previous studies around the world (Salomón-Sirolesi and Farinós-Dasí, 2019; Miraji et al., 2019; Ougougdal et al., 2020) and also this model has been widely used in different basins of the world in recent decades (Asghar et al., 2019; Ougougdal, 2020). Numerous studies worldwide have been conducted using WEAP to check the status of water resources in agriculture sector. Using WEAP to evaluate the irrigation system of Hablehrud region has shown that water scarcity will appear at the present condition. Therefore the acreage must be reduced or increased irrigation efficiency, pressure irrigation plans, and efficiency of water transmission. In addition new resources, dam construction can prevent this situation (Hafezparast and Kholghi, 2006). With application of WEAP, changes in water demand based on changing the cultivation pattern and determination of irrigation method was reviewed in Eizeh. The results showed that by increasing acreage surface, it is better to irrigate by drip and sprinkler or drip-sprinkler method together (Seifi et al., 2006). Modeling of water resources using WEAP to reduce water consumption in agriculture sector and groundwater management was done in Gaz. The results showed that increase irrigation efficiency can reduce water consumption (Akbari et al., 2009). The drought effects on water demand of agricultural sector have been investigated and management strategies have been evaluated using WEAP software (ArabiYazdi et al., 2010). Also allocation of Gharehsou water basin in Golestan Province was assessed. Based on study scenarios-priority of drinking and agricultural consumptions- it may allocated 14 and 3.5 million cubic meters of water respectively to drinking and agricultural sector annually (Sahebdel and Akbarpour, 2011). WEAP model was used to assess the current situation and a future scenario in the Blue Nile River in Sudan and Ethiopia. Results indicate that irrigation demand and flow of the Blue Nile are estimated to increase and decline respectively (McCartney et al., 2009). An integrated modeling for water resources planning and management was used to carry out water allocation analysis. The results showed that competition for Musi water is very high (George et al., 2011).

WEAP has been developed for evaluating water management strategies and simulating current water balances in the Aral Sea region (Raskin et al., 1992). To assess alternative water allocation scenarios at the Steelpoort sub-basin of the Olifants River, technicians will need user-friendly tools. WEAP model in this regard has been tested in assessing scenarios of water demand management which is the biggest user (Levite et al., 2003). In addition WEAP was used to assess the effects water consumption and development in upstream of Karkheh River Basin located in Iran on municipal, agricultural and industrial sectors located in downstream (Abrishamchi et al., 2007). WEAP and The System of Economic and Environmental Accounts for Water (SEEAW) have been applied in combination to assess the socio-economic water needs and the available water resources in the Vit River which is a tributary of the Danube River (Dimova et al., 2014).

Consumption for DashteBojnord basin was evaluated using WEAP and its adjunction to MODFLOW. Different management scenarios, were considered combinations of the scenarios alleviate reduce water demand including keeping cultivation and acreage area as constant against increasing irrigation efficiency in agriculture and increasing number of industries. The results showed that for reducing water withdrawing on different resources, simultaneous applying multiple water management strategies appears to be better than any of individual strategies (Hajipour et al., 2015).

Planning for allocating water resources under different scenarios was investigated in Gorganrood basin in Iran. The allocated percent of water volume for industrial, agricultural, aquaculture and environmental needs was obtained after modeling the basin with regard to the goals of plans. The results showed that reliability of water supply can be considerably preserved in system and prevent its reduction by increasing irrigation efficiency (Dehghan et al., 2015; Zohrabi et al., 2017).

A model was developed to promote the integrated management in basins of Citarum River in Indonesia. The system reliability was assessed by comparing allocated irrigation water and water demand. The results showed that because of climate change, the reliability of the system would be reduced by 15%-26% (Santikayasa, 2016; Zohrabi et al., 2017).

Dez basin as one of the agricultural centers, in Iran may be affected by the impacts of climate change. In this region, the low efficiency of irrigation networks leads to the loss of water each year that continuation of the current trend will evidently cause serious problems to the agricultural future and supply of water. By simulating Dez basin, the effects of increasing the irrigation efficiency on the reliability of agricultural water were analyzed. The study scenarios included management and short and long-term changes of consumption level. WEAP was simulated the combination of these scenarios. Results of the research have been discussed in both short- and long-term (Zohrabi et al., 2017).

In the Ur river watershed, distributed model by using WEAP-MABIA method has been developed for simulation and analysis of agricultural water demands. Since river flows are seasonal and the watershed falls in semiarid condition, different stress/deficit irrigation scenarios can be built using WEAP model to get higher yield (Agarwal et al., 2018).

The impact of socio-economic activities and climate change on water demand and supply in the Ourika watershed of Morocco has been assessed and evaluated the sustainability and efficiency of regional adaptation strategies for water supply management. Future water situation was simulated and analyzed using WEAP and SDSM for different scenarios of climate change. The results show that in all scenarios, water demand, the unmet water demand and the pressure on water resources will increase, leading to water scarcity that demonstrate the assessments of the proposed strategies are effective, but not sufficient to ensure water sustainability (Ougougdal et al., 2020).

This study intends to evaluate WEAP function by considering the mentioned objective. In particular, the focus is assessment of different scenarios of water demand management that covering agricultural, rural and industrial sectors.

2 Study Area and Methodology

2.1 Study area

In this research, Masouleh river basin in Guilan Province was studied. The Masouleh River is the best option for study due to it is considered in the development plan. The study area is limited from Fomanat Plain to the Masouleh River basin in Guilan province. Origin of this river is in 3,000m altitude that is permanent river. Its length is about 60 kilometers that more than 35 kilometers thereof flows in plain that was presented in Fig. 1 (Kankash Omran Consulting Engineers Co, 2009).

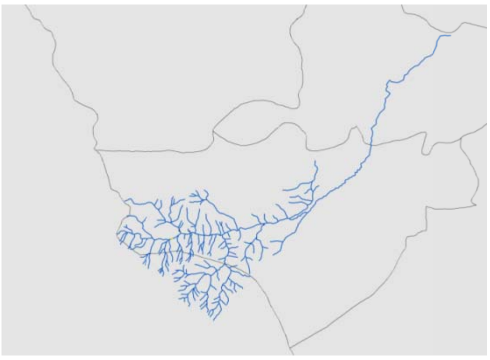

Fig. 1 Masouleh River Basin.

2.2 Materials and methods

Masouleh River Basin initial data consisting regional information, monthly and annually hydrometric statistics, monthly and annually average flow rate (Komadol Station) have been collected and classified from 1986 to 2011. In addition the model elements including nodes, industrial, rural and agricultural demand sites, links such as transmission from river, dam and groundwater to demand sites, return flow and rivers were determined.

Water evaluation and planning (WEAP) model has been developed to evaluate planning issues related to water resources for agricultural and municipal systems including water conservation, water rights, sector demand analyses, stream flow simulation, water allocation priorities, ecosystem requirements and project cost–benefit analyses (Arranz and McCartney, 2007; Omar, 2013). It is used to model water demand, water supply, the balance between water demand and supply, priorities and preferences. In addition, it has been used to assess the impact of a water management measures from conservation to wastewater reuse (Heaps et al., 2012).

Scenario of Agricultural Reuse: it is a subset of reference scenario and therefore inherits all the terms of this scenario. The new situation will be reviewed in this scenario that is the possibility to change the water need in case of agricultural water reuse. It is assumed that the amount of reuse can be increased in future years.

3 Results

The re-use amounts of agricultural water for future years were defined. It was considered 0, 5%, 10%, 18% and 25% respectively in 2011, 2020, 2025, 2030 and 2035 that 2011 was selected as the base year. Its impacts were estimated to be examined in the coming years.

The water demand not met for re-use scenario is variable over 25 years that is 6.1 to 5.4, 1 to 1.1 and 1 to 1.2 MCM respectively for agricultural, industrial and rural demand. It is presented at Fig. 2. This value is 191.3 MCM in 2035 for 25 years.

Results of Changing Supply Preference Scenario is presented that water demand is not met (Fig. 3). This is 6.1 to 3.7, 1 to 1.1 and 1 to 1.2 MCM respectively for agricultural, industrial and rural demand. It is presented at Fig. 2. This value is 150.1 MCM in 2035 for 25 years.

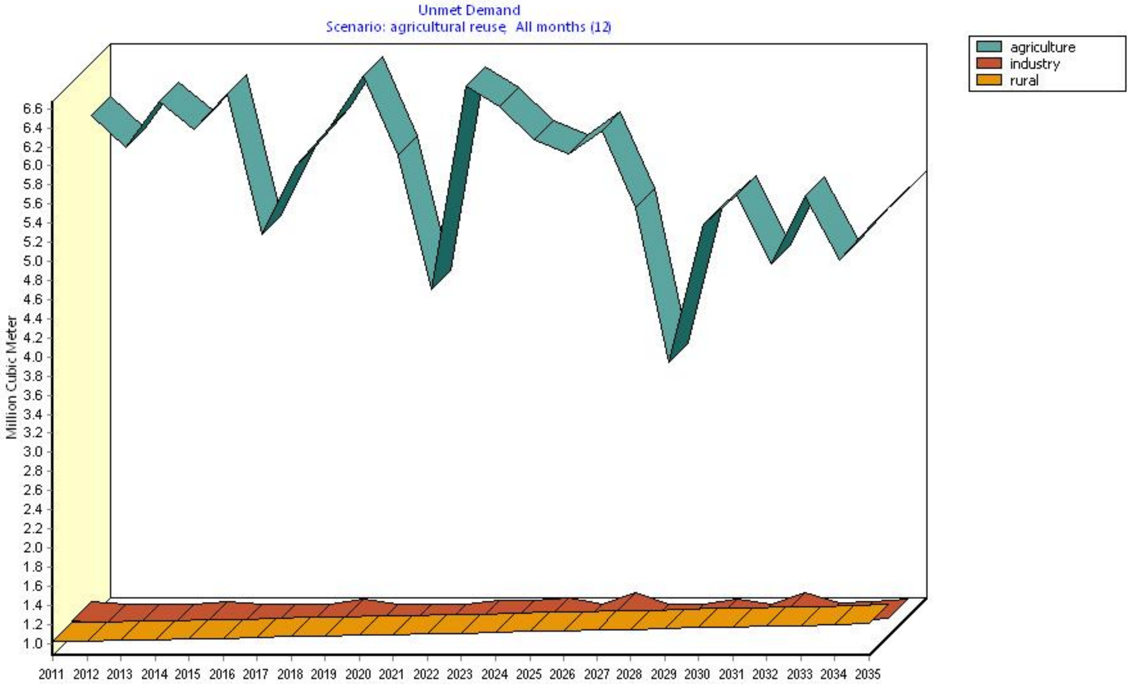

Fig. 2 Unsupplied water demand in re-use scenario on all demand points (2011 to 2035).

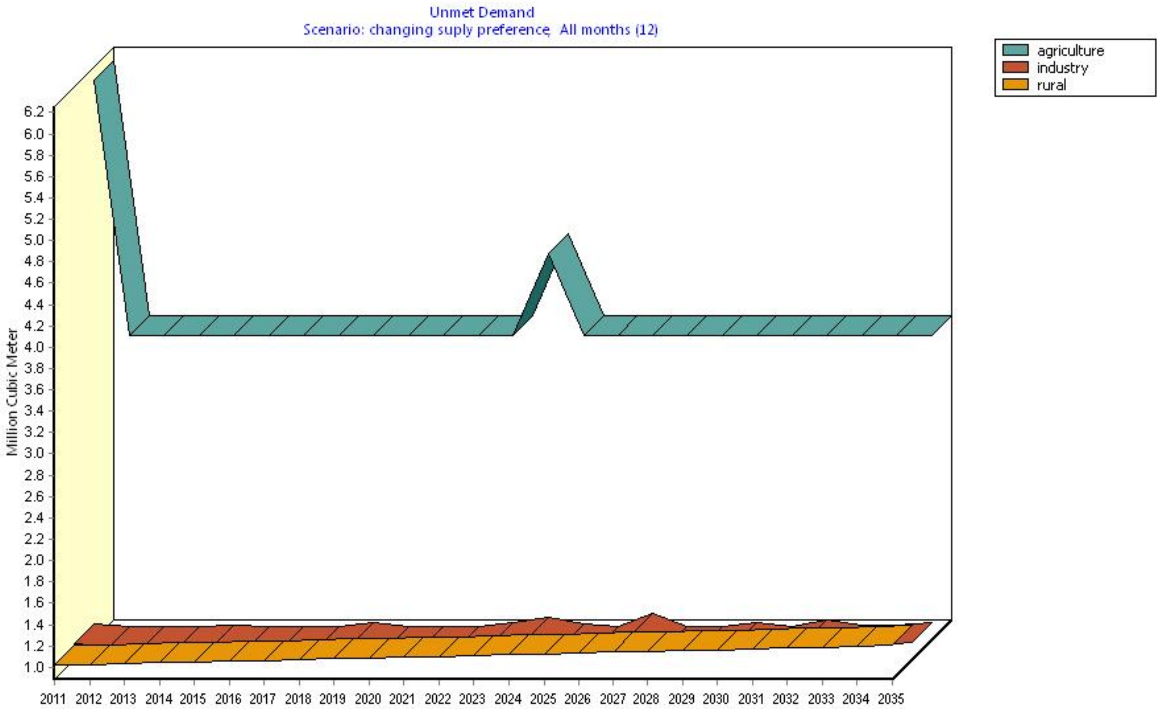

Fig. 3 Unsupplied water demand in Changing Supply Preference scenario on all demand points (2011 to 2035).

Ecological Water demand is variable in different months of the year. Maximum and minimum flow rate were investigated that happening in April and August (Table 1).

Table 1 Average Monthly Flow for Ecological Requirement Point.

Demand/Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Environment demand (MCM)	5.6	7.2	11.9	23.0	17.5	6.6	5.9	4.5	8.6	7.0	6.3	6.2

Water demand is not met that happening in August 2021 and increasing to peak value in 2024 (Table 2).

Table 2 Unsupplied water demand in Changing Supply Preference scenario for all demand points in August of 2020 to 2035.

Demand/Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Environment demand (MCM)	0.4	1.5	5.2	6.8	8.3	7.3	6.7	4.4	0.2	6.9	7.6	4.0	4.2	1.9	7.1	4.1

Comparison of the Reference Scenario and Reuse is presented at Table 3. It represent that unsupplied water to all demand point is 9.4 and 7.6 MCM respectively for reference and reuse scenario in 2035. The total unsupplied water is 191.3 and 206.7 MCM respectively for reference and reuse scenario in 25.

Table 3 Comparison of the Reference Scenario and Reuse for unsupplied water demand (2012 to 2035).

Scenario/Year	2011	13	15	17	19	21	23	25	27	29	31	33	2035	SUM
Reference	7.4	7.4	6.1	7.3	7.1	8.0	7.6	7.9	5.3	5.3	7.7	7.9	8.3	206.7
Agricultural reuse	7.4	7.3	5.9	7.1	6.8	7.5	7.0	7.1	4.7	4.7	6.5	6.6	6.6	191.3

4 Conclusions

In agricultural water reuse scenario the question is how it can reduce unsupplied water demand? It can appear from 153 to 137.5 million cubic meters per year based on the results of simulated model in 2011 to 2035 that is just for agricultural requirement. Since the related scenario shows that agricultural sector demand is considerably higher than other, therefore planning and management can have significant effects.

Agricultural water needs is supplied through three sources including Masouleh River, groundwater and SefidRood Dam. Supply preference is the same in the reference scenario but priority in changing supply preference is river, groundwater, SefidRood Dam. The supply preference priority in the industrial sector is river and groundwater and in the rural sector is groundwater.

The results obtained from comparison of the scenarios indicate that changing supply preference scenarios has the greatest effect on unmet demand reduction. The next preference is to reuse scenario. Therefore, it seems that in order to reduce water supply demand in the agricultural sector, changing supply preference is the best solution (Table 4).

The outcome of WEAP presented that preference on supply water demand would be Masouleh River, groundwater and SefidRood Dam. Reuse of agricultural water, changing preferences and demand management may be helpful to reduce unmet supplied water need.

Table 4 Unmet water supply and simulated demands (Agricultural, Industrial and Rural) for three scenarios during the year 2035.

Scenario/Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM
Reference	0.1	0.2	0.2	0.1	0.4	1.7	2.1	2.1	0.8	0.1	0.1	0.1	7.9
Agricultural reuse	0.1	0.2	0.2	0.1	0.3	1.5	1.8	1.9	0.7	0.1	0.1	0.1	7.0
Changing supply preference	0.1	0.2	0.2	0.1	0.3	1.3	1.5	1.6	0.6	0.1	0.1	0.1	6.2

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