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Research article

DECISION SUPPORT SYSTEM,MIKEBASIN FOR WATER ALLOCATION TO WATER USER ASSOCIATIONS IN ALBORZ IRRIGATION AND DRAINAGE NETWORK

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ABSTRACT: MIKEBASIN is one of major applied decision support system which developed for sustainable simulation and water allocation management in river basin. The objective of this study is evaluating the application of this model in Alborz integrated land and water management project. In this regard, the project area is divided into 20 water user associations and water supply resources including surface water, Ab-bandans and groundwater. As a matter of water allocation to WUAs, the simulation of resources and demand was done monthly in 28 years with the data of main catchment runoff and sub-catchment, reservoir and demand of WUAs, groundwater and Ab-bandans. In assessing the condition of water resources allocation by MIKEBASIN model in WUAs, demand volume with the aim of minimizing the deficiencies and spatial priorities on the basis of any association was evaluated. Accordingly upstream WUAs received more water. Also the result showed that demand of 460 MCM of WUAs, 277.02 MCM is supplied from surface water and 131.01 MCM from groundwater and remaining (1.92 MCM) is from Ab-bandans. According to criterion of 85% supply, the evaluated deficiency is 13.5 MCM. Finally, the result of this research was in accordance with the results of other studies in this case study.
Keywords: Alborz Scheme, Planning and management, Sustainable water allocation, Water Resources Allocation, Water User Association.

INTRODUCTION

Water is a basic necessity for sustaining life and developing society in the semiarid regions and developing countries. Furthermore, asymmetry of water supplies between upstream–downstream, an absence or weakness of institution of water management, leads to an inequitable distribution and inefficient water use [4]. In order to achieving water resources management for sustainable water allocation, irrigation management transfer (IMT) and participatory irrigation management (PIM) programs [7] are authorized and water user associations (WUA) was established which make significant contribution in the new institution issues to manage lower level systems, such as tertiary level canals and below and minor structures[8, 14].Furthermore, management practices of equity allocation for in water user associations (WUA), requires the use of decision support system as effective tool for supply and demand analysis[10]. A major feature of these kinds of simulation models is the ability to appraise water resources responses of extremes, non-equilibrium systems, and thereby determining which system are more failure prone [12]. Simulation models are widely developed by river basin authorities around the world. These models are involved in node/linked, linear program and user-defined priorities to allocate resources in a river system network. These accounting procedures is formed on volume-balance accounting tools which provide a system of reservoirs and river linked under priority water rights based water allocation policies. Furthermore, mathematical model estimates reservoir storage volume, water supply withdrawals, river flows for specified water user, system operating rules and net reservoir surface evaporation rates. There are many different programs developed for multi-purpose modeling and simulation water allocation management scenarios in river basins scale. [1, 3, 11, 12, 16 ,17].
One of the models that fall into this classification is MIKEBASIN which evolved to and full-blown application program. MIKEBASIN is a water resource management planning model that integrates a Geographic Information System (GIS) and with water resource modeling.

This model provides a mathematical representation of the river catchment encompassing the spatial configuration of the main rivers and their tributaries in time boundary, existing as well as potential major networks and their own different water use, water supply, multi-purpose reservoir operation, tunnels and diversion dams, and possible environmental constraints [3].
This research describes the main features of MIKEBASIN and provides potential users with an appreciation of its capabilities as a DSS to evaluate the current water management scenario and the effect of proposed water development projects in Alborz network. Construction of the Alborz reservoir is entirely funded by the Government of Iran and implemented in accordance with Iranian law. The World Bank has provided loan financing for the construction of the associated irrigation and drainage network the dam will feed, as part of the Alborz Integrated Land and Water Management Project.

METHODOLOGY

Project Area

The Alborz Integrated Land and Water Management project is one of the first attempts at developing an integrated approach to land and water management in the Islamic Republic of Iran. Moreover, the project area is intended to ultimately serve as a case example of the approach to and benefit of an integrated approach to planning and management of land and water resources. As such it will serve as the basis for replication in other regions and catchments in Iran. While some elements of the project have been in the planning and design phases for a number of years, this area is divided into 20 WUAs. The establishment of WUAs in the Project area aims at building user ownership and accountability for operation and maintenance (O&M) of the water distribution network.
Fig.1 shows the overall project area which encompassed the watersheds of the Babol River, Talar and Saih Rivers of the Mazandaran Province, Iran. The Alborz Irrigation and Drainage network is located in the lower catchment between the Babol and Siah Rivers (western and eastern boundaries respectively) and with the Caspian Sea to the north in. The site lies between 36˚15´N and 36˚46´N latitude and 52˚35´E and 53˚E longitude and covers 90520 hec. In downstream of Alborz reservoir, two diversion dam, Raiskola and Ganjafroz is located and two irrigation channels depends on these dam are constructed. The maximum flows of these dams are respectively 1.2 and 23.3 m^3/sec.

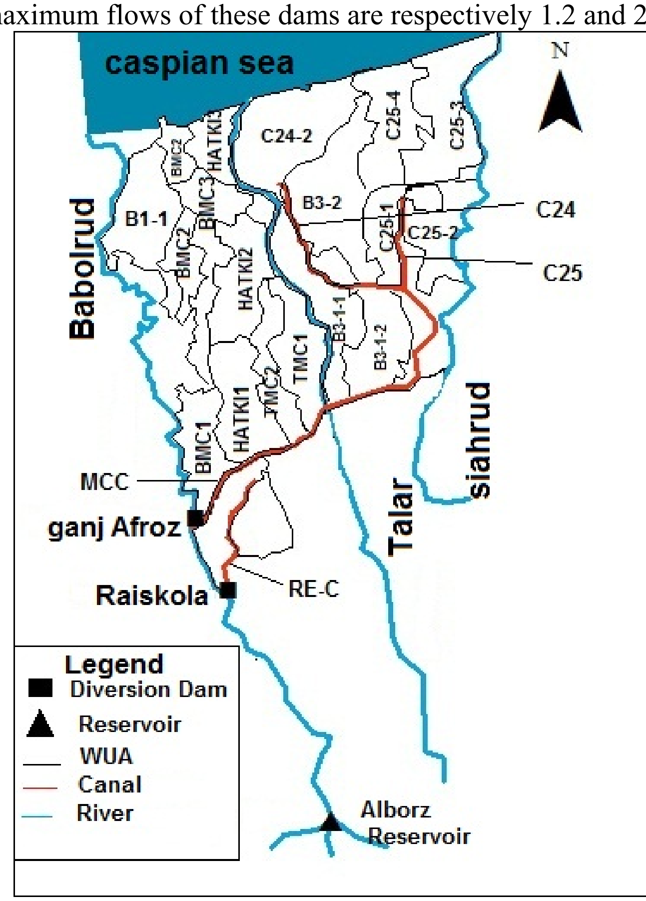


Figure 1. Alborz irrigation and drainage network

MIKEBASIN Model

MIKEBASIN consists of several major components: input processing, simulation and output processing, as shown in Fig. 2. A brief description of these components is given below; however, the reader is referred to MIKEBASIN User's Manual

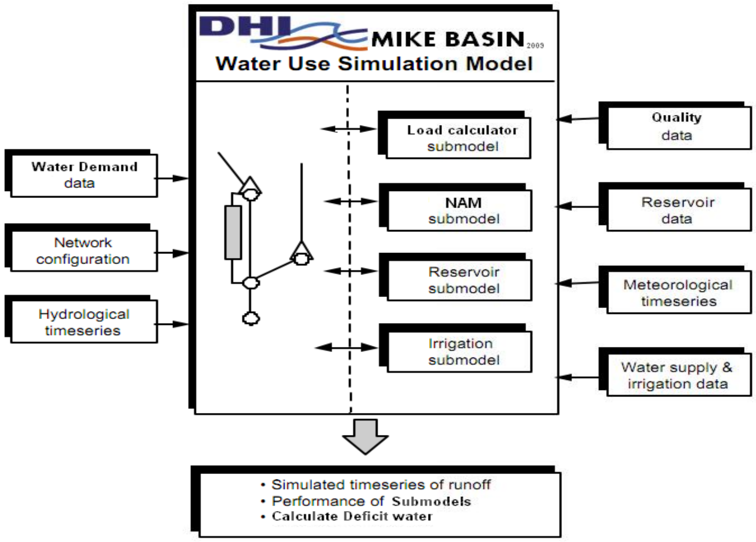


Fig. 2MIKEBSIN simulation

MIKEBASIN is a quasi-steady-state mass balance model, however, allowing for routed river flows. Reality it means input to system is equal to output and storage as shown in equation 1.

Inflow = Outflow+ Δ Storage (1)

In MIKEBASIN, linear reservoir routing distributes flow from upstream node over all time steps following an inflow and extraction to and from the node. For a pulse inflow, outflow peaks after a time given by the time lag, and then decays exponentially. The formula used is:

$qo=(1-x/((dt)/K)).q_i+x.s, \quad x = 1- e^{(-dt/K)}$ (2)

Whereqo is outflow from the node, dt is time step length, qi is inflow to the node, s is storage in the subsurface, and K is the linear routing time lag (or delay parameter).Linear reservoir routing can be chosen as a special case of Muskingum routing with $x = 0$. Unlike general Muskingum routing, linear routing is defined for all combinations of time step lengths and K values. For hydraulic simulation such as runoff several functions is applied that in this study linear reservoir routing is used.

In a linear reservoir model, groundwater discharge, i.e., flux through the outlet(s) is proportional with water level, and because catchment area is constant, it is also proportional with storage. Specifically, the coupled differential equations solved are: The dimensions of L and h are [Length]. It should be taken into account that an (outflow) rate constant k [1/Time] is the inverse of the outflow time constant that is specified in the catchment properties dialog. The fluxes q are area-specific [Length/Time] (equation 3).

$\frac{\partial h_l}{\partial t} = (-k_l-k_i)(h_l - L_l) - qi$ (3)

Simulation of Alborz Irrigation and Drainage Network

In the preliminary stage of the simulation, the average 28-year input flow from the main rivers of Babol, Talar and Siahrood and their was collected. Then, water user associations (WUA) demand time series derived from farming patterns in the discharge form on cubic meters per second was entered into the model. In the present study, each WUA is consolidated and prioritized based on the water supply from three sources of timely flow of rivers and dams, catchments and wells (ground water). In the next phase, regarding the simulation requirements, the reservoir information based on the geometric data in the form of volume-area-height curves is defined as the model default node. The evaluated network is the Alborz earth dam with functional volume of 129 million cubic meters with the crest height of 306 meters. Having an annual evaporation rate of 1071/5 mm from the Alborz dam river surface, the dam was constructed on Babol River and its main function is reserving water in non-farming seasons and discharging it in farming season [15]. In addition, in the specified model, rules related to the water discharge requirement should be defined as a function of time. The most important rules include flood control and environmental needs maximum values which are assumed to be 300 m and 1 cubic meter per second in the present study respectively [15].

Table 1. Summary characteristics of WUAs

WUAs	Demand (MCM)	Aquifer			Wetlands	
		Thickness cm)	Kcm/day)	Water level(m)	Area (ha)	Stored Colum MCM
B1-1	39.3	32	2.95	7.5	4	0.1
B3-1-1	27.3	40	7.05	20	108	2.1
B3-1-2	22.5	72	8.33	22.5	199	3.1
B3-2	30.1	40	2.36	5	784	10.9
BMC1	19.5	85	7.06	32.5	138	1.9
BMC2	22.2	31	2.08	7.5	219	3.9
BMC3	21.9	40	1.61	15	399	4.3
C24-1	10.6	72	3.53	12.5	-	-
C24-2	28.7	5.5	68.33	2.5	46	2.8
C25-1	38.4	65	11.91	22.5	3	0.1
C25-2	18.6	58	0.39	12.5	-	-
C25-3	24.1	12	1.88	2.5	327	5.1
C25-4	26.2	12	1.88	5	-	-
HATKI1	34.1	72	1.76	27.5	373	5.9
HATKI2	12.7	72	1.76	10	363	3.8
HATKI3	15.7	5.5	11.73	2.5	-	-
Halidasht	13.4	58.5	23.88	50	6	0.1
Raiskola	10.1	58.5	23.88	50	23	0.2
TMC1	35.2	72	19.4	22.5	59	1.2
TMC2	14.1	72	19.4	20	145	2.4

In the specified networks, in order to assess the operation of the reservoir, the dam rule curve operation was defined. Water level time series characteristics in the reservoir were further entered in the model. These rules include the elevation of the floor, passive volume elevation and the dam crest balance which are necessarily a function of time the values of which based on the network assumptions were considered fixed during the implementation of the project.

In the simulation model, the Alborz Dam discharge rate along with rivers timely flows were assumed which had the first priority. Correspondingly, the wetlands (Abbandan) were inserted in the model as the reservoir node in the next phase of the simulation, except the fact that the operation rule is the allocation pool. Also, the volume - area -height curves and other monthly time series characteristics in the reservoir water level were entered into the model for this node. The surface water resources level was enhanced using groundwater pumping taking the third priority in the model. The characteristics of which were defined in the model based on the aquifer information. Accordingly, the pumping abstraction was specified for WUAs and their groundwater resource in the catchment with the values of k (fixed time), h (underground water level), and the D (aquifer thickness) were entered into the model on which the simulation was conducted. Therefore, the underground water resources balance for the 28 year period from 1977 to 2005 was statistically analyzed.

The bifurcation node rule in the model was used to introduce the diversion weirs of Ganjafroz and Raiskola. The data for this node were defined according to the main river discharge and approved transferable amounts. Raiskola's channel system include the Raiskola's main channel RE-C with a discharge rate of 1.2 cubic meter per second and Ganjafroz channel system consists of the main channel (MCC) with a capacity of 23.3 cubic meters with C24 and C25 channels which ensure a discharge rate of 6/3 and 14 cubic meters per second with specific requirements in their hydraulic design the construction of which made the water transfer to all associations within the Alborz network possible [15].

RESULTS AND DISCUSSION

In order to evaluate the resources and WUAs in the Alborz Dam network, the MIKEBASIN model from each WUA to the Alborz Dam was implemented in which each of the 20 associations over 28 years with a monthly time step were simultaneously considered. The WUAs position, Alborz reservoir and wetlands, diversion weirs, main channels and groundwater uptake reservoirs were schematically shown in Figure 4.

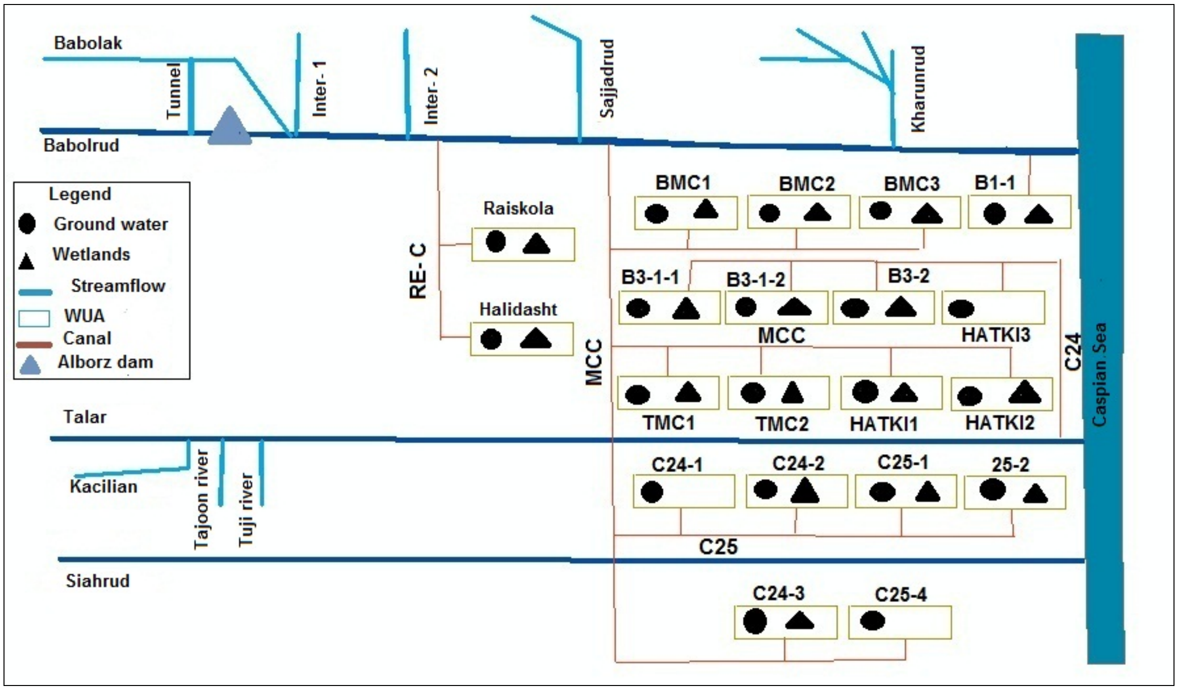
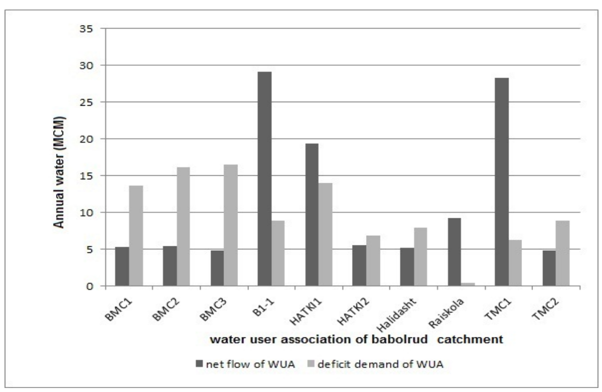
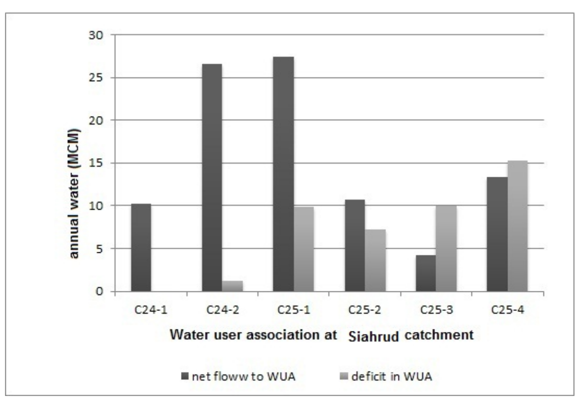


Fig. 2 Schematic representation of the Alborz Simulation Model

According to this figure, a reservoir dam and 16 reservoir wetlands, 20 agricultural purposes nodes and 56 water transfer channels were considered. Besides, 20 groundwater resources have also been included. In evaluating the allocation technique, first, the amount of input water for each association is examined. Figure 3 presents the results of the water simulation from Alborz Dam, Babol, Telar and Siahrood rivers catchments based on the agricultural months in 28 years period on average.



(a)



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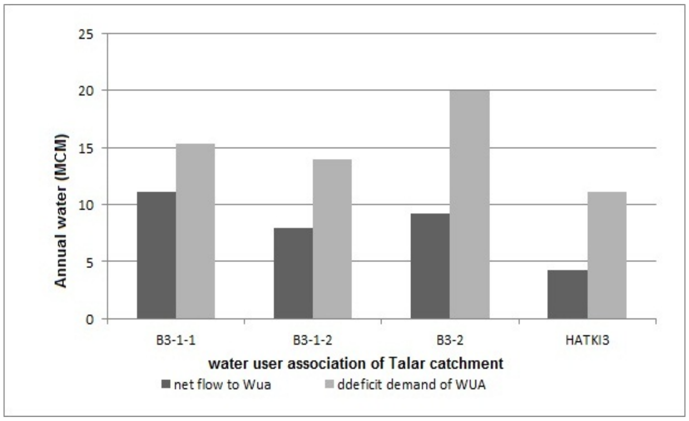


(c)

Fig. 3 Simulation of allocation water surface and water demand deficit at Alborz network

A glance at figure 3 reveals the point that the total surface water that can meet the demand of all associations is equal to 277.02 million cubic meters. Regarding the model output evaluation, it can be understood that the required amount, can be provided byAlborz dam reservoir with 74 million cubic meters and the rest, comes from the rivers. Also, considering the simulation of water inputs evaluation for the WUAs in the MIKEBASIN model, it can be concluded that if the location priority for water uptakes determines the priorities concepts in the model aiming at reducing shortages, accordingly, the MCC main channel and the water uptakes location for all three catchments can serve as the basis for location priorities, thus, it is expected that supply priorities face a reduction from Babol river catchment to that of Siahrood. Accordingly Siahrood River Catchment associations of (C24-2, C25-1, C25-2, C25-3 and C25-4) have the lowest location priority (to be located at the longest distance from the dam reservoir) expecting the fact that water inputs to these areas are relatively insignificant compared with Babol river catchment which will necessitate the use of other sources of water supply to meet the total WUAs' demand. For example, the model allocates higher levels of water input in Raiskola, BMC1, C25-1, B3-1-1, HATKI1 and TMC1 and showing dependence to network water. Consequently, we can conclude that MIKEBASIN model will provide more water for upstream water user which is consistent with the results of [2, 5].

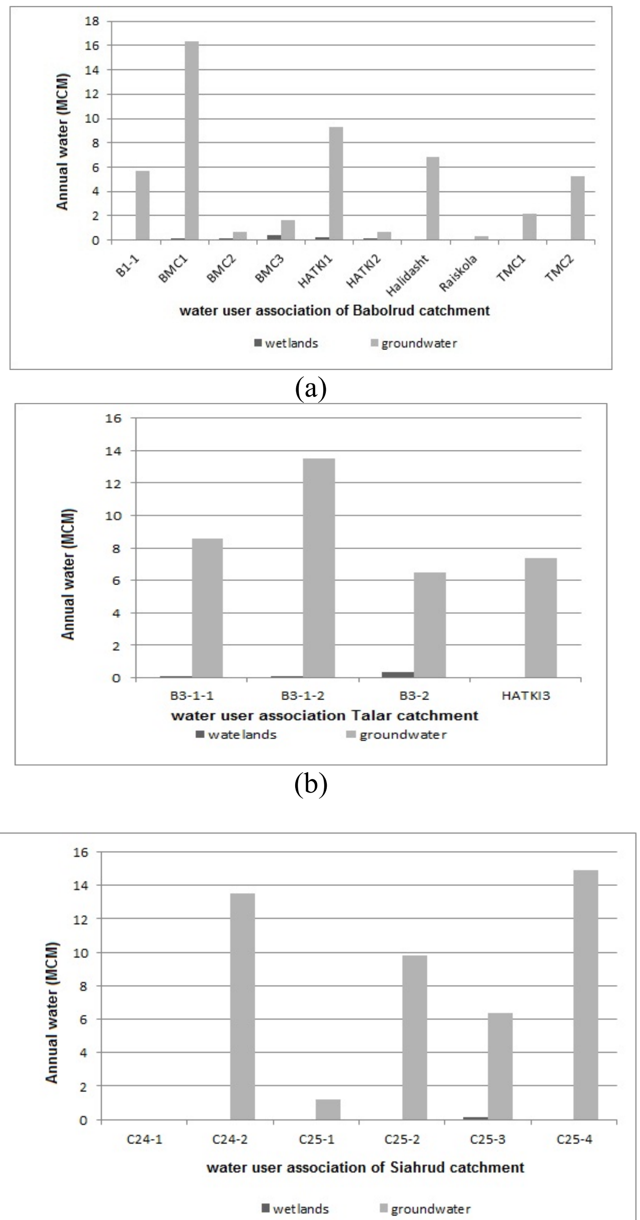
It should be added that except C25-1 association located in Siahrood river catchment which has the lowest location priority, all the other WUAs are supplied by Babol river catchment enjoying a higher priority. Accordingly, it is expected that the model will include higher levels of water input. But the C25-1 should be examined in terms of its estimated deficiency despite its relatively high demand for water and the fact that more water is allocated but still significant shortages are observed. This means that in the model, besides focusing on the location priority, the WUAs location priority which receive water from a single catchment should also be emphasized being schematically presented in Figure 4. These WUAs receive water from RE-C channels (Raiskola and Halidasht), MCC channel (BMC1, 2, 3, TMC1, 2 and HATKI1, 2), C24 channel (B3-1-1, 2, B3-2 HATKI3) and C25 channel (C24-1, 2 and C25-1, 2, 3, 4).

These two priorities provide the basis for MIKEBASIN model simulation. For example, HATKI1 association receives water from the MCC channel which has a higher location priority compared with BMC1, 2, 3 and TMC1, 2 and HATKI2 associations, therefore, more input water is allocated to it. Furthermore, results analysis in Table 2 shows that the C24-1 association has no water deficiency and Alborz Dam construction have had significant impact on meeting its demand.

In some seasons of the year (January, February, March, December, October and November) ground water including timely flows of Babol, Telar and Siahrood rivers along with the Alborz Dam water discharge meet demand (WUAs) which is in accordance with the results of the studies by Nespak [15] and regardless of other sources (catchments and underground water), these ground water resources can meet the Alborz Dam, the environmental necessity and outlet to the sea requirements. Further evaluation in Table 3 also pinpoints to the fact that considerable shortages is witnessed in the associations from June to August (farming season) coinciding with the rice paddies irrigation time, as a result, the system greatly need to use other sources of water to supply the association from the wetlands and underground water [15]. For example, B3-1-1, B3-1-2, B3-2 and C25-4, BMC2, 3 have significant water shortages. The given associations' location and their relative annual demand show that due to the association's relative low demand for C25-4, the criterion for the water levels allocation simulation is the location priority; therefore, regarding the association's lower location priority, it will not be able to completely meet their needs.

Considering the B3-1-1, B3-1-2, B3-2 associations, despite having higher location priorities, the shortages can still be observed which is due to the associations' relatively high demand and because of this shortage, the water allocation is managed in such a way that the water shortage is at its minimum level. Such trend can be seen more or less in other association as well.

In the present study, the water resource planning was conducted in a way that any shortage or deficiency in the water supply could be minimized. Accordingly, the shortage at the time of water uptake was accompanied by at least 85 percent of the requirements [5]. Whereas some of the requirements that cannot be supplied solely from ground water sources can be provided by underground water and catchments. As a result, each association provided its water requirements through the mentioned mechanisms besides using the networks flows [15]. Since the requirements of any associations will be met through obtaining water from more than one source, subsequently, supply priorities should be considered. Consistent with what was stated, the ground water network has the first priority and catchments and underground water have the second and third priorities, respectively. Also, four C24-1, C25-2, C25-4 and HATKI3 associations have no catchments. Due to the low water allocations in non-farming seasons, the results of catchments and underground water simulation in farming season were presented in figure 4 based on million cubic meters.



(c)

Fig. 4 Simulation of allocation wetlands and groundwater at Alborz network

The simulation is based on the assumption that the required underground water were pumped up from underground water aquifers [15]. The results in figure 4 shows that B1-1, B3-2, HATKI1, BMC3 and B3-1-2 WUAs are highly dependent on groundwater abstraction while the associations in Raiskola and C25-2, C25-3, C24-2 and B3-1-1 had the least amount of underground water uptake. An overview of these associations underground water status and their reservoir (in Table 1) show that in areas where significant shortages were observed, the underground water status is not satisfactory and their water reservoir is relatively insignificant which necessitates considering new strategies for its underground water management. Figure 4 also illustrates that the (C24-1, 2 and C25-1, 2,3,4) WUAs show more dependence on the underground water and , as expected, ground water and catchments conditions were not improved which is in line with the results of the [15] report. In fact, the catchments in this area were not effective in controlling and storing the ground water and their reservoir volumes were not significant.

The water allocation overall results among WUAs in the Alborz Dam irrigation network

Based on the given points and also the conducted analyses, the Alborz network water resources balance results can be estimated. The results are presented in Table 6 based on the mean values. Considering the water resources allocation management among WUAs in Alborz Dam irrigation systems, it was found that among 20 selected associations in the area, 5 associations of BMC2, B3-2, HATKI3, C25-3 and C25-4 were not able to supply all their needs despite using all resources available in the project.

Table 2.Water resources balance at Alborz reservoir irrigation and drainage

WUAs	Demand	Surface Water	Groundwater	Wetland	Deficit
Sum	460	277	131	1.92	13.5

CONCLOSION

The overall result of the present study indicate that 277.02 MCM is supplied from surface water and 131.01 MCM from groundwater and remaining (1.92 MCM) is from Ab-bandans. According to criterion of 85% supply, the evaluated deficiency is 13.5 MCM.

REFRENCES

[1] Andru, J, Capilaa, J, Sanchis, E. 1996. Aquatool: a generalized DSS for Water resources planning and Operational management, journal f hydrology, 177, pp. 269-291.

[2] Bagheri, M.H. and Morid, S. 2013. Comparison of WEAP and MIKE BASIN models in water resources allocation, case study: Tlavar River. Water and soil Conservation Journal, 168, pp. 151- 168.

[3] DHI. 2003. MIKEBASIN aversatile decision support tool for water resource Management planning, guide to getting started tutorial. Danish Hydrualic Institu, Denmark.

[4] Evans, M.E., Lee, R.D., Boisvert, R.N, Arce, B, Steenhuis, S.T, Pran, M.O, Poats, V.S. 2003. Achieving efficiency and equity in irrigation management: an optimization model of the El Angel watershed, Carchi, Ecuador. Agricultural Systems, 77, pp. 1–22.

[5] Hashimoto, T., Stendinger, J.R. and Loucks, D.P. 1982. Reliability, resiliency, and vulnerability criteria for water resources system performance evaluation. Water resources research, 18, pp. 14-20.

[6] George, B., H Malano, K. T Tri, & H Turral. 2003. Using modeling to improve the operational performance of the Cu Chi Irrigation System, Vietnam. Journal of Irrigation and Drainage.Vol 52:1-13.

[7] Garces-Restrepo, C., Munoz, G. and Vermillion, D. 2007. Irrigation management transfer-worldwide efforts and result. Food and Agriculture Organization of the United Nations, pp32.

[8] Jha, M.K. and Gupta, A.D. 2003. Application of MIKEBASIN for water management strategies in a watershed. International Water Resources Association, 28, pp. 27-35.

[9] Kazbekov, J, Abdullaev, I., Manthrithilake, H., Qureshi, A. and Jumaboev, K. 2009. Evaluating planning and delivery performance of Water User Associations (WUAs) in Osh Province, Kyrgyzstan. Agricultural Water Management 96, pp. 1259–1267.

[10] Levite, H., Sally, H., Cour, J. 2003. Testing water demand managem went scenarios in water-stressed basin in South Africa: application of the Weap model. Physics and Chemistry of the Earth, 28, pp. 779-786.

[11] Loucks, D.P., Stedinger, J.R. and Haith, D.A. 1981. Water resource systems planning and analysis. Prentice-Hall, Englewood Cliffs, NJ.

[12] Mugatsia, E.R. 2010. Simulation and scenario analysis of water resources management in Perkerra catchment using WEAP model. M asters Thesis, Department of Civil and Structural Engineering, School of Engineering, Moi University, Kenya,(December).

[13] Perera, B.J.C, James, B., Kularathna, M.D.U. 2005. Computer software tool REALM for sustainable water allocation and management. J Environ Manage, 77, pp. 291–300.

[14] Sotomayor, V Jorge. 1996. Perfil de Riego de la Repu´ blicadel Ecuador. Instituto International delManejo de la Irrigacio´ n (IIMI), Quito, Ecuador.

[15] Unkown. 2009. Basin water and scenario analysis, Alborz Integrated land and Water management project. National IWREMS Consultants, National Engineering Services Pakistan and TarhTadbir Engineering Company

[16] Wurbs, R.A. 2001. Assessing water availability under a water rights priority system. Journal of water Resources Planning and Management, 127, pp. 235-243.

[17] Yates, D., Sieber, J., Purkey, D., Huber Lee, A. 2005. WEAP21 — a demand-, priority and preference driven water planning model. Water international 30, pp. 501-512.