OPTIMIZATION OF WATER USE IN DOWNSTREAM LANDS OF SALMAN FARSI DAM

OPTIMISATION DE L'UTILISATION D'EAU DANS LES TERRES EN AVAL DU BARRAGE SALMAN FARSI

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ABSTRACT

Water shortage is the most important factor limiting agricultural development in arid and semi-arid areas. This situation is mostly due to the climatology factor and non-optimal use of available water resources. Critical conditions of water resources and negative balance of aquifers in Iran, has dramatically affected quality of life and creating some problems such as migration, and keeping the lands unused. This has forced the authorities to take necessary actions toward proper use of water resources by applying modern agricultural techniques to avoid wasting of water.

This field-study covers the case of downstream lands of Salman Farsi Reservoir Dam, located in Fars Province, Iran, with net area of 23,000 ha, including Ghirokarzin, Ali-abad, Afzar and Laghar Plains.

According to the plains water resources planning a quantity of 282.6 MCM was allocated to these lands. But due to potable water requirement of Jahrom City and other environmental needs, 87.6 MCM had to be allocated for this purpose, leaving 195 MCM for downstream use. This shortage of water resources has led to excluding 7000 ha out of 23,000 ha land under development project. That is a 30% reduction. Therefore, an attempt on "optimized solutions of water use" to find out feasible strategies to compensate the reduction of allocated water as well as preventing the reduction of planned land size as much as possible, was on the agenda.

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In the optimization studies, updating meteorological parameters, using new methods of estimating the crop water requirement, using new methods of irrigation, increasing land operation efficiency by assigning the operational management to farmers, applying deficit irrigation, reusing water, etc have been investigated.

Key words: *Water use optimization, Downstream lands, Irrigation and drainage network, Salman Farsi Dam (Iran).*

RESUME

La pénurie d'eau est le plus important facteur limitant du développement agricole dans les zones arides et semi-arides. Cette situation est principalement due au facteur de la climatologie et l'utilisation non optimale des ressources en eau disponibles. conditions critiques des ressources en eau et de solde négatif des aquifères en Iran, a considérablement la qualité effectuée de la vie et la création de certains problèmes tels que la migration, et de garder les terres inutiles. Cela a contraint les autorités à prendre les mesures nécessaires pour la bonne utilisation des ressources en eau en appliquant les techniques agricoles modernes, afin d'éviter de gaspiller l'eau. Cela signifie économie d'utilisation de l'eau est devenue plus importante et cruciale. Par conséquent, il est un sérieux défi pour trouver des solutions appropriées au moyen de ressources des projets sol et l'eau de développement, qui peuvent entraîner une utilisation optimale des ressources, accroître la production agricole et l'amélioration du niveau de vie, protection sociale, et le revenu national. Ce domaine spécifique d'étude couvre le cas des terres en aval du barrage-réservoir Salman persan, situé dans la province de Fars, Iran, avec la superficie nette de 23.000 ha, y compris Ghirokarzin, Ali-Abad, Afzar et plaines Laghar. Selon les ressources des plaines de l'eau la planification d'une quantité de 282,6 MCM a été attribué à ces terres. Mais en raison de l'exigence de l'eau potable de la Ville Jahrom et d'autres besoins de l'environnement une somme de 87,6 MCM doit être alloué à cette fin. Par conséquent fondées sur la répartition à la main, seulement 195 MCM a laissé des terres en aval en cours de développement. Cette pénurie des ressources en eau a conduit à l'exclusion de 7000 ha sur 23.000 ha de terres en vertu du projet de développement. C'est une réduction de l'échelle des 30%. Par conséquent, une tentative de "solutions optimisées de l'utilisation de l'eau" pour trouver des stratégies possibles pour compenser la réduction d'eau allouée ainsi que la prévention de la réduction de la taille prévue des terres autant que possible, a été l'ordre du jour. Dans les études d'optimisation qui a été effectué, la mise à jour des paramètres météorologiques, en utilisant de nouvelles méthodes d'estimation des besoins en eau des cultures, utilisation de nouvelles méthodes d'irrigation, en augmentant l'efficacité des opérations terrestres par l'attribution de la gestion opérationnelle aux agriculteurs, l'application de l'irrigation déficitaire, la réutilisation de l'eau, etc ont été enquête.

Mots clés: *Optimisation de l'utilisation d'eau, terres en aval, réseau d'irrigation et de drainage, Barrage Salman Farsi (Iran).*

(Traduction française telle que fournie par les auteurs)

1. GEOGRAPHIC LOCATION AND INVESTIGATION REGION

The investigation region is located in south-west of Iran in Fars Province between Firoozabad and Larestan Counties. The site is extended from E52º, 50' to E53º, 20' and N30º, 28' to N28º, 30'. This region contains Ghirokarzin, Ali-abad, Afzar and Laghar Plains. The total land under study was 55600 ha, and the net area of 22855 ha was under irrigation and drainage network.

2. PROJECT OBJECTIVES

Salman Farsi Dam is designed and constructed on Ghare-aghaj River in Fars province, aiming to regulate agricultural water requirement of downstream plains, as well as supplying potable water of Jahrom, Larestan and other cities along the route. The other purpose of the Dam is controlling periodic floods with total volume of 1400 Mm^3. In addition, there are some other objectives including reclamation of saline and sodic lands, increasing agricultural and livestock production, creating job opportunities and decreasing immigration to cities and improvement of social conditions and finally building infrastructures for national and regional development.

3. PROJECT COMPONENTS

The project components of Salman Farsi are:

- Reservoir Dam
- Ghir, Afzar and Laghar Diversion Dams
- Irrigation and drainage networks of Ghir, Ali-abad, Afzar and Laghar plains

3.1. Ghir Diversion Dam

The Ghir Diversion Dam is designed to supply the water for 10090 ha of land in Ghirokarzin and Ali-abad plains. This dam has ogee crest made of concrete with the design flood of 2710 m^3/s with the return period of 100 years. This dam is 180m in length and 4m in height above the river bed.

3.2. Afzar Diversion Dam

The Afzar Diversion Dam is designed with the purpose of supplying the water demand for 4515 ha of land in Afzar Plain. This dam has ogee crest with the design of 3000 m^3/s with the return period of 100 years. This dam is 97.5m in length and 5.5m in height above the river bed.

3.3. Laghar Diversion Dam

In order to supply the water demand of 8250 ha of lands in Laghar Plain, the construction of Laghar diversion dam on Ghare-aghaj River has been considered. This dam has ogee crest made of concrete with the design flood of 3125 m^3/s with the return period of 100 years. This dam is 250m in length and 4m in height above the river bed.

3.4. Irrigation and Drainage Network

At preliminary studies of the development project, total regulated volume of surface water resources for agricultural purposes was 282.6 MCM/year (according to the results of first stage studies) and it has been reduced to 195 MCM as a result of water allocation for potable water of Jahrom city and environmental needs. This surface water along with 32.9 MCM ground water, supply the water requirement of 22855 ha (net area) containing 15523 ha development area and 7332 ha improvement area.

The net area of downstream lands of Salman Farsi (according to preliminary study) that is going to be under irrigation and drainage network are as follow:

- Ghirokarzin Plain: net area of 4030 ha containing 2290 ha improvement area and 1740 ha development area.
- Ali-abad Plain: net area of 4800 ha containing 860 ha improvement area and 3940 ha development area.
- Afzar Plain: net area of 4515 ha containing 2415 ha improvement area and 2100 ha development area.
- Laghar Plain: net area of 8250 ha containing 1423 ha improvement area and 6827 ha development area.
- Dutilaghaz Plain: net area of 1260 ha containing 344 ha improvement area and 916 ha development area.

Considering 30% decrease in surface water resources two strategies can be used:

1. Decreasing 30% of downstream lands of Salman Farsi that is about 7000 ha.
2. Optimization studies of water use in order to save all downstream lands area.

In order to save all downstream lands area, revising and updating the previous studies, and also optimizing the studies of water usage has been done with the purpose of investigating the possible strategies to compensate the reduction of allocated water.

4. OPTIMIZATION STUDIES OF WATER USE

In optimization studies, after revising and up-to-dating some previous parameters, some methods of optimization use of water and soil resources are investigated. The main objectives of this study are as follow:

- Up-dating the climatology parameters
- Revision of development and improvement land area
- Investigating the irrigation methods
- Investigating the irrigating efficiencies
- Changing the surface irrigation of gardens to drip irrigation

- Changing the surface irrigation of Afzar lands to low pressure system (hydrofolume)
- Updating the water requirements of cropping pattern
- Revision of canals and intakes capacity (Hydromodule)
- Applying deficit irrigation
- Reusing water
- Water resources allocation planning

5. UPDATING THE CLIMATOLOGY PARAMETERS

The preliminary studies of downstream lands of Salman Farsi go back to 1990s. After about 2 decades since the initial studies, it became evident that some parameters of the former study required revisions. Therefore the climatology parameters, as the most important parameter affecting the irrigation requirement, were revised. Average rainfall and potential evapotranspiration base on studies of 1994 and 2009 are compared in Figs. (1) to (8).

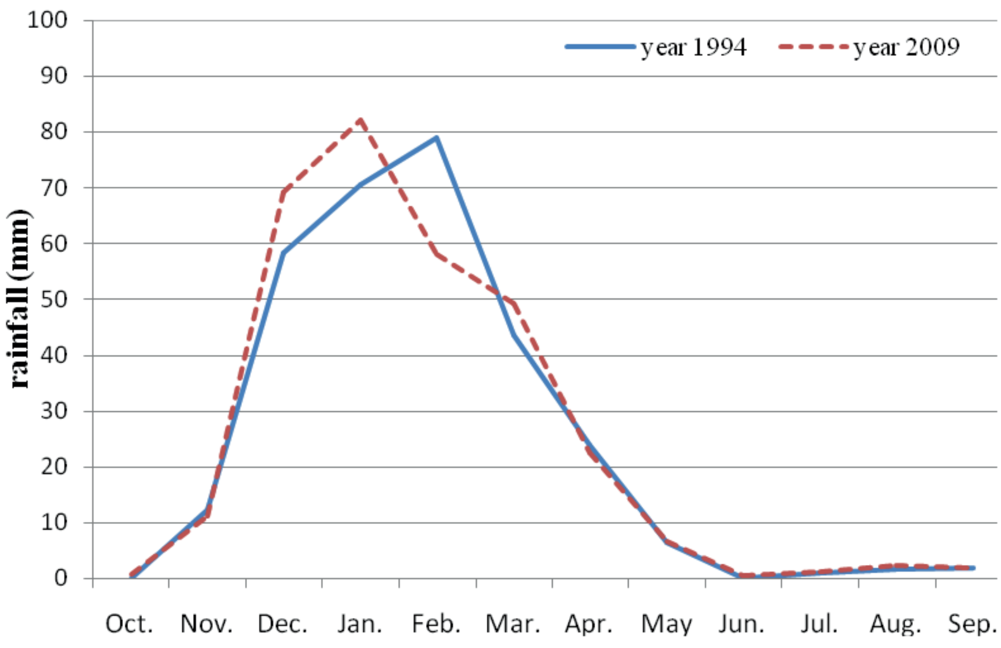

Fig. 1. Comparison of rainfall at 1994 and 2009- Ghir Plain (Comparaison des pluies de 1994 et 2009 - Plain Ghir)

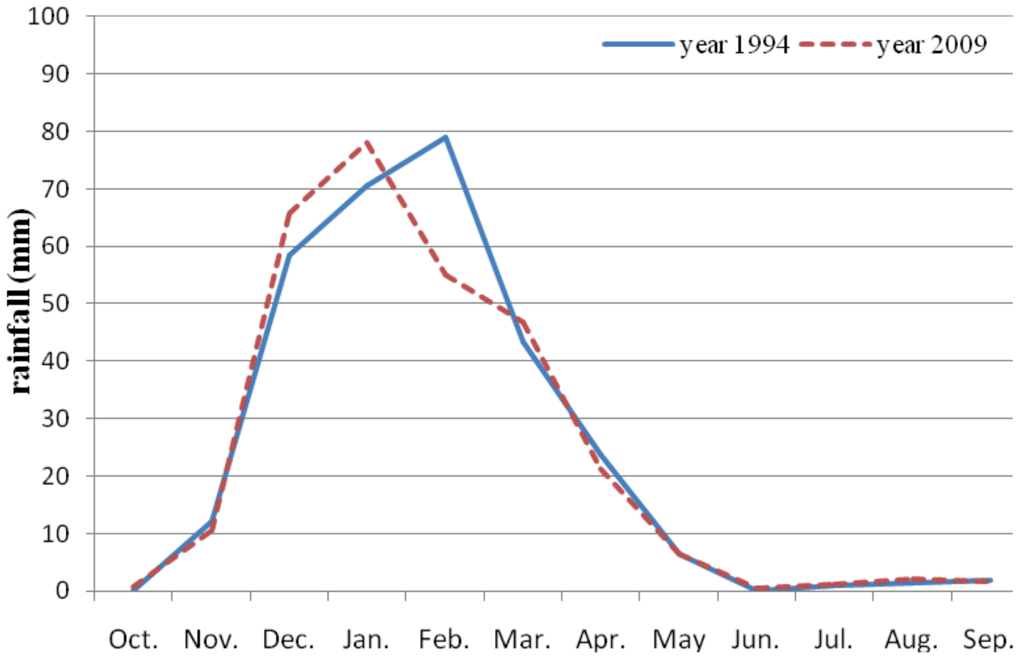

Fig. 2. Comparison of rainfall at 1994 and 2009- Aliabad Plain (Comparaison des pluies de 1994 et 2009 - Plain Aliabad)

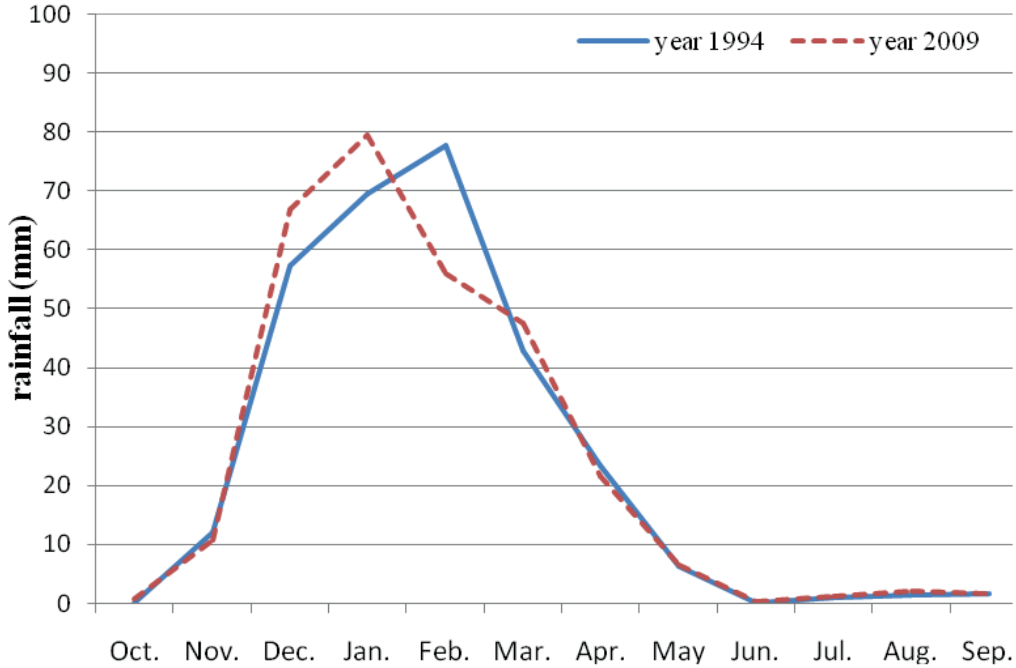

Fig. 3 Comparison of rainfall at 1994 and 2009- Afzar Plain (Comparaison des pluies de 1994 et 2009 - Plain Afzar)

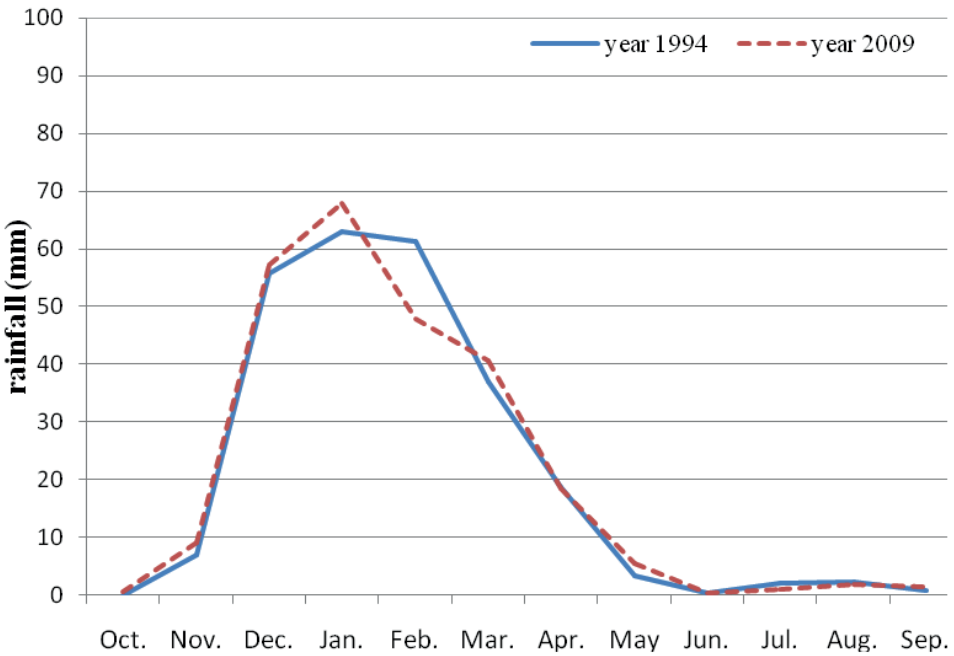

Fig. 4. Comparison of rainfall at 1994 and 2009- Laghar Plain (Comparaison des pluies de 1994 et 2009 - Plain Laghar)

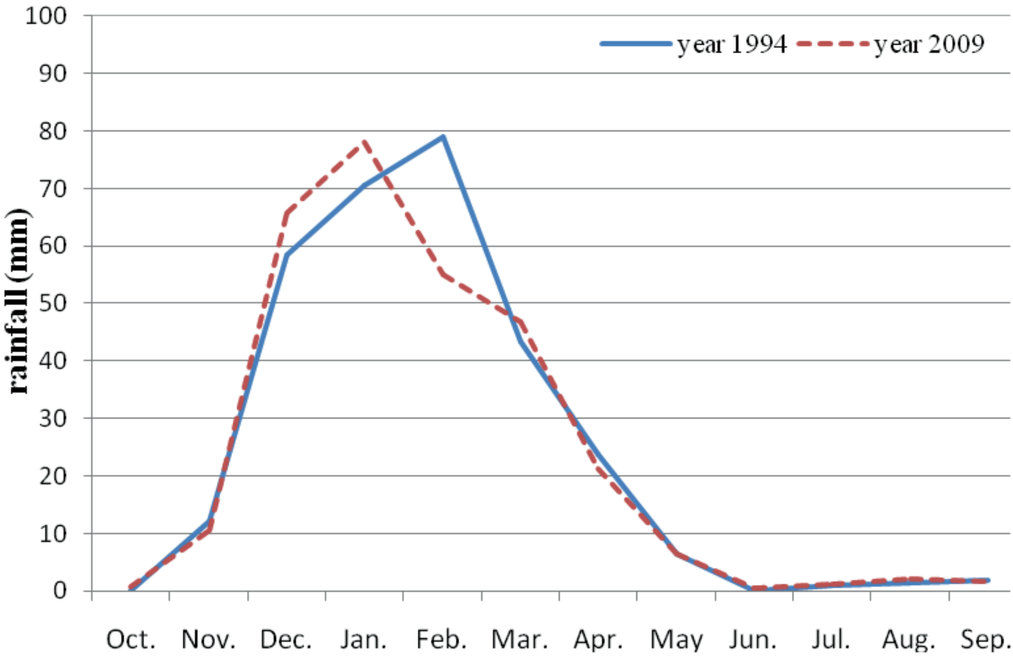

Fig. 5. Comparison of potential evapotranspiration at 1994 and 2009 - Ghir Plain (Comparaison de l'évapotranspiration potentielle de 1994 et 2009 - Plain Ghir)

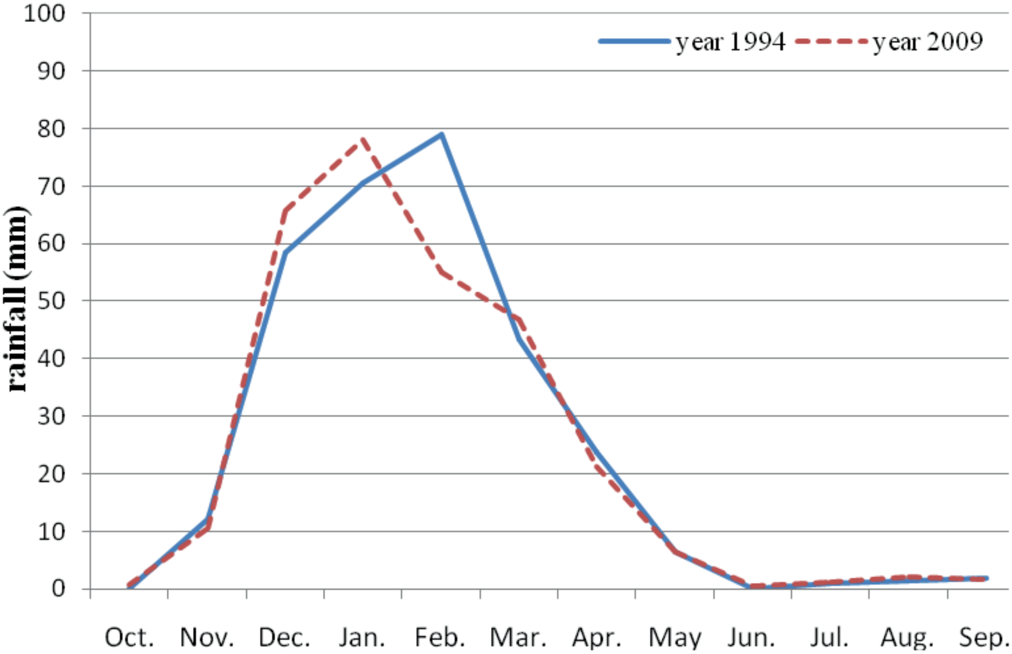

Fig. 6. Comparison of potential evapotranspiration at 1994 and 2009 - Aliabad Plain (Comparaison de l'évapotranspiration potentielle de 1994 et 2009 - Plain Aliabad)

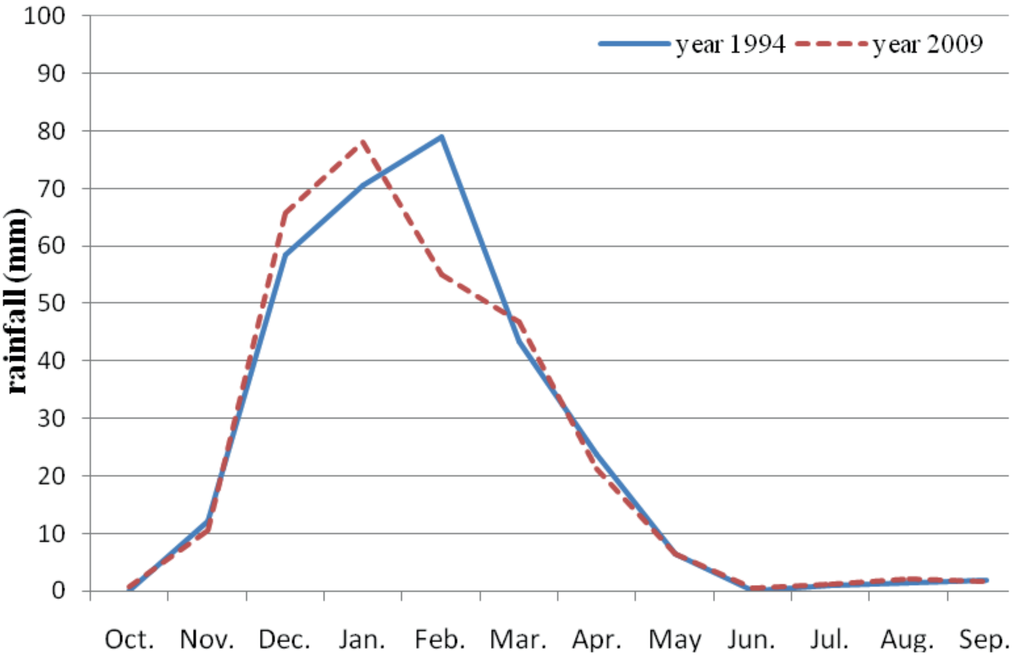

Fig. 7. Comparison of potential evapotranspiration at 1994 and 2009 - Afzar Plain (Comparaison de l'évapotranspiration potentielle de 1994 et 2009 - Plain Afzar)

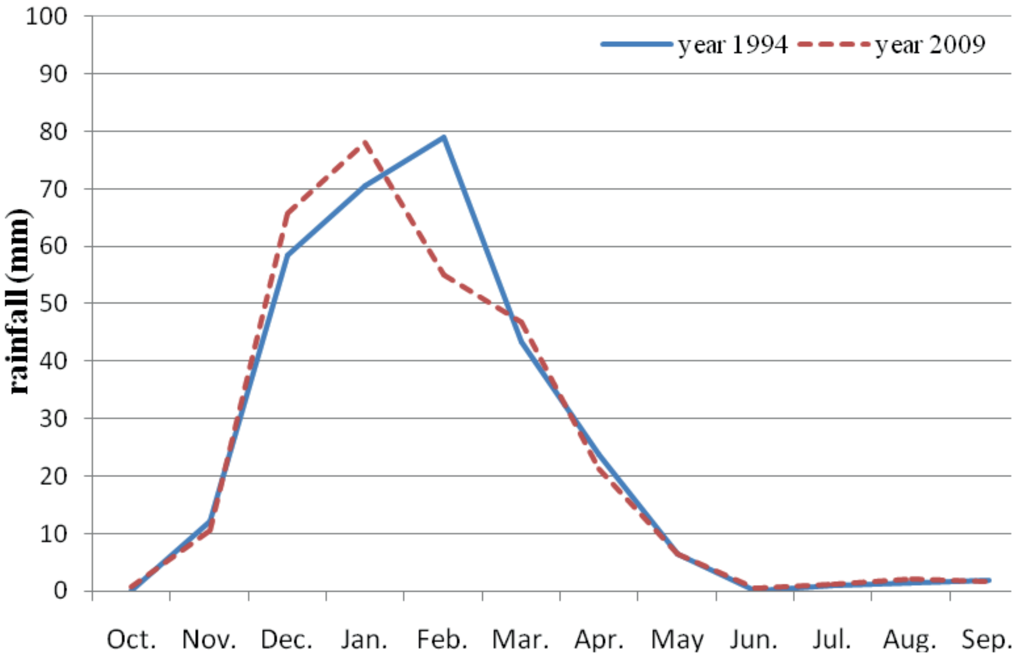

Fig. 8. Comparison of potential evapotranspiration at 1994 and 2009 - Laghar Plain (Comparaison de l'évapotranspiration potentielle de 1994 et 2009 - Plain Laghar)

6. REVISION OF IMPROVEMENT AND DEVELOPMENT LAND AREA

Improvement and development lands area according to the cadastre maps and field visit are revised.

The improvement and development lands area at each plain is presented in Table (1).

Table 1. Improvement and development land area of downstream lands of Salman Farsi (Amélioration et développement de la superficie des terres en aval de Salman Farsi)

Plain/Land	Ghir	Ali-abad	Dutilaghaz	Afzar	Laghar
Improvement Area (ha)	2822	1062	344	2999	1600
Development Area (ha)	1208	3738	916	1516	6650
Total Area (ha)	4030	4800	1260	4515	8250

7. INVESTIGATION OF IRRIGATION METHODS

Selecting the irrigation method is one of the most important stages of irrigation project studies. The water requirement of the proposed cropping pattern in the study region directly depends on the irrigation method and water use efficiency. Application of irrigation water in farmlands takes place in various ways. According to preliminary studies, the surface irrigation method has been selected as the best option to irrigate the downstream lands of Salman Farsi. One strategy to optimize the water use is the application of the modern irrigation methods at areas which have the ability and potential for implementing these methods. In this respect, changing the surface irrigation system of gardens to drip irrigation system and also applying low-pressure system in some areas of Afzar plain were studied and is described as follow.

8. INVESTIGATION OF IRRIGATION EFFICIENCIES

According to land leveling, formation of WUA and also former training in this project, the distribution efficiency should be revised. As a result at optimization studies, the irrigation efficiency has been increased from 80 to 85 percent.
Increasing distribution efficiency increases the total efficiency and therefore the total amount of required water will be decreased. As a result, the overall efficiency at the surface irrigation method will be 53 percent and at the drip irrigation will be 69 percent. Irrigation efficiencies according to the preliminary and optimization studies are presented in Table (2).

Table 2. Irrigation efficiencies for proposed cropping pattern (Efficacité de l'irrigation pour les cultures modèle proposé)

Efficiency/Irrigation method		Conveyance E_c	Distribution E_d	Application E_a	Farm E_f	Overall E_t
Surface Irrigation	Preliminary studies	0.95	0.80	0.66	0.53	0.50
	Optimization studies	0.95	0.85	0.66	0.56	0.53
Drip Irrigation	Preliminary studies	-	-	-	-	-
	Optimization studies	0.95	0.85	0.85	0.72	0.69

Water consumption volume at each plain of Salman Farsi in the case of increased distribution efficiency is presented in Table (3).

9. CHANGING THE SURFACE IRRIGATION OF GARDENS TO DRIP IRRIGATION

Investigations and field visits of downstream lands of Salman Farsi showed that the farmers used modern irrigation methods and had satisfaction from these methods and accepted them as a method in which more area can be irrigated using less water. At the current situation, general orientation of farmers who have enough water is toward using drip irrigation and therefore large area of gardens is equipped by this system. Consequently, according to the difference between the nature of gardens and farmlands, drip irrigation is selected as the better option for gardens of Ghir, Ali-abad and Afzar plains. When drip irrigation was considered for gardens, an increased efficiency in water consumptions was observed which is reported in Table (4).

Table 3. Water consumption volume at downstream lands of Salman Farsi in two cases of the preliminary and optimization studies (La consommation d'eau au volume des terres en aval de Salman Farsi dans deux cas des études préliminaires et l'optimisation)

Plain	Area (ha)	Land use	Area (ha)	Water consumption volume (MCM)		Water saved (%)
				According to preliminary studies	According to optimization studies	
Ghir	4030	Garden	820	11.22	10.57	5.8
		Cultivation	3210	41.21	38.88	5.7
Ali-abad	4800	Garden	216	2.96	2.79	5.8
		Cultivation	4584	56.73	53.52	5.7
Dutilaghaz	1260	Garden	0	0	0	-
		Cultivation	1260	15.60	14.71	5.7
Afzar	4515	Garden	590	8.08	7.61	5.8
		Cultivation	3925	44.82	42.28	5.7
Laghar	8250	Garden	150	3.77	3.56	5.8
		Cultivation	8100	103.76	97.89	5.7
Total	22855			288.15	271.81	5.67

Table 4. Water consumption volume of gardens at downstream lands of Salman Farsi in two cases of surface and drip irrigation (Le volume de consommation d'eau des jardins de terres situées en aval de Salman Farsi dans deux cas de l'irrigation goutte à goutte et la surface)

Plain	Plain Area (ha)	Garden Area (ha)	Water consumption volume (MCM)		Water saved %
			Surface irrigation for gardens (Efficiency= 65%)	Drip irrigation for gardens (Efficiency= 50%)	
Ghir	4030	820	19.93	11.22	43.6
Ali-abad	4800	216	5.25	2.96	43.7
Dutilaghaz	1260	0	-	-	-
Afzar	4515	590	14.34	8.08	43.7
Laghar	8250	150	3.77	-	-

10. CHANGING THE SURFACE IRRIGATION OF AFZAR TO LOW PRESSURE SYSTEM (HYDROFOLUME)

According to the necessity of changing the main channel of Afzar to pipe, the possibility of using low pressure system in some area of this plain was investigated. The comparison of these two irrigation systems showed that not only the social problem will decrease but also 18 percent (about 5.45MCM) of water consumption volume will be saved. The irrigation efficiency and water consumption volume in two cases of surface and low pressure irrigation is presented in Table (5).

Table 5. Comparison of water consumption volume in two cases of distribution by canal and low pressure pipes (Comparaison du volume de la consommation d'eau dans deux cas de la distribution par des canaux et des tuyaux à basse pression)

Land use	Irrigation method	Efficiency				water consumption volume (MCM)	Water saved (MCM)	Water saved (%)
		Conveyance	Distribution	Application	Overall			
Cultivation	Surface	95	80	66	0.50	29.69	4.53	-18
	Low pressure	95	95	66	0.59	25.16		
Garden	Drip*	95	80	85	0.65	5.48	0.92	-20
	Drip**	95	95	85	0.78	4.56		
Total	Surface	-	-	-	-	35.17	5.45	-18
	Low pressure	-	-	-	-	29.72		

* distribution is done by canals
** distribution is done by pipes

11. UPDATING THE WATER REQUIREMENT OF CROPPING PATTERN

Many Factors affect the water requirement of crops such as climatic factors, operating conditions of soil and water resources, characteristics of different plants, and soil and water quality. Among aforementioned factors the climatic parameters affect the consumptive use of crops directly and are investigate more carefully.

Due to the climate change and its effect on estimating the required irrigation water as well as development of new methods of calculating the potential evapotranspiration, revising the water requirement of farmlands and gardens is necessary. Thus, revising and updating the water requirement of cropping pattern based on Penman-Mantis method which proposed by Food and Agriculture Organization (F.A.O.) was performed.

12. REVISION OF CANALS AND INTAKES CAPACITY (HYDROMODULE)

In calculating hydromodule of proposed cropping pattern, minimum required area to complete this pattern is the area that irrigated by an intake or a canal and the maximum allowed area is calculated according to the cultivation of the most consumptive water crops. Canal and intake capacity is calculated considering the maximum volume of water that should be passing at a period of time in critical situation.

Based on the above definitions and assumptions, and factors that were considered for determining the hydromodule, irrigation canal capacity has been estimated using the relationship Q=q*A

That;

A is the net area covered by canal (ha)

q is the design hydromodule (Lit/(s*ha))

Q is the discharge (Lit/s)

Revising and updating the water requirement change the equations of network capacity.

Also the hydromodule of area smaller than 60 hectares and larger than 300 hectares according to the preliminary and optimization studies is illustrated in Figs. (9) and (10).

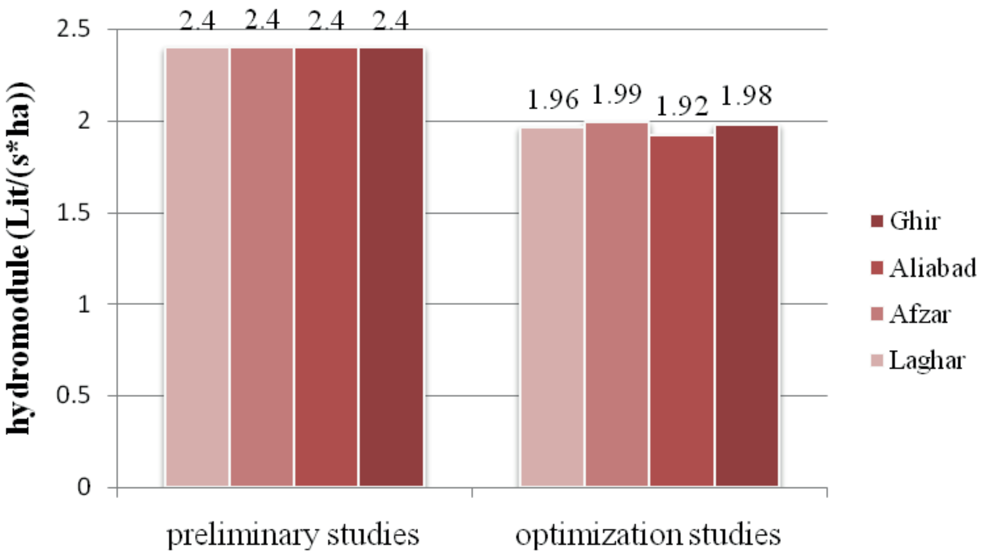

Fig. 9. Hydromodule of area smaller than 60 hectares (Hydromodule de superficie inférieure à 60 hectares)

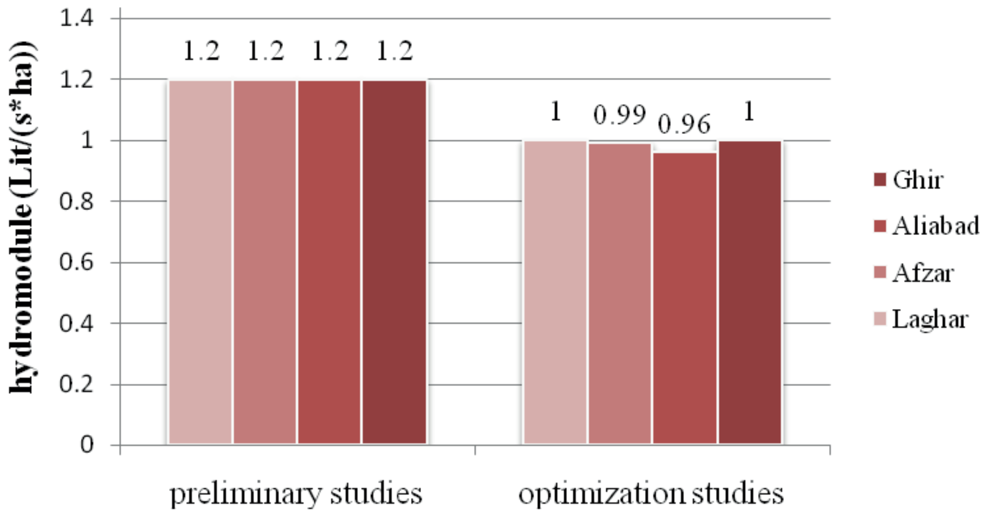

Fig. 10. Hydromodule of area larger than 300 hectares (Hydromodule de la superficie de plus de 300 hectares)

13. USING DEFICIT IRRIGATION

In some area where farmers have little water to irrigate the farmlands, two options can be used:

1. Cultivated area reduction along with supply full water requirements of remaining crops.
2. Supplying partially water requirement of crops, for all lands taken under cultivation

The second option is associated with the deficit irrigation.

Deficit irrigation has been used traditionally by farmers and maybe it has been known in other arid and semi-arid countries. This method has revolutionized the water economy at agricultural sector; therefore investigation about its facts and applications is necessary. Using deficit irrigation in some new irrigation systems that require allocation of huge costs make them economy and reasonable.

Deficit irrigation can be used as an optimal strategy which produces the crops at low water conditions. In this method the optimum use of water is not the amount of water that produces more products per hectares, but the amount of water that produces more products per unit of water. In case of limited water resources and high costs of water supply (funding, energy, labor force, etc) water use efficiency can be raised by deficit irrigation and eliminating the unnecessary cultivations.

Under limited water resources and frequency of cultivable lands (conditions dominated in most parts of Iran), main purpose should be increasing the products per unit of water consumption (so-called crop per drop vs. Crop per ha) and optimal use of these resources. Decrease in products has a non linear relationship with water loss. It has a moderate slop at the earlier stages and a sharp slop at the final stages. Additionally, investigations by many researchers showed that reduction of 20-30 percent in water requirement of most products doesn't create any severe problem for the crops.

According to the limited water resources at downstream lands of Salman Farsi, deficit irrigation has been investigated using F.A.O model. Therefore the water requirement of cropping pattern for 5, 10, 15, 20, 25 and 30 percent deficit irrigation or the supply of 95, 90, 85, 80, 75 and 70 percent of water requirement has been investigated. Based on the calculations of deficit irrigation for downstream lands of Salman Farsi and also considering the national and international studies in this field, 10% deficit irrigation for farmlands without any serious problem for the crops is recommended.

14. REUSING WATER

In order to reduce the water allocation from reservoir dam to 195 MCM, reusing water has been considered. Reusing water of Ghir, Ali-abad, Afzar and Laghar Plains estimated about 40 MCM at developing conditions. Due to the location of the plains, the wastewater of Ghir and Ali-abad plains return to the Ghare-aghaj River just before Afzar Plain. Therefore, the water requirement of Afzar and Laghar is supplied with combination of upstream plains wastewater. Also wastewater of Afzar Plain enters to Ghare-aghaj River using surface drainage and this wastewater in combination with Ghare-aghaj water supplies the water requirement of Laghar Plain. It should be mentioned that wastewater of Laghar Plain (according to its position) with the amount of 16.43 MCM per year is not considered as reusing water and only wastewater of Ghir, Ali-abad and Afzar Plains with amount of 23.64 MCM per year is used in the estimation of reusing water.

15. WATER RESOURCES ALLOCATION PLANNING

In preliminary studies of Salman Farsi, water resources planning were done based on Ghare-aghaj discharge in Salman Farsi dam site. In these studies, volume of 282.6 MCM was allocated to these lands that have been reduced to 195 MCM according to the change of the water allocation for potable water of Jahrom city and environmental needs. Water resources allocation planning at the downstream lands of Salman Farsi based on surface water (Ghare-aghaj River), underground water and reusing water is presented in table (6).

Table 6. Water resources of downstream lands of Salman Farsi (Les ressources en eau des terres situées en aval de Salman Farsi)

Water resource	Water volume
Surface water	195
Underground water	32.91
Reusing water	23.64
Total	251.55

Volume of water requirement at downstream lands of Salman Farsi according to the optimization studies and percent covered by surface and underground resources is illustrated in Tables (7) and (8).

Table 7. Volume of water requirement at downstream lands of Salman Farsi according to the optimization studies (Volume des besoins en eau à des terres en aval de Salman Farsi selon les études d'optimisation)

Plain	area (ha)	Type	Land use	area base on primarily studies (ha)	Annual water requirement (mcm)	Revision of development and improvement land area	Volume of water requirement: Up-to-dating the climatology parameters	Volume of water requirement: Changing the surface irrigation of gardens to drip irrigation	Volume of water requirement: revision of irrigating efficiencies	Volume of water requirement: Using deficit irrigation (10%)
Ghir	4030	Improvement area	Garden	435	16.59	820	19.93	11.22	10.57	10.57
			Cultivation	1855	24.31	2002	25.70	25.70	24.25	21.82
		Development area	Cultivation	1740	22.80	1208	15.51	15.51	14.63	13.17
			Total	**4030**	**63.70**	**4030**	**61.14**	**52.43**	**49.45**	**45/57**
Ali-abad	4800	Improvement area	Garden	25	1.5	216	5.25	2.96	2.79	2.79
			Cultivation	835	13.17	846	10.47	10.47	9.88	9.88
		Development area	Cultivation	3940	49.7	3738	46.26	46.26	43.64	39.28
			Total	**4800**	**64.37**	**4800**	**61.98**	**59.69**	**56.31**	**51/94**
Dutilaghaz	1260	Improvement area	Garden	0	0	0	0	0.00	0.00	0.00
			Cultivation	344	4.34	344	4.26	4.26	4.02	3.61
		Development	Cultivation	916	11.55	916	11.34	11.34	10.69	9.63
			Total	**1260**	**15.89**	**1260**	**15.60**	**15.60**	**14.71**	**13/24**
Afzar	4515	Improvement area	Garden	215	6.96	590	14.34	8.08	7.61	7.61
			Cultivation	2200	25.3	2409	27.51	27.51	25.95	23.36
		Development area	Cultivation	2100	24.15	1516	17.31	17.31	16.33	14.70
			Total	**4515**	**56/42**	**4515**	**59.16**	**52.90**	**49.89**	**45/68**
Laghar	8250	Improvement area	Garden	50	1.83	150	3.77	3.77	3.56	3.56
			Cultivation	1373	18.93	1450	18.57	18.57	17.52	15.77
		Development area	Cultivation	6827	94.35	6650	85.19	85.19	80.37	72.33
			Total	**8250**	**115.11**	**8250**	**107.53**	**107.53**	**101.45**	**91.7**
Total (water requirement of gardens)				**725**	**26.88**	**1776**	**43.29**	**26.03**	**24.53**	**24.5**
Total (water requirement of cultivations)				**22130**	**288.60**	**21079**	**262.12**	**262.12**	**247.28**	**223.6**
Total				**22855**	**315.48**	**22855**	**305.41**	**288.15**	**271.81**	**248.1**

Table 8. Volume of water requirement at downstream lands of Salman Farsi and percent covered by surface and underground resources (Volume des besoins en eau à des terres en aval de Salman le Farsi et pour cent couverts par les ressources souterraines et de surface)

Land conditions	Land use and supplying the water requirement		Plains: Ghir area (ha)	Ghir annual water requirement (MCM)	Ali-abad area (ha)	Ali-abad annual water requirement (MCM)	Dutilaghaz area (ha)	Dutilaghaz annual water requirement (MCM)	Afzar area (ha)	Afzar annual water requirement (MCM)	Laghar area (ha)	Laghar annual water requirement (MCM)	Total area (ha)	Total annual water requirement (MCM)
Land under irrigation and drainage network	Improvement Land	garden	820	10.57	216	2.79	0	0	590	7.61	150	3.56	1776	24.52
		Cultivation	2002	21.82	846	9.88	344	3.61	2409	23.36	1450	15.77	7051	74.45
		Underground water	-	12.15	-	13.17	-	0	-	7.59	-	0	-	32.91
		Surface water	-	9.67	-	0.00	-	3.61	-	15.77	-	15.77	-	41.54
		percent covered by underground resources	-	38	-	100	-	0	-	25	-	0	-	-
		percent covered by surface resources	-	62	-	0	-	100	-	75	-	100	-	-
	Development Land	Cultivation	1208	13.17	3738	39.28	916	9.63	1516	14.70	6650	72.33	14028	149.11
		percent covered by surface resources	-	100	-	100	-	100	-	100	-	100	-	-
	Total		4030	45.57	4800	51.94	1260	13.24	4515	45.68	8250	91.66	22855	248.09

16. CONCLUSIONS

Downstream lands of Salman Farsi reservoir dam with net area of 23,000 ha, including Ghirokarzin, Ali-abad, Afzar and Laghar plains is located in Fars province, Iran. According to the plains water resources planning a quantity of 282.6 MCM was allocated to these lands. But due to potable water requirement of Jahrom City and other environmental needs a sum of 87.6 MCM has to be allocated for this purpose. Therefore based on allocation at hand, only 195 MCM has left for downstream lands under development. This shortage of water resources has led to excluding of 7000 ha out of 23,000 ha land under development project. That is a reduction in the scale of 30%. Therefore, an attempt on "optimized solutions of water use" to find out feasible strategies to compensate the reduction of allocated water as well as preventing the reduction of planned land size as much as possible, was on the agenda.

In optimization studies which had been performed, updating meteorological parameters, using new methods of estimating the crop water requirement, using new methods of irrigation, increasing land operation efficiency by assigning the operational management to farmers, applying deficit irrigation, reusing water, etc have been investigated.

Updating meteorological parameters together with applying new methods of estimating the crop water requirement has resulted to a decrease about 3.2% of water quantity used. Applying new methods of irrigation for gardens has paid with a reduction of 5.6% in the quantity of water. In this project based on leveling of farms, training the farmers and stakeholders and also forming the WUA, the water application efficiency has been improved. An improvement on application efficiency has caused a reduction of 5.7% in the amount of water requirement. Also, deficit irrigation is investigated. Finally, considering the cropping pattern, deficit irrigation of 10% is proposed. In this case study, despite of 30% surface water resources reduction, all development area was fairly saved and utilized, by applying optimization methods of water use.

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