JEAS
Journal of Economics and Administrative Sciences
E-ISSN: 2148-1792 P- ISSN: 1302-2024
Volume 4, Supplement Issue 1
www.jeasweb.org

Evaluation of water-energy efficiency indicators of existing and proposed common crops in catchments

Siamak Gharibi Asl
Department of Agriculture, Ardabil Branch, Islamic Azad University, Ardabil, Iran
Email: siamakgharibi@gmail.com

ABSTRACT

This research was conducted in 2019 to analyze the water-energy efficiency indicators of existing and proposed common crops in areas of Ardabil province. The physical and economic-energetic efficiency indicators of water were executed as a completely randomized block design as a factorial test with two replications. The results showed that all the studied traits had a normal distribution. In addition, it was observed in the variance analysis of the evaluated indicators that there is a probability level in 5 and 1% between scenarios, the province catchments, and common crops, and their mutual effects based on all physical and economic-energetic indicators of water. Both indicators of total physical and irrigation water indicators of Kosar and Khalkhal areas were maximum with values of 0.992 and 1.38 kg/m3, and Khalkhal and Kosar area had 16.11 and 17.19% increase in water physical and total irrigation indicators. The hybrid of 80% common crops and 20% common medicinal plants of Kosar and Khalkhal areas in barely the common cultivation pattern of the catchment in Kosar and Khalkhal increased the irrigation water economic index by 97%. Totally, the obtained results from this research showed that changing the cultivation pattern toward the medicinal plants improved the physical and economic-energetic indicators. Therefore, it is suggested to make policies to increase the under-cultivation area for the medicinal plants for the studied area in short-term and long-term plans.
Keywords: catchments, common crops, and medicinal plants, water-energy efficiency indicators

Introduction

Common crops in the catchments of Ardabil province include *Triticum aestivum*, *Hordeum vulgare*, *Medicago sativa*, *Trifolium resupinatum*, and *Onobrychis viciifolia Scop* (Ardabil Jihad Agricultural Organization, 2018). *Triticum aestivum* is one of the major cereals that are widely produced in the world and Iran due to its ease of production and importance in human nutrition so that today it provides more than 35% of the world's main food (Kazemi-Arbat, 2005). *Hordeum vulgare* is one of the four most important grains in the world (Tuttolomondo and Labell, 2008) and is one of the oldest plants that have been exploited in Iran (Khajehpour, 2005). Leguminous plants are one of the most important forage plants that are widely cultivated all over the world today (Karimi, 2005). These plants are considered as animal protein supplements in most livestock forage breeding systems (Mehrdad et al., 2004). *Medicago sativa* is considered the most important forage plant of the leguminous family (Karimi, 2003). This plant is among the best forage plants and is called green gold because of its richness in protein, calcium, vitamins, good taste, and a low percentage of cellulose (Mofidian et al., 2013). *Trifolium resupinatum* is significantly mentioned for having about 16% protein, 60% to 85% carbohydrates, and a variety of vitamins including C, E, K, D, and A for forage production (Zamanian and Rezaei, 2015). These plants are palatable for livestock and even before the formation of seed pods, they do not dry out and retain the value of their fodder. Their dry matter is relatively low, but the amount of dry fodder protein of some cultivars reaches 26-24%. The total digestible matter of them in laboratory conditions is about 91% and the digestibility of all organic matter of autumn forage of these plants in ruminants is 93% (Nasri et al., 2015). *Onobrychis viciifolia Scop* is one of the cultivars cultivated in the catchment areas of Ardabil province and is one of the forage plants of the legume family that has drought resistance and adaptation to cold regions, for cultivation in a wide range. It has made favorable areas and pastures (Frame, 2005).

High levels of tannins in the leaves of *Onobrychis viciifolia Scop* prevent bloating in livestock and increase the absorption of amino acids in their intestines. *Onobrychis viciifolia Scop*, like other legumes, coexists with nitrogen in symbiosis with Rhizobium bacteria. However, the nitrogen fixation efficiency of *Onobrychis viciifolia Scop* is lower than that of *Medicago sativa* (Irani et al., 2015). Agriculture is one of the main consumers of water as it accounts for 85% of surface and groundwater resources (Molden, 2007 and Shiklomanov, 2000). In addition, reducing water consumption in this important part of the economy is part of the important strategies that are considered by experts to reduce the problem of water shortage (Chukalla et al., 2015). Water consumption efficiency is one of the indicators of optimal irrigation water consumption. According to the general definition, water efficiency is a ratio in the denominator of which is applied water (irrigation water, rainfall), and various cases of quantitative concepts are included in the numerator. These include product yield, net income (profit), amount of the produced energy, amount of the produced calories, amount of added value, etc. Generally, the two concepts of physical and economic water efficiency are more widely used in analysis and decision making. Based on the definition, the physical efficiency of water consumption is the amount of product produced per unit volume of the water consumption, which is expressed in kg/m^3. The value of the produced product or the profit is mentioned in the economic efficiency. In other words, it should be indicated how much income the farmer earns for the amounts of the consumed water. Water efficiency is a need and a first step and can never be considered the end of monitoring, which is the beginning of large activity. Obviously, the index of 5 kg of fodder corn per cubic meter of water consumption is never equal to the index of 0.4 kg of pistachios per cubic meter of water. Even the water efficiency index in the production of Triticum aestivum will be different in different places with different water qualities or different cultivars, and each one should be examined in its place. One policy of extensive evaluation is using a similar dimensional analysis and consideration of the net income which will actualize the economic efficiency concepts. The efficiency index at the beginning of the fourth development plan was 0.8-0.9 kg/m^3 and this is a target of 1.6 kg/m^3 in the 20-year landscape plan. Of course, water efficiency is a need and a first step and never is considered the end of monitoring, which is the beginning of a broad activity (Abbasi et al., 2017). Drought and water shortage in Iran is a climatic fact and due to the growing need for water in different sectors, this problem will become more acute in the coming years. The country's long-term mean rainfall is 243 mm (one-third of the global mean) and the evaporation potential in the country is about 2000 mm per year (three times the global mean). The total volume of rainwater resources in the country is 403 billion m^3 more than 70% of which is inaccessible through evaporation. The volume of renewable water resources is about 100 billion m^3, 70% of which is used in agriculture (Naseri et al., 2017). Therefore, the existing cultivation patterns, that are harmful based on physical and economic indicators of water, should be increased with new crops that require less water such as medicinal plants in these areas. To be noticed that farmers of these areas and the relevant organizations know the importance of this issue and have started them in initial steps. One of the most important indicators of the economic evaluation of a medicinal plant is its medicinal value, market demand, and level of processing. According to the World Food Organization report, the value of the global trade in medicinal plants, which is currently about 1000 billion $/y will reach five trillion dollars a year. Iran currently accounts for only $ 4 to $ 6 million in the global trade in medicinal plants with its much better climatic conditions and plant diversity than Europe. Fortunately, with the world, especially developed countries, intention to plant products and its incremental consumption in the world, both in the pharmaceutical industry and in the food and cosmetics industries, Iran has a golden chance to use in the best form and increase its presence in the global markets because of its climate varieties and the possibility of planting most plants. In such circumstances, one of the effective and practical solutions is the optimal and economical use of Hordeum vulgare is saving water consumption. Meanwhile, managing water consumption in the agricultural sector can be very effective and instructive which includes a major part of water consumption in Iran and the world. Obviously, it is essential to identify the main indicators of water consumption management and determine this indicator in the appropriate ways to achieve this goal. Irrigation efficiencies, agricultural water use efficiency, amount of water consumption in the agricultural sector, and sustainable development of new irrigation methods are the most important key indicators and basic approaches in macro planning related to the supply, allocation and principled use of water in Different sectors include agriculture (Abbasi et al., 2015). Irrigation efficiencies, agricultural water use efficiency, amount of water consumption in the agricultural sector, and sustainable development of new irrigation methods are the most important key indicators and basic approaches in relevant macro-planning to the supply, allocation, and principled use of water in different agricultural sectors (Abbasi et al., 2015). In this research, this research was evaluated to analyze and compare the energy-water efficiency indicators of existing a suggested common crops of catchments in Ardabil provinces in 2018-2019. The reasons for selecting these medicinal plants are as follows:

The new policy and cultivation pattern of the province are medicinal plants.

Medicinal plants need less water than existing cultivated plants

The added value and economic benefits of medicinal plants are higher than existing cultivated plants.
People's approach to the use of herbs and traditional medicine has increased.
The approach of the country's pharmaceutical centers has increased to supply the natural active ingredients in the preparation of medicines. Suitability of cultivation of medicinal plants with small and scattered lands (smallholder farmers)

Materials and methods

This research was conducted in 2018 to evaluate and compare the existing and suggested common water crop efficiency indicators of leading Aras, Moghan, and Ghezel Ozan catchments to Sefidrud in Ardabil province for 2016-2017 crop year. This research is applied based on objective because its results are usable for planners, authorities, and policies of the province agricultural development. The indicators of total physical efficiency of irrigation, physical efficiency of irrigation water, effective rain efficiency, evapotrans opiration efficiency, total economic efficiency of irrigation, total economic efficiency of irrigation water, and seasonal energy demand were evaluated in this research. In this test, a factorial test as a completely randomized block design was used with 2 replications. Four studied scenarios in this research include a1: common crop cultivation pattern of the catchment, a2: 90% common crop and 10% the common medicinal plants of the area, a3: 85% common crop, and 15% the common medicinal plants of the area, and a4: 80% common crop and 20% the common medicinal plants of the area), catchments in three levels (b1: Dareh Rud in Aras catchment, b2: Bolgar Chay in Moghan catchment, and b3: Kosar and Khalkhal areas in the leading Ghezel Ozan to Sefid Rud), and common crops at five levels (*Triticum aestivum, Hordeum vulgare, Medicago sativa, Trifolium resupinatum, and Onobrychis viciifolia Scop*).

Studied variables

In this research, physical and economic indicators of water and energy efficiency were estimated as follows:

Total physical efficiency of irrigation (kg/m^3)

As stated, outputs are defined as physical units that are generally the amount of crop production in water physical efficiency indicators. Therefore, they are placed in physical efficiency classifications. The production value of the products is often stated based on Kg/ha. The irrigation total physical efficiency is estimated by the following formula (Upadhyaya and Alok, 2016 and Vazifedoust et al., 2008):

$$\text{Total physical efficiency of irrigation (kg/m}^3\text{)} = \frac{\text{Crop yield}}{\text{Total water demand}}$$

Irrigation water physical efficiency (kg/m^3):

Irrigation water physical efficiency is calculated using the following formula (Upadhyaya and Alok, 2016):

$$\text{physical efficiency of irrigation water (kg/m}^3\text{)} = \frac{\text{Crop yield}}{\text{Irrigation amount}}$$

Evapotrans opiration efficiency (kg/m^3)

WPET evapotrans opiration is sometimes used because of the difficulty of separating transpiration, in which case water use efficiency is defined as follows (Nazari and Liyaghat, 2016; Kijne et al., 2003; and Vazifedoust et al. ., 2008):

$$\text{Evapotrans opiration efficiency (kg/m}^3\text{)} \quad \frac{\text{Crop yield}}{\text{Evapotrans opiration}}$$

The effect of eliminating unwanted evaporation in irrigation and agricultural systems on water efficiency can be evaluated by this index. This indicator can be measured and monitored. This index is relatively approximate and not accurate, and a lysimeter should be used to measure it accurately, which is a costly method and its facilities are not available everywhere (Vazifedoust et al., 2008).

Effective rain efficiency (kg/m^3)

Irrigation water physical efficiency is estimated by the following formula (Nazari and Liyghat, Kijne et al., 2003, and Vazifedoust et al., 2008):

$$\text{Rainfall efficiency (kg/m}^3\text{)} \quad \frac{\text{Crop yield}}{\text{Rainfall amount}}$$

Economic efficiency of total irrigation (Rials/m^3)

The total economic efficiency of irrigation is estimated using the following formula (Upadhyaya and Alok, 2016):

$$\text{Economic efficiency of total irrigation (Rials/m}^3\text{)} = \frac{\text{Gross revenue (yield} \times \text{price of the product)}}{\text{Total water demand}}$$

Economic efficiency of irrigation water (Rials/m^3)

Economic efficiency of irrigation water is calculated by the following formula (Upadhyaya and Alok, 2016):

$$\text{Economic efficiency of irrigation water (Rials/m}^3\text{)} = \frac{\text{Gross revenue (yield × price of the product)}}{\text{Irrigation amount}}$$

Seasonal energy demand (kWh)

Seasonal energy demand is estimated using the following formula (Kay and Hatcho, 1992; Abebe et al., 2017):

$$\text{Seasonal energy demand (kWh)} = \frac{\text{Irrigation volume × Dynamic height pressure}}{365 \times 0.6}$$

The existing and cultivated medicinal plants of farmers were in Aras catchment (Rosa damascene, Aloysia citrodora, Calendula officinalis, Cichorium intybus, Thymus), Bolgar-Chay in Moghan catchment (Rosa damascene, Aloysia citrodora, Crocus sativus L.), Kosar and Khalkhal in Ghezel Ozan catchment leading to Sefid Rud (Rosa damascene, Calendula officinalis, Crocus sativus L., Echium, Mentha piperita L). In addition, the mean yield of the medicinal plants is shown in Table 1. The evaluated price statistics (Table 2) and the yield of the crops (Table 3) by the Agricultural Jihad Organization of Ardabil Province, were collected. Part of the related data to the irrigation net need and rainfall was estimated using NET WAT software (Alizadeh and Kamali, 2018). Then, the evaluated indicators (six water efficiency indicators and one indicator for energy efficiency) were estimated separately for each product in three catchments of Ardabil province after collecting preliminary data.

Table 1: The mean yield and price of the evaluated medicinal plants of this research in 3 catchments

The province catchments	Yield (kg/ha)	Price of 2019 (Rial)
Aras catchment, (Dareh Rud) Meshkin Shahr	2250	127000
Moghan (Germi-Bileh Savar)	2760	382000
Ghezel Ozan catchment leading to Sefid Rud (Kosar-Khalkhal)	2300	281000

Table 2: The guaranteed price list of the evaluated crops of this research in Ardabil province (Agricultural Jihad Organization of Ardabil Province, 2019)

Product	Price of 2019 (Rial)
Triticum aestivum	13000
Hordeum vulgare	10300
Medicago sativa	12000
Trifolium resupinatum	10000
Onobrychis viciifolia Scop	12000

Reference: Agricultural Jihad Organization of Ardabil Province, 2019

Table 3: The yield of the evaluated irrigated and semi-irrigated crops in the studied catchments in the province in 2017-2018 (Agricultural Jihad Organization of Ardabil Province, 2019)

Province catchments		Yield of irrigated and semi-irrigated crops (kg / ha)
Aras catchment, (Dareh Rud) Meshkin Shahr	*Triticum aestivum*	13000
	Hordeum vulgare	10300
	Medicago sativa	12000
	Trifolium resupinatum	10000
	Onobrychis viciifolia Scop	12000
Moghan (Germi-Bileh Savar)	*Triticum aestivum*	13000
	Hordeum vulgare	10300
	Medicago sativa	12000
	Trifolium resupinatum	10000
	Onobrychis viciifolia Scop	12000
Ghezel Ozan catchment leading to Sefid Rud (Kosar-Khalkhal)	*Triticum aestivum*	13000
	Hordeum vulgare	10300
	Medicago sativa	12000
	Trifolium resupinatum	10000
	Onobrychis viciifolia Scop	12000

Reference: Agricultural Jihad Organization of Ardabil Province, 2019

The most proper hybrid treatment was selected based on the evaluated indicators after collecting the needed data from Agricultural Jihad Organization and estimating the water and energy efficiency for the common crops and the suggested medicinal plants in the catchments of Ardabil province using SPSS and MSTATC software.

Results and discussion

Data normality test showed that the test errors had normal distribution in all the studied traits. Results (Table 4) showed the significant difference in 5 and 1% probability level between the scenario levels, the province catchments, common crops, and their reciprocal effects based on all physical, economic, and water energy indicators. The minimum coefficient of variation (4.5) was obtained for evapotrans opiration index. However, the maximum coefficient of variation (11.33) was obtained for the effective rainfall index. The high coefficient of variation for this index shows its intensive effect on this index (Table 4).

Table 4: Variance analysis of the evaluated indicators

SOV	df	Mean of Square						
		Water physical indicators				Water physical indicators		Seasonal energy demand
		Total irrigation physical index	Irrigation water physical index	Effective rainfall	Evapotrans opiration	Total irrigation economic index	Irrigation water economic index	
Rep	1	0.128**	0.057**	37.34ns	0.532**	1.476**	0.139ns	0.3*
Factor a (scenarios)	3	0.649**	1.837**	2797**	132.6**	53337.3**	101257**	23216**
Factor b (catchments)	2	0.192**	0362**	9400**	77.2**	38615**	98600**	32982**
A×B	6	0.011ns	0.006**	275**	2.015*	4346**	10813**	97.48**
Factor c (common crops)	4	4.383**	0.41**	2818**	541**	25741**	83235**	491705**
A×C	12	0.126**	0.209**	220**	17.2**	2704**	8744.4**	1225**
B×C	8	0.302**	0.417**	2130**	19.4**	2212**	12649**	2730**
A×B×C	24	0.016*	0.003**	127**	1.03**	250.3**	1342**	19.69**
Eroor	59	0.01	0.0004	54.42	0.003	0.001	3.329	0.063*
C.V%		10.49	6.67	11.33	4.5	10.02	7.88	8.09

*and ** are 1 and 5% probability level

Total physical and irrigation water indicators

Many types of research have been conducted on water efficiency so far and this issue has been intensified in recent years for the more critical shortage of water resources (Zamani et al., 2014). Determining the water consumption efficiency indicators and their time and place change procedure are developing in many countries all over the world. This issue has been doubly significant in Iran for the water shortage crisis. Moreover, today the use of methods such as the use of GIS has made it possible for experts to analyze and evaluate water efficiency faster, easier, and more accurately because of the extension and diversity of water consumers (Ehsani and Khaledi, 2003). The three-way effect of scenarios× catchments × common crops (Table 5) showed that the hybrid of 80% common crops and 20% of common medicinal plants in Moghan had the maximum total physical index in Hordeum vulgare with a mean of 1.834 kg/m^3. There was no difference between the hybrids of 80% common crops and 20% common medicinal plants in Kosar and Khalkhal in Hordeum vulgare; 85% common crops and 15% common medicinal plants in Moghan in Hordeum vulgare; 90% common crops and 10% common medicinal plants in Moghan in Hordeum vulgare; 90% common crops and 10% common medicinal plants in Kosar and Khalkhal in Hordeum vulgare and Common cultivation pattern in Moghan catchment in Hordeum vulgare. Hence, they were in the same classification. Alternatively, consuming 1 ton of water only produces 1834 g crops of which 1467 g is Hordeum vulgare and 3668 g is medicinal plants. In addition, the hybrid of 85% common crops and 15% common medicinal plants of area × Moghan × Trifolium resupinatum with a mean of 0.12 kg/m^3 had the minimum total physical index. In other words, 120 g Trifolium resupinatum was produced by 1-ton water consumption. Moreover, the hybrids of 90% common crops and 10% common medicinal plants of Kosar and Khalkhal × Hordeum vulgare; a hybrid of 85% common crops and 15% of common medicinal plants of the region × Kosar and Khalkhal × Hordeum vulgare and hybrid of 80% common crops and 20% of common medicinal plants of the region × Kosar and Khalkhal × Hordeum vulgare with means of 2.671, 2.696, and 2.666 kg/m^3 were maximum, respectively. Alternatively, 1-ton water consumption produces 2671, 2696, and 2666 g Hordeum vulgare crop, and the hybrid of common cultivation pattern of catchment × Meshkin Shahr × Trifolium resupinatum and common cultivation pattern of catchment × Moghan × Trifolium resupinatum had the minimum physical index of irrigation water. According to Yang et al. (2006), water efficiency in the production of Triticum aestivum in different parts of the world has varied in the wider range of 15.15 to 2.4

kg/m^3. Ali et al. (2007) reported in three experiments on water efficiency in Triticum aestivum cultivation in Bangladesh, irrigation water efficiency and total water efficiency of this crop were 1.13 and 1.06 kg/m^3, respectively. Turknejad et al. (2006) reported that the grain yield of Triticum aestivum increased by 13% and the water efficiency of Triticum aestivum increased by 86% by changing the irrigation method from the surface to drip in the Islamabad region of Kermanshah. Verdinezhad et al. (2009) reported that the mean water consumption efficiency in the network for two years of 2006-2007 and 2007-2008 were 1.29 and 1.07 kg/m^3, respectively. The mean efficiency based on the basic product of Triticum aestivum was obtained 0.55 and 0.77 for the two mentioned crop years, respectively. Alizadeh et al. (2010) determined and reported the water use efficiency of Triticum aestivum irrigation and the total water use efficiency of Triticum aestivum (irrigation and rainfall water) as 1.5-2-9.5 kg/m^3, respectively. Water productivity of Triticum aestivum has been reported in different catchments of India, Punjab province of Pakistan, different parts of Turkey and Egypt are 0.47-2.7, 0.76-1.6, 0.43-1.2, and 1.35 kg/m^3, respectively (quoted by Keshavarz and Dehghani Sanih, 2012). Mohtadi et al. (2013) reported the mean water efficiency in Khuzestan province in three products of Hordeum vulgare, Triticum aestivum, and Medicago sativa as 0.85, 1.04, and 0.76 kg/m^3, respectively. Azizihan et al. (2014) reported the change range of water efficiency for Triticum aestivum 0.3-2.4 kg/m^3 by analyzing the garden test in water and soil research institutes all over the state. In this regard, the maximum water efficiency of this product was obtained in a water consumption range of 200-400 mm. Anabi and Zamani (2014) determined and reported the water consumption efficiency of Triticum aestivum of Alvand cultivar as 0.93 kg/m^3 in East Azerbaijan. The water efficiency of the Yellow River catchment in China was reported 0.59 kg/m^3 for Triticum aestivum. Studying the water efficiency in India showed it variation between 0.27 and 1.49 kg/m^3 between the various catchments of that country for Triticum aestivum (Tang et al., 2014).

Effective rainfall and evapotrans opiration

The amount of lost water by evaporation from the soil surface and transpiration of the plant is called evapotrans opiration. Evaporation is an energy-dependent process that involves changing from a liquid to a vapor state. Effective rainfall is the amount of useful rain to supply the water need of the plant or to restore in the soil for the next times for production. This is the minimum rainfall some of which will get stored in the soil if falls at once on the desired soil condition. Comparing the evapotrans opiration and effective rainfall indices in four catchments (Table 5) showed that the maximum and minimum mean effective rainfall indicators are 10.56 and 18.75 kg/m^3, respectively for the hybrids of 90% of common crops and 10% of common medicinal plants of the region × Moghan × Medicago sativa and the hybrid of the common cultivation pattern of the catchment area × Meshkin Shahr × Trifolium resupinatum. The maximum evapotrans opiration index was obtained in hybrids of 90% of common crops and 10% of common medicinal plants of the region × Moghan × Hordeum vulgare and the hybrid of 85% of common crops and 15% of common medicinal plants of the region × Moghan × Hordeum vulgare. The higher the number of physical indicators of water, the better for us; in other words, it was lower than the grain yield of common water products, evapotrans opiration, and effective rainfall. Hordeum vulgare in scenarios 3 and 4 and Moghan, Kosar, and Khalkhal regions is superior to other hybrids in the evaluated catchments based on the total physical irrigation and irrigation water indicators (Table 5). Cuenca (1978) used Gossypium (kg/ha) as a function of the real evapotrans opiration and concluded that the maximum point of the crop and the slope of the line follow the characteristics of the plant. However, he used the given amount of water curve relative to the product and showed that the crop efficiency is much higher in low irrigation amount to obtain the consumption efficiency. Najvani Moghadam et al. (2017) reported that 450 mm total applied water should be used and water shortage should be managed to reach 1.1 kg/m^3 applied water efficiency amount for Triticum aestivum by considering the effective rainfall of the area.

Total economic index and irrigation water

Comparing the three-way effect of two irrigation water economic index and total irrigation index showed that (Table 5) the hybrid of 80% of common crops and 20% of common medicinal plants in the region × Kosar and Khalkhal × Hordeum vulgare with a mean of 425.8 Rials/m^3 had the maximum irrigation water economic index and increased by 97% in irrigation water economic index than common cultivation pattern of the catchment area × Kosar and Khalkhal × Hordeum vulgare which has a mean of 11.97 Rials/m^3. Moreover, the hybrid of 80% common crops and 20% of common medicinal plants in the region × Kosar and Khalkhal × Hordeum vulgare with a mean of 247.42 Rials/m^3 had the maximum total irrigation economic index.

Seasonal energy demand

The importance of energy in this era is to the extent that not only economy and technology but also humans' lives will not be possible without energy because economic and industrial development is not possible without the use of energy. Energy plays an important role in production processes and economic prosperity as a final consumer good provides human welfare and comfort and as a productive input. Therefore, the secure and timely supply of the consumed energy and the proper condition to produce various goods and services on the one hand are associated with production growth and prosperity. On another hand, the existence of this good in the consumer basket of households plays an important role to increase the desirability of individuals and the welfare of society. In addition, the state water resources shortage made the agricultural sector, as the main consumer of the state's water resources, face water shortage for food production. In this condition, the most important challenge for the agricultural sector is to increase water efficiency and produce more food from less water (Dehghani Sanij et al., 2007). A significant difference was observed in the 1% probability level between the main factors and two-way and three-way effects invariance analysis of the obtained data from the seasonal energy demand index (Table 4). The hybrid of 80% common crops and 20% of common medicinal plants in Kosar and Khalkhal areas × Hordeum vulgare with a mean of 88 kWh had the minimum seasonal energy demand index (Table 5). Similar studies have been conducted (including studies all over the state such as Bushehr (Davani and Hassanzadeh, 2010), Khuzestan province (Mahdavi et al., 2010), Shushtar (Fibaei et al., 2011),

Ramhormoz (Attar et al., 2011), Eqlid of Fars province (Hosseini et al., 2012), Savojbolagh (Vejdani et al., 2010), Chaharmahal and Bakhtiari Province (Mihammadi Dashtaki et al., 2012), and west of Isfahan (Fereydoun and Fereydun Shahr)) about the consumed energy of the produced crops whose results show that the increased water consumption will increase the consumed energy and so increase the seasonal energy demand index. In addition, higher energies generally have negative effects that are in agreement with the obtained results from this research.

Conclusion

Determining the water consumption efficiency indicators and analyzing their time and place changes trends have developed in many countries of the world. This problem has signified in Iran and this province because of the water crisis. Two total physical and irrigation water indicators of Kosar and Khalkhal areas with values of 0.992 and 1.38 kg/m^3 were maximum, respectively, and Khalkhal and Kosar areas increased by 16.11% and 17.19% than Meshkin Shahr in water physical and total irrigation indicators, respectively.

Kosar and Khalkhal areas with values of 106.79 and 154.24 R/m^3 had the maximum total economic and irrigation water indicators and increased by 51.31 and 57% in total economic and irrigation water indicators, respectively.

The hybrid of 80% common crops and 20% common medicinal plants in Kosar and Khalkhal in barely crop with the value of 425.8 R/m^3 had the maximum irrigation water index and showed an increase by 97% in irrigation water index in barely with a mean of 11.97 R/m^3. Moreover, the hybrid of common crops and 20% common medicinal plants in Kosar and Khalkhal areas for barely with a mean of 247.42 R/m^3 had the maximum total economic irrigation index.

Table 5: comparing the water and energy mean physical and economic indicators water and energy

Scenarios effect × catchments × common crops			Mean squares						
			water physical indicators (kg/m^3)				water economic indicators (kg/m^3)		Seasonal energy demand (kW/h)
			Total irrigation	Irrigation water	Effective rainfall	Evapotrans opiration	Irrigation water economic index	Total irrigation economic index	
Common cultivation pattern of catchments	Meshkin Shahr	Triticum aestivum	0.525^{de}	0.73^{v}	24.5^{nop}	6.31^{z}	9.53^{z}	6.9^{z}	177^{ef}
		Hordeum vulgare	0.965^{fgh}	1.01^{r}	29.5^{mnop}	8.64^{z}	10.49^{z}	7.25^{z}	139^{f}
		Medicago sativa	0.925^{l-p}	1.12^{pq}	68.9^{efgh}	10.35^{v}	13.69^{z}	11.29^{z}	372^{de}
		Trifolium resupinatum	0.225^{stuv}	0.26^{z}	18.8^{p}	2.49^{f}	2.86^{z}	2.33^{z}	425^{c}
		Onobrychis viciifolia Scop	0.795^{k-o}	0.94^{st}	66.1^{fghi}	8.73^{z}	11.38^{z}	9.62^{z}	418^{cd}
	Moghan	Triticum aestivum	0.845^{de}	1.1^{q}	48.2^{ijkl}	9.92^{w}	14.34^{z}	11.1^{z}	200^{e}
		Hordeum vulgare	1.125^{ab}	1.54^{h}	56.9^{hijk}	13.8^{j}	10.49^{z}	11.74^{z}	152^{ef}
		Medicago sativa	0.955^{hijk}	1.12^{pq}	84.9^{bcde}	40.5^{u}	13.56^{z}	11.58^{z}	451^{bc}
		Trifolium resupinatum	0.255^{w}	0.26^{z}	35.8^{lmno}	3.64^{z}	3.85^{z}	3.44^{z}	517^{a}
		Onobrychis viciifolia Scop	0.575^{stuv}	0.66^{w}	61.3^{hij}	6.25^{z}	7.97^{z}	7.04^{z}	512^{ab}
	Kosar and Khalkhal	Triticum aestivum	0.895^{efg}	1.35^{k}	33.7^{l-p}	11.03^{t}	17.7^{z}	11.8^{z}	155^{ef}
		Hordeum vulgare	1.125^{abc}	1.54^{h}	21.5^{op}	8.65^{z}	11.9^{z}	7^{z}	110^{g}
		Medicago sativa	0.875^{i-n}	1.05^{r}	69.5^{efgh}	9.66^{x}	12.7^{z}	10.6^{z}	403^{d}
		Trifolium resupinatum	0.295^{stu}	0.33^{yz}	82^{def}	3.21^{z}	3.41^{z}	3.02^{z}	460^{b}
		Onobrychis viciifolia Scop	0.595^{n}	0.68^{w}	61.3^{hij}	6.25^{z}	8.28^{z}	7.21^{z}	452^{bc}
90% of common crops and 10% of common medicinal plants in the area	Meshkin Shahr	Triticum aestivum	0.989^{h-m}	1.411^{j}	48.66^{ijkl}	17.7^{f}	109.9^{pq}	78.66^{pq}	159^{ef}
		Hordeum vulgare	1.21^{fgh}	1.891^{g}	55.86^{hijk}	22.6^{a}	138.4^{k}	94.7^{k}	125^{fg}
		Medicago sativa	0.879^{k-o}	1.25^{mn}	84.9^{bcde}	13.1^{k}	60.58^{vw}	49.6^{vw}	335^{de}
		Trifolium resupinatum	0.419^{stuv}	0.53^{yz}	40.3^{klmn}	6.48^{z}	44.63^{yz}	37.6^{yz}	382^{de}
		Onobrychis viciifolia Scop	0.949^{i-n}	1.151^{p}	40.7^{klmn}	8.86^{z}	53.15^{yz}	44.5^{yz}	377^{de}
	Moghan	Triticum aestivum	1.46^{cde}	1.931^{fg}	86.1^{bcde}	17.4^{g}	122.8^{m}	94.3^{lm}	180^{ef}
		Hordeum vulgare	1.79^{ab}	2.491^{b}	93.2^{abcd}	17.7^{f}	154.1^{i}	116.6^{i}	137^{f}
		Medicago sativa	1.14^{ghi}	1.361^{k}	105.6^{a}	12^{q}	60.94^{vw}	51.8^{vw}	406^{d}
		Trifolium resupinatum	0.189^{vw}	0.53^{yz}	63.46^{ghi}	5.88^{z}	46.3^{yz}	40.4^{yz}	466^{b}
		Onobrychis viciifolia Scop	0.499^{rst}	0.99^{tu}	86.4^{bcde}	9.28^{y}	50.22^{yz}	43.9^{yz}	461^{bc}
	Kosar and Khalkhal	Triticum aestivum	1.34^{def}	2.10^{c}	54.46^{hijk}	17.73^{f}	276.1^{f}	182.4^{f}	140^{f}
		Hordeum vulgare	1.73^{ab}	2.67^{a}	43.56^{jklm}	22.6^{a}	380.6^{c}	216^{c}	90^{h}
		Medicago sativa	1.04^{h-l}	1.27^{lm}	86.2^{bcde}	13.01^{k}	112^{op}	93.4^{lm}	362^{de}
		Trifolium resupinatum	0.491^{rst}	0.58^{xy}	95.9^{abcd}	6.48^{z}	91.34^{t}	79.01^{pq}	414^{cd}
		Onobrychis viciifolia Scop	0.819^{l-p}	0.96^{s}	87.86^{bcd}	8.86^{z}	97.34^{s}	96.4^{lm}	407^{d}
85% of common crops and 15% of common medicinal plants in the area	Meshkin Shahr	Triticum aestivum	1.45^{de}	1.46^{i}	48.91^{ijkl}	12.6^{mn}	115.4^{no}	82.58^{mno}	150^{fg}
		Hordeum vulgare	1.22^{fgh}	1.94^{f}	56.11^{hijk}	16.5^{i}	145.5^{j}	99.52^{j}	118^{gh}
		Medicago sativa	0.82^{l-p}	1.26^{lm}	82.68^{cdef}	12.5^{n}	62.74^{uv}	51.32^{uv}	316^{ef}
		Trifolium resupinatum	0.39^{stuv}	0.57^{xy}	40.1^{klmn}	5.40^{z}	47.03^{yz}	39.62^{yz}	362^{def}
		Onobrychis viciifolia Scop	0.88^{k-o}	1.16^{p}	40.7^{klmn}	5.45^{z}	55.08^{xy}	6.32^{xy}	356^{def}
	Moghan	Triticum aestivum	1.45^{de}	2.02^{e}	88.2^{abcd}	18.1^{d}	128.6^{l}	98.62^{lm}	170^{efg}
		Hordeum vulgare	1.74^{ab}	2.53^{b}	92.8^{abcd}	22.5^{a}	162.3^{h}	122.33^{h}	129^{fg}
		Medicago sativa	1.07^{hijk}	1.36^{k}	102.7^{ab}	12.7^{lm}	63.21^{uv}	53.73^{uv}	384^{de}
		Trifolium resupinatum	0.12^{w}	0.58^{yz}	63.4^{ghi}	6.49^{z}	48.33^{yz}	42.32^{yz}	440^{bc}
		Onobrychis viciifolia Scop	0.42^{stuv}	0.91^{tu}	85.2^{bcde}	8.75^{z}	52.33^{yz}	45.72^{yz}	435^{bc}
	Kosar and Khalkhal	Triticum aestivum	1.32^{efg}	2.12^{c}	54.13^{hijk}	17.33^{g}	290.5^{e}	191.92^{b}	133^{fg}
		Hordeum vulgare	1.67^{abc}	2.69^{a}	43.9^{jklm}	17.85^{e}	402^{b}	233.6^{n}	93^{h}
		Medicago sativa	0.96^{i-n}	1.27^{lm}	84.04^{cde}	11.7^{r}	117^{n}	97.82^{lm}	342^{def}
		Trifolium resupinatum	0.442^{stu}	0.61^{x}	93.6^{abcd}	5.89^{z}	96.04^{s}	83.18^{r}	391^{de}
		Onobrychis viciifolia Scop	0.72^{n-r}	0.92^{tu}	80.23^{defg}	8.53^{z}	102.2^{r}	88.17^{lm}	384^{de}
80% of common crops and 20% of common medicinal plants in the area	Meshkin Shahr	Triticum aestivum	1.054^{h-l}	1.386^{jk}	49.51^{ijkl}	12.6^{mn}	121.7^{m}	87.03^{lm}	142^{fg}
		Hordeum vulgare	1.334^{efg}	1.926^{fg}	56.51^{hijk}	16.51^{i}	153.5^{i}	105.02^{i}	111^{gh}
		Medicago sativa	0.894^{j-o}	1.202^{o}	40.9^{klmn}	12.11^{p}	63.25^{uv}	53.42^{uv}	298^{de}
		Trifolium resupinatum	0.494^{rst}	0.56^{xy}	41.3^{klmn}	5.41^{z}	49.64^{yz}	41.82^{yz}	340^{bc}
		Onobrychis viciifolia Scop	0.954^{i-n}	1.106^{q}	41.5^{klmn}	5.45^{z}	57.32^{wx}	48.12^{wx}	335^{de}
	Moghan	Triticum aestivum	1.584^{bcd}	2.05^{de}	90.6^{abcd}	18.61^{c}	135.3^{k}	103.72^{k}	160^{efg}
		Hordeum vulgare	1.834^{a}	2.486^{b}	92.7^{abcd}	22.42^{b}	171.2^{g}	128.72^{g}	122^{gh}
		Medicago sativa	1.124^{ghij}	1.306^{l}	100.4^{abc}	12.33^{o}	65.74^{u}	55.9^{u}	361^{def}
		Trifolium resupinatum	0.21^{uvw}	0.56^{yz}	63.71^{ghi}	6.42^{z}	50.94^{yz}	44.62^{yz}	414^{cd}
		Onobrychis viciifolia Scop	0.484^{rst}	0.876^{u}	84.08^{cde}	8.55^{z}	44.74^{yz}	47.92^{yz}	409^{d}
	Kosar and Khalkhal	Triticum aestivum	1.394^{def}	2.1^{cd}	54.06^{hijk}	17.17^{h}	306.8^{d}	202.72^{d}	125^{fg}
		Hordeum vulgare	1.754^{ab}	2.67^{a}	44.51^{jklm}	17.91^{e}	425.8^{a}	247.42^{a}	88^{i}
		Medicago sativa	1.024^{h-m}	1.22^{no}	82.77^{cdef}	11.31^{s}	123^{m}	102.8^{m}	322^{efg}
		Trifolium resupinatum	0.539^{rs}	0.59^{xy}	91.5^{abcd}	5.84^{z}	102^{r}	88.3^{lm}	368^{def}
		Onobrychis viciifolia Scop	0.784^{m-q}	0.876^{u}	78.9^{defg}	8.33^{z}	107.8^{q}	92.94^{q}	361^{def}

The different letter shows the significant difference by Duncans test in 5% sig. level.

References

[1] Abbasi F., Abbasi N., and Tavakoli A., 2017, Water efficiency in agriculture, challenges and perspectives, Analytical Note, Journal of Water and Sustainable Development, Vol. 4, No. 1, 10 pages.

[2] Abebe D. Chukalla, Maarten S. Krol, and Arjen Y. Hoekstra, 2017. Marginal cost curves for water footprint reduction in irrigated agriculture: guiding a cost-effective reduction of crop water consumption to a permit or benchmark level. Hydrol. Earth Syst. Sci., 21, 3507–3524, 2017.

[3] Agricultural Jihad Organization of Ardabil Province, 1397. Extension Department. Site: http://tarvij.araj.ir/

[4] Agricultural Jihad Organization of Ardabil Province, 2016. Central Organization Site: http://www.araj.ir/

[5] Ali, M.H., M.R. Hoque, A.A. Hassan and A. Khair. 2007. Effects of deficit irrigation on yield, water efficiency and economic returns of wheat. Agric. Water Manage. 92:151–161.

[6] Alizadeh A and Kamali B., 2018, Net need for irrigation of crops and gardens, NETWAT software.

[7] Alizadeh H.A., Nazari B., Parsinehad M., Ramzani Etedali H., and Janbaz H.R., 2010, Evaluation of Aquacrop model in management of low irrigation of wheat in Karaj region, Iranian Journal of Irrigation and Drainage, No. 2, Volume 4, 283-273.

[8] Annbi Milani A., Zamani S.A., 2014, the impact of irrigation planning methods on yield and efficiency of wheat water consumption, Journal of Water Research in Agriculture, Vol. 28, No. 3, 489-502.

[9] Ardabil Province Program and Budget Organization, 2015. Economic, Social and Cultural Report of Ardabil Province, 279 pages.

[10] Ardabil Regional Water Company, 2018. Statistics and information, statistics and specifications of stations in the province, Website: arrw.ir

[11] Attar S., Sheikhdavudi M., J., and Almasi M., 2010, Evaluation of different rice production systems using energy and economic analysis in East Khuzestan. The first national conference on mechanization and new technologies in agriculture, Ahvaz.

[12] Azizizohan A.E., Shahabifar M., Ebrahimipak N.A., Razavi R., Ghalebi S., Sarae Tabrizi M., Toluei R., and Piri R., 2014, Evaluation of wheat water consumption efficiency in Iran and the world. The first national conference on soil and water management in wheat production. Soil and Water Research Institute

[13] Chukalla, A.D., Krol, M.S., and Hoekstra, A.Y. 2015. Green and blue water footprint reduction in irrigated agriculture: effect of irrigation techniques, irrigation strategies and mulching. Hydrology and Earth System Science. 19: 4877-4891.

[14] Cuenca R.H. (1987). Crop-Water Production Functions and System Design, Proceedings, American Society of Civil Engineers Irrigation and Drainage Division Specialty Conference, Portland, Oregon. Pp.271-278

[15] Davani D., Hassanzadeh A., 2010, Energy flow in dryland wheat fields Triticum aestivum L in Bushehr province and its impact on the environment. Sixth National Congress of Agricultural Machinery Engineering and Mechanization, Campus of Agriculture and Natural Resources, University of Tehran, Karaj.

[16] Dibaei M.H., Mahdizadeh Kuzari M.V., Ghorbani Birgani M., 2011, Investigation of energy efficiency for irrigated wheat cultivation in the northern region of Khuzestan. National Conference on Agricultural Management, Jahrom.

[17] Ehsani M. and KHaledi V.h., 2003, Agricultural water efficiency. National Irrigation and Drainage Committee of Iran 104 p ..

[18] Frame, J. 2005. Forage Legumes for Temperate Grasslands. Science Publishers Inc. Enfield, NH, USA.

[19] Ghahdarijani M., 2007, Determining the energy consumption of wheat and potato production in different levels of cultivation in the west of Isfahan. Master Thesis. University of Tehran.

[20] Hosseini S., M., Adzalinia, S., V., Molaei K., 2012, Investigation of energy indicators in wheat production with different tillage methods. 7th National Congress of Agricultural Machinery and Mechanization Engineering, Shiraz.

[21] Irani S., Majifi M.M., Mirlohi A., 2015, evaluation of the efficiency and drought tolerance in Ian agricultural Onobrychis viciifolia Scop cultivars, Journal of Production and Processing of Crops and Horticultural Products, vol. 5, No.18, 14 pages.

[22] Karimi 2005, Wheat, Tehran University Publishing Center, First Edition.

[23] Karimi, H. 2003. Alfalfa. Center for University Publications. Tehran. 376 pp. (In Persian).

[24] Kay, M. and Hatcho, N. 1992. Small-scale Pumped Irrigation: Energy and Cost: irrigation Water Management Training Manual, Food and

[25] Kazemi-Arbat, H. 2005. Morphology and anatomy of cereal crops (Firsted.). Tabriz University Press, Iran, 189 pp.

[26] Keshavarz A., Dehghani Sanich H., 2012, Water efficiency index and future strategy of the agricultural sector, Quarterly Journal of Economic Strategy, Vol. 1, No. 1, p. 18

[27] Khajepour M., 2005, Principles and foundations of agriculture. Isfahan University Press. 381 pages.

[28] Kijne, J. W., Toung, T. P., Bennett, J., Bouman, B., and Oweis, T. 2003. Ensuring food security via improvement in crop water efficiency. CGIAR challenge program on water and food (CP), Background paper1.

[29] Mahdav S., Mohammadi Mogharab M., Jafarian M., and Sadrnia H., 2010, Analysis of energy consumption in the production of major crops of Khezri Agricultural Joint Stock Company. The first national conference on mechanization and new technologies in agriculture, Ahvaz.

[30] Mehrdad M., Alikhani M., Ghorbani R. 2004. The impact of harvest's growth on the chemical composition and degradation of hay. Journal of Science and Technology of Agriculture and Natural Resources, 8 (2): 167-159.

[31] Mofidian S.M.A., Agha Shahi A.R., Moghadam A. 2013. Quantitative and qualitative forage yield of cold-region alfalfa ecotypes of Iran. Seed and Plant Journal, 1-29 (4): 745-729.

[32] Mohammadi Dashtaki K., Behrudi Lar M., and Maleki M., 2012, Evaluation of energy factor of irrigated wheat production in Chaharmahal and Bakhtiari province. The first national conference on sustainable development in arid and semi-arid regions, Abarkooh.

[33] Mohtadi M., Albaji M., and Dustmohammadi M., 2013, Evaluation of water efficiency of three crops of barley, wheat and alfalfa in Khuzestan province by city, Fourth National Conference on Irrigation and Drainage Networks Management, Ahvaz, Shahid Chamran University of Ahvaz. Pages:8

[34] Molden, D. 2007. Water for food, water for life: a comprehensive assessment of water management in agriculture. Earthscan, 664p.

[35] Nakhgavani Moghadam M., Ghahraman M., and Zareei Gh., 2017, Analysis of wheat water efficiency in irrigation management in some regions of Iran, Journal of Water Research in Agriculture, B, Vol. 31, No. 1, 15 pages.

[36] Naseri A., Abbasi F., and Akbari M., 2017, Estimation of water consumption in agriculture using water balance method. Journal of Irrigation and Drainage Structures Engineering Research, (18) 68: 17-32.

[37] Nasti R., Kashani A., Paknezhad F., Vazan S., and Barari M., 2015, Comparison of yield of new forage plants of Brassica genus with clover in Ilam climate. Iranian Journal of Crop Research, Volume 13, Number 1, pp. 146-153.

[38] Nazari B. and Liyaghat A., 2017, Principles and indicators of water efficiency in agriculture, Report of the Secretariat of Specialized Commissions of the Iran Chamber, Report No. 019574.

[39] Shiklomanov, I.A. 2000. Appraisal and assessment of world water resources. Water International. 25: 11-32.

[40] Statistical Yearbook of Water of the country 1391-1390, 1394. Ministry of Energy, Deputy of Water and Wastewater. Macro Planning Office of the Ministry of Energy, 302 pages.

[41] Tang J. Cheng H. Liu L. 2014. Assessing the recent droughts in Southwestern China using satellite gravimetry. Water Resour. Res.50, 3030–3038.

[42] Torknezhad A., Aghaei Sarbazeh M., Jafari H., Shirvani A.R., Roeintan R., Nemati A., and Shahbazi Kh., 2006, Technical and economic evaluation of drip irrigation method in wheat and its comparison with surface irrigation method, Journal of Research and Construction in Agriculture and Horticulture. No. 72: 36-44.

[43] Tuttolomondo, T., Labell. S., 2008. Simulation of the effects of climate change on barely yield inrural Italy. F.A.O.website. www.FAO.Org.

[44] Upadhyaya A, Alok KS. 2016. Concept of Water, Land and Energy efficiency in Agriculture and Pathways for Improvement. Irrigat Drainage Sys Eng 5:154. doi:10.4172/2168-9768.1000154

[45] Vazifedoust, M., van Dam J.C. Feddes R.A. and Feizi M. 2008. Increasing water efficiency of irrigated crops under limited water supply at field scale. Agricultural Water Management, 95: 89-102.

[46] Vejdani Haris F., Taghizadeh Z., Mohajerdust V., Almasi M., and Nasirian N., 2010, Determining the pattern of energy consumption in wheat production in Savojbolagh city and optimizing its consumption using linear planning model. Sixth National Congress of Agricultural Machinery and Mechanization Engineering, Agricultural and Natural Resources Campus, University of Tehran (Karaj).

[47] Yang, H., L. Wang, K.C. Abbaspour and A.J.B. Zehnder. 2006. Virtual water trade: An assessment of water use efficiency in the international food trade. Hydrology and Earth System Sciences 10:443-454.

[48] Zamanian M., Rezaei M., 2015, Evaluation of yield and forage quality of Iranian clover lines in climatic conditions of Karaj. Iranian Journal of Crop Sciences. 17 (4): 287-273.