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Iran's Agricultural Exports Policy from the Perspective of Virtual Water and Its Economic Value

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ABSTRACT

Export is an essential part of trade, and is the main mechanism of any country to increase its economic growth. It would be prudent for countries facing water stress to consider the role of Virtual Water besides the economic aspects of exports. This would, in turn, lead to more purposeful export strategies while preserving valuable domestic water resources. Here, a three-step framework is presented to judge how to export better-targeted products in the agricultural sector, as the largest water-consuming sector of Iran, where water shortage is currently one of the main national challenges. The framework is established based on two indices: Price and Revenue. The price index stands for the cost that must be paid, and the revenue index measures the economic value earned from exporting a certain amount of Virtual Water hidden in sold products. Comparison of these two criteria between Iran and the World trade can lead to maximizing incomes from exports and minimizing domestic water resource consumption. The efficiency of the proposed approach was investigated for six exported agricultural products: dates, pistachios, and saffron as the most well-known international brands of Iran's agricultural industry, and tea, rice, and watermelon as the representative water-intensive products during 2005-2016. The results show that the current states of exports have unfavorable conditions both from the perspective of water resources exploitation and export incomes. Furthermore, the results show that the proposed framework can provide a better platform for considering not only export incomes, but also volume and economic value of exported Virtual Water.

1. Introduction

Iran has been experiencing a serious water crisis, especially in arid and semi-arid regions with extensive water challenges/shortages [1]. Persistence of successive drought conditions in Iran has led to new strategies in water resources management with a focus on modifying current consumption patterns. Virtual Water (VW), as the volume of water required in order to produce a commodity or service, was first introduced by Allan [2], and as a result, is being more carefully examined. While the volume of VW can never provide a clear picture about social, environmental, and economic condition of a community [3], it is certain that, the volume of VW of a nation can be a sign of country's water need [4]. From this point of view, virtual water trade can be a barrier or an accelerator for economic growth. Recent studies have concluded that virtual water can be directly related to water scarcity [5-7], water availability [8], and water dependency [9].

The concept of VW plays a strategic role in how sustainability in production patterns can be achieved while the pressure on domestic water resources becomes minimal. As a general rule, the more VW (embedded in products) is exported, the more pressure on domestic water resources will be exerted. Although this rule sounds acceptable within the conventional water resources management, it may be incorrect from the perspective of the economic world, marketing, VW trades, and their corresponding theories. Needless to say, focusing solely on the economic aspect of trade can expose very harmful effects on the water resources.

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For example, Guan & Hubacek [10] showed that the success of China's economic growth rate in recent years has led to profound impacts on the quantity and quality of water resources. This finding has come out through studying imported and exported VW between different hydro-economic regions of China and comparing net flows of goods and services, volume of VW exports, and ratio of value added to amount of water and wastewater.

Many researchers have conventionally used the VW concept to classify Iran's agricultural sector as a country importing or exporting VW [11, 12] and consequently evaluating Iran's dependency on VW imported/exported [9]. Some other studies investigated VW as a means to alleviate Iran's water resources management challenges [13, 14]. The common point of all previous studies is the neglect of the economic value of Iran's VW trade.

Negative impacts of this neglect on international VW exports are indisputable, especially for the Iranian agricultural sector, which consumes more than 90% of the water resources. For example, Iran traditionally has been recognized as a prestigious international brand of unique agricultural products in world trade. The export of these unique products not only gives exclusive and political credits to Iran, but it always has abundant added economic value. Agricultural self-sufficiency is perceived to be a notion that can adversely deplete water and fund resources requirements to trade products with other countries to meet the basic needs of the people of Iran. In this regard, Ward & Michelsen [15], while reviewing different influencing issues on the economic value of water in agriculture, claimed that information on water's economic value not only leads to more informed choices on water resources management but also can maximize the product or revenue obtained from the water usage. In this regards, Wang et al. [16], not only showed that compensation for crop virtual water export can increase the efficiency of agricultural water use, but also it can increase the competitiveness of financial gain for agricultural production. This application of the economic value of water for crops had been discussed before [17], and its usage has rarely been studied for regulating national trade and purposeful exports.

This study aims to examine VW trade of some agricultural products and their related economic issues to address Iran's current agricultural export. For this reason, a three-step framework enriched with new defined indexes (Price and Revenue) is presented. Six agricultural products; dates, pistachios, and saffron as the most well-known international brands of Iran agricultural industry export, tea, rice, and watermelon as the water-intensive products in Iranian food diary basket were selected to show how a better platform can be established to maximize incomes and minimize VW (agricultural water resources consumption) of Iran exports simultaneously. In this regard, a comparison with the world export figures would be necessary.

2. Methodology

In order to identify better-targeted agricultural products with higher export margins in terms of their VW gains, this section has been divided into two parts. First, Iran's and the world's export trends in the global market are investigated in order to gather a reliable database. In fact, in this step, the past operating conditions of Iran and the world export for the mentioned agricultural products from 2005 to 2016 were identified. The needed information was gathered from the FAO, Iran Ministry of Agriculture-Jihad and the Chamber of Commerce, Industries, Mines, and Agriculture. Some of the main information about exported products, including the export quantity and value, producer prices, average volume of VW embedded in each product, and its trade for Iran and the world, was examined. Second, with the gathered known values of input data, the efficiency of the proposed approach is investigated for each agricultural crop. Here, the suggested framework with its main key basic features (shown in Fig. 1) consists of the following steps. It is worth nothing that developed indexes are formulized based on some previous proposed studies [16].

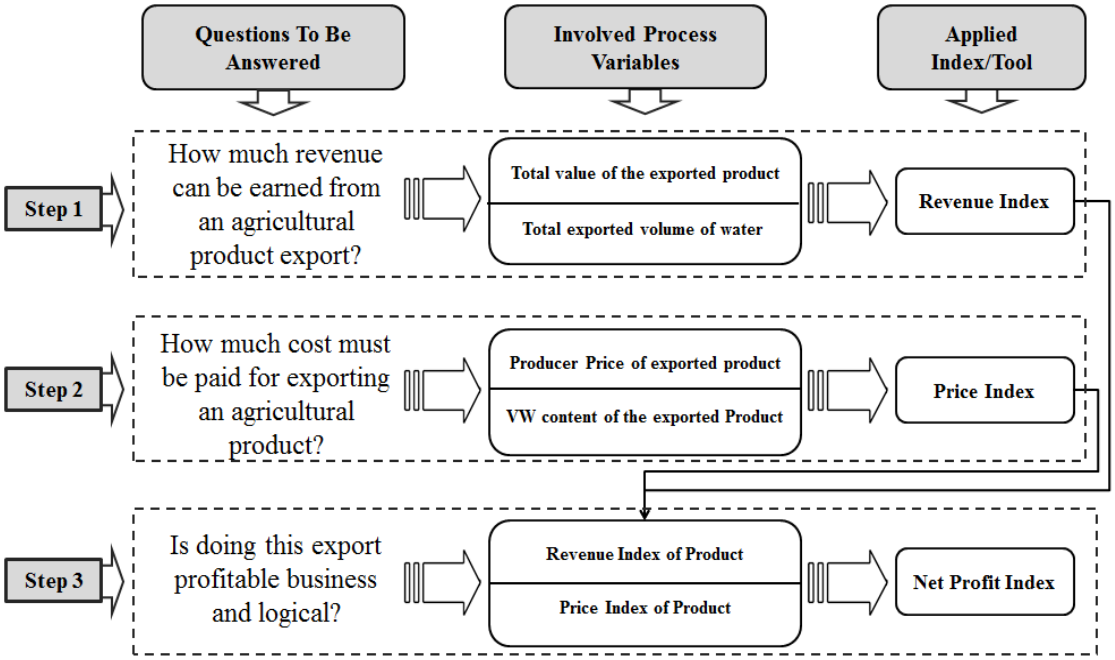

Fig. 1. Process of the proposed framework for assessing export policies.

- Step 1: Evaluating the economic index of Revenue:

  In this step, the amount of export values for each product is used to assign an economic index of revenue to the sold exported VW in world trade. Here, the Revenue Index (RI) is defined as the ratio of the financial value of exported products to the exported volume of VW (equation 1). In fact, the revenue index of each product is equivalent to how much revenue can be earned from selling per cubic meter of exported VW. The RI with a higher amount is more desirable.

  $$RI_i = \frac{VEP\ (M\ US\$)_i}{EVW\ (Mm^3)_i} \quad (1)$$

  where RI_i is Revenue Index, VEP is the total value of exported products (Million US$), EVW is the total exported volume of water (Million m^3), and i corresponds to each agricultural product.

- Step 2: Evaluating the economic index of Price:

  As the RI_i of selling each volume of exported VW is necessary to evaluate, the cost that must be paid to obtain revenue from selling each volume of exported VW must be assessed. These costs usually depend on all grades, kinds, and varieties costs received by the producer (many factors such as water price, type of irrigation, water quality, climate, crop water requirements, seed, planting, pesticides, fertilizers). Based on FAO's definition, this cost is called the Producer Price (PP). This average price is usually different from one point to another. This price can be used as a measure of how much cost must be paid (through the entire life of production and export of a crop) to sell each volume of exported VW in world trade. Here, the PP is used to define the Price Index (PI) of each product. It is defined as the ratio of the PP of products to the amount of VW hidden in one unit of weight of each exported product (equation 2). Actually, this index corresponds to how much it costs to export one cubic meter of water as the exported VW. The PI with a lower amount is more desired.

  $$PI_i = \frac{PP\ (\frac{US\$}{ton})_i}{VW\ (m^3/ton)_i} \quad (2)$$

- Step 3: Identifying and assessing the priority of each product in the VW world trade:

  In the last step, having the economic benefit and cost per unit volume of exported water (two identified indexes in previous steps), the Net Profit (NP) of exporting each volume of VW for each product is calculated. The decision about which product is more suitable and affordable, or should be exported or not exported anymore can be made based on equation 3. A product with higher NP can provide more incentive for export. Furthermore, if there are more NP for Iran rather than the world (for any specific product), higher priority can be assigned to the export of the corresponding product.

  $$Net\ Profit\ of\ Exported\ VW_i\ (\frac{US\$}{m^3}) = RI_i - PI_i \quad (3)$$

3. Results

3.1. Virtual water trade of Iran and the world

The required information on agricultural products and their corresponding VW values was obtained for 2005-2016 from FAO, the Iranian Ministry of Agriculture, Jihad, and Iran Chamber of Commerce, Industries, Mines, and Agriculture. Figs. 2 and 3 present the quantity and value of exported VW of selected agricultural products of IRAN during the study period. The collected data shows that while the export quantity of pistachio, tea, and saffron shows a decreasing trend, the amount of export for date has not changed noticeably. It means that the opportunity of exporting products has been raised for other competitors in world trade. Another remarkable fact belongs to the watermelon export with an increase in financial value and quantity in order by 4.2 and 2.3 times during the period 2005-2012. In other words, the share of Iran from watermelon world trade increased from 7% to around 12% within only a few years, and in 2012, the financial value of exporting watermelon reached 1.5 times the revenue of date trade. It is worth noting that the estimated virtual water (VW) values of products presented in Hoekstra (2011) and Alizadeh (2015) were used as reference points for calculating the virtual water equivalent at the global level and for Iran, respectively.

Table 1 represents the summation of financial value and the amount of VW for exported products during the study period. According to this table, the amount of exported VW hidden in saffron is about 1.4 times more than watermelon, while the financial gain of it is more than 3 times. The amount of saffron exported by VW is around 1.02 billion m^3, which is around half of the annual consumption of potable water in Isfahan Province, with around 4 million inhabitants [18]. Another fact about saffron is the lower gains of exporting it in comparison with exporting pistachios. In other words, although saffron is the most well-known international brand of Iranian agriculture but exporting pistachios was able to provide more income for Iran. However, this income from export may be interpreted as an economic success, but from the perspective of water resources exploitation, it can be a tragedy for Iran facing with severe water resources crisis. In fact, the financial gains of Iran resulting from pistachio exporting are impressive (about 9.74×10^9 US$), but the corresponding amount of water exported by VW during the study period is around 2 times Iran's annual domestic water consumption. In other words, Iran had lost 2 years of its domestic water consumption quantity only by 12 years of exporting pistachio. This reality about pistachios would be much worse/unfortunate when knowing that only 36% of Iran's annual production had been exported during the last years (on average). It is worth noting that pistachio is only one of hundreds of agricultural products in Iran. Furthermore, comparison of existing export trends between rice and the other products reveals that the export of rice during the study period not only consumed water resources severely, but also it could not provide suitable economi c

gains. Therefore, rice should not be considered as an export commodity.

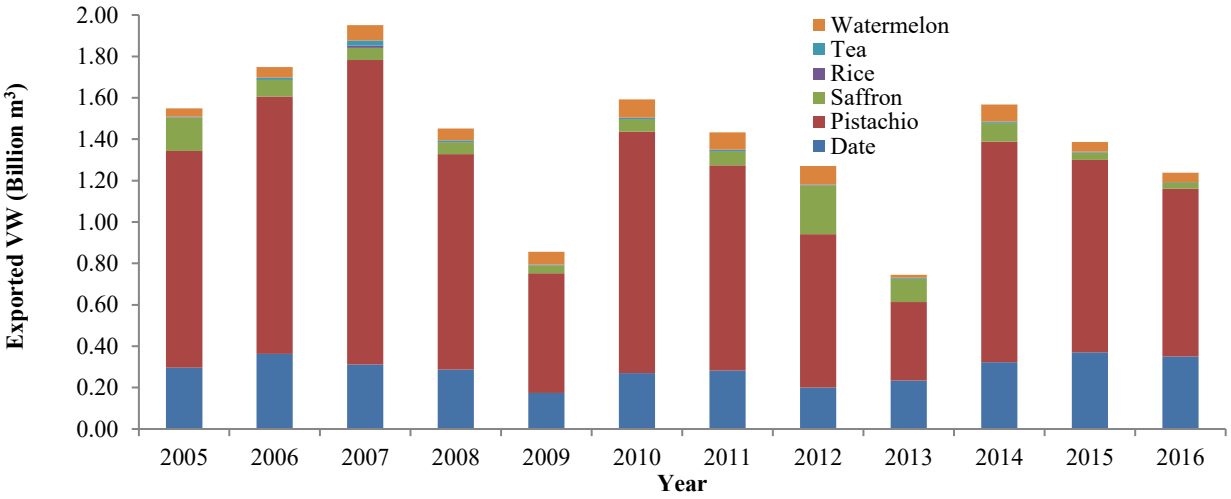

Fig. 2. Exported VW from IRAN during the study period (Million m^3).

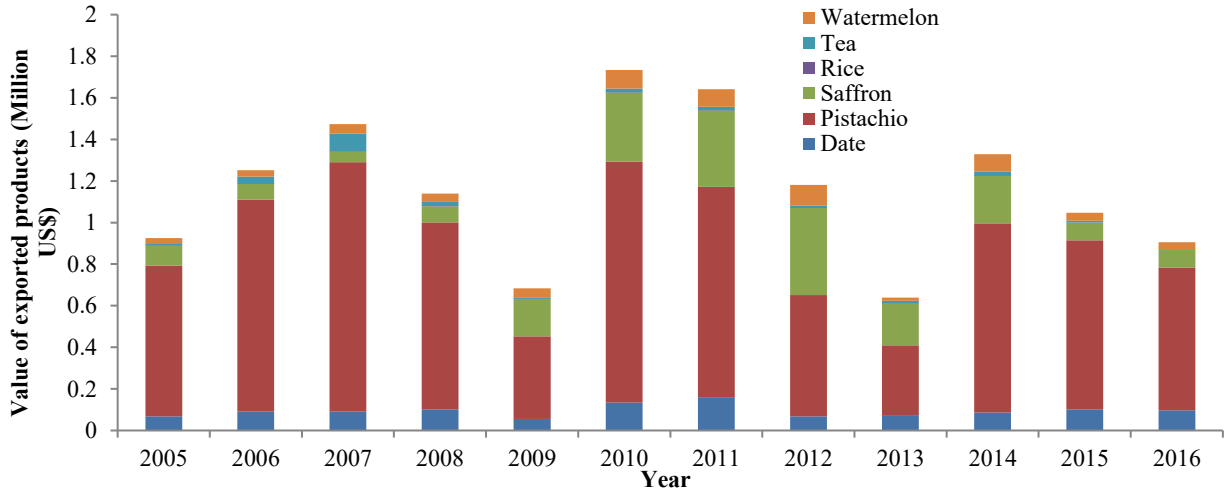

Fig. 3. Value of exported products during the study period from IRAN (Million US$).

Table 1. A brief glance on Iran's export during the study period.

	Date	Pistachio	Saffron	Rice	Tea	Watermelon
Value of Exported VW (Million US$)	1129.38	9735.32	2197.03	7.34	252.67	628.09
Volume of Exported VW (Million m^3)	3462.7	11463.8	1023.4	22.7	82.2	732.3

3.2. Application of proposed framework

In the following, the detailed analysis of implementing the proposed framework for each agricultural product is discussed separately, and then a comparison is presented in order to prioritize the export policies of various crops.

3.2.1. Pistachio

About 70% of Iran's pistachios are produced in Kerman Province, currently facing serious water scarcity. During the study period, overexploitation of groundwater resources in this region has caused a 10 m depletion in groundwater levels, which is equivalent to an annual decline of 840 million cubic meters of aquifer reserves. In many areas, water salinity has increased severely, implying serious complications for the future. Over the recent years, Iran's pistachio export has shifted towards wholesale trade with less business risk for the Iranian exporters. As a result, Iran's high-quality pistachios are exported with very low added value while the importing countries gain the main profit.

As seen in Table 2, the statistics have shown a downward trend in the export rate of pistachios over the past decade, and Iran has been unable to retain its share in the world pistachio market, and has provided competitors the opportunity to gain the market share. One of the main reasons for the decline in Iran's pistachio trade in the global market is the sanctions against Iran. The USA, as the main competitor of Iran’s pistachio trade, has restricted Iranian pistachio exports. In this regard, China, as the world's largest pistachio market, is gradually seeking to replace the import of pistachios from Iran with the United States [19]. Without these sanctions, Iran could benefit from its geographical location in this respect.

Table 2. Changes in Iran pistachio exports over the past years.

Year	Quantity (Ton)	Value (M US$)	Share form World Trade (%)
2005	137712	724.06	51.04
2006	163463	1017.89	56.19
2007	193350	1199.51	52.06
2008	136893	898.80	37.74
2009	76124	396.40	26.13
2010	153259	1159.35	39.50
2011	130137	1010.87	36.01
2012	97448	583.83	27.02
2013	49661	335.24	16.60
2014	140109	909.80	37.11
2015	121995	812.87	38.50
2016	106493	686.71	27.15

However, on one hand, the revenue index of Iran for the VW of the pistachios highly outweighs the global average, almost $0.2 to $0.5 more (Fig. 4). On the other hand, the price of VW exports in Iran, in proportion to the whole world, has always been higher over the period of studies (Fig. 5). Moreover, the cost index in the country has skyrocketed over the recent years. In other words, compared to global figures, Iran gains more financial profit from virtual water export per cubic meter of water while having higher export costs. It is worth noting that the price index of virtual water is much higher than the rate of revenue index; therefore, pistachios cannot be considered as an export product with high added value.

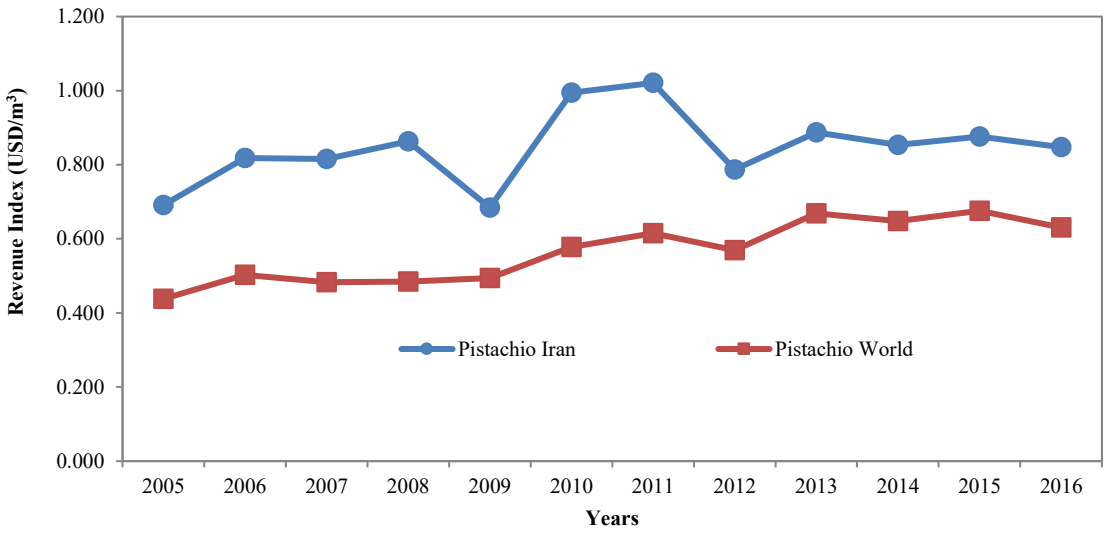

Fig. 4. Comparison of pistachio revenue index for Iran and the world.

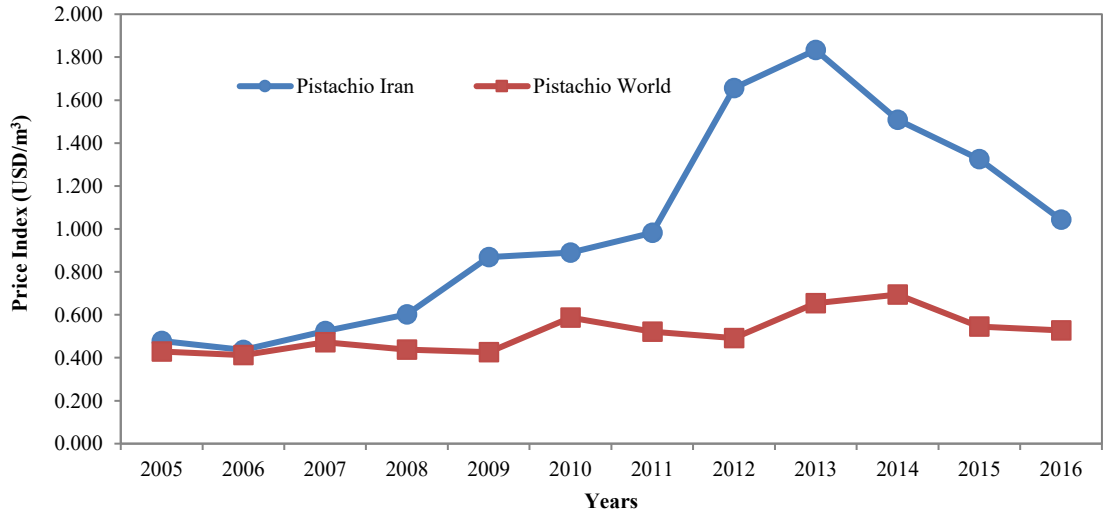

Fig. 5. Comparison of pistachio price index for Iran and the world.

3.2.2. Date

Kerman Province, with 52700 hectares of palm tree land (26.5% of the entire date production land), is the biggest producer of dates in Iran. The next rank belongs to Khuzestan Province. Palm trees in both regions are dying and losing their productivity. Extreme quantitative and qualitative water restrictions, the aging of palm trees, the proliferation of heavy dust storms, and the lack of agricultural insurance coverage are the most emerging problems in the production of dates today. Over the past years, Iran has been able to retain its own share (10-15%) of the world's export market (Table 3), and neighboring countries are the ultimate destination of Iran's exports. The costs of shipping/transporting to distant countries are the main barriers to increasing the share of date exports to other countries. In recent years, the government's financial policies, alongside the resumption of sanctions, have exerted additional pressures on Iran's export markets.

Table 3. Changes in Iran date exports over the past years.

Year	Quantity (Ton)	Value (M US$)	Share form World Trade (%)
2005	117052	68.493	14.81
2006	143434	91.645	30.58
2007	123260	91.028	14.15
2008	113539	101.783	12.04
2009	68837	55.819	10.44
2010	106760	134.001	16.01
2011	112030	160.251	15.77
2012	79196	67.404	10.36
2013	93030	74.695	11.27
2014	127516	85.722	10.78
2015	146910	101.015	12.53
2016	138844	97.519	11.93

As seen in Table 3, the export rate of dates has had an almost steady trend in the past decade, and Iran has been able to retain its own share of the world export market. Fig. 6 shows that the growth of the virtual water revenue index of the date during the early decade of studies has had a competitive aspect for Iran and the world, but in recent years, Iran's financial gains from the sales of exported VW in dates have reduced, as compared to the other countries. To put it differently, Iran has been selling its VW for a lower price, as compared to other countries. On the other hand, the upward trend in the cost index of VW exported from the world and Iran is obvious, and over the entire period of studies, the cost of exporting VW for date from the world has been two to four times as much as that of Iran (Fig. 7). The difference in the cost index in Iran and the world should be taken into account as a potential for Iran. The little differences between the amounts of Iran's revenue and price indices in recent years need to be revised the current trend in date export. In other words, the date export compared to other countries shows that Iran pays less cost to supply water for its export products, whereas it also gains less financial benefit.

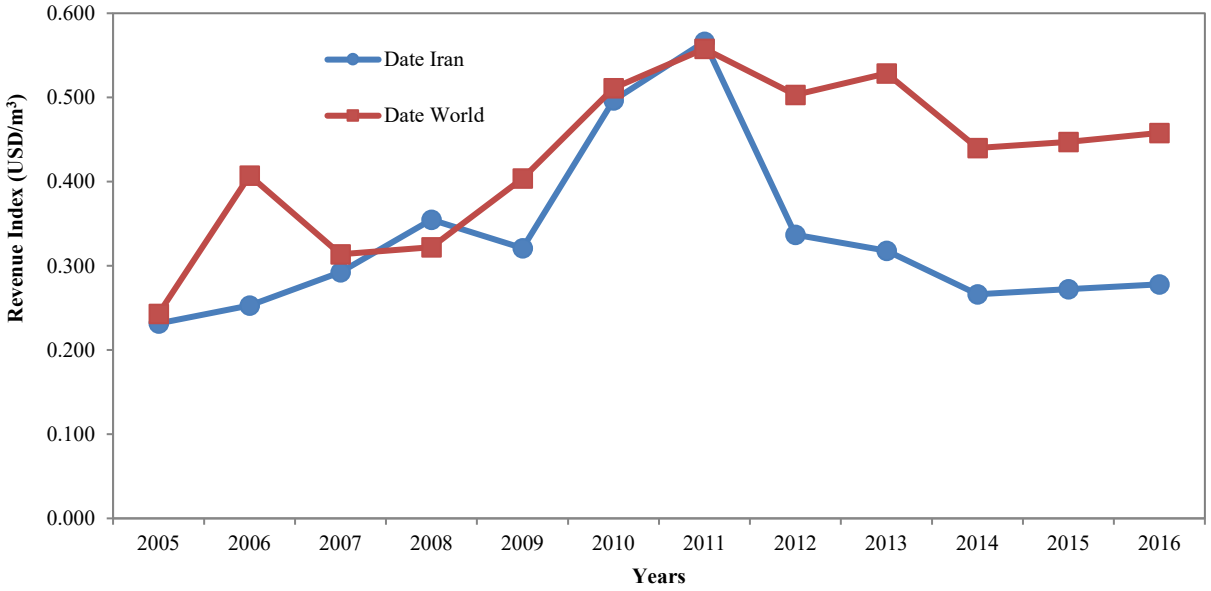

Fig. 6. Comparison of the date revenue index for Iran and the world.

3.2.3. Saffron

As Table 4 shows, the export rate of saffron has approximately had an up and down trend over the past years. According to this table, the ratio of the economic value to the weight of exported saffron has had an upward trend till 2012, and then a sudden drop in the price of one kilogram of exported saffron from IRAN is observed. The main reasons for this may include:

1) The lack of a credible Iranian brand in the global market, with no attention to globalization.

2) The lack of marketing channels with global supply-demand chains.

3) The lack of international standards in the production and distribution process.

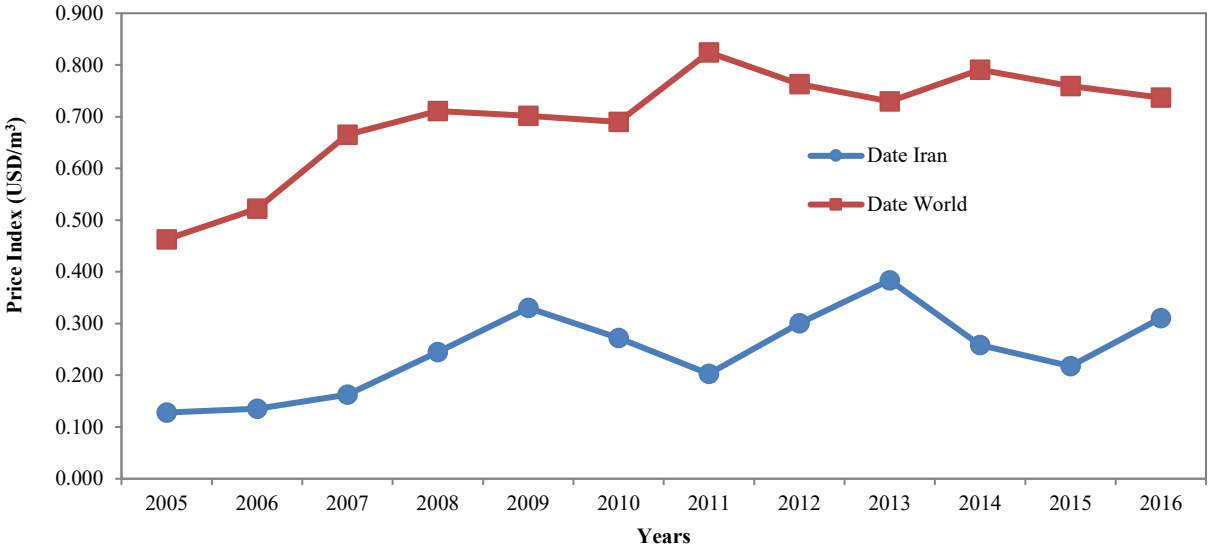

Fig. 7. Comparison of date price index for Iran and the world.

Table 4. Changes in Iran saffron exports over the past years.

Year	Quantity (Ton)	Value (M US$)	Share form world trade (%)
2005	286.8	95.6	Unavailable Data
2006	142.5	75.9	
2007	103.5	50.6	
2008	100.0	78.0	
2009	65.8	180.0	
2010	107.9	332.0	
2011	122.3	368.0	
2012	139.2	419.0	
2013	137.2	200.0	
2014	158.8	228.0	
2015	65.1	86.0	
2016	55.2	84.0	

These challenges have led the Iranian saffron producers to export their products to destination countries in wholesale (usually in large quantities without marketing considerations). Some of these countries re-export through re-packing Iran's saffron under different international brands.

Lack of precise statistics on the production rates, export quantities, and the value of saffron in other countries has led to incapability to compare Iran's position in terms of saffron exports in the global markets. As the largest producer and exporter of saffron in the world, Iran can direct and control the sales market of saffron in the world. The results obtained from the analysis of revenue index and the price index of virtual water in saffron show huge fluctuations in these indices over the early years of study (Figs. 8 and 9). These unfavorable changes and fluctuations in Iran's saffron trade led the programs in Iran's export sector to gain a steady and positive trend from 2012. In this respect, the best productivity method is planned and reviewed for the export and cultivation policies of the product. Also, the results from revenue and cost indices of saffron reveal that in many years (e.g., 2006, 2007, 2008, 2012 and 2013.), the export price of a specified amount of the virtual water in saffron has become higher than the revenue gained from the sales of the same amount of exported virtual water. That is, Iran has had huge volumes of its water resources on sale for free or even at spending highly expensive financial cost. The results also show that the rate of revenue index of virtual

water for saffron is much higher than pistachio and date. On the other hand, the cost required in order to produce and export saffron is not much more than the price index of virtual water for date and pistachio. These results can confirm naming the saffron as the international brand of Iranian agricultural products.

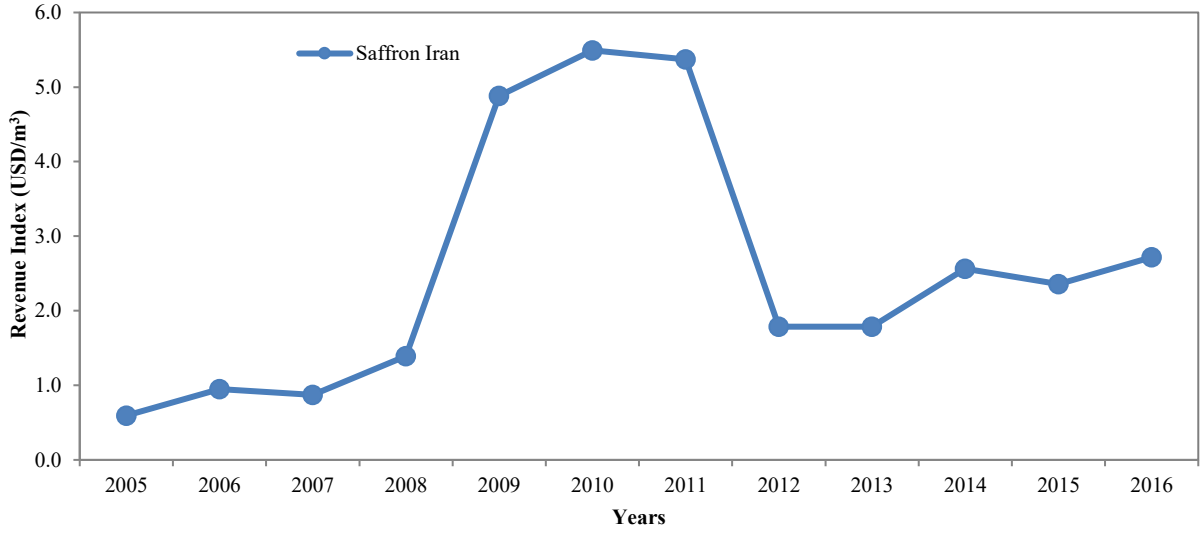

Fig. 8. Saffron revenue index for Iran.

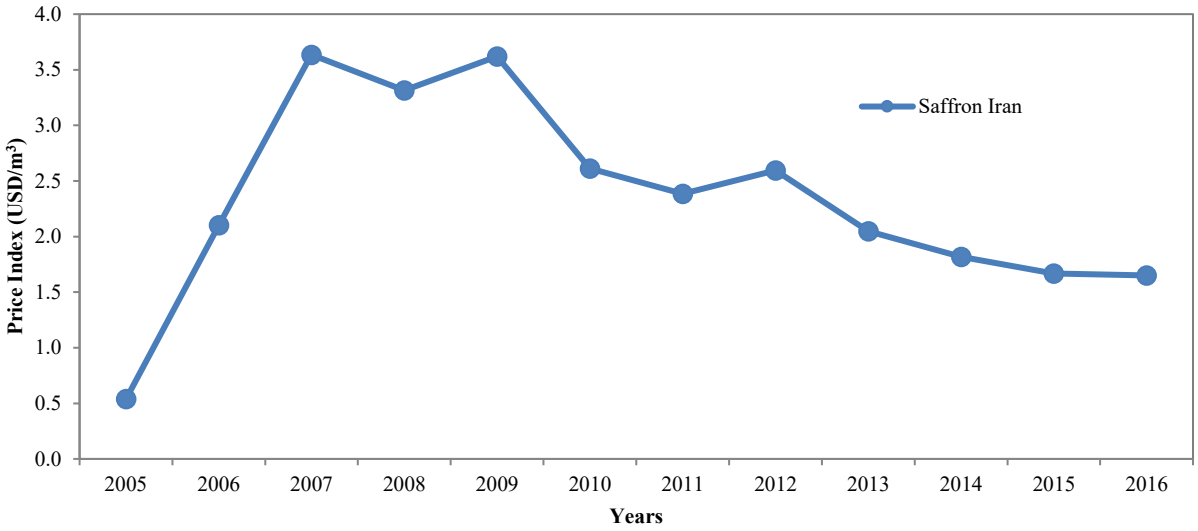

Fig. 9. Saffron price index for Iran.

3.2.4. Watermelon

Agricultural production in Iran has moved towards the production of the cheapest and the most water intensive crops because of 1) the high subsidies allocated to the water sector, 2) the lack of restrictions on the use of water resources (especially groundwater) and 3) the supportive governance policies for farmers in rural areas. Watermelon production, as one of the most high-yielding products, has increased rapidly as a result of these policies, consequently taking a high share of agricultural exports.

Over the past years, Iran has raised its watermelon production from 2.8 million tons to 4 million tons, while the share of dry farmed production has decreased from 140,000 tons in 2005 to about 60,000 tons in 2016. This amount of change in watermelon production has imposed high pressure on the corresponding water resources, mostly located in relatively dry regions of Iran. Currently, the Iranian Ministry of Agriculture-Jihad pursues the policy of increasing water productivity and efficiency to produce more crops from every cubic meter of water. Widespread installation of smart water energy meters and improving irrigation systems are the main implemented steps towards water conservation policies, which are expected to increase the water productivity by more than 15%.

As shown in Table 5, the export rate of watermelon has had an upward trend, and Iran has been able to improve its position and share in the world export market in the early years of the study. The share of Iran's export from world trade for watermelon has climbed from %4.4 in 2004 to %12 in 2012, while its value rate, in US$, has increased around 5 times for the same period. Such an unanticipated growth on one hand and high consumption of water resources for watermelon export on the other hand make the need to seriously review the cultivation and export polices of this product. The results obtained from the investigation of watermelon's revenue index and price index (Figs. 10 and 11) show that the rate of such indices has had an upward, but steady trend (with a few

fluctuations) in the world and in Iran. A very important point from the results is that both the world's revenue and price indexes have held higher values over the past years, as compared to Iran's. In other words, in comparison to Iran, the world gains more revenue from the export of virtual water in watermelon and also pays more cost. Stated differently, in comparison to the world, Iran sells off its virtual water, while it pays less cost. Further studies on such trends can help the export policies better.

Table 5. Changes in Iran watermelon exports over the past years.

Year	Quantity (Ton)	Value (M US$)	Share from World Trade (%)
2005	158878	24.00	7.32
2006	200784	30.42	8.56
2007	301346	45.42	11.83
2008	229812	39.17	8.64
2009	250000	42.00	8.84
2010	348316	89.76	10.94
2011	334248	84.94	12.19
2012	359402	99.89	12.09
2013	56284	15.52	2.00
2014	325644	85.29	10.32
2015	186178	38.52	5.69
2016	178118	33.18	5.02

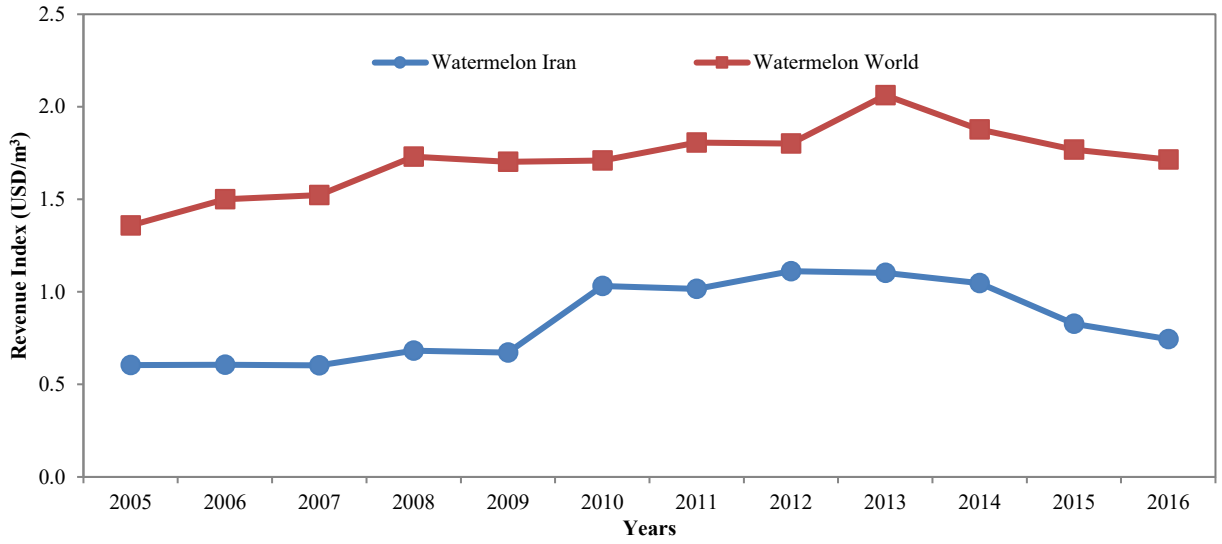

Fig. 10. Comparison of watermelon revenue index for Iran and the world.

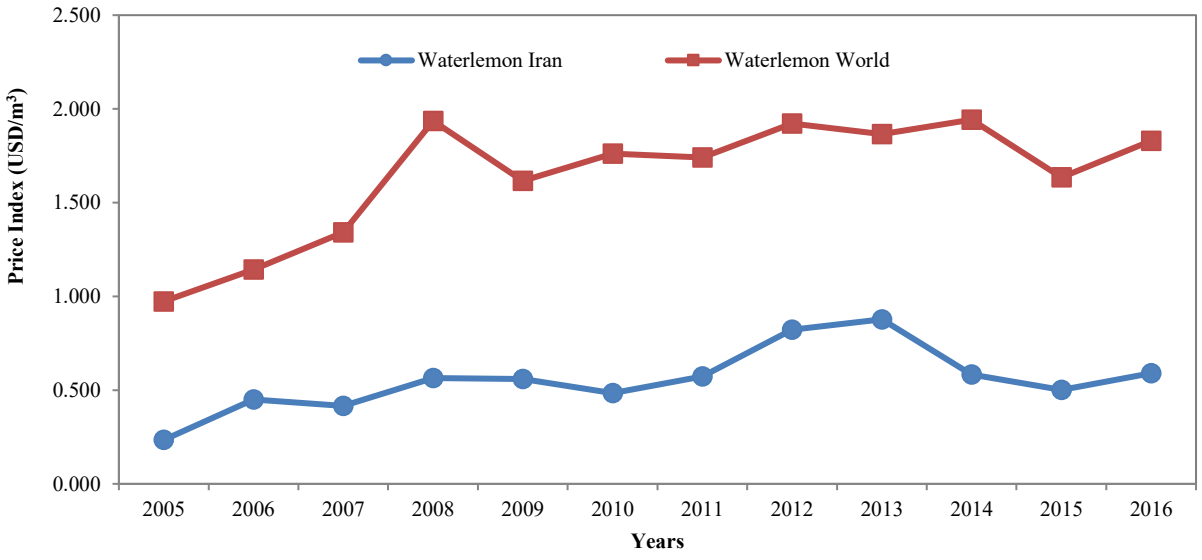

Fig. 11. Comparison of watermelon price index for Iran and the world.

3.2.5. Tea

Due to climatic reasons, most of the tea produced in Iran is cultivated in the northern regions of the country (with high average rainfall), and this causes Iran's share of blue water for tea production to be lower than the world's. Based on official data of the Iranian Ministry of Agriculture Jihad and FAO [20], during the past years, Iran's tea production has always been around 100 thousand tons. Furthermore, Iran has been ranked the world's 8th largest producer of tea from 2011 to 2015. Meanwhile, over the same years, Iran's name has been among the top 10 importing countries of tea. The main volume of imported tea comes from India and Sri Lanka.

Investigating the available data on tea export and its value over the past years shows that Iran hasn't had much of a share of the world export markets, and depending on the conditions, the export rate has varied over different years (Table 6). The results from the investigation of revenue index and the price index of virtual water in tea are indicative of the higher rates of these indices for Iran, as compared to the world (Figs. 12 and 13). In other words, Iran earns more revenue from the exported virtual water in tea, while it pays more costs proportional to the world. Although the cost index in Iran has followed an upward trend over the past years, it can provide the required explanation for the tea export since the amount of this index is still much lower than the revenue earned. The results for the world's indices of revenue and price show a steady increasing trend for these two indices. It should be pointed out that the world's rate of revenue index lies within the narrow margin of its cost index. Economically speaking, other tea-exporting countries gain less benefit from the exported virtual water. Therefore, tea can be considered as an export product with high added value, and Iran would be able to use the opportunity to gain more benefit from tea export through improving the quality level of its products and reinforcing its economic structure.

Table 6. Changes in Iran Tea exports over the past years.

Year	Quantity (Ton)	Value (M US$)	Share from World Trade (%)
2005	12756	12.70	0.74
2006	33548	35.43	2.06
2007	77028	82.65	4.31
2008	24084	20.66	1.26
2009	10772	8.53	0.59
2010	24611	18.50	1.22
2011	22429	17.61	1.13
2012	11208	11.37	0.62
2013	14620	13.37	0.71
2014	17584	19.80	0.96
2015	7968	8.62	0.46
2016	1950	3.42	0.11

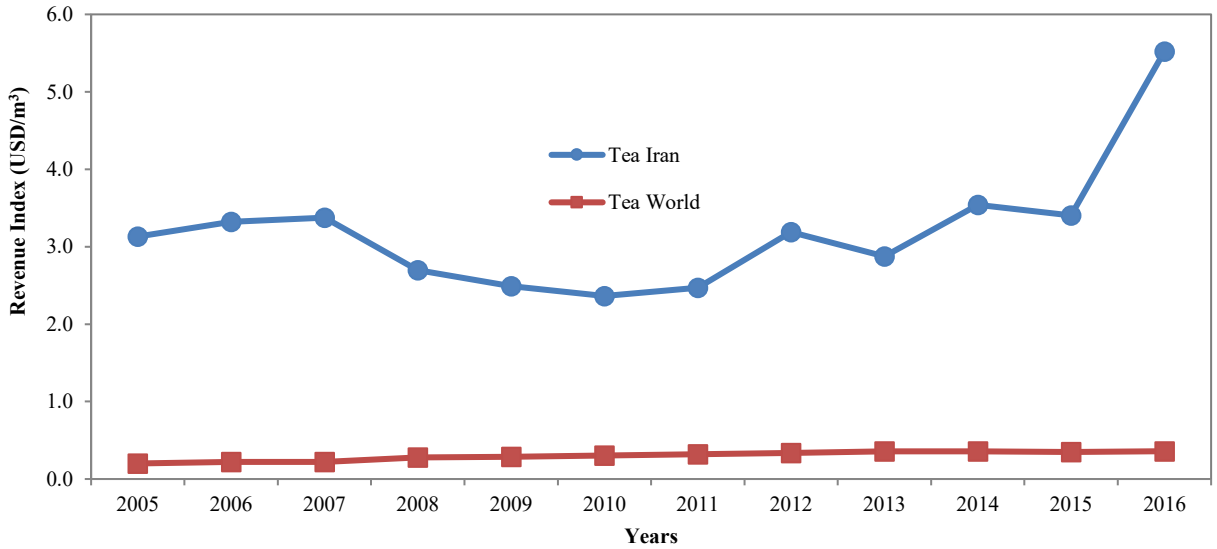

Fig. 12. Comparison of tea revenue index for Iran and the world.

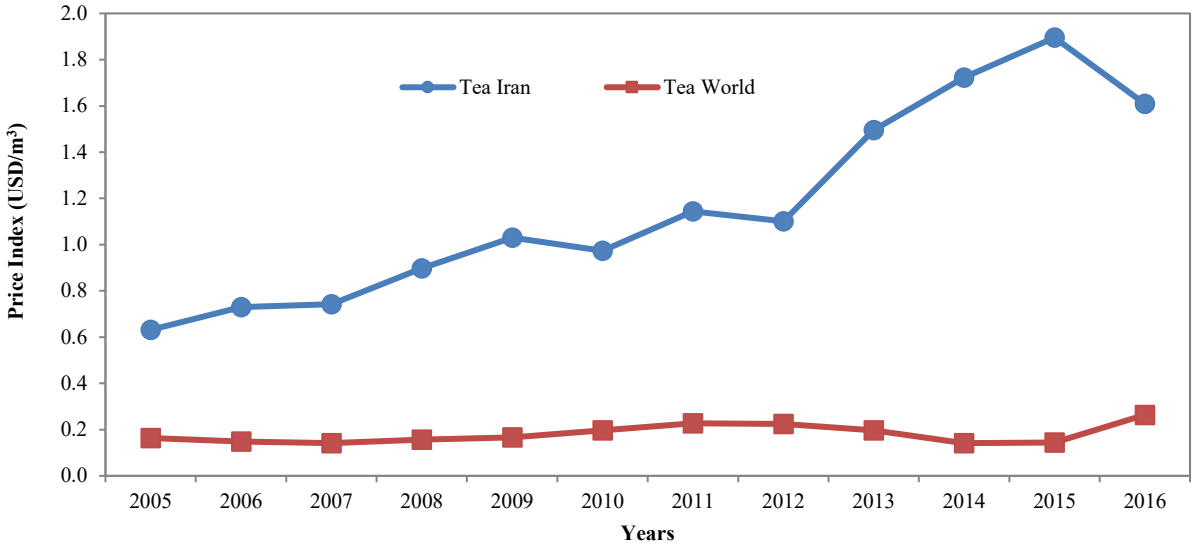

Fig. 13. Comparison of the tea price index for Iran and the world.

3.2.6. Rice

Based on the official estimation, around 4 million tons of rice are consumed annually in Iran, 1 to 1.5 million tons of it is imported from abroad (mainly from India and Pakistan). About 5% of the total agricultural area in IRAN belongs to rice cultivation, of which only 32% is located in rainfed farms. The traditional way of rice cultivation (flood irrigation) and the lack of agricultural mechanization across the country have not only caused serious limitations for rice production and export but have also imposed high labor costs. According to the export-related available data (Table 7), Iran has practically not taken a share of this product in world trade during the past years. The comparison of the obtained results in cost and revenue indices for Iran and the world reveals that Iran gains a smaller benefit from rice export, while it also spends more (Figs. 14 and 15). Thus, rice cannot be considered a product with value added for Iran's export. This reason can even be a sign for the need to modify rice cultivation methods and to change the import and export plans for this product. The results also demonstrated that the world's cost and revenue indices have had steadier trends with fewer fluctuations, as compared to Iran's. From the virtual water-trading perspective, it can be interpreted that rice export is still profitable for the world; however, it is unprofitable for Iran.

Table 7. Changes in Iran Rice exports over the past years.

Year	Quantity (Ton)	Value (M US$)	Share form World Trade (%)
2005	920	0.318	0.003
2006	763	0.314	0.002
2007	10598	3.731	0.032
2008	1942	0.629	0.006
2009	542	0.215	0.002
2010	237	0.055	0.001
2011	110	0.032	0.000
2012	1224	0.158	0.003
2013	1309	0.554	0.004
2014	2626	0.462	0.006
2015	1218	0.455	0.003
2016	495	0.413	0.001

3.2.7. Comparison of the different products

The results of evaluating the economic index of RI for each product are condensed in Table 8. Based on this table, the RI of pistachio and tea has a higher income margin than the world trade, while in the trade of date and watermelon, Iran has earned around half of the world (Table 8). In other words, Iran has gained more financial efficiency/productivity due to exporting VW embedded within the pistachio and tea. On the contrary, Iran has sold its VW at the date, rice, and watermelon cheaper than the world. This means that Iran is losing out on world trade. Furthermore, the results show that while the revenue indexes of different products for the world have a more consistent trend (with less variations and fluctuations) with a very mild and smooth increase, Iran's revenue indexes have not experienced stable trends during different years within the study period. These trends may be indicative of the fact that the world has a more stable mechanism for selling and pricing its products in the world market compared to Iran. Consequently, a better water pricing structure is provided in the world, but Iran is facing agricultural water shortage and financial challenges.

Hence, Iran has to reconsider its export and agriculture programs, both from the economic and water consumption perspectives.

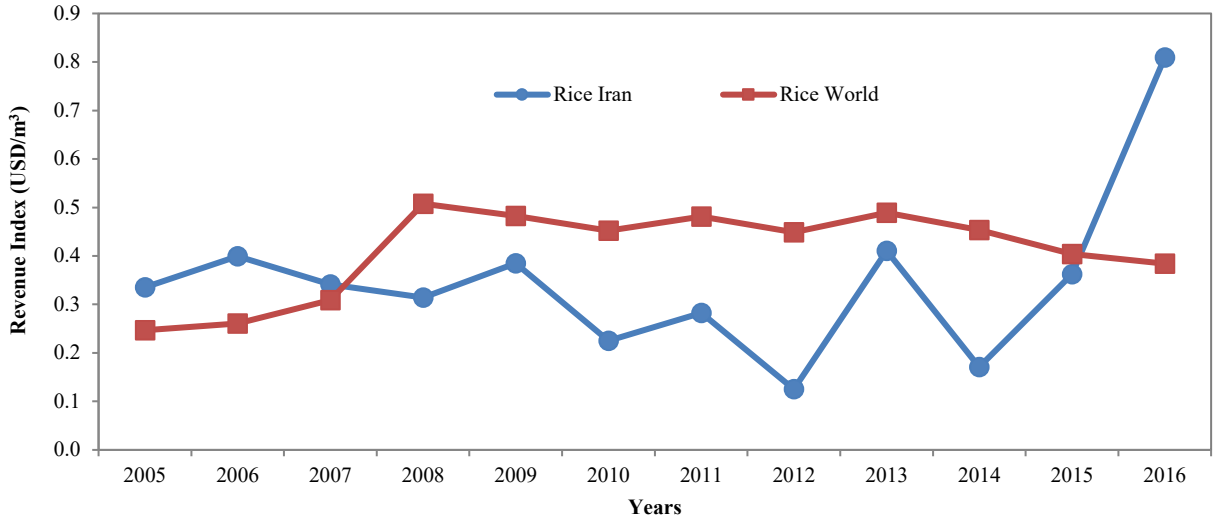

Fig. 14. Comparison of rice revenue index for Iran and the world.

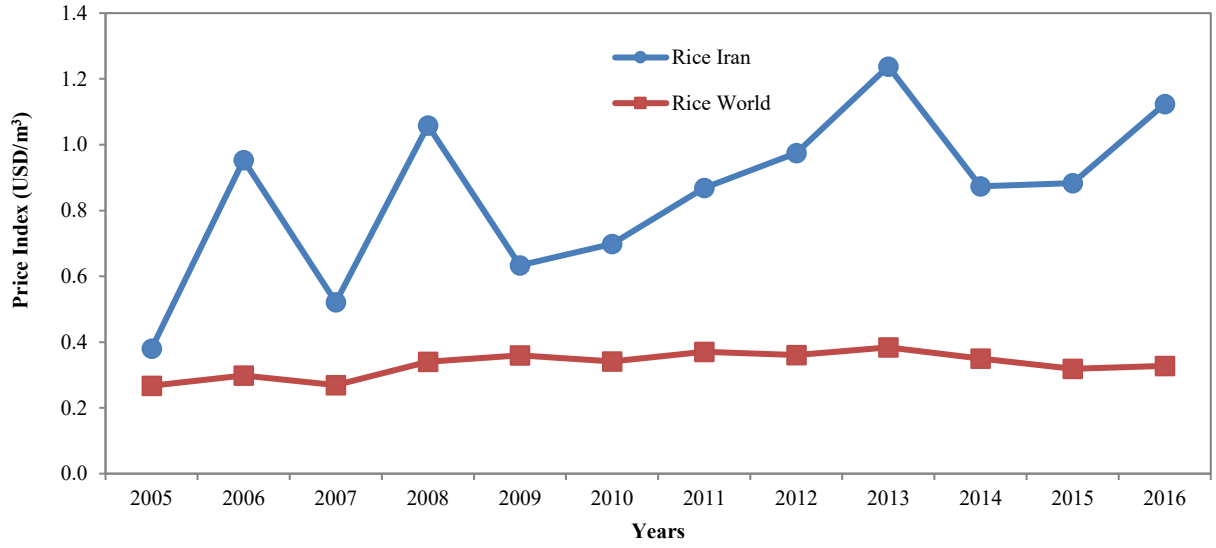

Fig. 15. Comparison of rice price index for Iran and the world.

Table 8. Revenue Index of Exported VW (USD/m³).

Year	Date		Pistachio		Rice		Tea		Watermelon		Saffron	
	Iran	World	Iran	World	Iran	World	Iran	World	Iran	World	Iran	World
2005	0.23	0.24	0.69	0.44	0.34	0.25	3.13	0.20	0.60	1.36	0.59	Unavailable Data
2006	0.25	0.41	0.82	0.50	0.40	0.26	3.32	0.22	0.61	1.50	0.95	
2007	0.29	0.31	0.82	0.48	0.34	0.31	3.37	0.22	0.60	1.52	0.87	
2008	0.35	0.32	0.86	0.48	0.31	0.51	2.70	0.28	0.68	1.73	1.39	
2009	0.32	0.40	0.68	0.49	0.38	0.48	2.49	0.29	0.67	1.70	4.88	
2010	0.50	0.51	0.99	0.58	0.23	0.45	2.36	0.30	1.03	1.71	5.49	
2011	0.57	0.56	1.02	0.62	0.28	0.48	2.47	0.32	1.02	1.81	5.37	
2012	0.34	0.50	0.79	0.57	0.13	0.45	3.19	0.34	1.11	1.80	1.79	
2013	0.32	0.53	0.89	0.67	0.41	0.49	2.88	0.36	1.10	2.06	1.79	
2014	0.27	0.44	0.85	0.65	0.17	0.45	3.54	0.36	1.05	1.88	2.56	
2015	0.27	0.45	0.88	0.68	0.36	0.40	3.40	0.35	0.83	1.77	2.36	
2016	0.28	0.46	0.85	0.63	0.81	0.38	5.52	0.36	0.75	1.71	2.72	

Comparison of price indexes between Iran and the world during the study period for the different considered products is condensed in Table 9. According to this table, Iran has paid the minimum cost of exporting VW for dates and watermelon. Furthermore, Iran's price index for watermelon and date is much lower than the world price indexes. In other words, Iran has paid less for selling its VW in comparison with the world. On the contrary, the world has benefited from lower prices, which it has had to pay for exporting other products (tea, rice, and pistachio). Among all the products, saffron has the highest price index value for exported VW. Table 9 also shows that during the study period, the world price indexes of different products have very limited variation and they have increased with a very gentle slope. Not surprisingly, Iran's price indexes have had more fluctuations over the last years. These trends of Iran may be attributed to the ineffectiveness of existing programs in the agricultural sector (water pricing structure, water efficiency, and …), and the export policies need to be revised and planned carefully.

Table 9. Price Index of Exported VW (USD/m^3).

Year	Date		Pistachio		Rice		Tea		Watermelon		Saffron	
	Iran	World	Iran	World	Iran	World	Iran	World	Iran	World	Iran	World
2005	0.13	0.46	0.48	0.43	0.38	0.27	0.63	0.16	0.23	0.97	0.54	Unavailable Data
2006	0.14	0.52	0.44	0.41	0.95	0.30	0.73	0.15	0.45	1.14	2.10	
2007	0.16	0.67	0.52	0.47	0.52	0.27	0.74	0.14	0.42	1.34	3.64	
2008	0.25	0.71	0.60	0.44	1.06	0.34	0.90	0.16	0.56	1.94	3.31	
2009	0.33	0.70	0.87	0.43	0.63	0.36	1.03	0.17	0.56	1.62	3.62	
2010	0.27	0.69	0.89	0.59	0.70	0.34	0.97	0.20	0.48	1.76	2.61	
2011	0.20	0.82	0.98	0.52	0.87	0.37	1.14	0.23	0.57	1.74	2.38	
2012	0.30	0.76	1.66	0.49	0.97	0.36	1.10	0.22	0.82	1.92	2.60	
2013	0.38	0.73	1.83	0.65	1.24	0.38	1.50	0.20	0.88	1.87	2.05	
2014	0.26	0.79	1.51	0.69	0.87	0.35	1.72	0.14	0.58	1.94	1.82	
2015	0.22	0.76	1.32	0.55	0.88	0.32	1.90	0.14	0.50	1.64	1.67	
2016	0.31	0.74	1.04	0.53	1.12	0.33	1.61	0.26	0.59	1.83	1.65	

Comparison of the net profit of products between Iran and the World trade is shown in Table 10. In this table, the better data values are also shown in bold. As seen in this table, tea, watermelon, date, and saffron have the highest net profit for Iran, respectively. Furthermore, Iran could acquire 17.23 and 4 times more profit than the world from exporting tea and watermelon, respectively. On the contrary, the world can gain more profit than Iran from a cubic meter of VW exported for pistachio and rice. In other words, while pistachio is one of the well-known international brands of the agricultural sector of Iran, the net profit belonging to the world is much higher than Iran. Therefore, pistachio, as the key strategic product, requires better decision-making in export planning. The results also indicate that Iran has never been a contender for the export and production of rice. This policy is absolutely correct both from the water consumption and economic aspects of VW. While the lack of reliable data about saffron in world scale has limited the cost-benefit analysis of Iran's export but one fact is obvious: Iran's profit from VW trade of saffron has always been fluctuating.

Table 10. Net profit value of exported VW (USD/m^3).

Year	Date		Pistachio		Rice		Tea		Watermelon		Saffron	
	Iran	World	Iran	World	Iran	World	Iran	World	Iran	World	Iran	World
2005	**0.10**	-0.22	**0.21**	0.01	-0.05	**-0.02**	**2.50**	0.04	0.37	**0.39**	0.06	Unavailable Data
2006	**0.12**	-0.12	**0.38**	0.09	-0.55	**-0.04**	**2.59**	0.07	0.16	**0.36**	-1.15	
2007	**0.13**	-0.35	**0.29**	0.01	-0.18	**0.04**	**2.63**	0.08	**0.19**	0.18	-2.76	
2008	**0.11**	-0.39	**0.26**	0.05	-0.74	**0.17**	**1.80**	0.12	**0.12**	-0.21	-1.92	
2009	**-0.01**	-0.30	-0.18	**0.07**	-0.25	**0.12**	**1.46**	0.12	**0.11**	0.09	1.26	
2010	**0.22**	-0.18	**0.10**	-0.01	-0.47	**0.11**	**1.39**	0.11	**0.55**	-0.05	2.88	
2011	**0.36**	-0.27	0.04	**0.09**	-0.59	**0.11**	**1.33**	0.09	**0.44**	0.07	2.99	
2012	**0.04**	-0.26	-0.87	**0.08**	-0.85	**0.09**	**2.09**	0.11	**0.29**	-0.12	-0.81	
2013	**-0.07**	-0.20	-0.95	**0.01**	-0.83	**0.11**	**1.38**	0.16	**0.23**	0.20	-0.26	
2014	**0.01**	-0.35	-0.65	**-0.05**	-0.70	**0.10**	**1.82**	0.22	**0.46**	-0.06	0.75	
2015	**0.05**	-0.31	-0.45	**0.13**	-0.52	**0.09**	**1.51**	0.20	**0.33**	0.13	0.69	
2016	**-0.03**	-0.28	-0.20	**0.10**	-0.31	**0.06**	**3.91**	0.10	**0.15**	-0.12	1.07	
Mean	**0.09**	-0.27	-0.17	**0.05**	-0.50	**0.08**	**2.03**	0.12	**0.28**	0.07	0.23	

To briefly sum up, the current conditions of exporting VW embedded in tea, watermelon, saffron, and date trades are still reasonable. Conversely, exporting any cubic meter of VW for pistachio and rice can impose more cost than revenue. Therefore,

supporting current policy for exporting pistachio and rice not only can intensify the depletion of water resources dramatically but also impose an exorbitant cost on policymakers. Furthermore, the price and revenue indexes of Iran have never gained their favorable or stable trends in comparison with the world's trend. It is worth noting that the more net profit will be available for a product, the higher priority can be assigned to a given product for being in the export basket. Similarly, an export basket comprised of higher priority products can return more economic profits.

4. Summary and conclusions

Countries develop agricultural export policies for many reasons, while, more often than not, the availability of water resources is overlooked. Moreover, attention to the value and price of water, as a production input, is often neglected. Hence, investigation of these underutilized potentials would positively impact export policies. This study aims to present an approach for considering the role of both financial value and volume of VW in Iran trade, especially in export business. This issue has not been addressed deservedly from both commercial and academic points of view collectively. As a response to this necessity, a three-step framework with two new identified indices is presented. The presented approach was implemented for six agricultural products of Iran. The results show that, although products such as watermelon, tea, and rice are considered water-consuming ones, they do not consume as many water resources as Iran's international brands do. In other words, however, saffron, pistachio, and dates are known as the international brands of Iran, but blindfold-supporting export of these products can cause severe consequences on water resources, the financial value of export, and the economic net profit of selling each cubic meter of VW in world trade. It is worth mentioning that among all water-consuming products, watermelon and tea have been able to provide a considerable financial added value in Iran's export sector. Providing reliable databases with robust decision support systems may be nominated as the most significant fundamental prerequisites for future planning in order to achieve better-targeted export and world trade.

To pursue further research on implementation of the proposed framework and hence increasing the net profit of export policies, not only appropriate plans must be codified, but the agriculture sector must attempt to increase the agricultural productivity, irrigation efficiency, applying new technologies and modern irrigation systems, using various farming methods and locating suitable replacements for different cultivation patterns and methods. Hence, a better management of the virtual water in different products would be achieved, in which not only would the benefit gained from exported virtual water increase, but the use of water resources would decrease. Furthermore, using tools, namely portfolio theory, could determine the appropriate portion of each of the products in Iran's export basket so that the risk of using water resources and financial benefits tends to a minimum and maximum, respectively.

Statements & declarations

Author contributions

Ardalan Izadi: Conceptualization, Project administration, Investigation, Formal analysis, Resources, Writing - Original Draft.

Farhad Yazdandoost: Conceptualization, Supervision,Writing - Review & Editing.

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Declaration of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data presented in this study are available on request from the corresponding author.

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