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The analysis of water trade in Persian Gulf Countries

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Abstract
During the recent years, water deficiency has been lead to innovation of modern techniques for saving water in countries which suffered from the shortage of water supplies. One of the notable concepts in this regards is the concept of virtual water trade in management of water supplies. The concept of virtual water trade is defined synonymously as the sum of the needed water for production of certain quantity of a product. Accordingly, prevention from exportation of products, which may lead to exiting water from the country and emphasis on importation of water-bearing products, is considered as one of the strategies which have been taken by some countries in the management of their own restricted water supplies. This strategy means that the water supplies of countries should be employed for manufacturing of the products, which are followed by further income economically. The present article is an innovation in calculating virtual water values by 6-digit SITC codes for all sectors of the economy in the selected countries (Persian Gulf countries). For each commodity code exported and imported in countries, the amount of virtual water (cubic meters per ton) is also calculated. In this regard, the rate of hidden water in imports and exports of the aforesaid countries during 2001 to 2012 is explored. The results reveal the fact that Iran has not taken any certain defined strategy regarding the management of water supplies by means of virtual water concept.

Keywords: Virtual Water Trade, Agricultural Goods, Management of Water Resource, Iran, Persian Gulf Countries.

JEL Classification: Q18, Q25, O13

1. Introduction

The water shortage crisis in Iran has created essential problems concerning water provision (particularly in agriculture sector) despite of the subsequent droughts. Under such circumstances, paying attention to the management of water supplies and taking new and efficient strategies such as concept of virtual water trade will be especially important in this regard. The water that is consumed within different phases of producing a commodity is called virtual water stored in the given goods and world trade of commodities creates an international stream of virtual water (Rahmani, 2009). The net exportation of virtual water to regions with lesser water supplies may reduce the stress exerted on water supplies in these countries. Thus, virtual water is assumed as alternative of water supply in the importing countries. As a result, exchange of virtual water is suggested as a strategy to manage water supplies in arid and the semi-arid countries (Hoekstra & Hung, 2002). The exportation of water physically to arid countries with lesser water supplies will be accompanied with a lot of problems ad bottlenecks due to financial problems caused by great volume and heavy weight of these commodities; therefore, the subject of virtual water trade is suggested as one of the practical solutions.

Iran has been situated in a region where several other countries also encounter the problem of water shortage. The choice of the Persian Gulf countries has been based on this logic that all of them are seriously faced with the problem of water scarcity. One of the objectives of this paper is to compare the strategies used in these countries despite the differences in climate and economic conditions. Hence, the comparison of the strategies taken by littoral states in Persian Gulf regarding virtual water trade may propose some strategies to improve the management of water supplies in Iran. Thus, the present study is mainly aimed at comparing virtual water trade strategy in Iran with littoral states of Persian Gulf. In this regard, the rate of hidden water in the import and export of virtual water is compared in the aforesaid countries and finally by means of the index of ratio of imported virtual water to exported virtual water, strategy of Iran about using the concept of virtual water trade is characterized. The present article is an innovation in calculating virtual water values by 6-digit SITC codes for all sectors of the economy in the selected countries (Persian Gulf countries)

Accordingly, this article is provided in 7 sections. The concept of virtual water is discussed in Section 2. Section 3 is devoted to the review of literature regarding virtual water. The research methodology is presented in Section 4. Indicators for virtual water import and export are calculated in Section 5. In Section 6, based on the calculations carried out in the previous section, the results are analyzed using the Heckscher– Ohlin (H- O) Theory. Section 7 is also dedicated to the conclusion.

2. The Concept of Virtual Water Trade

The virtual water trade is defined as an essential tool in the computation of water real consumption in a country. This concept was defined for the first time by Tony Allan as the water that is included in commodities or products (Allan, 1998). Such a definition of virtual water refers to the water, which is consumed for a commodity or services during production process until it is completed and the quantity of this water is equal to sum of the consumed water in different phases of the production cycle from the beginning to the end. Simply, the virtual water may be defined as the amount of water that is needed for the production of a commodity (Ehsani et al, 2008). The virtual water content for any product directly depends on ambient and atmospheric conditions at its production place. Accordingly, Hoekstra (2003) proposed more perfect definition about virtual water. In this definition, virtual water is the sum of the water needed to produce certain amount of a product (commodity) with respect to climatic, spatial, and temporal conditions of production and efficiency (Hoekstra, 2003).

Since Allan introduced the virtual debate, it took nearly 10 years to reach the scientific community. The first international conference about this subject was held in Delft (Netherland) on December 2002. But given that the virtual water will not remain as a product with the fixed quantity and this rate highly varies depending on the region where it is produced; therefore, the presentation of this definition will be also followed by the concept of virtual water trade. As a result, different quantity of virtual water of a certain product in different zones may form this idea that if the rate of virtual water in Zone-1 for a product is lesser than virtual water of the same product in Zone-2, production of that product in Zone-1 and its exportation to Zone-2 may be followed with less amount of consumed water. As a result, virtual water input and output streams along with importation and exportation of various commodities and services will form in any country. These streams have been known as virtual water trade and over the time different countries (especially countries located in arid zones with water shortage) considered certain strategies for their own concerning virtual water trade.

3. The literature of Virtual Water

Based on the main object in the present paper, virtual water trade and strategies of different countries about this topic are explored. Many studies have been carried out among scientific sources regarding virtual water trade. Inter alia, many researchers have mentioned the concept of virtual water trade as a strategy to manage water supplies. Of this group, one can refer to Chapagain and Hoekstra (2003), Renault (2003), and De Fraiture (2004).

In their study, Dehghanpour ad Bakhshoodeh (2008) showed that virtual water trade was considered as a basic criterion and tool for the calculation of real rate of water consumption in a country. During recent 40 years, virtual water trade has been increased permanently. About 15% of consuming water in the world is exported as virtual water. Thus, trade of agricultural crops is considered as the main component of virtual water trade. 67% of virtual water trade in the world is related to world trade of farming crops and 23% of their trade is attributed to livestock products and the related commodities while only 10% of them is related to industrial products. During years (1995-1999), wheat product has exclusively devoted 30% of volume of virtual water trade among the countries of the world and it was followed by soybean and rice, which are ranked later with higher than 17% and 15% of this rate, respectively. In this investigation, they have implied that the negative consequences and positive outcomes of virtual water exchange should be measured in which one of these consequences is the cost of opportunity for the consumed water.

In their survey, Moosavi et al (2009) express that with respect to the exacerbation of water shortage crisis in different countries in the world, the subject of virtual water will be crucially important due to the depth of this concept in planning and policymaking for water at macro level in the future. At present, also with the exportation and importation of goods and products between various countries of the world, some calculations are also implemented about the amount of imported or exported water as virtual water. Accordingly, the given study estimates the amount of virtual water for producing certain quantity of some products in Iran. Eventually, this study implies that, with respect to the restriction of water supplies, humans have noticed the choice of unconventional waters including treated wastewaters, water drainage zones, and desalination from sea water etc. The other alternative that has been discussed today to provide and store water, especially in arid and semi-arid countries in the world is water trade that is called virtual water trade.

In their investigation, Razavi and Davari (2013) implied that with respect to the existing sources and current demand, the existing water supplies will not be responsive to the next generation for water provision. Thus, considering modern techniques for water supply is very essential. One of the prevalent techniques in the world is to notice virtual water and water-bearing canal of products, and virtual water trade. They mention the concept of reversible water and its proper consumption as the strategy for the management of the given supplies since under current conditions the role of virtual water trade is unique in reduction of stress on water supplies. They assume the absence of the needed statistics and information about virtual water trade as one of the problems they encounter in this path. In their study, Dehghan Manshadi et al. (2013) have suggested a structure for the analysis of the potential for the use of virtual water in the destinations field in water transfer projects. They imply in this investigation that what it has occurred in some zones of the countries during recent years and caused drought and reduction of water supplies in rivers and springs have been due to overlooking the climatic assets in any zone and mismanagement of water supplies. The results of this study about project of water transfer from Soolgan to Rafsanjan indicate that rather than reducing of costs for transferring and hazardous consequences of water transfer for this region, using of virtual water concept will be also followed by lots of profits for cultivation and Khuzestan industry.

In their research titled 'virtual water exchange in order to improve productivity in water consumption (case study: Kerman Province)', Abolhassani et al (2014) have calculated the virtual water exchanges volume in this province. The results came from this study showed that Kerman Province was a virtual water-exporter and the size of exportation of virtual water has been estimated more than 64.2billion m³. This study indicates that pistachio and date are deemed as extravagant water-consuming crops and on the other hand other crops such as grains, fruits, and cucurbits are assumed as less water-consuming crops. With lower yield, pistachio includes higher rate of virtual water but date is place at lower rank with more suitable yield while both crops include higher rate of virtual water content than the standard level.

In addition to the analysis of international stream of virtual water trade their study, Hoekstra and Hung (2002) imply that if water is considered as an economic commodity, the problems of water shortage and surplus as well as reduced quality of water will be resolved in different parts of the world since the exportations and importations of crops in the countries may create an exchange of virtual water between countries. In this study, total extracted water in Iran has been mentioned as 72.6 billion m³ per year, available water as 137.5 billion m³; the net importation of virtual water was estimated 5.8 billion m³ with respect to farming plants and 1.02 billion m³ given the livestock crops and the related products.

Verma et al (2008) have examined the virtual water stream caused by exchanges of crops within different states of India during period 1997-2001. The results of this study showed that the virtual water stream in India included more than 106 billion m³ and or 13% of total volume of consuming water in this country.

Delbourg and Shlomi (2014) have explored the effect of water demand and its efficiency on rate of virtual water trade at world scale. This investigation has been carried out about all the related activities to agriculture sector during period 1994-2007. It is shown in this study that the countries with shortage of water supplies trade the nutrients and food products to compensate for their water supplies shortage.

In their survey titled 'the virtual water trade as a strategy for management of water supplies in Iran', Mohammadi et al (2014) have explored the relationship between exportations of virtual water with the scarcity of water supplies in Iran. The results of this study show that during the period 2001-2008, Iran was dependent purely on water imports and the net rate of virtual water imports of Iran is averagely about 12.7 billion m³ every year. Similarly, the calculation of virtual water rate in the given products indicates that the exported products need more water demand than imported products.

Analysis of these studies shows that the specific strategy of any country in using virtual water trade concept may play an essential role in the management of water supplies in that country so that the role of water has been always emphasized and suggested as one of the key factors in producing extravagant water-consuming crops and products where the virtual water trade is employed as a strategy to provide water supplies in arid area with water shortage. Hence, the application of virtual water trade concept in Iran may also be efficient in the management of water supplies. Accordingly, in the following theoretical bases and method of estimation of virtual water trade is presented in this study and the by means of the given estimations, virtual water trade strategy in Iran is compared with littoral states in Persian Gulf region.

4. Methodology

The concept of virtual water can be used as a useful tool in calculating the actual amount of water consumed in the country. If international water exchanges are to be considered, it can be used to determine the real demand for water in the country due to the pattern of people's consumption of global water resources. On this basis, it can be shown whether the domestic water resources in each country will provide water for the current or future population of that country. It can also show how much a country relies on the country's water resources.

By definition, water productivity and virtual water are related inversely. Water productivity includes the quantity of commodity that is produced from unit of volume of water (How much product is produced from one cubic meter of water) and its unit may be usually defined as ton per cubic meter. But, virtual water consists of the consumed water for the production of certain quantity of a product and its unit is liter per ton (cubic meter per ton). In other words, in productivity concept, it is emphasized on the amount of production from water so that as the amount of production from water is increased further, the productivity of the given product will be higher. But, regarding the concept of virtual water, it is focused on the amount of the consumed water in producing one unit of that product. Therefore, with improving water productivity, the quantity of virtual water will be reduced in the given product or commodities and reverse reduction in rate of the virtual water consumed for one unit of product denotes rising water productivity in that product. Thus, rate of virtual water for any product may be derived from the following formula (Ehsani et al, 2008):

$$\mathrm{VW_{kj}} = \frac{W_{kj}}{\mathrm{P_{kj}}} \qquad (1)$$

Where:

VW_{kj} denotes the amount of virtual water per unit of k^{th} product in j^{th} country.

W_{kj} is the total volume of the water needed in the process of producing of k^{th} product in j^{th} country.

P_{kj} is the total production of k^{th} product in j^{th} country.

To compute the rate of virtual water trade in different zones, initially the orientation of virtual water streams should be identified. As it mentioned, the exchange of commodities between different countries may be also led invisibly to the exchange of the existing virtual water in those goods. Thus, the rate of virtual water exchange should be separately calculated both in exportation and importation side for goods and services. These two sides are separated because the amount of virtual water in any commodity will be different with respect to climatic, spatial, and temporal conditions of production and similar factors in any region according to the definition of virtual water. Therefore, even though a country imports and exports of the given products along with the rate of virtual water per unit of the exported goods (with respect to climatic conditions of the exporting country) will be different from the amount of virtual water for a unit of the imported goods (with respect to climatic conditions of country of origin) at the same time. As a result, the amount of hidden virtual water in the exportation of any product should be computed with respect to climatic conditions of the exporting country of the given product. Consequently, the rate of hidden virtual water in exportation of j^{th} country to i^{th} country is derived from the product of the multiplication of the quantitative amount of exportations of j^{th} country to i^{th} country of each of these commodities to the amount of virtual water in that commodity (with respect to climatic and cultural conditions etc in j^{th} country).

Regarding the calculation of the amount hidden virtual water in the importation of various commodities, this process will be done inversely. Namely, the rate of virtual water of any product in importing country of origin is considered as the criterion for the calculation of virtual water. If this ratio is greater than one (1), it can be said that the amount of hidden water in importations of that country is greater than the hidden water in exportation of the same country and as a result the given country has removed its limitation for water supplies practically by means of using water supplies from other countries. As this ratio is greater for a country, it indicates that the aforesaid country has used virtual water trade in the management of its water supplies. Of course, it should be noted that the greatness of this ratio may be unconscious and only due to the limited availability of water resources in a country and there is no definite strategy in this regard. But, in any case, greater amount of this ratio shows using the limited water supply of a country more appropriately in line with producing less water-consuming products and importation of water-bearing products.

5. Virtual Water Trade Situation in Iran and other Persian Gulf Countries

This article is mainly intended to explore virtual water trade strategy in Iran in comparison to littoral states in Persian Gulf region. Then the index of ratio of imported virtual water to the exported water is calculated by means of the extracted information. Using this parameter, the strategy of different countries about application of virtual water trade in management of water supplies may be relatively evaluated. The related statistics about the rate of virtual water for any product code and the relevant standards have been formulated for the assessment of the real volume of the water by Water Track

Institute. The rate of hidden water in the exportation and importation of any country has been computed by means of this statistic and separately based on six-digit codes of any commodity.

5-1- Analysis of Importation of virtual water in Persian Gulf region

As it was mentioned in the previous section, the rate of virtual water for any product of importing country of origin is considered as the criterion for the calculation of virtual water regarding computation of the rate of hidden virtual water in the importation of different commodities. Therefore, in order to compute the importation of virtual water in Persian Gulf region, firstly, the rate of stored virtual water in any product should be identified with respect to country of origin and then with respect to size of importation in any country, the amount of hidden water should be determined in importation. Finally, the rate of hidden water in any unit of imported product can be generally calculated by dividing the amount of the virtual water accompanied to the importation to total volume of importation in any country.

Accordingly, the amount of the hidden water in importation of littoral states of Persian Gulf region has been computed for time period 2001-2012 in Table (1). Analysis of this table indicates that the maximum rate of hidden virtual water among countries locating in Persian Gulf in 2001 belongs to Oman, Iraq, and Saudi Arabia. In fact, the maximum rate of virtual water has been consumed per one ton of the imported product by these countries compared to other nations.

Table 1: The Amount of the Hidden Water in Importation of Persian Gulf Countries Region (m^3/t)

country	Year 2001		Year 2012		Total period	
	hidden water in importation	rank	hidden water in importation	rank	hidden water in importation	Rank
Iraq	888	2	918	1	879	1
Saudi Arabia	812	3	809	2	798	2
Iran	614	4	795	3	584	3
Oman	899	1	504	4	580	4
United Arab Emirates	350	5	354	6	322	5
Kuwait	244	7	357	5	309	6
Qatar	271	6	295	7	169	7
Bahrain	170	8	173	8	89	8

Source: writer's calculations

This suggests that importation of these countries are more reliant on water-based products, these countries have managed relatively to save in consuming their limited water supplies and used these supplies for producing commodities with higher value.

But in 2012, Iran was included in first three higher ranks in the hidden water in importation. In 2012, the highest amount of hidden virtual water in importation among littoral states of Persian Gulf belonged to Iraq, Saudi Arabia, and Iran, respectively. At this year, Iraq has imported about 918m^3 of virtual water per one ton of imports in average. Also, Saudi Arabia and Iran have imported about 800m^3 of virtual water per one ton imported products in average in this year. The minimum amount of the hidden water in importation belongs to Bahrain. In 2012, Bahrain has imported only about 173m^3 of virtual water per one ton of imported products. In fact, most of the imported commodities by this country included lesser amount of virtual water. As a result, in average the amount of virtual water along with any ton of the imported product is much less than in other countries of Persian Gulf region. This status has been much inappropriate during the period of analysis. As a result, the mean rate of the hidden water in imports is 89m^3/ton throughout the studied period. Thus, it may not be implied that this country has taken the strategy for the importation of virtual water to manage its water supplies.

The comparison of the hidden water in importation during the first and final years of the studied period may show that the mean rate of hidden water has been almost increased at final year in all of these countries. With respect to subsequent droughts during recent years, this indicates that the littoral states in Persian Gulf region have inevitably tended to virtual water trade due to lack of possibility for providing the domestic water-bearing products and have tried to provide their domestic needs with importation of water-bearing products.

5-2- Analysis of exportation of virtual water in Persian Gulf region

Table (2) shows the rate of hidden water in the exportation of littoral states in Persian Gulf region for time period 2001-2012. Analysis of this table shows that the maximum rate of hidden virtual water in exportation among Persian Gulf countries during 2001 has belonged to Oman, Iran, and Saudi Arabia, respectively. In fact, compared to other countries, any ton of the exported products by these countries has included the highest rate of virtual water. This issue indicates that exportation of these countries have mainly relied on water-bearing products and these countries have really exited great volume of their limited water supplies virtually with the exportation of water- bearing products.

In this year, Oman has exported virtually about 545m³ of water in average per any ton of exports. Also in this year, Iran has virtually exported about 500m³ of water in average per one ton of exported product.

Table 2: The Amount of the Hidden Water in Exportation of Persian Gulf Countries Region (m^3/t)

country	Year 2001		Year 2012		Total period	
	hidden water in exportation	rank	hidden water in exportation	Rank	hidden water in exportation	rank
Iran	499	2	141	2	273	1
United Arab Emirates	251	3	89	5	168	2
Oman	545	1	116	3	148	3
Saudi Arabia	96	5	142	1	128	4
Iraq	80	6	106	4	106	5
Kuwait	97	4	64	6	73	6
Bahrain	24	7	13	8	24	7
Qatar	21	8	16	7	21	8

Source: writer's calculations

Also in 2012, Iran is placed at second rank in terms of the parameter of virtual water in exportation. The maximum rate of hidden virtual water in exportation among countries at Persian Gulf region in 2012 belonged to Saudi Arabia, Iran, and Oman respectively. The least rate of hidden water in exportation is related to Qatar and Bahrain. In 2012, only about 13m³ of virtual water has been exported per one ton of the exported product by Bahrain. In fact, this country has often exported some products, which need to less water consumption. As a result, in average, the rate of virtual water embedded in one ton of the exported product is much less than other countries in Persian Gulf. As a result, exportation has least effect on domestic water supplies in countries of Qatar and Bahrain.

In addition, the comparison of the hidden water in exportation at first and final years of the studied period indicates that the hidden water in exportation has extremely reduced in most of the countries. The subsequent droughts during recent years have caused the given countries to be less able to export the water-bearing products and consequently this index has extremely decreased. In particular, the rate of this index has been further reduced noticeably for the countries such as Oman and Iran where their exportation has been mainly dependent on domestic water supplies. For instance, the rate of hidden water index in Iranian exportation has been extremely reduced from approximately 500m³/ton in 2012 to about 141m³/ton.

At last, the comparison of hidden water indices in importation and exportation may show that the main policy of Iran has been implemented in the course of self-sufficiency in water-bearing products (especially the agricultural crops including wheat). But finally the incremental trend of hidden water index in Iranian importation along with extreme reduction in hidden water index for exportation signifies the instability of aforesaid policy. This strategy is visible in many countries in Persian Gulf region. The main reason for this strategy can be seen in the issues of food security and domestic supply of strategic products (including wheat). But what can provide a more accurate picture of the strategy of different Persian Gulf countries is to calculate the index of ratio of the imported virtual water to exported virtual water. If this ratio is greater than one (1), it can be said that the amount of hidden water in importation of the given country is greater than hidden water in its exportation, and as a result, the aforesaid country has practically removed its limitation for water supplies by means of supplying water from other countries.

5-3- Analysis on ratio of the imported virtual water to exported virtual water

The index of ratio of the imported virtual water to exported virtual water has been computed in Table 3. This parameter is greater than 1 for all of the studied countries. This shows that particularly trade in these countries has been led to One can assume the main reason the importation of virtual water inside them. But as this ratio is greater for a country, it indicates that country is more tended to use the concept of virtual water trade in the management of its water supplies. The comparison of this index among countries in Persian Gulf indicates that during the studied period, Iran has devoted the least index. This issue signifies that, in comparison to other countries in Persian Gulf, the strategy taken by Iran in management of its water supplies has less relied on the concept of virtual water trade.

Table 3: The Ratio of the Imported Virtual Water to Exported Virtual Water of Persian Gulf Countries Region (m^3/t)

country	hidden water in importation			hidden water in exportation			ratio of the imported virtual water to exported virtual water
	2001	2012	average	2001	2012	average	
Iran	614	795	581	499	141	342	1/7
United Arab Emirates	350	354	327	251	89	183	1/8
Oman	899	504	716	545	116	260	2/8
Kuwait	244	357	322	97	64	74	4/4
Bahrain	271	295	113	24	13	23	4/8
Saudi Arabia	812	809	810	96	142	123	6/6
Iraq	888	918	883	80	106	102	8/7
Qatar	170	173	207	21	16	22	9/5

Source: writer's calculations

The index of ratio of the imported virtual water to exported virtual water is about 1.7 for Iran. While, the given index for the country such as Saudi Arabia is about 6.6, and about 9.5 for Qatar. Namely, regarding commodities trade in Qatar, the amount of virtual water per one unit of the imported goods is 9.5 times greater than the rate of virtual water per unit of the exported product.

Of course, it should be noticed that the magnitude of this ratio may be achieved unconsciously because of limitation of water supplies in a country and there may be no certain strategy in this regard. However, in any case, increasing this ratio signifies using the limited water supplies more appropriately in a country in the course of producing less water-consuming products and the importation of water-bearing products. This issue may finally lead to reduce stress on domestic water supplies to great extent.

6. Analysis of the results using the Heckscher–Ohlin theory

Heckscher–Ohlin theory is based on the two terms of the severity of production factors and abundance of production factors (Heckscher & Ohlin, 1991).

According to this theory, each country exports goods that do not require the use of fairly abundant and inexpensive factors, and in turn impose goods that require relatively few and expensive agents to produce. Given that water is a production factor (especially for the production of agricultural commodities), the country must therefore export water- intensive goods that has abundant water resources and, on the other hand, countries facing water scarcity should import water- intensive goods.

But based on the results of calculations in section 5, it was noted that the Persian Gulf countries, despite the lack of water resources, export large quantities of virtual water from their countries by exporting goods. This suggests that the strategies adopted in the management of water resources in these countries are not compatible with the Heckscher–Ohlin theory. The reason for this is that the relationship between the scarcity of water resources and the price (as emphasized by Heckscher–Ohlin) does not exist in most of these countries. In this regard, despite the scarcity of water resources in most Persian Gulf countries, pricing of water resources is not based on its economic value, so that water resources are cheap despite their scarcity.

In Huckcher-O'Hellen's theory, the relative frequency of factors is shown in the prices of internal factors and they contribute to determining the relative advantage of a country in the production of a commodity and the relative proportions of factors of production. This theory prefers the supply side to determine the price of the factors, whereas if the demand side is to be considered in determining the price of the factors, it is possible that a country with more labor force will export capital-intensive goods. Based on the results of the calculations carried out in Section 5 of the paper (especially the index of ratio of the imported virtual water to exported virtual water), it can be said that the strategy adopted in the Persian Gulf region has been based on the demand side. Therefore, these countries are exporting water- intensive goods. However, if the supply side were to be considered, due to the scarcity of water resources, fundamental changes would be made in determining the price of water. As a result of adopting this strategy in managing water resources, Persian Gulf countries export goods with lower virtual water content.

Therefore, water resource management in these countries requires a fundamental change in existing strategies. At present, the strategy of these countries, based on the high demand for water – intensive goods, has been based on the provision of water resources. Transition and exchange of real water between low and high water areas, whether inside a country or internationally, is not logical due to the costly nature of such projects. While virtual water exchange is easier and more economical by importing water- intensive products. In this way, poor countries in terms of water resources can reduce the pressure on their limited water resources by importing these products.

7. Discussion and conclusion

This article is mainly intended to compare Iran's strategy in terms of virtual water trade and other countries in Persian Gulf region. In this course, using the concept of virtual water trade in the management of Iranian water supplies and their important and real position for fighting with water shortage problems were explored. To this end, the rate of hidden water in importation and exportation of countries in Persian Gulf region was computed during period 2001-2012. Analysis of the rate of the given index in different countries indicated that these countries have not approximately taken any certain and predetermined strategy to use virtual water trade concept in managing their water supplies, so that during recent years and with exacerbation of drought in these regions and lack of possibility to provide water- bearing products inside the country, the importation of such products has been extremely increased. This issue has led to sharp increase in amount of hidden water index in importation for most of countries in Persian Gulf region. Also, regarding Iran, the main national policymaking trend has been directed in the course of self-sufficiency in water- bearing products (especially agricultural crops such as wheat). However, finally the ascending trend of importation of virtual water during recent years along with rising hidden water index in Iranian importation signifies instability of the given policy. This issue shows the absence of a certain policy regarding virtual water trade in Iran. In fact, virtual water trade has not been affected by certain policy and it extremely affects the existing fluctuations in precipitations rate and the created droughts within different years and rate of hidden water index in exportation and importation of Iran.

Analysis of the index of ratio of the imported virtual water to exported virtual water also indicated that the rate of this index has been also greater than one for all of studied countries. This shows that trade in these countries has purely led to the importation of virtual water in them. But, the comparison of the rate of index of ratio of the imported virtual water to exported virtual water among the aforesaid countries indicated the quantity of this index in Iran is much less than other studied countries. Small rate of this index signifies that Iran is less tended to use concept of virtual water trade than other countries in managing its water supplies. As a result, it is suggested to allocate special position to take this modern strategy regarding fighting against water shortage problems in managing national water supplies by giving information to politicians and economic planners about the importance of virtual water trade concept. In fact, the virtual water should be exchanged with respect to interests caused by virtual water trade and unconsciously thereby the resulting economic benefits can be practically used. In this sense, a change in cultivation pattern and paying attention to producing less-consuming crops may be assumed as one of the main priorities in strategy of managing national water supplies. Of course, it should be noticed that virtual water trade is proposed as a complementary strategy in managing water supplies. In fact, one of the important issues regarding the concept of virtual water trade is to pay attention to the approach of nutrient security and self-sufficiency in strategic products. Therefore, the optimal amount of food and nutrient importation for different countries may vary with respect to possession of water supplies, farming lands, and other production sources as well as national food security policies. In any case, it seems that revision of policies regarding management of water supplies to develop virtual water trade based on relative advantage should be converted into one of the main preferences for national politicians and economic planners.

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