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Extended Abstract

Application of the Concept of Virtual Water in Water Resources Management of Iran

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Introduction

Iran is a country with arid and semi arid Climate. More than 94 percent of the water resources of the country is being used in the agriculture sector. This makes agriculture the main sector that uses water in Iran. With the increasing water scarcity in Iran, the virtual water content became an important subject in water resources management studies. Virtual water is defined as the volume of water required to produce a commodity or service (Allan, 1998). When these goods or commodities enter the global market, virtual water trade will occur. Zimmer and Renault (2003) estimated the global virtual water trade between nations as 1340×10^9 cubic meters in 2000. Of this total value, 60% was related to the vegetal products trade, 14% to the fish and seafood trade, 13% to the animal products (non-meat) trade, and 13% to the meat trade. The virtual water trade related to the crop and the livestock product trade was about 17 % of the total water used for crop production (Chapgain & Hoekstra, 2003). The present study quantifies the Iranian virtual water trade related to the agricultural products according to the global studies on the virtual water flows (Hoekstra and Hung , 2002 and 2005, Zimmer and Renault, 2003, Oki et al., 2003, Chapagain and Hoekstra, 2003, and De Fraiture et al., 2004). This study focuses on the agricultural commodities due to their major part in global water use (Postel et al., 1996).

Objectives

1. Study of the agricultural trade plan of Iran.
2. Find main agricultural export and import products.
3. Calculate the virtual water content of the main importing and exporting products.
4. Find the trend of the virtual water trade in the period of 1996 to 2006.
5. Calculate the net virtual water content of the selected agricultural products.
6. Answer the question whether Iran is a virtual water importer or exporter?
7. Identify the factors effecting the virtual water trade.

Methodology

Figure 1 shows the steps in calculating the virtual water content for crop products.

The virtual water trade between nations has been calculated by multiplying international crop trade flows by their associated virtual water contents. The latter depends on the crop specific water demand in the exporting country i.e. where the crop is produced. Virtual water trade is thus calculated as:

$$VWT_{(ne,ni,c,t)} = CY_{(ne,ni,c,t)} \times SWD_{(ne,c)} \qquad (1)$$

VWT denotes the virtual water trade (m^3yr^{-1}) from the exporting country n_e to the importing country n_i in year t as a result of the trade in crop c. CT represents the crop trade $(ton\ yr^{-1})$ from the exporting country n_e to the importing country n_i in year t for crop c. SWD represents the specific water demand $(m^3\ ton^{-1})$ for crop c in the exporting country (Hoekstra & Hung, 2002).

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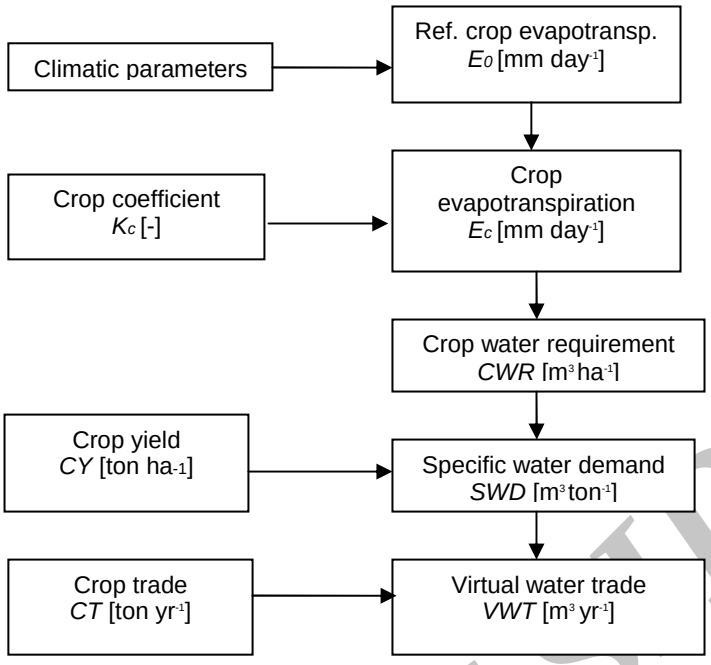

Figure 1. Steps in the calculation of virtual water trade.
Ref: Hoekstra & Hung (2002)

The gross virtual water import to a country n_i is the sum of all imports:

$$GVWI_{[t]} = \sum_{ne,c} VWI_{[ne,c,t]} \quad (2)$$

The gross virtual water export from a country n_e is the sum of all exports:

$$GVWE_{[t]} = \sum_{ne,c} VWE_{[ne,c,t]} \quad (3)$$

The net virtual water import of a country is equal to the gross virtual water import minus the gross virtual water export. The virtual water trade balance in the country n for the year t can thus be written as:

$$NVWI_{[t]} = GVWI_{[t]} - GVWE_{[t]} \quad (4)$$

NVWI stands for the net virtual water import (m^3yr^{-1}) into the country. Net virtual water import into the country can have either a positive or a negative sign.

Results and Discussion

Virtual water Calculation

Table 1- Virtual water content of selected agricultural exporting products
Unit= 109 M3Year-1

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average*
Pistachio	0.9	0.43	1.94	0.708	0.2	0.65	0.1	0.94	1.4	1.5	1.95	0.97
Date	192	0.22	0.305	0.355	0.39	0.26	0.3	0.3	0.28	0.37	0.435	0.31
Raisin	0.38	0.26	0.42	0.42	0.45	0.28	0.35	0.4	0.4	0.42	0.444	0.39
Apple	0.12	0.12	0.207	0.16	0.1	0.05	0.055	0.1	0.053	0.15	0.176	0.12
Water melon	-	-	0.07	0.05	0.035	0.019	0.019	0.032	0.018	0.03	0.04	0.035
Fig	-	0.05	-	0.07	0.06	0.036	0.036	-	0.04	0.045	0.39	0.048
Citrus fruit	-	0.05	-	0.054	-	-	-	-	0.011	0.014	0.023	0.031
Almond	-	-	0.042	0.05	0.052	0.21	0.098	-	-	-	-	0.092
Walnut	-	-	0.028	0.025	0.02	-	-	-	-	-	-	0.025
Melon	0.092	079.0	-	-	-	-	-	-	-	-	-	0.086
Orange	-	-	-	-	-	-	-	-	0.011	0.012	-	0.012
Apricot	-	0.032	-	0.048	-	-	-	-	-	-	-	0.04
Share (%) **	93.3	93.8	94.2	94.5	95.3	95.6	94.3	88	94.7	94.9	92.3	-
Total Virtual Water export	1.68	1.25	3.01	1.94	1.31	1.52	0.98	1.79	2.24	2.56	3.11	-

* Average virtual water export for selected product in the study period
** This Share shows the sum of the exported value of the selected products compared to the total value of the agriculture export in each year

Table 2- The virtual water content of the selected agricultural importing products
Unit= 109 M3Year-1

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average*
Wheat	4.32	7.42	3.61	7.43	7.91	5.44	2.41	0.51	-	-	0.69	4.42
Barley	0.30	0.63	0.20	0.56	1.41	0.68	1.52	0.14	0.71	1.00	0.31	0.68
Maize	1.98	0.20	1.23	1.55	1.75	1.54	-	2.52	1.83	1.89	2.33	1.68
Rice	1.27	1.04	0.97	1.91	2.32	0.80	1.20	0.94	1.46	1.22	1.15	1.30
Raw Oil Soybean	10.60	3.62	3.32	10.12	9.10	6.22	4.28	4.35	3.25	4.45	4.11	5.77
Raw Oil Sunflower	0.64	2.03	3.01	1.13	1.44	-	0.20	0.48	0.04	-	0.93	1.10
Raw sugar, cane	1.76	2.33	2.04	2.60	1.56	1.05	0.86	0.26	0.18	0.96	2.51	1.46
Soybean solid Residues	-	-	-	-	-	3.86	3.28	2.61	3.08	0.69	3.04	2.76
Palm Oil	-	-		-	-	-	-	1.42	2.69	4.61	5.20	3.48
Soybean Oil	-	-	0.63	-	0.49	-	-	-	-	-	-	0.56
Tobacco	-	-	-	-	-	-	-	-	-	0.18	0.24	0.21
Raw sugar, beet	-	-	-	-	-	-	0.31	-	-	-	-	0.31
Share (%) **	78.2	83.8	72	80	77.6	82.2	70.2	62	56.9	64.7	67.4	-
Total Virtual water Import	20.88	17.27	15.02	25.31	25.99	19.59	14.05	13.23	13.25	14.99	20.51	-

* Average virtual water import for the selected product in the study period
** This Share shows the sum of the imported value of the selected products compared to the total value of the agriculture import in each year

Conclusion

The factors affecting the virtual water trend can be divided into two main categories only one of which is manageable. The quantity of the trade and the export and import products can be controlled. The climate parameters like rain and air humidity which affect the agricultural production are however uncontrollable. This study showed that in all studied years, the virtual water import was more than export and the net virtual water import was positive. The results also showed that the quantity of the trading product is a more effective parameter than the water special demand in determining the quantity of the virtual water trade. In order to verify the results of this study for further applications in the society a parallel study is suggested which regard the technical means of using water for tradable products. The results should then be compared to this research to decide which method is more suitable for calculating the virtual water trade; i.e. more adjustable with the agricultural condition.

Keywords: Virtual Water, Adaptive Capabilities, Agricultural Products, Iran.

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