Assessing Water Consumption of Industrial Sectors in Iran, Using Input Output Technique

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Abstract

A nation's future growth and development depends upon more efficient and more productive use of its water resources. This is more important for a water scarce country such as Iran. In this paper through input output technique we tried to estimate water consumption pattern of Iran's manufacturing industries. To do this we have aggregated 99 sector input output of Iran in to 32 sectors emphasizing more on manufacturing for which we have taken into account 26 branches based on ISIC, in addition to sectors such as agriculture, construction, services, electricity, gas and water. In addition to estimating direct and indirect multiplier impact of water consumption, using usual Leontief Inverse formula, we have also used Extraction Methods as suggested by Diatzenbakher and Linden, to study the importance of water for other sectors to highlight the water content of transaction within Iranian economies. The result shows that both direct and indirect coefficients were relatively high for sectors such as agriculture, and industries like paper and paper products, food industries, basic metals, refined petroleum and coal, non metallic minerals, glasses, textiles and other transport equipments, construction and chemical materials. This result remains more or less the same when using extraction method except that in the later case service sector appear to be a leading water consuming sector. Taking into account the facts that these are the main economic activities of the country, it is therefore, an imperative for policy makers to coordinate their activities in such a way that adequate supply of water is provided and efficient use of it is made and to respond quickly and timely to the structural changes of Iranian economy and to prevent water crisis in the country.

Keywords: Water Consumption, Extraction Method, Input Output technique, Iranian Industrial Economy.

JEL: L6, O21, Q25, Q28

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1- Introduction

A nation's future growth and development depends upon more efficient and more productive use of its water resources. This is more important for a water scarce country such as Iran. Although, shortage of water in Iran might have been due to climate and physical reasons, or constraints, nevertheless inadequate attention paid by policymakers and inefficient management of resources resulting from non-reasonable use are increasingly cited as water problem in Iran[1].
While traditional response to the water problem has been centred on the management of the resources from supply standpoint[2], increasingly attention have been shifted to consumption and management of existing resources[3] . The relation between consumption of water resources and the production structure have been studied by scholars such as Lofting and Mc Gauhey(1968),Sanches-choiz,Bolsa and Arrojo(1992), Duarta Sanchez –Cholizand Bielse (2002) and in Iran by Ardakanian(2004,2003), Babakani(2000), Fotlz(2002), MadaniLarijani(2003), Panahi (2000) and IMPO(2002,2004 and IWRMO(2002).
Comparing Iran's ARWA Index with International Standard, Ardakani (2003) estimated that by the year 2025 Iran with Annual Renewable Water Availability(Cubic Meters Per Capita) 1300 of ARWA per capita would face water stress(see also Panahi (2000). Water cycle of Iran is of the volume of 159 billion cubic meters as the total Renewable Fresh Water Resources of which 130 billion is the Available Fresh Water Resources, and the rest (29 billion) is the volume of return water from consumption., Evidently there are a great differences in geographic and climate conditions from north to south and east to west. Sixty –five percent of Iran is considered to be arid, 20 percent is semi arid and only 15 percent of the country has a humid and semi humid climate.[4]
While the aim of policy makers in Iran is to implement policy to manage the use and increase the efficiency of its consumption, however lack of knowledge about relationship between water, the economy and society hamper their plan. Policy makers and decision taker in Iran need to have a clear idea about the estimation and evaluation of the impact of water policies such as water tariffs on production sectors or the impact of economic policies such as irrigation policies on water resources. The purpose of this paper is to study the relationship between the various production sectors and the water sector in Iran, and present an evaluation of the direct and indirect impacts of water on the rest of the economy. The paper is divided as follows; the next section would provide a profile of Iranian economy and discusses the position of Water sector. Methodology and Data sources are presented in section three. Section four shall analyses findings. Finally, section fifth and the last conclude the paper.

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[1]- Foltz(2002)
[2]- Attention have been paid to increase the availability of water resources through the construction of dams and other hydrological works see IWRMO(2002)
[3]- IWRMO(2004)
[4]- Ardakani (2003) cited in Kaveh Madani Larijani (2005)

2- Water and Iranian Economy

Although we do not have separate data for water, it is aggregated with electricity and gas under one title .Table 1 and 2 provide a picture of Iranian economy. It can be seen that while the share of agriculture declined and remained at less than 9 percent in output, it still absorbs one-fifth of total employment. The share of manufacturing industries also was relatively low at around 13 percent of output and

Table 1: Percent Share of Economic Activity in the GDP

Year	Agriculture	Mining and Quarrying	Manufacturing	Electricity, gas and water supply	Construction	service activities
2001	11.23%	15.82%	13.87%	1.97%	4.89%	51.85%
2002	11.12%	17.71%	13.73%	2.10%	4.89%	50.05%
2003	10.83%	17.94%	13.89%	2.12%	4.39%	50.42%
2004	9.46%	19.94%	13.00%	2.11%	4.44%	50.49%
2005	8.88%	22.26%	12.89%	2.34%	4.67%	49.17%
2006	8.82%	21.39%	13.02%	2.42%	4.97%	49.51%
2007	8.53%	22.11%	12.77%	2.39%	5.54%	47.73%
2008	7.92%	19.22%	12.86%	2.57%	6.59%	50.42%
2009	8.89%	14.57%	12.98%	2.10%	7.59%	53.08%
2010	8.61%	16.52%	13.02%	2.30%	6.28%	52.11%

Source: Statistical Center of Iran(2012)

more than 17 percent of employment. Electricity, gas and water accounted for nearly 2 percent of output and almost one percent of employment. Mining and quarrying though had 16.6 percent of output its share in employment was insignificant .Construction activity is increasing its share in output and employment. But as can be seen from the tables 1 and 2, services account for more than 52 percent of GDP and less than 49 percent of employment. While decline in the share of agriculture and increase in the share of industry in the course of economic development is a natural phenomenon[1], this in Iran's context , however , was not the result of its development process bur rather superimposed on it by growing oil revenues.[2]

[1]- Fisher(1933),Clark(1957)and Chenery(1960)
[2]- Yousefi(1993)

Table 2 - Percent Share of Economic Activity in the Employment

Year	Agriculture	Mining and quarrying	Manufacturing	Electricity, gas and water supply	Construction	service activities
2001	26.00%	0.70%	17.80%	0.90%	11.30%	43.50%
2003	22.00%	0.80%	16.20%	1.00%	12.70%	47.20%
2004	22.90%	0.70%	15.70%	0.90%	12.80%	46.90%
2005	24.70%	0.60%	18.40%	1.00%	10.40%	44.90%
2006	23.20%	0.70%	18.70%	0.90%	11.40%	45.00%
2007	22.80%	0.60%	18.20%	0.90%	12.30%	45.10%
2008	21.20%	0.60%	17.10%	0.90%	13.60%	46.50%
2009	20.90%	0.50%	17.30%	0.80%	13.10%	47.40%
2010	19.20%	0.50%	17.10%	1.00%	13.70%	48.70%

Source: Statistical Center of Iran(2012)

3- Methodology and data

Input output technique is an ideal way to present the relationship between economic sectors and water consumption[1]. It also allows us to distinguish the direct and indirect water use. Through understanding of the relevance of various industrial sectors within Iranian economy, we can better equip water authorities to make sound policy decisions in the event of emergency. To do this we try to aggregate 99 sector input output of Iran in to 29 sectors emphasizing more on manufacturing for which we have taken into account 23 branches based on ISIC classification, in addition to sectors such as agriculture, Construction, Mines, Services, Electricity, Gas and water, into account. The basic data is input-output table of the Iranian economy for the year 2001 prepared by the Statistical Centre of Iran .Statistics for water consumption for different sectors is taken from the energy balance sheet in 2001 and the survey of Large Iranian Manufacturing Industries for the year 2001 Statistical Centre of Iran (Statistical Centre of Iran, 2006).

In this section, an input-output model of sectoral water consumption is constructed. For this purpose, the basic equation in Input-output model of production are used as the basis for developing an input- output model of water consumption.

3/1- First approach: the Input-output model of production

The basic equation in Leontief Model which shows that production depends on inter sectoral relations and final demand is:

$$X=Z+F \tag{1}$$

Relationship (1) shows that, Total output(X) of an economy is divided into intermediate demand (Z) and final demand (F). In the standard model of input-output is assumed that

[1]- Bouhia(1998)

there is a constant ratio between intermediate exchange and total product of each sector, assuming that the IO coefficients can be calculated.

$$A_{ij} = \frac{Z_{ij}}{X_j} \qquad (2)$$

And,

$$Z=AX \qquad (3)$$

By substituting equation (3) in (1):

$$X=AX+F \qquad (4)$$

$$X = (I-A)^{-1} . F \qquad (5)$$

Relation (5) is a production balance showing changes in the production sectors of the economy based on changing in final demand and by assuming the stability of the production structure.

The direct water consumption coefficient is calculated as follows.

$$w = \frac{W}{X} \Rightarrow W = \hat{w}.X \qquad (6)$$

In relation (6) W represents the total water consumption (m^3) in different sectors of the economy, ($\hat{w}$) is diagonal matrix of direct water consumption coefficients and X represents the total output in each sector. By replacing equation (5) in (6), the new relationship is derived which shows the relationship of final demand, Production structure and water consumption.

$$w = \hat{w}(I - A)^{-1}.F \qquad (7)$$

Relation (7) shows, how a unit change of final demand affect water consumption in different sectors directly and indirectly.

3/2- Extraction Methodology

We have used hypothetical extraction method to measure forward linkages of Water industry to show dependency of other sectors on water sector.The basic idea of the hypothetical extraction method, given by Strassert (1968), is to extract a sector hypothetically from an economic system, and then to examine the influence of this hypothetical extraction on other sectors of the economy (Andresso & Yue, 2004). Starting with the basic balance equation of Leontief's model:

$$X = (I - A)^{-1} F \tag{8}$$

It may be assumed that one sector is extracted from the economy. Extraction of the *k*th sector, for example, simply means that the *k* th row and column of the input matrix, *A,* are deleted (not replaced by zero). Thus the equation can be rewritten as:

$$X'(k) = [I - A'(k)]^{-1} F'(k) \tag{9}$$

Where $A'(k)$ is a $(n\text{-}1)\times(n\text{-}1)$ input matrix by deleting *k* th sector from *A*; $X'(k)$ and $F'(k)$ are $(n\text{-}1)$ dimensions vectors corresponding to output vector *X* and final demand vector *F*, respectively. If, given *F* and $F'(k)$, the results $X'(k)$ should be less than *X*, i.e.,

$$X'_i(k) < X_i \quad for\ i = 1,2,\ldots,k\text{-}1,k+1,\ldots,n. \tag{10}$$

Then, the sum of the differential between the output vector *X* excluding *k*th element and $X'(k)$ may measure the linkage effect of the extracted sector *k* on total output, i.e.,

$$L(k) = \sum_{i=1, i\neq k}^{n} (X_i - X'_i(k)) \tag{11}$$

Where $L(k)$ denotes the linkage indicator of sector *k*. Obviously, there are two shortcomings in the above original extraction method. First, it cannot distinguish the total linkages into backward and forward linkages. Second, the hypothesis of simply scrapping an entire sector from the economy seems to be rather excessive (Andresso & Yue, 2004).

To overcome the former drawback of the original extraction method, other researchers presented some improvements on the original extraction method. A revised extraction method was presented by Dietzenbacher and van der Linden (1997), who measure the backward and forward linkages separately by using a non-complete extraction method. In this study we have followed Dietzenbacher- Linden approach. It is assumed in the case of backward linkages, sector *j* buys no intermediate inputs from any production sectors. In other words, that all the elements of column j of the input coefficient matrix are equal to zero, i.e., $A_{jj}= 0$, $A_{rj} = 0$, (A_{jj} denotes the input coefficient of sector j to itself; A_{rj} denotes the input coefficient vector of sector j to the other sectors).

For the measures of forward linkages in supply-driven system, it is assumed that sector *j* sells no output to any of the production sectors. Row *i* in the output coefficient matrix *B* is set to zero. Forward linkages, show dependency of the water sector on the other sectors.

Calculation of forward linkage with extended basic supply-driven model equation ($x' = x'B + v$) by extracting the row to the desired sector, is possible:

$$[x'_1 \quad x'_2] = [x'_1 \quad x'_2]\begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} + [v_1 \quad v_2] \tag{12}$$

$$[\bar{x}'_1 \quad \bar{x}'_2] = [\bar{x}'_1 \quad \bar{x}'_2]\begin{bmatrix} 0 & 0 \\ B_{21} & B_{22} \end{bmatrix} + [v_1 \quad v_2] \tag{13}$$

Above relations, expresses the gross product of each block before and after extraction. After rewriting, we shall have the following equation:

$$[x'_1 \quad x'_2] = [v_1 \quad v_2]\begin{bmatrix} K & KB_{12}G_{22} \\ G_{22}B_{21}K & G_{22}(I + B_{21}KB_{12}G_{22}) \end{bmatrix} \tag{14}$$

$$[\bar{x}'_1 \quad \bar{x}'_2] = [v_1 \quad v_2]\begin{bmatrix} I & 0 \\ G_{22}B_{21} & G_{22} \end{bmatrix} \tag{15}$$

Where $K = (I - B_{11} - B_{12}G_{22}B_{21})^{-1}$ and $G_{22} = (I - B_{22})^{-1}$.

Hence, reduction in output showing the size of forward linkage of desired sector can be obtained as:

$$[\Delta x'_1 \quad \Delta x'_2] = [v_1 \quad v_2]\begin{bmatrix} K - I & KB_{12}G_{22} \\ G_{22}B_{21}(K - I) & G_{22}B_{21}KB_{12}G_{22} \end{bmatrix} \tag{16}$$

Where *v***,** *B* and *G* denote the primary input row vector, output coefficient matrix and output inverse matrix derived from the output coefficient matrix, respectively.
These relations, about water sector indicate that how much production of each sector, is reduced if the water sector is extracted from the economy.

4-Analysis of Findings

We have presented the result on Table 3 and 4. As can be seen water consumption coefficients both “direct” and “direct and indirect” are high in the sectors such as generation, transmission and distribution of water , agricultural sector, Manufacture of Food and beverages ,fuel processing , basic metals and non metallic minerals, textiles. These sectors have the largest water output multiplier. This means that when these sectors have transaction with the others, they push water consumption up more than other sector does so. Thus, say a unit increase in their final demand; water consumption will increase to an above average level. This result remains more or less the same when using extraction method except that in the later case service sector replaces textile industries. This result indicate that water content of transaction in Iran is high and remain the same for the sectors mentioned .The fact that service sector appear to be a leading water consuming sector, is a sign of precaution that must be taken seriously specially when service sector is a large and growing sector of Iranian economy.

Table 3- Water Dependency of Economic Sectors (Water consumption coefficients)

No.	Sectors	Direct & Indirect Coefficient	Rank	Direct Coefficient	rank
1	Agriculture	0.0091	**2**	0.0079	**2**
2	Manufacture of food products and beverages	0.0054	**3**	0.0003	11
3	Manufacture of tobacco products	0.0017	15	0.0002	19
4	Manufacture of textiles	0.0021	8	0.0005	9
5	Manufacture apparel, processed and colored furs	0.0005	28	0.0000	**31**
6	Tanning of leather, manufacture of luggage, handbag, saddle, shoes	0.0010	21	0.0001	27
7	Manufacture of wood and wood products	0.0017	12	0.0001	23
8	Making paper and paper products	0.0024	7	0.0013	**4**
9	Publishing, printing and recorded media	0.0010	22	0.0002	21
10	Manufacture of refined petroleum products and coal, coke and nuclear fuel processing	0.0046	**4**	0.0008	6
11	Construction materials and chemical products	0.0031	5	0.0023	**3**
12	Manufacture of rubber and plastic products	0.0017	11	0.0003	13
13	Manufacture of glass and glass products	0.0017	13	0.0007	8
14	Non-metallic mineral products not elsewhere classified	0.0021	9	0.0007	7
15	Production of basic metals	0.0028	6	0.0012	5
16	Fabricated Metal Products except Machinery and Equipment Manufacturing	0.0012	17	0.0003	16
17	Construction machinery with general application	0.0005	**29**	0.0002	22
18	Construction machinery, with particular application	0.0008	25	0.0003	17
19	Manufacture of household appliances	0.0012	18	0.0003	14
20	Manufacture of office machinery, accounting and computing	0.0001	**32**	0.0000	**30**
21	Manufacture of electrical machinery and apparatus not elsewhere classified	0.0011	20	0.0003	12
22	Manufacture of radio, television and communication equipment	0.0004	**31**	0.0001	26
23	Manufacture of medical and optical instruments	0.0004	**30**	0.0001	24
24	Manufacture of motor vehicles, trailers and semi-trailer	0.0006	27	0.0001	28
25	Manufacture of other transport equipment	0.0008	24	0.0004	10
26	Furniture Manufacture	0.0011	19	0.0002	20
27	Manufacturing products not classified elsewhere and Recycling	0.0017	14	0.0000	**32**
28	Generation, transmission and distribution of water	0.0009	23	0.0003	18
29	Generation, transmission and distribution of gas	0.0019	10	0.0001	**29**
30	Generation, transmission and distribution of water	0.0290	**1**	0.0249	**1**
31	Construction	0.0013	16	0.0001	25
32	Service	0.0007	26	0.0003	15

Source: Research results

Table 4- Water Dependency of Economic Sectors(Forward Linkages in Hypothesis Extraction Method)

No.	Sector	Production Loss Due to Extract of Water Sector	Rank
1	Agriculture	1473685	**1**
2	Manufacture of food products and beverages	324412	**4**
3	Manufacture of tobacco products	2720	**29**
4	Manufacture of textiles	35435	11
5	Manufacture apparel, processed and colored furs	4628	23
6	Tanning of leather, manufacture of luggage, handbag, saddle, shoes	4488	24
7	Manufacture of wood and wood products	5236	20
8	Making paper and paper products	10698	17
9	Publishing, printing and recorded media	2378	**30**
10	Manufacture of refined petroleum products and coal, coke and nuclear fuel processing	55636	8
11	Construction materials and chemical products	69933	7
12	Manufacture of rubber and plastic products	12661	14
13	Manufacture of glass and glass products	2969	27
14	Non-metallic mineral products not elsewhere classified	39511	10
15	Production of basic metals	71428	6
16	Fabricated Metal Products except Machinery and Equipment Manufacturing	22374	13
17	Construction machinery with general application	5830	19
18	Construction machinery, with particular application	11203	15
19	Manufacture of household appliances	5156	21
20	Manufacture of office machinery, accounting and computing	321	**32**
21	Manufacture of electrical machinery and apparatus not elsewhere classified	10803	16
22	Manufacture of radio, television and communication equipment	2785	28
23	Manufacture of medical and optical instruments	2043	**31**
24	Manufacture of motor vehicles, trailers and semi-trailer	34653	12
25	Manufacture of other transport equipment	3650	26
26	Furniture Manufacture	3711	25
27	Manufacturing products not classified elsewhere and Recycling	4780	22
28	Generation, transmission and distribution of Electricity	53809	9
29	Generation, transmission and distribution of gas	7229	18
30	Generation, transmission and distribution of water	542079	**3**
31	Construction	163137	5
32	Service	994202	**2**

Source: Research results

5-Conclusion

In this paper through input output technique we tried to estimate water consumption pattern of Iran's manufacturing industries. To do this we have aggregated 99 sector input output of Iran in to 32 sectors emphasizing more on manufacturing for which we have taken into account 26 branches based on ISIC, in addition to sectors such as Agriculture, Construction, Services, Electricity, Gas and water, into account. Estimating direct and indirect multiplier impact of water consumption , using usual Leontief Inverse formula, the result shows that both direct and indirect coefficients were relatively high for sectors such as agriculture, and industries like paper and paper products, food industries, basic metals, refined petroleum and coal, non metallic minerals, glasses, textiles and other transport equipments, construction and chemical materials. This result remain more or less the same when using extraction method except that in the later case service sector replaces textile industries and appearing to be a leading water consuming sector. This result indicate that water content of transaction in Iran is high and remain the same for the sectors mentioned. The fact that service sector appear to be a leading water consuming sector, however, is a sign of precaution that must be taken seriously specially when service sector is a large and growing sector of Iranian economy.

Taking into account the facts that these are the main economic activities of the country, adequate supply of water and efficient use of it is imperative and policy makers must coordinate their activities in such a way to response quickly and timely to the structural changes of industrial sectors to prevent water crisis for economy of Iran.

References

Ardakanian , R (2004) Long –Term Development Strategies for Irans Water Resources", Public Relations and International Affairs Bureau of Iran Water Resources Management Company.

Ardakanian , R (2003) "An Overview odf Water Management in Iran", Dushanbe International Fresh Water Forum, Tajikistan.

Babakani F (2000) "Country Presentation: Iran" University of Gent-Belgium, Faculty of Agriculture and Applied biological Sciences, International Course in Food Science and Nutrition, Academic Year 1999-2000,available at http://allserv.rug.ac.be.-aremautd/iran.htm.

Bouhia, H (1998)" Incorporating Water into the I-O table" ,Harvard University, Presented in the World Congress of I-O Techniques, New York.

Cella, G. (1984) "The Input-output measurement of Interindustry Linkages", Oxford Bulletin of Economics and Statistics, 46, 1, pp.73-84.

Dietzenbacher , E. (2005) . More on Multipliers . Journal of regional Science , Vol 45, No. 2 ,2005 , pp : 421-426.

Dietzenbacher , E & Streenge , A. (1993) . The Regional Extraction Method : EC Input-Output Comparisons , "Economic Systems Research , 5, 1993 . 185-206

Dietzenbacher, E., and van der Linden, J. (1997) “Sect oral and Spatial Linkages in the EC Production Structure”, Journal of Regional Science, 37 (2), pp.235-57.

Duarte,R,Sanchez-choliz,J. Bielsa,J(2002) “Water Use un the Spanish economy: an Input-output Approach” ,Ecological Economics,43,71-85.

Fotlz R.C(2002) “Iran’s Water Crisis; Cultural and Ethical Dimensions” ; Journal of Agricultural and Environmental Ethics;2002, Kluwer Academic Publishers, 15: PP.357-380.

IMOO, Water Affairs Bureau(Management and Planning Organization Of I.R.Iran)(2003)Report of Water Sectors Operation and Problems” Analysis (in Persian).

IMOO, Water Affairs Bureau(Management and Planning Organization Of I.R.Iran) (2002)” The Integrated Climate Compatibility program(establishment of Bureau between Water Supply and Water Demand in Each Basin)” (in Persian).

Lofting,E.M, Megauhey,P.H(1968), Economic Valuation of Water, An Input-Output Analysis of California Water Requirements, Contribution,Vol.116,Water Resources Center.

Miller,R., and Blair ,P.,(1985) Input-Output Analysis: Foundations and Extensions, Englewood Cliffs, New Jersey, Prentice Hall.

Sanches-Choliz,J.,Arrojo,P(1992), Water Values for Aragon, Environmental and Land Issues.In : Wissenschaftsverlag .G, Albisu,L.M, Romero,C(eds), EAAE, CIHEAM

Stone, Richard(1961) Input –Output and National Accounts, OECD.