The Role of Water in Iranian Economy: A CGE Modeling Approach

ALI YOUSEFI

Department of Rural Development, Isfahan University of Technology, Isfahan, I.R. IRAN

yousefia601@yahoo.com

SADEGH KHALILIAN

Department of Agricultural Economics, Tarbiat Modares University, Tehran, I.R. IRAN

s_khalilian@modares.ac.ir

MAHMOOD HAJIYAN

Ghods-niroo Engineering Company, Tehran, I.R. IRAN

The Role of Water in Iranian Economy: A CGE Modeling Approach

Abstract

Water is one of the most important factors in the Iranian agricultural production. In most districts, farming is not possible without irrigation. However, with increasing industrial and domestic water demand and other new demands like aquatic production and ecosystem preservation, the inter-sectoral competition for water is likely to intensify sharply; moreover the possibility for increased water supply appears more limited. Therefore, it is necessary to assess the important aspect and prerequisite of water sector in the future. The aim of this study is to analyze the role of water as a factor of production and intermediate consumption in Iranian economy by using computable general equilibrium (CGE) approach. The new agriculture and water-focused Iranian social accounting matrix and CGE model were constructed. The data framework is the Iranian input-output table 2001, national accounts and the database of ministries of agriculture and energy. The model identifies five factors of production: labor, capital, raw water, irrigated land and rainfed land. To incorporate irrigation water into the model, the shadow rent of irrigation water was considered as a value added in SAM. Results show that the share of water sector in GDP has been undervalued and there are some problems in water national accounting. Also under the water scarcity shock, macroeconomic indicators change significantly and the balance of trade in agricultural products becomes negative.

JEL: C68, Q25, N55.

Key words: water, general equilibrium model, shadow rent, social accounting matrix.

1. Introduction

Water is a vital resource for every biological and human phenomena. Nowadays, the management and maintenance of water is very important not only in developing countries but also in developed ones (Fiorilloa *et al.,* 2007). During 20th century, the world population got three times; while, water usage exceeded sixfold. World available water suffices just for current population with minimum access to appropriate water. The heterogeneous water distribution, population growth and increasing per capita water usage; intensifies this situation (Cosgrove and Rijsberman, 2000). Despite decrease of available water, the demand for water resources grow up and would become twice as now on 2025.

Moreover, the crisis of water scarcity (WS) in the world led to create new political and economic relations among countries and will cause emerging crisis in the future; so, the management of water resources would be more important, regarding common resources and trade-off among countries (Yang and Zehnder, 2007).

Iran is located in an arid and semiarid climate region; 13% of the area in alpine climate, 14% in temperate climate and 73% in dry and semidry climate. The average of annual precipitation is 250 mm that is much less than of Asia and world (respectively 732 and 831 mm). One of the major Iranian climate characteristics is WS that has caused many difficulties throughout the history.

Water consumption in Iran was 86.8 billion cubic meters (BCM) in 1996; agriculture sector consumed more than 90 percent of it and about 7 percent belonged to domestic and industry consumption. In 2001, water consumption was 93.1 BCM with the same ratio as 1996. As population is predicted to exceed 90.4 million people in 2021, required water will be 130 BCM if consumption per capita is constant till 2021. Providing this volume of water from Iranian renewable water resources will obviously be impossible. One of the most important challenges against Iranian development would be WS in next decades (Mohammad V. Samani, 2005).

Regarding complexity and instability of water sector, policy makers are not able to manage this sector properly without planning its future perspective; so, it is necessary to scheme future views, conditions and prerequisites of water sector. Refining water consumption structure is a major subject in long-term development strategy for Iran water resources so that the share of agriculture water consumption will decrease from 92 percent to 87 percent by the next 20 years (IWRM, 2003).

Because of increasing water demand in agriculture, domestic and industry sectors and emerging new demands like as fishery and ecosystem preservation, the inter-sectoral competition for water is likely to intensify sharply; moreover the possibility for increased water supply appears more limited. As water usage in a sector affect of other sectors, water resources management must consider the whole water sector as an integrated set and investigate environmental and economic effects of policies. Regarding the importance of agriculture sector in Iranian economy and rural societies, WS and transfer lead to social and political disputation.

Water issue studies in Iran have done just based on partial equilibrium analysis. The objective of this research is to investigate the role of water in the Iranian agricultural sector and macroeconomy indicators. In this study, the role of water in Iranian economy is analyzed under different scenarios by using computable general equilibrium (CGE) model and is compared with the current situation of water sector in Iranian national accounts.

2- Literature Review

There are two main approaches in water economics: partial equilibrium model and general equilibrium model. Each approach is applying based on the assumptions and conditions affecting the problem. Partial equilibrium models investigate the effects of policies in a specific market or sector, supposing no relation between it and the whole economy. In other words, changes in the other sectors do not reflect in the considered sector or market; for example, water market in a river basin. General equilibrium models inspect the effects of different policies on income distribution among different social groups in the whole economy. However, partial equilibrium models are not used for analyzing the whole economy. Regarding the share of agriculture sector in water consumption, each kind of shock in water supply will influence macroeconomic variables.

As water supply is insufficient while it is used vastly in different sectors, each kind of change in water supply or allocation affects other sectors as well as institutions in the economy. In order to investigate water resource management policies in a macro analysis, general equilibrium model should be used as a comprehensive framework.

CGE models, regarding to water issue, can be categorized in 3 groups: in river basin level (Berck et al., 1991; Seung et al., 1999, Goodman et al., 2000; Seung et al., 2000), in national level (Decaluwe et al. 1998; Horridge et al. 2003 Van Heerden et al., 2008; Brouwer et al., 2008; Diao et al, 2008) and in global level (Calzadilla et al., 2008; Berrittella et al., 2007).

The first model was applied by Berck et al (1991) to investigate the effects of investment direction policy on water distribution projects in a valley in California. The model has 14 production sectors from which 6 sectors belong to agriculture sector. In this model, water sector is exogenous and agriculture sector is the only water consumer.

Using regional general equilibrium model, Seung et al (1998) investigate the effects of water transfer from agriculture sector for recreational activities in Walker river basin of Nevada. The model has 8 sectors and production inputs are labor, capital, water and intermediate inputs.

Decaluwe et al. (1999) analyze the effect of water pricing policies on demand and supply of water in Morocco. They distinguish two types of production in water technology; the water produced by dams and the combination of retrieving surface water and ground water from pumping stations.

In order to compare two alternatives for purchasing farmers' water right (water transfer) or constructing new dams for providing urban water in Arkansas river basin in Colorado, Goodman (2000) used dynamic CGE model. The model has 4 production inputs including land, capital, labor and water as well as 4 production sectors involving rainfed agriculture, irrigated agriculture, industry and services. The utility function is a CES one. He shows that temporary water transfers are less costly than building new dams.

Seung et al (2000) investigated the effects of water transfer from agriculture sector by combined dynamic CGE model with recreation demand model in rural areas of Nevada. The model has 8 production sectors and 3 inputs of capital, labor and land. They apply land use as a proxy of water and suppose transferring water right from agriculture causes a proportional reduction in land use in agriculture. Model results show that the increase in non agricultural production does not offset the reduction in agricultural production due to water transfer.

Diao and Roe (2003) and Diao et. al. (2005) uses an intertemporal CGE model for Morocco, analyzing water and trade policies. The model is a combined model that takes both micro and macro aspects of policy interventions for improving irrigation water allocation. The model allows for analysis of both top-down (trade reform) and bottom-up (farm water assignments and the possibility of water trading) linkages. The model consists of two modules, a farm level model and a macro level model. The farm level model solves the monthly irrigation water allocation for crops. Prices are exogenous for the farm model. On the other hand The CGE model accounts for the whole economy and prices are determined endogenously. They conclude that trade reform (top-bottom or macro to micro linkage) has a higher effect compared to water reform (bottom-up or micro to macro linkage) and sequencing of reforms is also important in determining the final effect. Diao et. al (2008) in extension of their previous works, consider ground water as an input for the agricultural production and urban water demand in Morocco model.

Horridge et al. (2005) developed a bottom-up CGE model of Australia (TERM) which treats each region as a separate economy, based on the ORANI model. To properly model the drought at the regional level, they estimate productivity losses due to the drought for each agricultural industry in each region. Application of the model in this paper is not to a policy scenario, but rather to a depiction of the Australian drought of 2002.

Gomez et al (2004) used CGE model to analyze the welfare effects of water transfer from agriculture sector to urban sector through creating water market in Spain Balearic Island. In this model, inputs are capital, labor, land, water and sea water. Land is used just in agriculture sector so that rainfed and irrigated area can be varied. Labor can be mobile among sectors. They show that increased efficiency provided by water markets makes this option more advantageous than building new desalinization plants.

Beritella et. al. (2007) use a multi-region world CGE model, a refinement of the GTAP model, to analyze the possible effects of reductions in water availability on global trade. Water supply is supposed to be unconstrained, so that water demand is lower than water supply, and the price for water is zero. Water is supplied to the agricultural industry, which includes primary crop production and livestock, and to the water distribution services sector, which delivers water to the rest of the economic sectors. The distributed water can have a price, even if primary water resources are in excess supply. The mechanism through which water scarcity is introduced into the model is the potential emergence of economic rents associated with water resources. In other word, water scarcity shock implies that the relative price of water-intensive products increase and the relative competitiveness of all industries would change.

3- Methodology

Partial equilibrium approach has limited scope to handle issues arising from general shocks which affect the outputs and prices of other industries as well. The partial equilibrium analysis is clearly unsuitable when the feedback effects of a particular policy change or a shock are considered to be significant (Bandara, 1991). For example, drought causes most likely reduction in the agricultural and livestock production, decreasing the farm income, disruption to drinking water supply systems, high risks of epidemic diseases, migration of population, increasing unemployment and other serious social and political instability. In order to analyze the macroeconomic effects of WS a broader framework should be used. To overcome the limitations of partial equilibrium approaches, efforts attempted to develop computable general equilibrium (CGE) models for analyzing economic and policy aspects of water management. In other words CGE models start the integration procedure from the economic system and attempt to link economic relationships to the hydrological system (Brouwer and Hofkes, 2008). The main purpose of a general equilibrium methodology is to determine how the entire economy adapts after a shock and in this framework the interactions between the different economic activities are of paramount importance. CGE models are applicable tools for analyzing policy variables in several markets. The advantage of this method is measuring policy effects on society welfare with considering interaction and reflections among markets. Researchers use CGE model as an instrument for future prediction in strategic planning.

CGE are solvable numerically and provide a full accounting of production, consumption and trade in a particular economy. The equations define the behavior of the different actors. The standard CGE model explains all of the payments recorded in the social accounting matrix (SAM).

A SAM is a comprehensive, economy wide data framework, typically representing the economy of a nation. It is a square matrix of monetary accounts which each account represents a specific economic process. Sequence of accounts is basically created by linkage between economy structure and income distribution among different economic sectors and institutions. In other words, SAM is a statistical representation of the circular flow of a market economy, in which every transaction between the actors distinguished in the system is accounted for. More technically, a SAM is a square matrix in which each account is represented by a row and a column. Each cell shows the payment from the account of its column to the account of its row. Thus, the incomes of an account appear along its row and its expenditures along its column. The underlying principle of double-entry accounting requires that, for each account in the SAM, total revenue (row total) equals total expenditure (column total) (Lofgren et al, 2002).

4- Practical Application

Social accounting matrix, which is developed in table (1), is used to investigate the role of water in Iranian economy. This matrix involves commodities, activities, factors, transaction cost, institutions, tax and capital accounts. Separating commodity and activity accounts is for a commodity may be produced by more than one activity and an activity can produce several commodities.

Insert Table (1)

To construct social accounting matrix, a set of statistical data from different sectors is required. Statistical data, used in Iranian social accounting matrix 2001, consist of: Input-output table (supply and use table), national accounts sequence of accounts in sectors of household, financial and non-financial firms, government and rest of world), cost and production statistics of agricultural ministry, urban and rural household budget, Financial accounts of water resources management company and water and wastewater company and metrological data.

Taking natural resources into account is very important in developing SAM. As non-monetary flows are not taken into accounts of this matrix, in order to consider inputs like irrigation water, which are none-tradable or traded in none-economic value, a statistical framework and extended calculations is required for estimating the value of water. In this study, Natural resources like water and land are taking into account as factor of production in SAM.

In order to consider irrigation water as a primary factor in SAM, water rent is taken into account. As mentioned before, irrigation water is not traded in market price; so, it is necessary to calculate water shadow rent as a value-added. For this purpose, irrigation water derived demand function was estimated as well as water shadow rent by positive mathematical programming approach and the results were used in developing social accounting matrix.

In the figure (1), at the water-charge *w*, farmers' demand is *a*. In shadow price λ, the demand decreases to *b*. Implicit or shadow rent is the difference between farmers' willingness to pay and real payment for water. In the other words, hachured region in the curve is water shadow rent, so, real cost paid for water purchase is subtracted from shadow price and the residual is taking into account in social accounting matrix (Yousefi, 2010).

Insert Figure 1

In addition, interaction among water-related sectors like water authority companies (WAC) and urban and rural water and wastewater companies (WWC) are developed in SAM. For this purpose, water activity is divided into water resources management activity (WRMA) and purification and distribution of water activity (PDWA). Moreover, water commodity is separated to unpurified water commodity (UWC) and purified water commodity (PWC).

WRMA produces UWC which is sold to agricultural and industrial activities and PDWMA. After purification and distribution, PWC is sold to services activities and domestic consumption by PDWA. It is worthy to mention that only WRMA and agricultural activities use water as a primary factor.

Furthermore, in SAM, agricultural activities is divided into rainfed and irrigated. In addition, input account is separated into capital, labor, irrigated land, dry land and water. Land is used only by agricultural activities.

Analysis presented here is based on an extended version of IFPRI's Standard CGE model, written in the GAMS (General Algebraic Modeling System) software. The computer code separates the model from the database – with a social accounting matrix (SAM) as its main component – making it easy to apply the model in new settings. For a more detailed discussion of the model and application see Lofgren et al. (2002).

As shown in figure (2), production technology in irrigated agricultural activities is such that irrigated land, water, capital and labor are combined and produce added value through constant elasticity of substitution function (CES), firstly. In the second level, outputs are produced by added value and intermediate inputs with a constant ratio. Rainfed land, capital and labor are production factors in rainfed production technology. In non-agricultural technology structure, land and water are not in the model; but, capital and labor are combined into CES function and produce the added value.

Insert Figure 2

According to high unemployment rate in Iran, it is supposed that there is considerable unemployment for labor and the real wage is fixed and each activity is free to hire any desired labor at its fixed, activity-specific wage. On the other side, as capital transfer is time consuming process, activity-specific factor closuer is chosen for capital; the factor market is segmented and each activity is forced to hire the observed, base-year quantity. In addition, irrigated and rainfed lands are used only by agricultural activities; the land can be transferred among agricultural sectors. On the other words, farmer can decide to change the cropping pattern and the land allocated to each crop. The model has this ability to change irrigated production technology into rainfed one. Yet, this assumption has little effect on rainfed production because decreasing raifed production is more than of irrigated one in WS situation. Furthermore, water is assumed not to transfer from agricultural sector to the others (WRMA). However, water can be transferred among agricultural activities because water right and land ownership are linked in Iran; water right is transferred when the land is sold.

4- Results

4-1 Water scarcity scenarios

Water supply and demand management is one of the most important problems to which policy-makers encounter. Proper management is impossible without designing water sector future perspective by policy makers; so, it is necessary to design future views, conditions and prerequisites of water sector.

The CGE model described above used to examine the economy-wide effects of a WS in Iran. In order to investigate the impact of WS, three scenarios (optimistic, probable and pessimistic) are investigated. These scenarios are based on the results of climate change office of environment protection organization that is shown in table (2).

Insert Table 2

The model is first run in what is termed a Benchmark using a 2001 Iranian SAM, then to see the effects of a water shortage, is run by changing the raw water (factor supply shock). By decreasing raw water, agricultural production will be reduced in two way, first by reduction in raw water (as a factor) which is the none tradable water and the second by reduction in UWC (as an intermediate consumption) which show the tradable water. Also the other sectors will be affected by direct effect of WS and indirect effect of decreased agricultural production in intermediate consumption procedure. Besides, the domestic consumption will be affected by PWC reduction.

In order to investigate the effects of WS, GE model, mentioned before, is run for the base period by using social accounting matrix, first. Then, endogenous shock of decreasing rare water supply is considered in the model and the results are compared to of base period. Decreasing in rare water supply leads agriculture production to decrease in 2 ways: first, decreasing water supply leads water consumption to decrease in agriculture sectors that caused agriculture production decrease. Second, as WRMA use water as a factor in its technology structure, WS shock leads UWC and PWC to decrease.

Decrease of UWC lead agriculture production to decrease through decreasing intermediate consumption. Decreasing PWC will affect service activities and households through intermediate and final consumptions. Additionally, decreasing agricultural, industrial and service outputs influence indirectly on intermediate consumption of all economic activities and final consumptions of institutions.

Insert Table 3

As the results of CGE model show, optimistic WS scenario will reduce GDP 0.8 percent. Moreover a probable scenario will lead to an 8.4-percent decrease in GDP. Private consumption decreased in optimistic, probable and pessimistic scenarios respectively 1.4, 5.8 and 14.5 percent. Inflation rate (CPI) raises 2 percent in probable scenario. Besides, as water supply decreases, average of water shadow price will increase intensively (from 18% to 212%); that is because of high value of water in dry regions like Iran.

Impact of WS on production is shown in table 4. Results show that agricultural productions are influenced sharply by water shortage shock; for example, the wheat and horticulture production decrease respectively 4 to 34and 8.4 to 39 percent in different scenarios. Moreover, there are descending trends in the outputs of activities related to agriculture sector like food products and textile.

Insert Table 4

In probable scenario, WS decreases WRMA and PDWA respectively 18 and 14 percent. The effects of WS on mineral, industrial and service activities are relatively insignificant so that it has no influence on extraction of crude petroleum and natural gas activities; that is because of weak linkage between water and these sectors (just 1 percent of renewable water resource is consumed in industry and mineral sector). Because of strong linkage between water and electricity sector, WS influences production and distribution of electricity seriously so that electricity production decrease 14-percent in pessimistic scenario.

Furthermore, WS affects strongly agricultural crops export; in optimistic scenario there is a 12-percent decrease in agricultural crops export average. Reductions of horticulture crops in different scenarios are respectively 21, 60 and 87 percent. Moreover, WS influences sharply on agricultural import. The import of strategic crops like wheat and rice has a 55-percent increase in pessimistic scenario.

Insert Table 5

As shown in table (5), increasing WS extends agriculture import intensively; so, it has a high influence on deficit trade balance. For example, in probable scenario, horticulture crops export would decrease 60 percent and import would exceed 13 percent.

4-2 The state of water sector in national accounts

Based on International Standard Industrial Classification of all Activities (ISIC) in SNA 93, water collection, purification and distribution activity involves collecting, purification and distributing water to households, activities. The value of irrigation water whose supply is a duty of government, not receiving any charge instead of water, must not be calculated in this activity; but, as governmental services. In addition, the value of irrigation water networks should be taken into account in the agricultural output.

Sub-sectors of water activity in Iranian national accounts involves: authority water companies (AWC), urban and rural water and wastewater companies (WWC), drainage companies, water wells, Kish water and electricity company.

Insert Table 6

Water sector output in Iran includes receipts earned from selling water to subscribers and supervision cost for sustainable water usage. Besides their major activity, water purification and distribution companies usually perform some other activities like as producing electricity which are calculated as their output. The value of water sector is unclear in Iranian national account. Based on national account system prescription, the value of sold irrigation water is not considered in this sector; in contrary, the value of agriculture water, sold by AWC is calculated in this sector.

The water sector value added was 1149 billion Rials (each USD is 10000 Rials) in 2003. The share of water sector added value in Iranian GDP is 0.3 percent. The reasons why this share is insignificant as below:

1- The value of exchanged water is considered in national accounts; in contrast, the value of irrigation water, which is not paid by farmers, is not calculated. Furthermore, the value of informal water exchange is not taken into account.

2- Water exchange in agriculture sector is not based on volumetric pricing and economic value of water. The water charge, paid by farmers, is not noticeable (about 2 percent of production value in hectare for surface water and about 0.5 percent for underground water). As the difference between water shadow price and water charge is considerable, farmers are not motivated to economize water and increase the water efficiency; furthermore, private sector is not interested in investment on water-saving technologies.

3- Although pricing of domestic water is based on volumetric method, raw water price covers only 8 percent of water cost price (cost price of water per cubic meter was 1593 Rials in average on 2007).

Insert Table 7

The cost paid by WWC for purchasing raw water per cubic meter water is 130 Rials. In addition, because of government energy subsidy, electricity charge covers only 4 percent of cost price.

5- Conclusion

The share of water sector is underestimated in national accounts (0.3 percent of GDP), but the results of CGE model show that 10-percent decrease in water supply will cause 0.8-percent decrease in GDP. Population growth, increasing water demand in agricultural, domestic and industrial sectors as well as emerging new demands and no possibility for increasing water supply will intensify competition among consumers.

Improving water resources management requires extended comprehensive information of water resources quantity and quality. The most important problem in Iranian water sector national account is lack of information; so, it is supposed that

Physical and monetary water input-output tables can be provided by using such information system that will be helpful for evaluation and analysis of problems to which economy is encountered like as environmental pollution.

CGE models can be used for water valuation in different region, comparing water projects like as water transfer, building dams, creating water bank and investigating economic, social and environmental influences of water projects. In this study, by using GE models, impacts of WS are investigated just in macro level.

In order to obtain the operational results at the basin level, the multi-sector CGE model is needed. On the other words, economic accounts and water physical circle are linked by CGE and hydraulic models. As a result, it is suggested that first, CGE model is run at the basin level; then, the method of organizing basin information and economic accounts are surveyed to create an integrated information system for Iranian water resource management.

6- References

Bandara, J. S. (1991). Computable general equilibrium models for development policy analysis in LCDs. *Journal of Economic Surveys, 5*(1), --69.

Berck, P., **Robinson, S.**, & **Goldman, G.** (1991). The use of computable general equilibrium models to assess water policies. In A. Dinar & D. Zilberman (Eds.), *The economics and management of water and drainage in agriculture* (pp. 489-509). Boston: Kluwer Academic Publisher.

Berrittella, M., Hoekstra, A. Y., Rehdanz, K., Roson, R., & Tol, R. S. J. (2007). The economic impact of restricted water supply: A computable general equilibrium analysis. *Water Research, 41*(8), 1799-1813.

Brouwer, R., & Hofkes, M. (2008). Integrated hydro-economic modelling: Approaches, key issues and future research directions *Ecological Economics, 66*(1), 16-22.

Calzadilla, A., Rehdanz, K., & Tol, R. (2008). *Water scarcity and the impact of improved irrigation management: A CGE analysis*.

Cosgrove, W., & Rijsberman, F. (2000). *World water vision: making water everybody's business*. London: Earthscan Publications.

Decaluwe, B., Patry, A., & Savard, L. (1999). *When Water Is No Longer Heaven Sent: Comparative Pricing Analysis in an AGE Model*: Laval - Recherche en Politique Economique.

Diao, X., Dinar, A., Roe, T., & Tsur, Y. (2008). A general equilibrium analysis of conjunctive ground and surface water use with an application to Morocco. *Agricultural Economics, 38*(2), 117-135.

Diao, X., & Roe, T. (2003). Can a water market avert the "double-whammy" of trade reform and lead to a "win-win" outcome? *Journal of Environmental Economics and Management, 45*(3), 708-723.

Fiorillo, F., Palestrini, A., Polidori, P., & Socci, C. (2007). Modelling water policies with sustainability constraints: A dynamic accounting analysis. *Ecological Economics, 63*(2-3), 392-402.

Gomez, C. M., Tirado, D., & Rey-Maquieira, J. (2004). Water exchanges versus water works: Insights from a computable general equilibrium model for the Balearic Islands. *Water Resour. Res., 40*.

Goodman, D. J. (2000). More reservoirs or transfers? A Computable General Equilibrium Analysis of Projected Water Shortages in the Arkansas River Basin. *Journal of Agricultural and Resource Economics, 25*(2), 698-713.

Heerden, J. H. V., Blignaut, J., & Horridg, M. (2008). Integrated water and economic modelling of the impacts of water market instruments on the South African economy. *Ecological Economics, 66*(1), 105-116.

Horridge, M., Madden, J., & Wittwer, G. (2005). The impact of the 2002-2003 drought on Australia. *Journal of Policy Modeling, 27*(3), 285-308.

ICCO (2003). *Initial national communication to united nations framework convention on climate change*. Tehran: Iran's Climate Change Office, Departmnet of Enviroment.

IWRM (2003). *Long-term development strategy for Iran water resources*. Tehran: Iranian water resources management company.

Löfgren, H., Lee Harris, R., & Robinson, S. (2002). *A standard computable general equilibrium (CGE) model in GAMS*: International Food Policy Research Institute.

Mohammad V. Samani, J. (2005). *Water resource management and sustainable development*. Tehran: research assistance of Iranian Islamic Council Parliament, infrastructure study office.

Seung, C. K., Harris, T. R., Englin, J. E., & Netusil, N. R. (2000). Impacts of water reallocation: A combined computable general equilibrium and recreation demand model approach. *The Annals of Regional Science, 34*(4), 473-487.

Seung, C. K., Harris, T. R., MacDiarmid, T. R., & Shaw, W. D. (1998). Economic impacts of water reallocation: A CGE analysis for the Walker river basin of Nevada and California. *Journal of Regional Analysis and Policy, 28*(2), 13-34.

Yang, H., Reichert, P., Abbaspour, K. C., & Zehnder, A. J. B. (2003). A Water Resources Threshold and Its Implications for Food Security. *Environmental Science & Technology, 37*(14), 3048-3054.

Yousefi, A., Khalilian, S., & Keramat-zadeh, A. (2010). *The role of water in Iranian macroeconomy*. Paper presented at the 7th conference of Iranian agricultural economics, Tehran University, Karaj, Iran

Appendix A: Tables and Figures

Table 1. Iranian social accounting matrix

Receipts \ Payments	Composition		Activities	Commodities	Factors	Transaction cost	Tax	Institutions: Internal: Household	Institutions: Internal: Enterprise	Institutions: Internal: Government	Institutions: Rest of World	Saving/Investment
												-
Activities	*Framing of Irrigated Crops*		-	*Marketed Output*	-	-	-	*Home-Consumed Output*	-	-	-	-
	Framing of Rainfed Crops											
	Production of None-agricultural											
Commodities	*Agricultural*		*Intermediate Inputs*	-		*Trade and Transport Margin*	-	*Final Consumption*			*Export*	*Investment*
	None-agricultural											
Factors	*Capital*		*Value-added*	-	-	-	-	-			*Factor Income from ROW*	-
	Labor											
	Land	*Irrigated*										
		Rainfed										
	Water											
Transaction Cost	*Domestic Sales*			*Trade and Transport Margin*	-	-	-	-				-
	Exports											
	Imports											
Tax/Subsidy	*Direct*		-	-	-	-	-	*Income and Wealth Tax*		-		-
	Indirect		*Producer Tax*	*Sale Tax, Tariffs, Export Tax*				-				
Institutions	*HH*	*Urban (10 Deciles)*	-	-	*Factor Income*	-	-	*Current Transfer*				-
		Rural (10 Deciles)										
	Enterprise											
	Government						*Tax Income*					
	ROW			*Import*			-					
S/I	-		-	-	-	-	-	*Saving*				-

Table 2. Water scarcity scenarios used in the CGE model

Scenario	Temperature Increase (° C)	Precipitation Reduction (%)
Optimistic	1 to 1.5	11 to 19.1
Probable	2.5 to 4.1	30.9 to 50
Pessimistic	5.9 to 7.7	58 to 80

Table 3. Impact of water scarcity on macroeconomy indicators (% Change)

Indicator	Optimistic	Probable	Pessimistic
Gross Domestic Product (GDP)	-0.8	-3.3	-8.4
Private Consumption	-1.4	-5.8	-14.5
Shadow Price of Water	18	43	212
CPI	-0.6	-2	-7

Table 4. Impact of water scarcity on activities output (% Change)

Activity	**Optimistic**	**Probable**	**Pessimistic**
Farming of Wheat	-3.9	-14.9	-33.7
Farming of Rice	-4	-15.6	-34
Farming of Sugar beet	-0.8	-3.6	-11.6
Farming of Oilseeds	-4.7	-17.6	-37.6
Farming of Barley and Corn	-5.2	-19.3	-40.6
Farming of Beans	-8.4	-28.7	-52.6
Farming of Vegetables	-5.1	-17/8	-32/9
Farming of Melons	-5.3	-18.3	-33.6
Farming of Forage	-2.5	-13	-30.2
Gardening	-8.4	-24.6	-39.0
Agricultural & animal husbandry service	-0.5	-1.9	-5.4
Farming of Animal and Poultry	-0.4	-1.9	-7.7
Forestry	-0.1	-0.8	-3.4
Fishing	-0.4	-1.9	-6.1
Extraction of crude Petroleum & Natural Gas	0	0	-0.2
Mining	0	-0.4	-2.4
Manufacture of Food Products	-0.8	-3.7	-11.7
Manufacture of textiles and dressing	-0.1	-1.6	-8.0
Industry	-0.2	-1.2	-4.2
Production a& Distribution of Electricity and Gas	-1.5	-5.2	-14
Water Resources Management (WRMA)	-3.1	-18.5	-35
Purification & Distribution of water	-2	-14.6	-24.3
Construction	-0.1	-0.2	-0.7
Services	-0.7	-2.7	-7.5

Table 5. Impact of water scarcity on agricultural trade (% Change)

Water Scarcity Scenarios	Import			Export		
	Pessimistic	Probable	Optimistic	Pessimistic	Probable	Optimistic
wheat	57	24	6	-	-	-
Rice	53	22	4.5	-	-	-
vegetables	-	-	-	-78	-48	-11
Beans	-	-	-	-48	-24	-6
Barley and Corn	22	10	2	-	-	-
Oilseed	42	21	5	-76	-47	-14
Horticulture	45	13	2	-87	-60	-21

Table 6. Output value of water sector in Iranian national accounts (2006, Billion Rials)

Urban Water and Wastewater Co.	3352
Rural Water and Wastewater Co.	1258
Authority Water Co.	1586
Drainage Co.	506
Well	3226
Total	9925

Table 7. Cost price of domestic water production

Costs	Cubic meter/Rials	Percent
Compensation of Employees	587	37
Depreciation	346	22
Operation and Maintenance	122	8
Purchasing raw water	130	8
Electricity	61	4
Rest	347	21
Total	1593	100

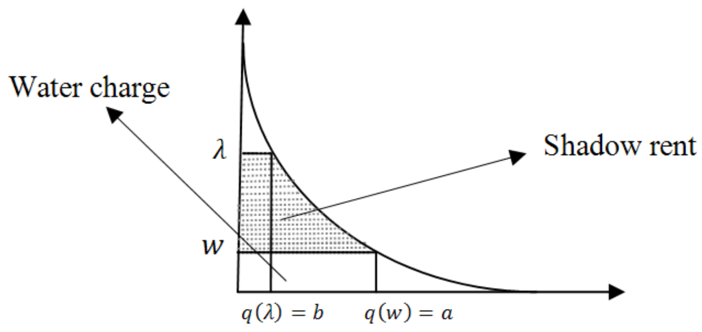

Figure 1. Water shadow rent.

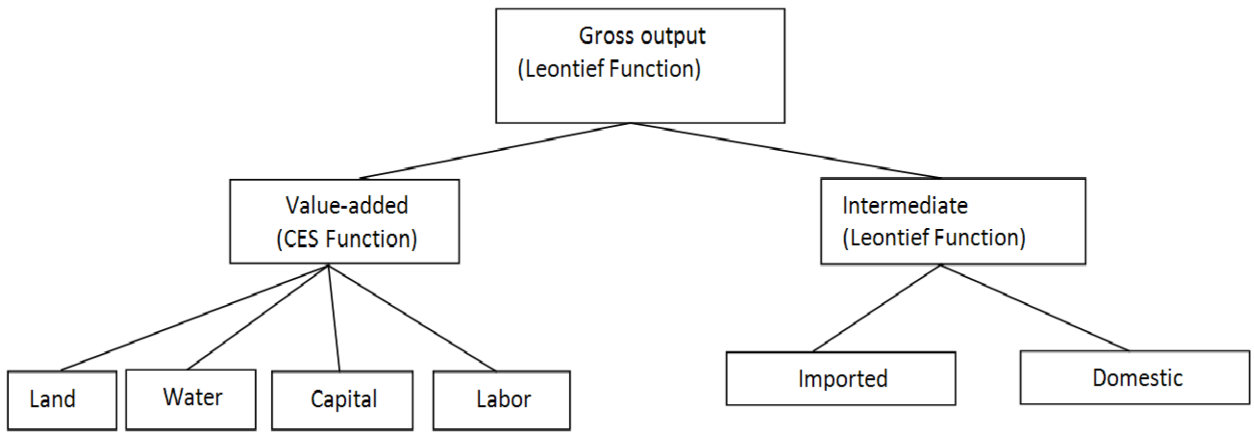

Figure 2. Production technology of the irrigated agricultural sectors.