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اقتصاد و توسعه کشاورزی
(علوم و صنایع کشاورزی)

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Measurement of the Impact of Water Reduction on Economic Sectors Production using Social Accounting Matrix (SAM)

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Abstract

Water is one of the most valuable resources available to mankind. Today, international communities are aware of the importance of water for sustainable economic growth in the present and future. In this study, the effect of reducing water resources on economic sectors and agricultural sub-sectors was investigated through a social accounting matrix model. The results are presented in the form of absolute and relative effects. The direct and indirect impacts of a 10 and 50 percent reduction in water resources have been a decrease in the production of 3.4 and 22 percent from the viewpoint of a demanding, 4.7 and 24 percent from the viewpoint of a supplier, for agricultural products. From the perspective of a demanding, a 10 percent reduction in water resources has led to 10.5 percent production reduction of other economic sectors. The relative effects of 10 percent water reduction from a supplier's point of view indicate that the greatest reduction was in water and other resources sectors. The relative reduction in water resources from the viewpoint of demanding has the greatest impact on water and veterinary sectors. From the perspective of the absolute effects on the demanding and the supplier, the vulnerability of urban households as a result of water resource reduction has been greater than that of rural households. Considering the relative impacts on a supplier, the impact of reduced income is greatr on urban low-income households than low-income rural households. Relative reduction of water resources from the perspective of demanding has a greater impact on capital factor than on labor factor.

Keywords: Social Accounting Matrix, Production, Water Resources
Classification JEL: C67, E23, O13

Introduction

Water is required as one of the important basic resources for country development. Renewable water per capita is one of the global indicators in the determination of the status of countries in terms of water. Inadequate spatial and temporal distribution and increased population and water consumption per capita have exacerbated this issue. The World Bank has predicted that water demand in developing countries would be double by 2025 (Berrittella *et al*., 2007).

Given the scarcity of water resources, the emergence of the water crisis in the future is not

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unexpected and this event can have many economic, social, and political consequences. Considering the recent droughts, the importance of water as a critical input becomes increasingly prominent. If we do not plan on the basis of sustainable development for water resources, the country will face insoluble problems in the future. If the impacts of crisis and water resource scarcity on agricultural sector development are not taken into account, the country's food security will definitely face serious problems (Yang *et al*., 2003). Given the essential role of water resources in economic development and the existence of various constraints, resource consumption should be controlled on the demand side. Water-related policies are one of the important issues in today's societies. For this reason, water scarcity is the agenda of policymakers and researchers in different countries around the world, especially in the Middle East and Africa.

Social Accounting Matrix (SAM) is a database by which the production potential in economic sectors can be measured and socioeconomic issues such as economic growth and interrelationship between different economic variables (production, income, consumption, and capital formation) can be simultaneously examined in the form of a single matrix. In many cases, SAM is used in socio-economic planning and policymaking, as well as to analyze the relationship between structural characteristics of an economy (Central Bank, 2008).

Understanding the importance of the issue, the present study examines the impact of water resource reduction on production of agricultural sub-sectors and other sectors, and by analyzing this issue will emphasize the use of SAM to improve this sector and examine positive strategies and effects. The present study aims to investigate the impact of water scarcity measurement on economic sectors and agricultural sub-sectors through the SAM model.

Review of literature

General equilibrium models in the form of input-output models and SAM can be used in conventional and special conditions. Accordingly, based on the approach, empirical studies can be divided into two groups according to their theoretical foundations.

A: Research literature based on two input-output and SAM approaches under special circumstances. In their study, Chang and Waters (2009), using a modified model of SAM evaluated the economic and social impacts and consequences of a 10% reduction in fishing on the entire economy. In this study, the production of the fishing sector is presented as a restricted sector. Zand *et al*. (2019a) used the social accounting matrix to study the socio-economic effects of investment development policy in the agricultural sector in Iran. The results included three scenarios: 15% increase in investment in agriculture, 10% and 15% in agriculture and horticulture, and 10% in other sub-sectors. They stated that with the implementation of these scenarios, the total income of the economy has increased. However, the first scenario had a greater impact on the total income of the economy (13.12%) than the other scenarios. Sotoodeh Nia *et al*. (2020) have studied the effect of green taxation on fossil energy consumption, greenhouse gas emissions and social welfare in Iran using social accounting matrix. The results showed that along with the increase in the green tax rate, if there is a positive shock to GDP, the trend of increasing consumption of oil, gas, natural gas and gasoline will decrease. Abbaszadeh and Ashrafi (2020) in a study using the social accounting matrix in 2011, evaluated the effect of developing the incoming tourism sector on the income of households and companies and its distribution. The results showed that companies, urban and then rural households experience the highest increase in income from tourism development, respectively, and the most important factor of production in this transfer of income to households and companies is labor and capital, respectively. Zand *et al*. (2019b) analyzed the effects of investment growth policy in agriculture based on the social accounting matrix method. The effects of this policy were analyzed in three scenarios. The results of net effects showed that the income of production activities increases in each of these scenarios. The findings also showed that the closed effects of the above scenarios on industries, services and trade were greater than the agricultural sector and its sub-sectors.

Sahabi *et al*. (2016) examined the measurement of economic and social impacts of drought in the framework of a modified model of supply-oriented SAM. In their study, the effects of a 26.1 percent decrease in agricultural sector production resulted from the 2007 drought on the decrease in other sectors' production, the decrease of income of production agents, and the decrease of income of entities that have been studied. The results showed that the direct and indirect effects of a 26.1%

decrease in agricultural sector production from the viewpoint of demanding lead to 1.8% decrease in value-added of the country, while the corresponding figure from the viewpoint of supplier is 2.9% value-added. Banouei *et al*. (2013), in the form of a research project, measured the social and economic impacts and consequences of drought in the agricultural sector in the framework of the modified supply-driven SAM model. The results of their study showed that a 25% decrease in agricultural production from the viewpoint of demanding leads to a 3.2% reduction in value-added of the country. Faridzad and Mohajeri (2016), using the framework of a modified supply-driven model of SAM with a quantitative (production) approach, have addressed the important question of what economic and social implications will occur if there is a restriction on supply (or import) of any industry sub-sectors. Their results showed that the most restriction in the supply of intermediate imports occurs in coke manufacturing, petroleum products, and chemical sectors. In all industry sub-sectors that were faced with intermediate import restrictions, except for coke manufacturing sector, production of petroleum products, and chemical products, in other cases, urban households have experienced the highest income reductions compared to rural households and corporations, as expected. Other studies have also been done in this field by Hortono and Resosudarmo (2008), Faridzad *et al*. (2012).

B: Research literature based on two input-output and SAM approaches under conventional circumstances

Use of SAM models in conventional conditions in various economic, social, and energy areas has attracted a wide range of scholars among which the studies by Seyyed Mashhadi *et al*. (2011), Permeh *et al*. (2011), Sadeghi *et al*. (2015), Gakuru and Mathenga (2015), Afaqeh *et al*. (2015) can be highlited.

Due to taking into account most of the economic relations, SAM has been accepted as a comprehensive tool in analyzing the economic and social policy makings of countries. For this reason, in the above studies, the analyses have focused on this matrix aiming to examine the potential of production. There have been studies on the impact of water resource reduction on various sectors, including agriculture as well like studies by Nokkala (2000), and Banouei (2005).

SAM model in conventional conditions

The framework of the conventional model of SAM in conventional conditions is obtained by simultaneous relationships between productive balance and income balance of production agents and internal inputs of society which is as follows:

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \end{bmatrix} = \begin{bmatrix} (I - A_{11}) & -A_{12} & -A_{13} & 0 & -A_{15} \\ -A_{21} & (1 - A_{22}) & -A_{23} & 0 & -A_{25} \\ -A_{31} & -A_{32} & (1 - A_{33}) & 0 & -A_{35} \\ -A_{41} & -A_{42} & -A_{43} & 1 & 0 \\ 0 & 0 & 0 & -A_{54} & (1 - A_{55}) \end{bmatrix}^{-1} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \end{bmatrix} \quad (1)$$

Equation (1) is generally used in effective and short-term economic and social analyses and policy makings under conventional conditions.

Modified SAM model in special conditions

Under certain conditions, production of some specific sectors or commodities is affected by factors such as climatic changes such as drought and flood and faces production constraints. In order to present a modified SAM model under special conditions, the process of modification is the following five general stages. Under this situation, it is needed to modify equation (1). In the first stage, the sector(s) and commodity(s) that are under special conditions are determined. In the second stage, based on endogenous and exogenous variables, the main SAM accounts are modified as follows.

$$(1 - A_{11})y_1 - A_{12}y_2 - oy_4 - A_{15}y_5 - oX_3 = X_1 + 0X_2 + 0X_4 + 0X_5 + A_{13}y_3 \quad (2)$$

$$-A_{21}y_1 + (1 - A_{22})y_2 - A_{23}y_3 - oy_4 - A_{25}y_5 = 0X_1 + X_2 + 0X_4 + 0X_5 + A_{23}y_3 \quad (3)$$

$$-A_{31}y_1 - A_{32}y_2 + (1 - A_{33})y_3 - oy_4 - A_{35}y_5 = 0X_1 + 0X_2 + X_4 + 0X_5 + B_{43} \quad (4)$$

$$-oy_1 - oy_2 - oy_3 - A_{54}y_4 + (1 - A_{44})y_5 = +0X_1 + 0X_2 + 0X_4 + X_5 + 0Y_3 \quad (5)$$

$$-A_{41}y_4 - A_{42}y_4 - A_{43}y_3 - y_4 - oy_5 = +0X_1 + 0X_2 + 0X_4 + 0X_5 - (1 - A_{33})y_3 \quad (6)$$

The third stage reveals the partitioned matrix of the above equations which is a combination of conventional and special conditions. In the above equations, production in the third sector, formerly known as the endogenous variable under conventional conditions, is now in special conditions and due to constraints on supply and inflexibility against the changes in final demand in the third sector, is considered as the exogenous variable. Therefore, the equations (2) to (6), given the change in the status of exogenous and endogenous variables of the third sector, can be rewritten as follows:

$$\begin{bmatrix} (1-A_{11}) & -A_{12} & 0 & -A_{15} & 0 \\ -A_{21} & (1-A_{22}) & 0 & -A_{25} & 0 \\ -A_{41} & -A_{42} & 1 & 0 & 0 \\ 0 & 0 & -A_{54} & (1-A_{55}) & 0 \\ -A_{31} & -A_{32} & 0 & -A_{35} & -1 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_4 \\ y_5 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & A_{13} \\ 0 & 1 & 0 & 0 & A_{23} \\ 0 & 0 & 1 & 0 & A_{43} \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & -(1-A_{32}) \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_4 \\ x_5 \\ y_3 \end{bmatrix} \quad (7)$$

In the fourth stage, the equation (7) is stated as follows.

$$\Delta \begin{bmatrix} y_1 \\ y_2 \\ y_4 \\ y_5 \\ x_3 \end{bmatrix} = \begin{bmatrix} (1-A_{11} & -A & 0 & -A_{15} & 0 \\ -A_{21} & (1-A_{22}) & 0 & -A_{25} & 0 \\ -A_{41} & -A_{42} & 1 & 0 & 0 \\ 0 & 0 & -A_{54} & (1-A_{55}) & 0 \\ -A_{31} & -A_{32} & 0 & -A_{35} & -1 \end{bmatrix}^{-1} \times \begin{bmatrix} 1 & 0 & 0 & 0 & A_{13} \\ 0 & 1 & 0 & 0 & A_{23} \\ 0 & 0 & 1 & 0 & A_{43} \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & -(1-A_{32}) \end{bmatrix} \Delta \begin{bmatrix} x_1 \\ x_2 \\ x_4 \\ x_5 \\ y_3 \end{bmatrix} \quad (8)$$

The fifth stage is a comparison of the reduced form of equation (1) and equation (9). Equation (9) as an MN matrix is introduced below.

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \end{bmatrix} = M_a \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} \quad (9)$$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_4 \\ y_5 \\ x_3 \end{bmatrix} = MN \begin{bmatrix} x_1 \\ x_2 \\ x_4 \\ x_5 \\ y_3 \end{bmatrix} \quad (10)$$

Equation (10) is used as the basis for the calculation of the economic and social impacts and consequences of water sector production reduction from the perspective of demanding on production reduction of other economic sectors, production reduction of the whole economy, income reduction of production agents, and production reduction of income of community entities.

$$M = \begin{bmatrix} (1-A_{11} & -A & 0 & -A_{15} & 0 \\ -A_{21} & (1-A_{22}) & 0 & -A_{25} & 0 \\ -A_{41} & -A_{42} & 1 & 0 & 0 \\ 0 & 0 & -A_{54} & (1-A_{55}) & 0 \\ -A_{31} & -A_{32} & 0 & -A_{35} & -1 \end{bmatrix}^{-1}$$

$$N = \begin{bmatrix} 1 & 0 & 0 & 0 & A_{13} \\ 0 & 1 & 0 & 0 & A_{23} \\ 0 & 0 & 1 & 0 & A_{43} \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & -(1-A_{32}) \end{bmatrix}$$

However, equation (10) compared to equation (9) has features that, in addition to being methodologically significant, can be used in the measurement of the effects and consequences of water resource constraints in special conditions:

Ghosh Supply – Driven Forward Multiplier of SAM (GSDSAM) in conventional and special conditions

In the real world, the sector considered as an intermediary supplier also appears in other economic sectors. This means that the effects and consequences of production reduction in this sector will lead to a reduction of intermediate demand of other economic sectors and reduction of income of production agents and a decrease in the income of community entities as well (Banouei, 2012).

Therefore, firstly the product-income relationship of the conventional and standard GSDSAM in conventional conditions is used (Kershner and Hubacek, 2009).

$$\acute{y}_n = \acute{y}_n G_n + W'_n \quad (11)$$

$$y_n - G'_n y_n = W_n \quad (12)$$

$$(I - G'_n) y_n = W_n \quad (13)$$

$$y_n = (I - G'_n)^{-1} W_n \quad (14)$$

$$\overline{M_a} = (I - G'_n)^{-1} \quad (15)$$

$$G'_n = \left[G'_{ij}\right], \quad G'_{ij} = T'_{ij}[\hat{y}_i]^{-1} \quad (16)$$

$$(I - G'_n) = \begin{bmatrix} (1-G_{11}) & -G_{21} & -G_{31} & -G_{41} & 0 \\ -G_{21} & (1-G_{22}) & -G_{32} & -G_{42} & 0 \\ -G_{13} & -G_{23} & (1-G_{33}) & -G_{43} & 0 \\ 0 & 0 & 0 & 1 & -G_{54} \\ -G_{15} & -G_{25} & -G_{35} & 0 & (1-G_{55}) \end{bmatrix} \quad (17)$$

$$y_n = (y_i) = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \end{bmatrix} \qquad W_n = (W_i) = \begin{bmatrix} W_1 \\ W_2 \\ W_3 \\ W_4 \\ W_5 \end{bmatrix} \quad (18)$$

In the above equations, G'_{ij} is the direct coefficients of three endogenous accounts called allocation direct coefficients matrix, distribution direct coefficients matrix, or output direct coefficients matrix, which is obtained by linear division of $G'_{ij} = T'_{ij}[\hat{y}_i]^{-1}$ from the supplier's perspective. This is while A_{ij} is calculated by column division of $A_{ij} = T'_{ij}[\hat{y}_i]^{-1}$ and from the demanding's perspective. Thus, A_{ij} matrix is an input matrix. The production agents (W) and its constituents for all sectors are exogenous and production (y) of all sectors is endogenous. The constituent variables in W_i vector are generally known as leakage items (imports, taxes, payment of production agents to the outside world) (Ghahramani, 2012).

In order to better understand the functions of the above equations under conventional conditions and then to modify them under special conditions, equation (19) must be written as independent equations for the three main SAM accounts.

$$(1-G_{11})y_1 - G_{21}y_2 - G_{31}y_3 - G_{41}y_4 - oy_5 = W_1 \tag{19}$$

$$-G_{12}y_1 + (1-G_{22})y_2 - G_{32}y_3 - G_{42}y_4 - oy_5 = W_2 \tag{20}$$

$$-G_{13}y_1 - G_{23}y_2 + (1-G_{33})y_3 - G_{43}y_4 - oy_5 = W_3 \tag{21}$$

$$-oy_1 - oy_2 - oy_3 + y_4 - G_{54}y_5 = W_4 \tag{22}$$

$$-G_{15}y_1 - G_{25}y_2 - G_{35}y_3 - 0 + (1-G_{55})y_5 = W_5 \tag{23}$$

Based on equations (19) to (23) for the endogenous and exogenous variables of the main SAM account assuming that the third sector is in special conditions, equations (19) to (23) need to be modified. The modification process is as follows.

$$(1-G_{11})y_1 - G_{21}y_2 - G_{41}y_4 - oy_5 - OW_3 = W_1 + OW_2 + OW_4 + OW_5 + G_{31}y_3 \tag{24}$$

$$-G_{12}y_1 + (1-G_{22})y_2 - G_{42}y_4 - oy_5 - ov_3 = OW_1 + W_2 + OW_4 + OW_5 + G_{32}y_3 \tag{25}$$

$$-OW_1 - Oy_2 - y_4 - G_{54}y_5 - OW_3 = OW_1 + OW_2 + W_4 + OW_5 + 0 \tag{26}$$

$$-G_{15}y_1 - G_{25}y_2 - oy_4 + (1-G_{55})y_5 - OW_3 = OW_1 + OW_2 + OW_4 + W_5 + G_{35}y_3 \tag{27}$$

$$-G_{13}y_1 - G_{23}y_2 - G_{43}y_3 - Oy_5 - W_3 = OW_1 + OW_2 + OW_4 + OW_5 - (1-G_{35}) \tag{28}$$

Therefore, the partitioned form of the above matrix, which is, in fact, a combination of conventional and special conditions, is stated below.

$$\begin{bmatrix} (1-G_{11}) & -G_{21} & -G_{41} & 0 & 0 \\ -G_{21} & (1-G_{22}) & -G_{42} & 0 & 0 \\ 0 & 0 & 1 & -G_{54} & 0 \\ -G_{15} & -G_{25} & 0 & (1-G_{55}) & 0 \\ -G_{13} & -G_{23} & -G_{43} & 0 & -1 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_4 \\ y_5 \\ W_3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & G_{13} \\ 0 & 1 & 0 & 0 & G_{32} \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & G_{35} \\ 0 & 0 & 0 & 0 & -(1-G_{33}) \end{bmatrix} \begin{bmatrix} W_1 \\ W_2 \\ W_4 \\ W_5 \\ y_3 \end{bmatrix} \tag{29}$$

Based on the general equation (14), the exogenous and endogenous variables of equation (29) in partial policy-making and planning are stated as below.

$$\begin{bmatrix} y_1 \\ y_2 \\ y_4 \\ y_5 \\ W_3 \end{bmatrix} = \begin{bmatrix} (1-G_{11}) & -G_{21} & -G_{41} & 0 & 0 \\ -G_{21} & (1-G_{22}) & -G_{42} & 0 & 0 \\ 0 & 0 & 1 & -G_{54} & 0 \\ -G_{15} & -G_{25} & 0 & (1-G_{55}) & 0 \\ -G_{13} & -G_{23} & -G_{43} & 0 & -1 \end{bmatrix}^{-1} \times \begin{bmatrix} 1 & 0 & 0 & 0 & G_{13} \\ 0 & 1 & 0 & 0 & G_{32} \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & G_{35} \\ 0 & 0 & 0 & 0 & -(1-G_{33}) \end{bmatrix} \begin{bmatrix} W_1 \\ W_2 \\ W_4 \\ W_5 \\ y_3 \end{bmatrix} \tag{30}$$

The reduced form of equation (30) is written as below:

$$\begin{bmatrix} y_1 \\ y_2 \\ y_4 \\ y_5 \\ W_3 \end{bmatrix} = \bar{M}^{-1}\bar{N} \begin{bmatrix} W_1 \\ W_2 \\ W_4 \\ W_5 \\ y_3 \end{bmatrix} \tag{31}$$

$$\bar{M}^{-1} = \begin{bmatrix} (1-G_{11}) & -G_{21} & -G_{41} & 0 & 0 \\ -G_{21} & (1-G_{22}) & -G_{42} & 0 & 0 \\ 0 & 0 & 1 & -G_{54} & 0 \\ -G_{15} & -G_{25} & 0 & (1-G_{55}) & 0 \\ -G_{13} & -G_{23} & -G_{43} & 0 & -1 \end{bmatrix}^{-1}$$

$$\bar{N} = \begin{bmatrix} 1 & 0 & 0 & 0 & G_{13} \\ 0 & 1 & 0 & 0 & G_{32} \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & G_{35} \\ 0 & 0 & 0 & 0 & -(1-G_{33}) \end{bmatrix}$$

From a policy-making perspective, equation (31), similar to equation (10), is a combinative equation for two reasons. First, it depicts conventional conditions and special conditions, and second, it contains hybrid exogenous and endogenous variables. That is, the exogenous and endogenous variables of sectors 1 and 2 (W_1, W_2, and y_1, y_2, respectively), income of production agents (W_4 and y_4), and income of community entities (W_5 and y_5) are considered as in conventional conditions. For example, sector 3 has a limited supply of production. Thus, the endogenous variable of the sector is considered as an exogenous variable (W_3) and the endogenous variable as an exogenous variable (Ghahramani, 2012).

The matrix $\bar{M}$ in equation (31), similar to the matrix M in equation (25), is a matrix of coefficients, except that $\bar{M}$ is calculated on the basis of the Ghosh supply model and from the viewpoint of a supplier, but M is obtained based on the demand-driven model of Leontief and from the viewpoint of demanding. In addition, both the equation of (10) and (31) are functionally supply-driven in nature. That is, the effects and consequences of production reduction due to different factors on production reduction of other sectors in both models is production-to-production. That is, by a reduction in the production of water sector, production reduction in other sectors is obtained and, unlike conventional conditions, supply constraint is considered (Chang and Waters, 2009).

$$\begin{bmatrix} y_1 \\ y_2 \\ y_4 \\ y_5 \\ W_3 \end{bmatrix} = \begin{bmatrix} \bar{G}_{11} & \bar{G}_{12} & \bar{G}_{13} & \bar{G}_{14} & \bar{G}_{15} \\ \bar{G}_{21} & \bar{G}_{22} & \bar{G}_{23} & \bar{G}_{24} & \bar{G}_{25} \\ \bar{G}_{41} & \bar{G}_{42} & \bar{G}_{43} & \bar{G}_{44} & \bar{G}_{45} \\ \bar{G}_{51} & \bar{G}_{52} & \bar{G}_{53} & \bar{G}_{54} & \bar{G}_{55} \\ -\bar{G}_{31} & -\bar{G}_{32} & -\bar{G}_{33} & -\bar{G}_{34} & -\bar{G}_{35} \end{bmatrix} \begin{bmatrix} W_1 \\ W_2 \\ W_4 \\ W_5 \\ y_3 \end{bmatrix} \quad (32)$$

Calculations and analysis of results

SAM has been used in the present study. The matrix has been developed in accordance with the available statistics and information and given the research goals. After the integration of some sectors, it includes 36 economic sectors in the production account. External world accounts (import and export), and accumulation (savings and investment) also each have their own row and column. Production agents' accounts include labor factor and capital factor, and entities' accounts include low-income, middle-income, and high-income urban and rural families and companies. Exogenous accounts also include other accounts obtained from the integration of three accounts of the government, the outside world, and the accumulation account.

Results and Discussion

It is necessary to mention two key points before the presentation of results and their analysis: In practice, three general criteria are used to measure the economic and social impacts and consequences of production reduction under special circumstances: in this study, production reduction will be as percentage and in different scenarios and the obtained results will be actual figures. The obtained results are organized in terms of absolute effects and relative effects. Figures of absolute effects are more important for overall economic policies and their contribution to GDP and ultimately for economic growth, while relative effects are applied for sectional policies and inter-sector interactions. In light of the above, the effects and consequences of a reduction in the percentage of water resources are calculated as a part of supply constraint on the production of other economic sectors (sectors without supply constraint), and the results are presented in the following tables.

Absolute effects of water resource reduction on production of agricultural sub-sectors

According to the results in Table 1, the reduction of water resources causes the most damage to agriculture and horticulture and the least damage to the forestry sector in terms of demand-driven and supply-oriented patterns. However the impact of water reduction is different in the context of a mixed demand-driven and supply-driven model. The vulnerability of the agriculture and horticulture sector due to the depletion of water resources reflects the fact that the production of this sector is highly dependent on the amount of water.

Relative effects of water resource reduction on agricultural sector productions

The results in Table 2 are related to the relative percentage of production reduction in agricultural sectors that are not subject to special conditions. This ratio has been obtained by dividing agricultural sector production reduction by the actual output value of those sectors multiplied by 100.

Table 1- Effects of 10, 30, and 50% reductions in water resources on production in the agricultural sector in demand-driven and supply-driven models (figures: million Rials)

Economic sectors	Demand-driven			Supply-driven		
	10	30	50	10	30	50
Agriculture and gardening	56501	169503	282506	1108697	3326092	5543486
Livestock, poultry, silkworm and bee breeding, and hunting	33602	100806	168010	421879	1265637	2109395
Fishing	22587	67762	112936	22785	68354	113924
Forestry	20581	61743	102904	6320	18961	31601
Total	133271	399814	666356	1559681	4679044	7798406

Source: research results

The results related to relative effects of production reduction show that: firstly, the highest relative reduction has been in forestry sub-sector as equal to -0.2382 for 10% reduction, -0.7146 for 30% reduction, and -1.1911 for 50% reduction; secondly, the rank and position of agricultural sub-sectors that have been associated with the highest relative production reduction is different from the agricultural sub-sectors that have experienced the highest absolute production reduction. Also, the ratio of production reduction of agricultural sub-sectors in the whole economy resulted in limited supply (reduced water resources) to the total value added of the country has been calculated. The highest relative reduction of production has been related to the sub-sector of agriculture and gardening as equal to -0.2008 for 10% reduction, -0.6025 for 30% reduction, and -1.0042 for 50% reduction. The effects of production reduction in agricultural sectors are not the same in terms of relative impacts. The forestry sector from the perspective of demanding and the agriculture and gardening sector from the perspective of supplier show the most relative decreases. The order of relative reduction in different agriculture sectors is also different from the viewpoint of demanding and supplier. The nature of the four sub-sectors of agriculture in terms of the absolute effects of production reduction is also different from the nature of the four sub-sectors in terms of relative effects of production reduction. Also, based on the results of Banouei (2012), the nature of the five economic sectors in the absolute effects of reduced production is different from its relative effects.

Table 2- Relative effects of reduced production of agricultural sub-sectors on their actual production resulted from reduced water resources on demand-driven and supply-driven model bases (figures are in percentage)

Economic sectors	Demand-driven			Supply-driven		
	10	30	50	10	30	50
Forestry	-0.2382	-0.7146	1.1911	-0.0732	-0.2195	-0.3658
Fishing	-0.0796	-.2388	-0.3979	-0.0803	-02409	-0.4014
Agriculture and gardening	-0.1020	-0.0307	-0.512	-0.2008	-0.6025	-1.0042
Livestock, poultry, silkworm and bee breeding, and hunting	-0.0095	-0.-285	-0.0476	-0.1194	-0.3583	-0.5972

Source: research results

Absolute effects of water resource reduction on production of other economic sectors (demand-driven model)

The effects and consequences of water resource reduction as the sector included in special conditions on production reduction of other economic sectors in the framework of the demand-driven model in terms of absolute effects are presented in Table 3. It shows that the decrease in water resources by 10% has led to 3767033 Rials of production reduction in other economic sectors. The decrease of water resources by 20% to 50%, respectively, has led to 7534067, 11301100, 15068133 and 18835166 Rials of loss in production of different economic sectors. In the first 15 sectors of production that have had the highest production reduction, the largest impact of reduction has been on the water, education, other services, and transportation sectors, with real estate services, public affairs, urban affairs, and business services being the next ones. The reason for water sector loss is completely clear according to the accounting and social matrix table, and it is because of the direct dependence of this sector from the viewpoint of demanding. However, the most important reason for production reduction in education, other services, and transportation sectors due to decrease in water resources is not direct dependence of water upon these sectors because the direct intermediate needs of the water sector (from the viewpoint of demanding) in the above sectors are lower than the direct intermediate needs of water sector (from the viewpoint of supplier). The lowest amount of production reduction with water supply limitation was in hotel and restaurant sectors with 32369 Rials, other mines sector with 33645 Rials and chemical, rubber, and plastic products production with 33873 Rials. Also, the vulnerability of the public affairs sector, urban affairs sector, and business services, banks, insurance, and other financial intermediaries due to a decline in the supply of water resources indicates that the mentioned sector is indirectly dependent so much on the sectors most connected to water supply sector.

Table 3- Absolute effects of 10 to 50 percent reduction in water resources on the production of other economic sectors in the demand-driven model (figures: million Rials)

Economic sectors	10	20	30	40	50
Water	2573732	5147464	7721196	10294927	12868659
Education	196885	393771	590656	787541	984426
Other services	101396	202792	304188	405584	506980
Transportation	82634	165267	247901	330535	413169
Real estate services	80347	160694	241041	321389	401736
Public, urban, and business service affairs	60711	121422	182133	242844	303555
Bank, insurance, and other financial intermediaries	50621	101242	151863	202484	253105
Defense and military affairs	48680	97361	146041	194722	243402
Health and medication	44937	89875	134812	179750	224687
Construction	39917	79834	119750	159667	199584
Manufacturing, processing, and tanning of textiles, clothing, and leather	36737	73474	110211	146947	183684
Post, telecommunications, and warehousing	36293	72585	108878	145170	181463
Manufacturing of food, beverage, and tobacco products	34358	68715	103073	137431	171788
Manufacturing of chemicals, rubber, and plastic products	33873	67746	101619	135492	169365
Other mines	33645	67290	100935	134580	168225
Hotel and restaurant	32369	64738	97107	129476	161845
Sum of all other sectors	3767033	7534067	11301100	15068133	18835166

Source: research results

Absolute effects of water resource reduction on production of other economic sectors (supply-driven model)

The results in Table 4 show the absolute effects of water resource reduction from the perspective of production suppliers on other economic sectors in the framework of the supply-driven model. The results of the absolute effects are presented in this table. In the first 15 production sectors that have been associated with the largest reduction in production, the obtained figures show that the water sector experiences the highest production reduction compared to other economic sectors due to a decline in water resources. The reason for this, as mentioned earlier, is the direct dependence of this sector from the perspective of the supplier. However, wholesale, retail, vehicle and goods repair, construction, food, beverage, and tobacco production, chemicals, rubber, and plastic production, transportation, and real estate services sectors are among the top six sectors that experience loss due to reduction of water resources, indicating the direct and indirect dependence of the aforementioned sectors on water-limited sector. For example, the direct and indirect impacts of a 10% reduction in water resources lead to production reduction equal to 938954 Rials in wholesale, retail and repair of vehicles and goods sector, 573521 Rials in the construction sector, and 573521 Rials in food, beverage, and tobacco products sector. Transportation and real estate services sectors are among the first five sectors experiencing loss due to water resource reduction from the perspective of demanding and supplier. The lowest rate of production reduction with water supply constraints equal to 187522 Rials is related to the health and medication sector, and 188949 Rials in the manufacturing of motor vehicles, trailers, semi-trailers, and other transportation equipment sector.

Relative effects of 10 to 50 percent water resource reduction on production of economic sectors from the perspective of a supplier

The second part of the results, which can be seen in Table 5, is the relative decline in the production of economic sectors due to water supply constraints. Conceptually, relative effects are the quantities that show the decline in production of other economic sectors (after water supply constraint) on their corresponding actual production caused by a decrease in the water supply. The results related to relative effects of 10% decrease in water show that the highest relative production reduction is related to water, other mines, public, urban, and business service affairs, education, and manufacturing of food, beverages, and tobacco sectors with 9.1483, 0.1196, 0.1003, 0.0897, and 0.0890 percent, respectively. The economic sectors that experienced the highest relative production reduction were different from the economic sectors that experienced the highest absolute production reduction. Although they are common in some manufacturing sectors, their position and rank are different. For example, in the wholesale, retail, and repair of vehicles and goods sector, percentage of relative production reduction is much lower than the absolute production reduction such that with a water supply restriction of 10% to 50%, the mentioned sector is in the second place of absolute production reduction while among the 15 production sectors with the highest relative production reduction, is in the seventh position.

Faridzad and Mohajeri (2016), among the industrial sub-sectors, the most limited supply of intermediate imports has been in the field of coke, petroleum products and chemical products, which has caused the greatest decrease in production in the whole economy.

Table 4- Absolute effects of 10 to 50 percent reduction in water resources on the production of other economic sectors in the supply-driven model (figures: million Rials)

Economic sectors	10	20	30	40	50
Water	2573732	5147464	7721196	10294927	12868659
Wholesale, retail, repair of vehicles and goods	938954	1877908	2816861	3755815	4694769
Construction	573521	1147042	1720563	2294084	2867605
Manufacturing of food, beverage, and tobacco products	558710	1117420	1676130	2234840	2793550
Manufacturing of chemicals, rubber, and plastic products	426336	852672	1279008	1705344	2131681
Transportation	353698	707395	1061093	1414790	1768488
Real estate services	302079	604157	906236	1208314	1510393
Manufacturing of basic metals and fabricated metal products	292977	585954	878931	1171909	1464886
Crude oil and natural gas	292062	584124	876187	1168249	1460311
Manufacturing of coke, refined petroleum products, and nuclear fuels	274469	548938	823408	1097877	1372346
Education	240112	480224	720337	960449	1200561
Electricity and gas	224713	449427	674140	898854	1123567
Defense and military affairs	194279	388557	582836	777115	971393
Manufacturing of motor vehicles, trailers, semi-trailers, and other transportation equipment	188949	377897	566846	755794	944743
Health and medication	187522	375044	562566	750088	937610
Sum of all other sectors	8896617	17793234	26689852	35586469	44483086

Source: research results

Table 5- Absolute effects of 10 to 50 percent reduction in water resources on the production of 15 economic sectors with the highest production reduction from the supplier's perspective

Economic sectors	10	20	30	40	50
Water	-9.1483	-18.2966	-27.4449	-36.5931	-45.7414
Other mines	-0.1196	-0.2392	-0.3588	-0.4784	-0.5980
Public, urban, and business service affairs	-0.1003	-0.2006	-0.3009	-0.4011	-0.5014
Education	-0.0897	-0.1794	-0.2691	-0.3588	-0.4485
Manufacturing of food, beverage, and tobacco products	-0.890	-0.1780	-0.2670	-0.3560	-0.4450
Defense and military affairs	-0.868	-0.1737	-0.2605	-0.3473	-0.4342
Wholesale, retail, repair of vehicles and goods	-0.0858	-0.1715	-0.2573	-0.3431	-0.4288
Other services	-0.0808	-0.1617	-0.2425	-0.3234	-0.4042
Veterinary	-0.801	-0.1602	-0.2402	-03203	-0.4004
Health and medication	-0.0798	-0.1596	-0.2394	-0.3192	-0.3990
Compulsory social security	-0.743	-0.1486	-0.2229	-0.2972	-0.3715
Manufacturing of other non-metal mineral products	-0.740	-0.1480	-0.2220	-0.2961	-0.3701
Banks, insurance, and other financial intermediaries	-0.732	-0.1463	-0.2195	-0.2926	-0.3658
Construction	-0.698	-0.1397	-0.2095	-0.2794	-0.3492
Publication, printing, and copying of recorded media	-0.697	-0.1394	-0.2091	-0.2787	-0.3484

Source: research results

Relative effects of 10 to 50 percent water resource reduction on production of economic sectors from the perspective of demanding

The effects and consequences of the relative reduction of water resources as the sector included in special conditions on the reduction of the production of other economic sectors (sections not included in special conditions) in the framework of the demand-driven model are presented in Table 6. According to the figures shown in Table 6, it can be seen that relative decline in water resources from the perspective of demanding has the highest effects on water, veterinary, publication, printing, and copying of recorded media, compulsory social security, and education sectors, with other services, and other mines sectors being the next ones. The economic sectors that were associated with the highest relative production reduction from the perspective of suppliers were different from the economic sectors that experienced the highest relative production reduction from the perspective of demanding. For example, the veterinary sector experiences the highest loss after the water sector in terms of relative effects from the perspective of demanding, but in terms of absolute effects is not even among the first 15 affected sectors. The reason for this is that among the 71 economic sectors of SAM table, the veterinary sector has the smallest share of value-added in the country. So, the veterinary sector experiences a significant decline in proportion to its production, but this decline is not significant in terms of absolute effects. The water sector is the first sector to be affected both in terms of absolute and relative effects and this shows that this sector has a huge impact on the economic growth of the country. In this regard, Salami and Permeh (2001) concluded that the agricultural sector can play a very effective role in the economic growth of the country due to its close relationship with other economic sectors and due to the significant use of other economic sectors.

Table 6- Relative effects of water resource reduction on production of economic sectors from the perspective of demanding

Economic sectors	10	20	30	40	50
Water	-9.148	-18.297	-27.445	-36.593	-54.741
Veterinary	-0.744	-1.487	-2.231	-2.974	-3.718
Publication, printing, and copying of recorded media	-0.203	-0.406	-0.608	-0.811	-1.014
Compulsory social security	-0.163	-0.325	-0.488	-0.651	-0.813
Education	-0.074	-0.147	-0.221	-0.294	-0.368
Other services	0.060	-0.121	-0.181	-0.192	-0.302
Other mines	-0.048	-0.096	-0.144	-0.139	-0.240
Public, urban, and business service affairs	-0.035	-0.096	-0.104	-0.103	-0.173
Manufacturing of wood, paper, and their products	-0.026	-0.051	-0.077	-0.101	-0.128
Manufacturing, processing, and tanning of textiles, clothing, and leather	-0.025	-0.51	-0.076	-0.098	-0.127
Hotel and restaurant	-0.025	-0.049	-0.074	-0.087	-0.123
Defense and military affairs	-0.022	-0.044	-0.065	-0.084	-0.109
Banks, insurance, and other financial intermediaries	-0.021	-0.04	-0.052	-0.076	-0.105
Health and medication	-0.019	-0.038	-0.047	-0.074	-0.096
Post, telecommunications, and warehousing	-0.019	-0.037	-0.037	-0.069	-0.093

Source: research results

Absolute effects of 10, 30, and 50 percent water resource reduction on production agents and entities

The effects of income reduction of production agents and income reduction of community entities from the viewpoint of demanding and supplier in terms of the absolute effects resulted from water resource reduction are presented in Table 7. The direct and indirect effects and consequences of 10, 30, and 50 percent of water resource reduction from the perspective of demanding leads to a reduction in value-added equal to 65968, 197905, and 329842 million Rials in the whole economy, respectively. The corresponding figures from the perspective of the supplier are also 3716096, 11148288, and 18580479 Rials, respectively. According to the results presented in Table 7, among the two constituent categories of production agent accounts, the labor factor (compensation for services and mixed-income, gross) has decreased absolutely more than the capital factor (operational surplus, gross).

Table 7 also presents the results of water resource reduction on the income of domestic community entities (except the government). The results obtained from the distribution of income of entities show that in terms of absolute demanding and supplier effects, the vulnerability of urban households resulted from water resource reduction has been more than rural households. This impact on the income of low-income households is higher than that of high-income households. Sahabi *et al.* (2016) also showed that the absolute figures for the decrease in the income of urban salaried labor are higher than the decrease in the income of rural salaried labor, which confirms the results of the above study.

Table 7- Absolute effects of 10, 30, and 50 percent water resource reduction on the income of production agents and income of entities from the perspective of demanding and supplier (million Rials)

Production agents and entities	demanding			Supplier		
	10	30	50	10	30	50
Labor factor	60007	180022	300037	2990304	8970912	14951521
Capital factor	5961	17883	29805	725792	2177375	3628959
Sum of production agents	65968	197905	329842	3716096	11148288	18580479
Urban low-income	99172	297515	495859	537918	1613754	2689590
Urban middle-income	127436	382308	637180	1186099	3558296	5930493
Urban high-income	85935	257805	429674	1601088	4803264	8005439
Rural low-income	89134	267403	445672	135289	405868	676447
Rural middle-income	129248	387745	646242	312268	936803	1561339
Rural high-income	87375	262126	436876	404086	1212257	2020428
Companies	34	101	169	3106	9318	15530
Sum of entities	618335	1855004	3091673	4179853	12539560	20899266

Source: research results

Relative effects of 10, 30, and 50 percent water resource reduction on production agents and entities from the perspective of demanding and supplier

According to the results in Table 8, it can be seen that a relative reduction of water resources from the perspective of demanding has a greater impact on capital factor than the labor factor. However, the opposite is true from the perspective of the supplier. In other words, the labor factor has experienced more income loss than capital factor and relatively has had the largest reduction. But in terms of relative impacts, the highest impact of income reduction from the perspective of supplier is on urban low-income households, and the highest impact of income reduction from the perspective of demanding is on rural low-income households. Regarding the effects of distribution of income of entities, given the Table 8, from the perspective of supplier, urban low-income, rural middle-income, urban middle-income, rural low-income, rural high-income, urban high-income households, and companies, respectively, are mostly affected; and from the perspective of demanding, urban low-income, rural middle-income, urban middle-income, rural low-income, rural high-income, urban high-income households, and companies, respectively, have the highest income reduction.

In a study conducted by Sahabi *et al*. (2016), it was found that reducing the production of the agricultural sector causes the most damage to mixed income, which is due to the high volume of mixed income compared to others and this group constitutes the largest number of people in society.

Table 8- Relative effects of 10, 30, and 50 percent water resource reduction on the income of production agents and income of entities from the perspective of supplier and demanding

Production agents and entities	Supplier			demanding		
	10	30	50	10	30	50
Capital factor	-0.0212	-0.0636	-0.1059	-0.0002	-0.0005	-0.0009
Labor factor	-0.1065	-0.3195	-0.5325	-0.0021	-0.0064	-0.0107
Urban low-income	-0.1176	-0.3529	-0.5881	-0.2169	-0.652	-0.1084
Rural middle-income	-0.1150	-0.3451	-0.5751	-0.0476	-0.1428	-0.2380
Urban middle-income	-0.1128	-0.3385	-0.5642	-0.121	-0.0364	-0.0606
Rural low-income	-0.1065	-0.3195	-0.5325	-0.0702	-0.2105	-0.3508
Rural high-income	-0.1001	-0.3004	-0.5007	-0.02165	-0.0650	-0.1083
Urban high-income	-0.0993	-0.2980	-0.4967	-0.0053	-0.0160	-0.0267
companies	-0.00012	-0.00036	-0.0006	-0.0000013	-0.0000039	-0.0000065

Source: research results

Recommendations

The results of this study can be of great importance for the economic and social dimensions of the country. Water resource reduction indicates that production sectors, due to their direct and indirect intermediary links with the water sector, will face production reduction. For this reason, it is necessary to invest in a variety of areas, including improved water use practices, improved crop cultivation methods, proper use of running waters in industry and agriculture, and controlling of surface waters to further exploit water resources.

Optimization of water use in agriculture is more important because a relative share of water consumption in agriculture is higher than in other economic sectors. Attention to issues such as development of long-term strategies for greater water efficiency, educating and informing about the problems resulted by water resource reduction, use of modern methods of irrigation such as drip and tubular irrigation instead of flood irrigation in farms and gardens and use of tree species resistant to water shortage, major changes in irrigation system and crop production technology, financial incentives and investment in reducing water consumption, and creating a culture for consumption pattern of households through the media can provide a procedure of reduction and optimization of water consumption.

In the present study, it was found that production reduction due to water resource constraints leads to a change in the income distribution of production agents and income distribution of entities and increases poverty across different economic sectors. However, this constraint has not taken into account the increase in other economic indicators and households' living cost index. So, it is recommended that policymakers and researchers take it into account in future studies.

References

1. Afaqeh, M., Y. Andayesh, and M. Chenari. 2014. Tax Prioritization of Economic Sectors to Improve the Income Distribution in Iran's Economy Using Social Accounting Matrix. Quarterly Journal of Quantitative Economics, 11(1): 1-18.
2. Banouei, A.A. 2012. The impacts of Agricultural Sector Production Reduction on production of Other Sectors in the form of mixed pattern with an emphasis on conventional and special conditions. Agricultural Economics and Development, 20: 155-186.
3. Banouei, A.A. 2005. Investigation of relationship between income distribution and output growth in Iran using social accounting matrix. Journal of Iranian Economic Research, 23: 95-117.
4. Banouei, A.A. 2012. The effects of reducing the production of the agricultural sector on the production of other sectors in the form of mixed patterns with emphasis on conventional and special conditions. Agricultural Economics and Development, 20 (79): 155-186.
5. Banouei, A.A. F. Momeni, H. Amadeh, Z. Zakeri, and M. Karami. 2012. Measurement of Decrease of Agricultural Output to the Total Output in the Framework of Supply-Driven SAM. The Journal of Economic Policy, 7(4): 1-30.
6. Berrittella, M., A.Y. Hoekstra, K. Rehdans, R. Roson, and R.S.J. Tol. 2007. The economic impact of restricted water supply: A computable general equilibrium analysis. Water Research, 41(8): 1799-1813.
7. Cosgrove, W. and F. Rijsberman 2000. World water vision: making water everybody's business, Earthscan Publications, London.
8. Faridzad, A., A.A. Banouei, F. Momeni, and Kh. Amadeh. 2013. Investigating the Economic and Social Impacts of Petroleum Products Supply Constraints Using Mixed Social Accounting Matrix. Journal of Economic Modeling Research, 3(10): 99-123.
9. Faridzad, A. and P. Mohajeri. 2016. Quantitive Analysis of Economic and Social Impacts of Industrial Sub-Sectors Supply Constraint Using Supply-Driven Social Accounting Matrix Mixed Approach. Applied Economic Studies in Iran, 5(19): 155-185.
10. Farzin, M.R. N. Abbaspour, Y. Ashrafi, and H. Zargham. 2020. The effects of incoming tourism development on income distribution between households and companies. Journal of Social Tourism Studies, 8(16): 1-26.
11. Gakuru, W.R. and N.M. Mathenga. 2015. Poverty, growth and income distribution in Kenya: A SAM perspective, AGRODEP working paper 0001.
12. Ghahramani, F. 2012. Measurement of the Socio-Economic Effects of Drought in the Framework of Supply- Driven SAM (Case study of agriculture and gardening), MA Thesis, Faculty of Management and Economics, Tarbiat Modarres University.
13. Hortono, D. and B.P. Resosudarmo. 2008. The Economy-Wide Impact of Controlling energy Consumption in Indonesia: An Analysis Using a Social Accounting Matrix Framework. Energy Policy, 36: 1404-1419.
14. Kershner, K. and K. Hubacek. 2009. Assessing the suitability of input- output analysis for enhancing our understanding of potential economic effects of oil peak. Energy, 34: 284-290.

15. Miller, R.E. and P.D. Blair. 2009. Input-Output Analysis: Foundations and Extension. Cambridge University Press, New York (Second Edition).
16. Nokkala, M. 2000. Social accounting matrices and sectoral analysis: The case of agricultural sector investment in Zambia. Proceedings of 13th international conference on input-output techniques. Macerata, Italy. August 21-25.
17. Permeh, Z., B. Maleki, A.A. Banouee, Y. Andayesh, and M. Karami. 2011. Estimation of Energy Subsidy Targeting on Commodity Price Index. Iraniian Journal of Trade Studies, 58: 1-32.
18. Pyatt, G. 1988. A SAM Approach to Modeling. Journal of Policy Modeling, No. 10.
19. Pyatt, G. and J. Round. 1979. Accounting and Fixed Price Multiplier in a Social Accounting Matrix. The Economic Journal, 89(356): 850-873.
20. Rocchi, B., D. Romano, and G. Stefani. 2002. Agriculture and income distribution: Insights from a SAM of the Italian economy. Proceedings of 8th joint conference on food, agriculture and the environment. August 25 28, Red Cedar Lake, Wisconsin.
21. Sadeghi, S.K., Z. Karimi Takanloo, M.H. Motafakker Azad, H. Asgharpour qourchi, and H. Andayesh. 2015. Measuring the water ecological footprint of Iranian economic sectors: by emphasis on social accounting matrix (SAM) approach. Scientific Journal Management System, 11(3): 81-111.
22. Sahabi, B., A.A. Banouee, and F. Ghahramani. 2016. Measurement of the Socio-economic Impact of Drought in the Framework of Modified Supply-Side Social Accounting Matrix (SAM): Case Study of Farming Sector. Agricultural Economics and Development, 24(94): 95-121.
23. Salami, H. and Z. Parmeh. 2001. The effects of increasing exports of agricultural and industrial sectors on the Iranian economy: An analysis in the context of the social accounting matrix. Journal of Economic Research, 59: 149-181.
24. Seyedmashhadi, P.A., F. Ghalambaz, and A.A. Esfandiary. 2011. The importance of oil industry in the output and employment of Iran’s economy and its influence on other economic activities. Economic Growth and Development Research, 1(2): 133-161.
25. Social Accounting Matrix of Iranian Economy 1999. Methodology and Structure of Social Accounting Matrix, 1999, Central Bank of Islamic Republic of Iran.
26. Sotoodeh Nia, S., M. Ahmadi Shadmehri, S.M.J. Razmi, and M. Bahnameh. 2020. Studying the Effect of Green Tax on Iran’s Energy Consumption and Social Welfare Using Recursive Dynamic Computable General Equilibrium (RDCGE) Model, Journal of Economic Growth and Development Research, 10(20): 15-34.
27. Yang, H., P. Reichert, K.C. Abbaspour, and A.J.B. Zehnder. 2003. A water resources threshold and its implications for food security. Environmental Science and Technology, 37: 3048-3054.
28. Zand, P., H.R. Mirzaei, H. Mehrabi, and S. Nabieian. 2019a. Socio-economic of the Investment Development Polici on Agriculture Sector. Internanal Journal of Agricultural Mamagement and Development, 9(4): 347-362.
29. Zand, P., H.R. Mirzaei, H. Mehrabi, and S. Nabieian. 2019b. Analysis of Economic and Social Impact of Investment Development Policy in Agricultural Sector, Journal of Agricultural Science and Technology, 21(7): 1737-1751.

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سنجش تأثیر کاهش آب بر تولید بخش‌های اقتصادی با استفاده از ماتریس حسابداری اجتماعی (SAM)

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چکیده

آب گرانبهاترین ثروتی است که در اختیار بشر قرارگرفته، امروزه جوامع بین‌المللی از اهمیت آب در جهت داشتن رشد اقتصادی پایدار در زمان حال و آینده آگاه‌اند. در این مطالعه، تأثیر کاهش منابع آب بر بخش های اقتصادی و زیرشاخه های کشاورزی از طریق یک مدل ماتریس حسابداری اجتماعی بررسی شد. نتایج آن در قالب آثار مطلق و نسبی ارائه شده‌است. آثار و تبعات مستقیم و غیرمستقیم کاهش ۱۰ و ۵۰ درصد منابع آب منجر به کاهش تولید ۳/۴ و۲۲ درصد از دید تقاضا کننده، ۴/۷ و ۲۴ درصد از دید عرضه کننده برای محصولات کشاورزی شده است. از منظر تقاضا کننده کاهش منابع آب به میزان ۱۰ درصد، ۱۰/۵درصد کاهش تولید در سایر بخش‌های اقتصادی داشته است. آثار نسبی کاهش۱۰ درصدی آب از منظر عرضه کننده نشان می‌دهد که بیشترین کاهش مربوط به بخش‌های آب و سایر معادن بوده است. کاهش نسبی منابع آب از منظر تقاضا کننده بیشترین تاثیر را بر بخش آب و دامپزشکی می‌گذارد. از منظر آثار مطلق تقاضا کننده و عرضه کننده، میزان آسیب پذیری خانوارهای شهری ناشی از کاهش منابع آب بیش از خانوارهای روستایی بوده است. از منظر آثار نسبی عرضه کننده ، بیشترین تاثیر کاهش درآمد بر خانوارهای کم درآمد شهری از منظر تقاضا کننده مربوط به خانوارهای کم درآمد روستایی می‌باشد.کاهش نسبی منابع آب از منظر تقاضا کننده بر روی عامل سرمایه تاثیر بیشتری از عامل کار دارد.

واژه‌های کلیدی: تولید، ماتریس حسابداری اجتماعی، منابع آب

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Investigating the Factors Affecting the Sugar Stock Surplus and Ways to Get out of it in Iran

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Abstract

Due to the importantance of sugar in daily consumption of Iranian households, governments annually store sugar as a strategic reserve. Therefore, managing and timing adjustment for the inventory of this product is essential in its ability to compete in markets, modifying the temporal and spatial distribution of products and inputs in economic subdivisions. In recent years, at national scale there was extra sugar in warehouses and a few cases of shortages in stock were exception. Higher sugar production along with lower sale, will increase the costs, so the aim of this study was to investigate the factors affecting sugar surplus and its export in Iran data time searies 1991-2017. In this study our results showed that sugar beet and sugar price as product price did not play a decisive role in stock surplus. Therefore, the stock surplus can neither be the result of price policies nor it be resolved through price policies. It seems that the government should adopt other policies, such as adjusting the timing of import decisions, resolving conflicts between government objectives, and providing strategic reserves from domestic products and gradual elimination of imports, support factories for improving and upgrading equipment, and help sugar beet producers to achieve cheaper product rather than using price policies related to sugar and sugar beet prices.

Keywords: Iran, Sugar, Simulation, Stocks

Introduction

Inventory management plays a key role in the competitiveness of foreign markets, modifying the temporal and spatial distribution of products and production inputs in economic subdivisions (Prasad and Parkar, 1996). According to Eden (2001), business cycle shocks often reduce product output and employment levels. Similar situations may occur in agriculture section. Concerning agricultural products, inventory adjustment is one of the policies adopted to maintain an inventory level at an acceptable level aiming to stabilize domestic prices against market shocks (Praskad and Parker, 1996; John and Srinivasan, 2001). However, many factors in the economy can affect the performance of these policies. These factors can be divided into four groups of producer decision variables, demand formation variables, structural factors, and government policies.

In classical models of warehouse management, the producer's decision variables (i.e. shortage cost and surplus and sales value) are the only factors controlling inventory (Booney and Jarab 2011). Pierce and Wisley (1983) and Ian and Dooley (2010) considered two sources affecting the inventory: sales prediction (demand) and expected loss profits. Booney and Jaber (2011) believed that the producers decision making in practice are also a function of other factors such as waste rates, transportation costs and environmental considerations. Phillips *et al.* (2001) stated that production for storage and production for sale are two different categories. They showed that when the purpose

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of production is to store it, firstly, warehousing and storage costs gradually eliminate the importance of exchange and sale in decision. Secondly, when sellers seek to raise prices, their behavior causes a surplus in stock. However, if the goal of production is to sale, the stock surplus is much lower.

Various variables are involved in the formation of demand, including income and market prices of products. However, in inventory modeling, their behavior often is regarded as extrinsic. The reason for this attitude is partly related to the experience of the studies. Mostleman *et al*. (1987) by dividing production approaches into post-demand and pre-demand production approaches and presenting theoretical models showed that stock surplus is not generally affected by consumer behavior and by increasing producer experience, the difference between two approaches will be eliminated over time. In fact, they had no difference with each other. In other words, whether supply follows demand or vice versa, stock surplus is not affected by this relationship.

Market structure has been considered both in terms of pricing power and the existence of monopoly as well as supply chain length as a determinant of supply surplus. Wong (2004) investigated the role of market structure on inventory surplus by mathematical modeling. According to his findings, market structure plays a key role in generating inventory surplus. When the market is comprised of a small number of producers, the market structure enhances the producers' benefits, and the surplus of inventory at the retail level increases as well. Pierce and Wisely (1983) have previously emphasized that retailers tend to make shorter time horizons in decision making than manufacturersand react strongly to price shocks and consequently they drastically reduce the inventory rates. Therefore, it can be concluded that in monopoly structures, in the absence of price shocks, there is a surplus of inventory at the retail level, and in conditions where shocks exist; there is a surplus of inventory at the level of warehouses of manufacturing plants. In other words, theoretically, under the monopoly conditions, the stock surplus is predictable.

Governments influence the surplus of stockpiles through various policies. Despite the reasoning behind the government's actions, it is believed that these measures are ineffective. Ja and Srinivasan (2001) argued that although the purpose of food storage is to stabilize prices, but since global prices have a potential role on domestic prices, national price volatility in trade liberalization scenarios has much less intervention effect than government policies. Many countries use the strategy of import for storage when there is a risk of potential production shortages, including end-products and production factors. According to Prasad and Parkar (1996), imports are performed by either private (and often restricted) or public sectors (often by law) however their costs are high and structural reforms for globalization are far more efficient. Therefore, many studies resulted that encouraging the producers is an appropriate policy which in addition to commercial liberalization, can also reduce production profitability and inventory fluctuations (Prasad and Parkar, 1996; Zhong and Zhou, 2013). However, the structure and methods of storage and the nature of the product play an important role in its success (Matto *et al*., 2015).

In Iran, sugar is one of the products that has strategic reserves and is managed with different import policies, guaranteed purchase price for sugar beet and demand side policies. The procedure of sugar production in Iran from 1971 to 2014 is illustrated in Fig. 1, which shows sugar production has a rising trend. Of the total domestic sugar production, shares of public, ingovermental, governmental and private factories are 14.5%, 52%, 21.5% and 12%, respectively; that represent a monopoly on sugar production industry (Kazemnejad *et al*., 2007).

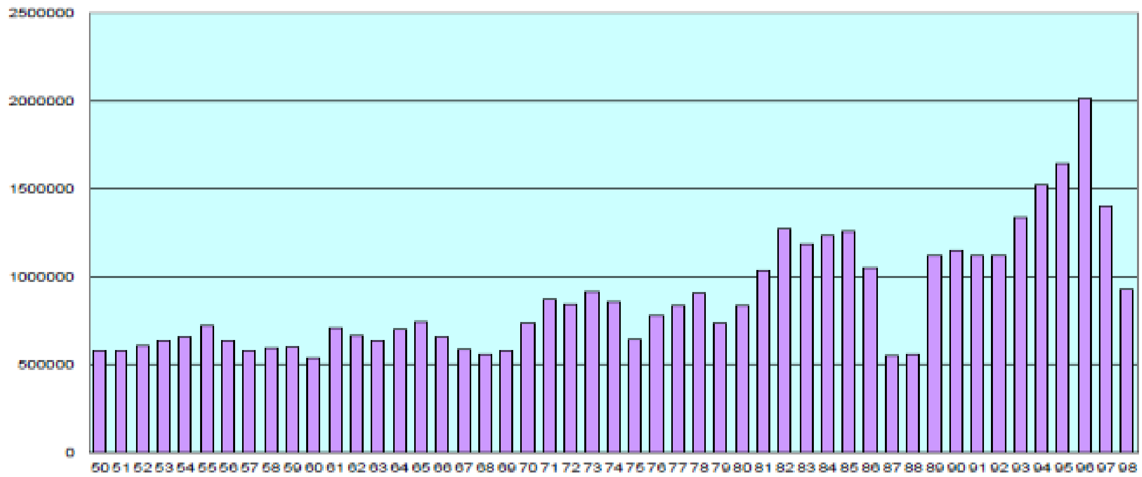

Fig. 1- Total sugar production (ton) from sugar beet and sugar cane during 1971-2019

Source: Iranian Sugar Association

In the last decade sugar consumption per capita shows a decreasing pattern of that per capita consumption rate, which may be due to reducing sugar advertising. Governments generally try to keep sugar stocks at optimum levels by encouraging domestic production. However, some countries that are unable to produce all their needs must import sugar. Statistics show that about 64 percent of domestic demand is supplied by domestic producers and the remainder is supplied through imports (Sugar Association, 2005).

Sugar imports are made by both the private and public sectors as a strategy to keep market prices stable. Sugar imports statistics in the 1980s showed that imports have been increasing until 2013 and the share of private sectors imports was higher than government imports. However, imports have declined dramatically over the past two years. As a result of increasing domestic production in 2014-2015, the country faced a surplus of 1.1 million tons of sugar in its warehouses and the temporary import of sugar was temporarily suspended.

World Bank statistics show that global and domestic sugar stocks have increased in recent years. This increase in sugar inventories in Iran could be due to the excessive increase in private imports, increased sugar beet cultivation, and increased guaranteed purchase prices of sugar beet. Whether through increased production or direct imports of sugar, if direct support policies of other related industries with proper planning and control are not implemented, there will be a surplus of sugar stocks, leading to a surplus in supply and thus a reduction in market prices which can damage domestic the sugar factories. Imports and surpluses playing a greater role than demand-side changes and according to the literature, the possible effective factors include imports, surplus production, and demand shortages. In this study to simulate the sugar industry, consumption is assumed to be exogenously affected by the growth of per capita consumption and population. Imports are determined endogenously by the production of sugar, sugar tariffs and national income. In addition, the supply of sugar is considered a coefficient of sugar cane and sugar beet productions which indirectly depends on the guaranteed purchase price. Given the importance of this strategic commodity, the present study seeks to identify the effective key factors and provide recommendations accordingly to explore the possible sources of the aforementioned surplus.

Materials and methods

In this study, a simulation method was used to determine the contribution of different quantitative and price factors to sugar supply surplus (Clarke *et al.*, 2007) the procedure is to identify the various sources of inventory surplus first and then attempt to quantify the existing descriptive relationships. Finally, by simulating quantitative relationships by an Analytical software, the effect of different quantitative and price scenarios would be investigated and the stock surplus response to different factors is calculated (Clarke *et al.*, 2003). Figure 1 illustrates the conceptual model of the factors affecting the inventory changes. The inventory is the difference between the quantity of supplied sugar and its demand quantity, which is directly and indirectly influenced by various factors such as producer behavior, consumer behavior, trade status, general economic conditions of the national economy, the state of the prior markets, and the policies imposed by government.

The conceptual pattern in Fig. 1 did not include all the details, and some are ignored due to the lack of information and statistics, the lack of quantitative relationships and the inability to quantify. For example, the relationship between the sugar industry and the economy as a whole is stated only about trade. While the sugar industry is associated with various back and forth industries, all of which are affected by general economic conditions. This model assumes that policies related to the sugar industry are based on adopted laws and based on the information available from the sugar market and consumer behavior, while policymakers follow greater cautions in practice that were not considered in the model. In this model, only the former industries arrived to sugar beet and sugar cane. However, the energy sector is a very important factor in practice for the costs of sugar factories. Although these simplifications reduce the accuracy of the predictions of this model but given that in practice the implementation of large and complete models is encountered with limited statistics and information, it seems that taking into account price and key factors in providing simulation-based analyzes can at the same time provide the clues for effective decision-making in sugar industry.

To implement the conceptual model of Fig. 2 as a simulation model, the relationships between different factors have to be quantified. The conceptual pattern of Fig. 2 is first transformed into the flow of quantitative relations in Fig. 3. Inventory surplus is calculated by inventory, supply value, consumption or demand value, annual strategic reserve, and import value (Fig. 3). Through quantification of the relationships between each of these variables with the price factor as well as some policy scenarios, the impact of different factors on the stock surplus would be quantified and compared.

The quantitative relationships used in this study are a set of statistical, hypothetical, unity and regression relationships. Statistical relationships were derived by statistical methods, and in particular, regression methods. Hypothetical relationships are approximations of real and self-evident relationships. For example, the value of one arbitrary variable per year is equal to multiplication of the product value of the preceding year by the growth coefficient of that year. Now, if an average growth rate is taken into account instead of annual growth rates, the values predicted by this relationship will be approximations of reality. Unities are also always good relationships emerge from definitions. For example, the amount of production per year is equal to multiplication of the area under cultivation in that year by yield per area unit, and this relationship is very accurate. The production predictions of the simulated model depend on how accurately the model predicts yield and area under cultivation.

The relationships used in this study are listed in Table 1. The dependent variable names, the subordinate form of the relation, the explanations and the accuracy of its simulation are reported in the first, second, third and fourth columns of the table, respectively.

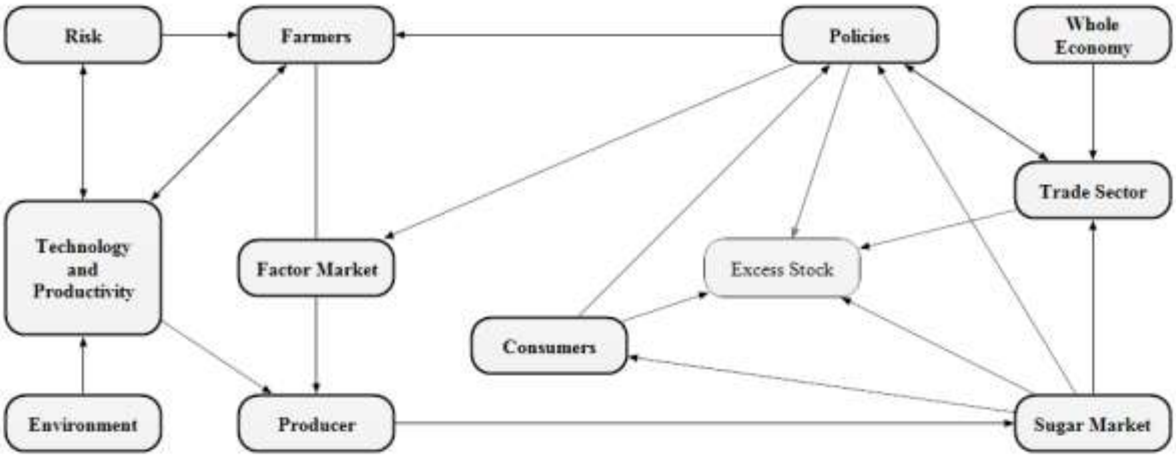

Fig 2. Conceptual model of factors affecting sugar surplus

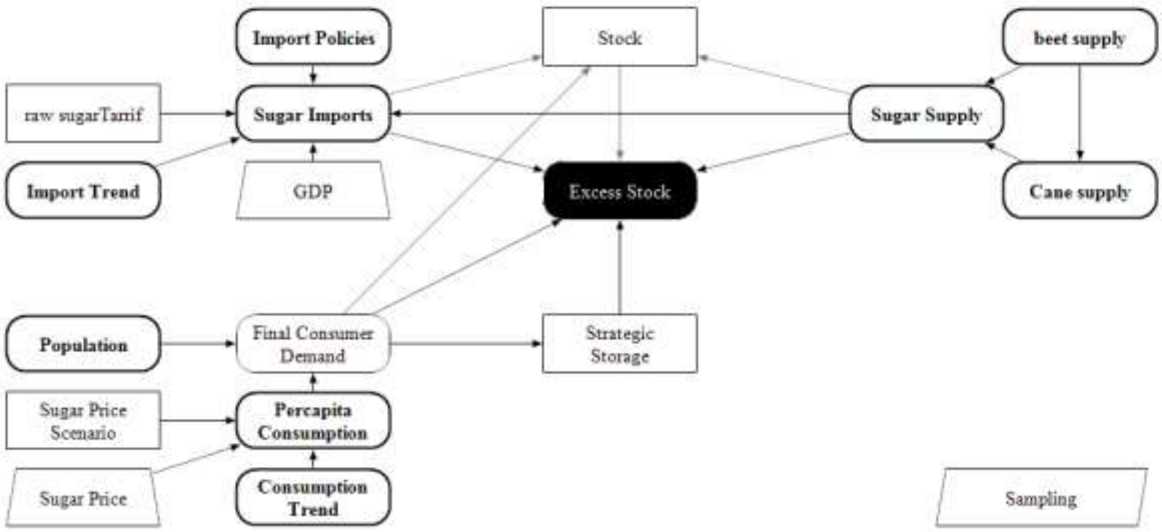

Fig. 3- The flowchart of quantified relationships needed for the model

The accuracy of the simulation can be calculated by comparing the actual time series with the predicted ones. The RMSE[1] calculates the root mean square of the prediction error. The MSD[2] statistic shows the mean deviation of the predicted values from the real values. The MAP[3] statistic calculates the average percentage of model prediction error, which is numerically equal to the ratio of the errors to the true values

1- Root-mean-square error

2- Mean square deviation

3- Mean absolute percentage error

Table 1- Relations used in the simulation

Simulation acuracy	description	equation (subordinate form)	Name
RMSE=407.6 MSD=35.33 MAPE=0.069	hypothetical equation g: Average growth rate The minimum expected price is equal to last year's price and its maximum is at least the minimum expected price	$\ln p_t = \ln(1+g) + \ln p_{t-1}$	Price expectations
RMSE=11.89 MSD=1.92 MAPE=0.057	Research findings	$Y_t = 18.24 + 0.29\, Y_{t-1} + 0.01\, P_t + \varepsilon_t$	Sugar beet yield
RMSE=135.5 MSD=9.3 MAPE=0.20	Research findings	$Y_t = 107.52 + 0.44 Y_{t-1} - 0.08\, P_{t-1} + \varepsilon_t$	The sugar beet area
RMSE=4745000 MSD=817400 MAPE=0.19	Unity	Area under cultivation * yield	sugar beet Supply
RMSE=30.8 MSD=4.35 MAPE=0.09	hypothetical equation	$Y_t = 1.07\, Y_{t-1}$	Sugar Cane Area
RMSE=66.78 MSD=9.25 MAPE=0.12	hypothetical equation	$Y_t = 0.07 - Y_{t-1}$	Sugar Cane yield
RMSE=2823000 MSD=409900 MAPE=0.12	Unity	Area under cultivation * yield	Cane Supply
	Unity	$\frac{(\text{sugar Beet consumption} * \text{Production coefficient} * \text{Grade})}{10000}$	Sugar Supply From beet
		Sugar consumption * Sugar to sugar cane ratio	Sugar Supply From cane
RMSE=972200 MSD=125400 MAPE=00.0	Unity	Sugar Supply from Sugar cane + Sugar supply from Sugar Beet	Sugar Suply
RMSE=2513000 MSD=364800 MAPE=0.39	Obtained from Farazmand et al. (2015) In this equation, the trend is assumed to be random ⁕	$Y_t = lny_t + trend$ $lny_t = 12.91 + 0.77 lny_{t-1} - 0.2\ln(sugar\ supply) + 0.47\ln(GDP) + 0.003(raw\ sugarTarrif)$	Import Demand

RMSE=2273 MSD=358.9 MAPE=0.01		$\ln p_t = \ln(1+g) + \ln p_{t-1}$	Population
RMSE=6.40 MSD=1.01 MAPE=0.04	Research findings In this equation, the trend is assumed to be random *	$C_t = 29.12 - 0.0003 * sugar\ price + trend$	Per capita Consumption
	Unity	per capita consumption* population	Consumer Demand
	Unity	Last Year Supply + Last Year Import-Last Year Consume	Stock
	90 days stock	$Y_t = 0.25\ consumer\ demand$	Strategic Stock
	Unity	Last year inventory + supply + import - strategic stock consume	Exess Stock

* In fact, the equation estimated by Farazmand *et al.* (2015) has no trend. In this study, a random trend is added to the model assuming the same parameters are constant.

In addition to equations mentioned in Table 1, To introduce the risk, disruptive components and probable error distributions were also simulated. Given that the mean of the disruptive components of the regression equations is zero, the inclusion of probable risk variables does not change the mean values, but it does cause that the estimated variables and its dependent variables have probable distribution, and their range of variations can be obtained based on probability density curves.

Results and Discussion

Further to the implementation of equations (Table 1) in Analytica software, the impact of different policy scenarios on the stock surplus was examined. Then the stock surplus response to changes in different variables was calculated and finally the impact of these scenarios on the stock surplus response to different factors was investigated.

Sugar Price Scenarios

Fig. 1, shows the surplus response of sugar stocks to different sugar price scenarios. This scenario includes: 1% decrease / increase of sugar prices, 10% decrease / increase of sugar prices as well as no change in sugar prices. It can be concluded (Fig. 4) that prices increase caused inventory surplus to become far from zero, in other words, if there is surplus stock in the economy, the surplus will increase as prices rise. On the other hand, if the economy is faced with a shortage of inventory, rising prices will increase sugar shortages. This finding has a key message in the sugar industry's policy making - that the rise in prices has an undesirable consequence and is solver of problems of overcapacity and shortage of sugar supply.

Source: Research findings

The average elasticity of stock surplus in relation to price is 0.73. Therefore, it is generally expected that the effect of rising sugar prices on the stocks increase will be greater than the effect on increasing sugar shortages. Investigation of the impact of other scenarios on the above-mentioned elasticity indicates that

1- Both increasing and decreasing imports reduce the elasticity.
2- Increasing the price of sugar beet increases the elasticity.
3- Increasing the production efficiency of sugar beet and sugar cane reduces the elasticity.
4- If the adjustment rate of sugar beet growers' increases, the elasticity will decrease.
5- Changes in consumption patterns, either by increasing per capita consumption or by reducing per capita consumption, reduce the elasticity.

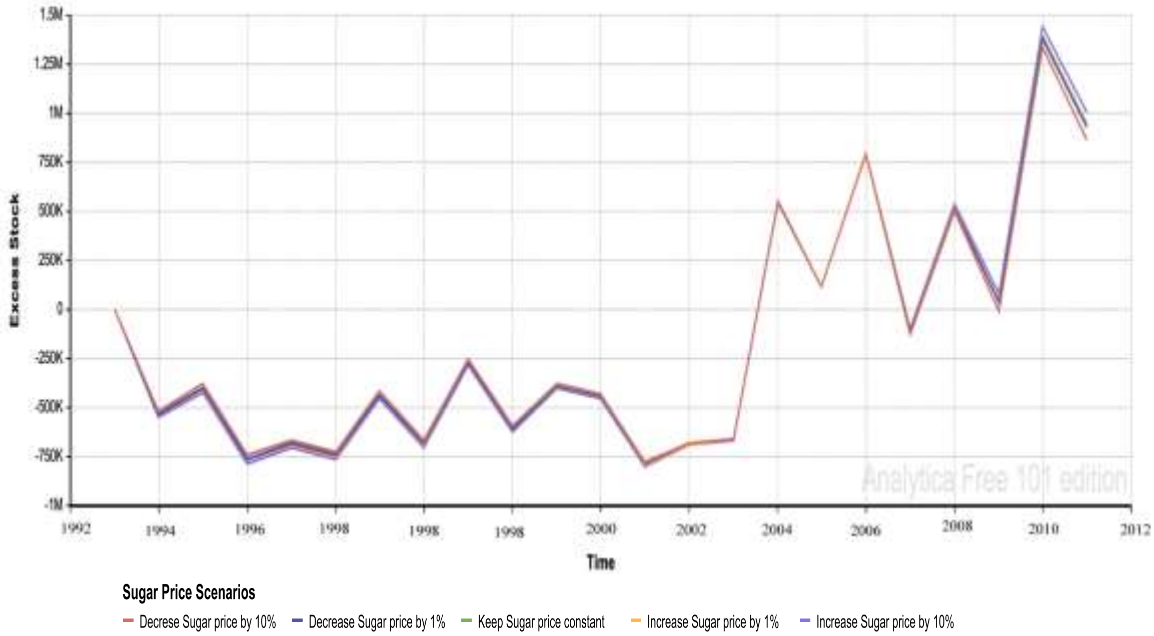

Fig. 4- Impact of sugar price scenarios on surplus of sugar stock

Import scenarios

Fig. 5 shows the impact of different import scenarios on the stock surplus. These scenarios include change of imports as 10% decrease, 10% increase or no change in the current import rate. According to Fig. 5, the stock surplus was potentially affected by the volume of imports so by reducing the amount of imported inventory, surplus was reduced. Eliminating imports will cause sugar shortages in the market. Elasticity of inventory surplus to imports ratio is 1.60. Thus, with 1% increase in imports, the surplus of inventory increases by more than 1%, which in turn can create a high shock in the market and consequently increase prices. Investigating the impact of different scenarios on the import elasticity showed that

1- Increasing the price of sugar beet increases this elasticity.
2- Increasing the production efficiency of sugar beet and sugar cane reduces this elasticity.

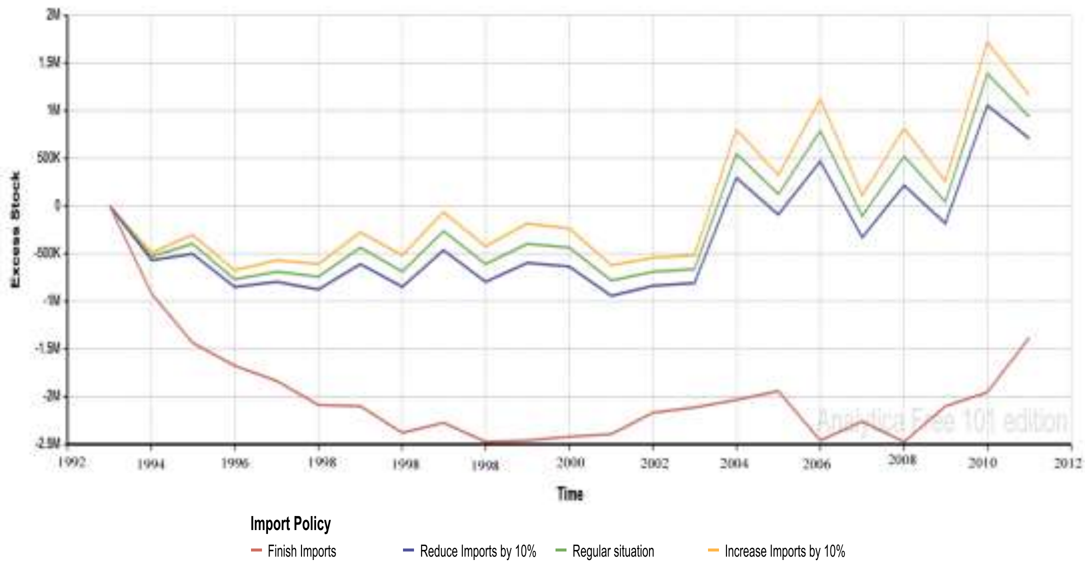

Fig. 5- Impact of imports scenarios on surplus of sugar stocks
Source: Research findings

1- The faster the sugar beet growers adjust their supply, the lower the elasticity.
2- By changing the consumption pattern to higher consumption, the surplus of inventory relative to imports was reduced.
3- With the rise in the price of sugar, the elasticity decreased.

Per capita consumption scenarios

Fig. 6 shows the impact of different levels of per capita consumption on stock surplus. Results showed that the effect of per capita consumption on stock surplus is similar to the effect of sugar price on sugar surplus. In other words, with increasing per capita consumption of inventory, surplus or shortage of inventory, both increased. This conclusion is not unexpected as it increases with the increase in per capita consumption. Therefore, the effect of increasing per capita consumption will be similar to the effect of increasing price. The amount of inventory surplus in relation to per capita consumption is -1.72 which means that with 1% increase in sugar consumption, the surplus of inventory decreases by 1.72%. The effect of different scenarios on the elasticity showed that

1. By increasing the sugar beet price, the elasticity decreases.

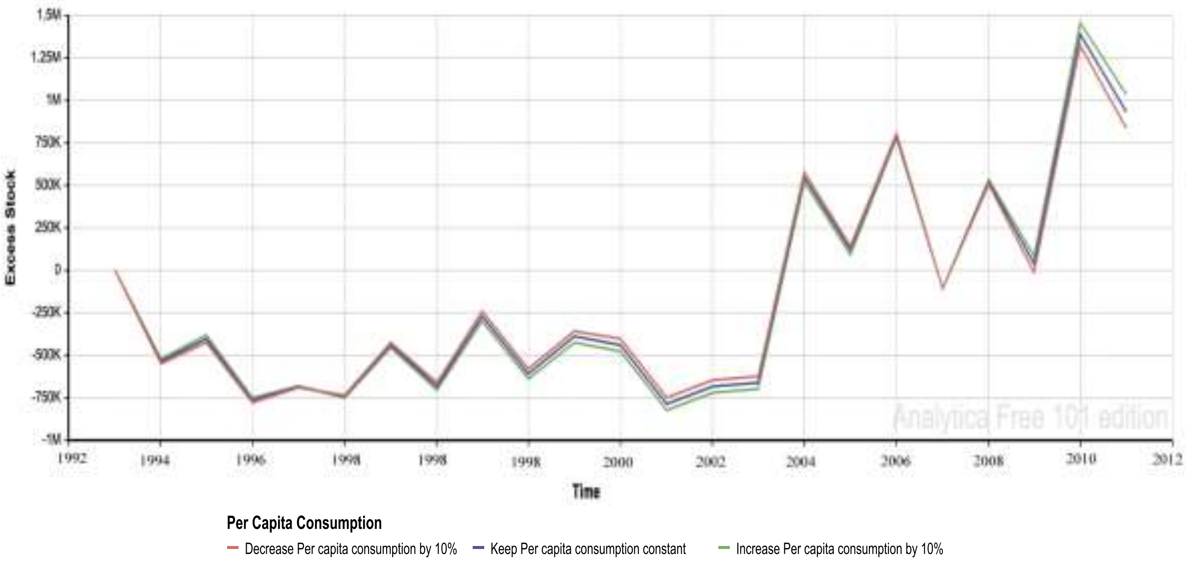

Fig. 6- Impact of consumption pattern scenarios on sugar stock surplus
Source: Research findings

1- Increasing the productivity of sugar beet production increases the elasticity.
2- The faster the sugar beet growers adjust, the greater the elasticity.
3- By increasing sugar price, the elasticity will increase.
4- Change in the volume of imports, either increasing or decreasing, will potentially increase the elasticity.

Guaranteed purchase price scenarios for sugar beet

Fig. 7 shows the impact of different scenarios of sugar beet price on stock surplus. By 10% increase in the price of sugar beet, both the inventory surplus and the shortage of inventory decreased (Fig. 7). On the other hand, the elasticity of inventory surplus relative to sugar beet price was 0.17. In general, it can be concluded that the changes in sugar beet price does not have a significant impact on the stock surplus. Examination of different scenarios on this elasticity also showed that even with changing conditions, this elasticity did not significantly increase or decrease (elasticity was constant). For example, increasing productivity, speeding up the adjustment of sugar beet producers, and increasing sugar price reduced this elasticity, and this change did not exceed 0.5%. Therefore, the policy of guaranteed purchase price cannot have a significant impact on the stock surplus.

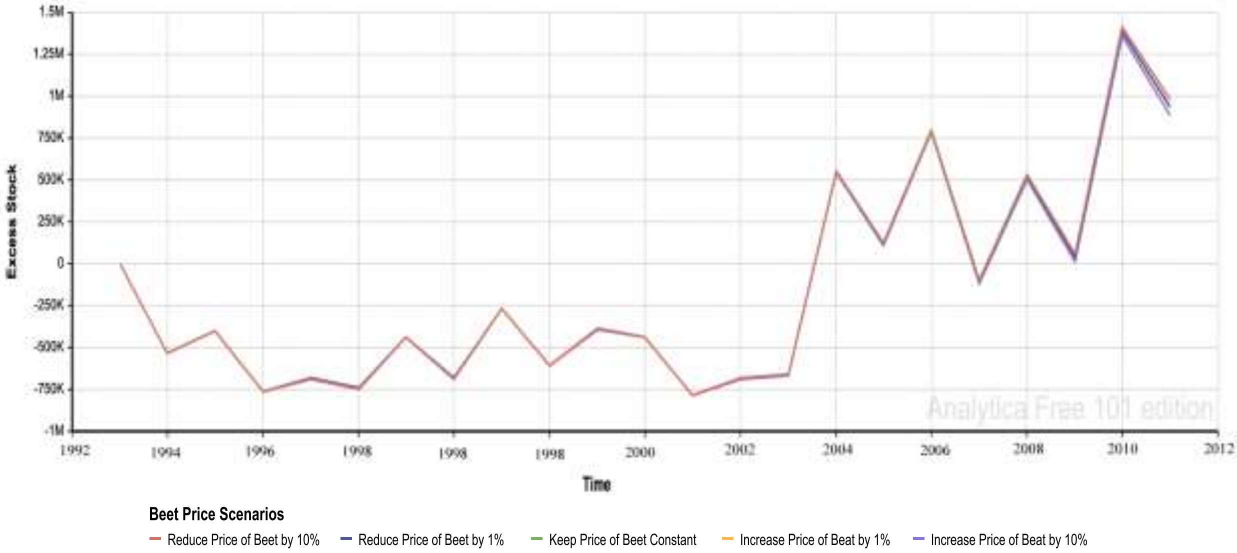

Fig. 7- Impact of Guaranteed sugar beet Price Scenarios on Stock surplus
Source: Research findings

Environmental and technical scenarios

Fig. 8 shows the impact of technical and environmental shocks on the stock surplus. For this reason, these shocks are called environmental and technical shocks that can basically increase or decrease the yield. In fact, because yield is a function of environmental and climatic, technological and productivity factors, the yield changes are considered as scenarios of technology change and environmental factors. These shocks are yield-related and introduced into this model (Fig 5). As their origin was not precisely quantified, quantitative values of elasticity did not provide much information on the impact of technology and productivity. However, comparing the impact of yield changes with the surplus inventory of other variables may indicate the importance of technical and environmental factors on the farm productivity. As shown in Fig. 5, there is a potential increase in the inventory surplus with increased productivity of sugar cane and sugar beet.

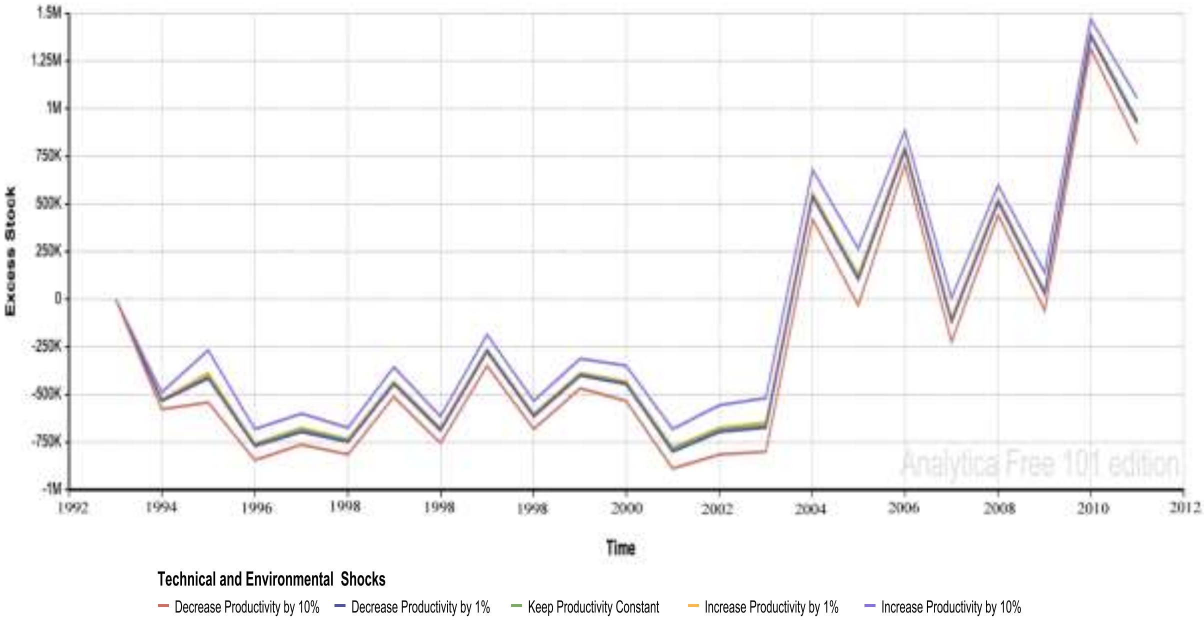

Fig. 8- Impact of yield shocks (technical and environmental shocks) on stock surplus
Source: Research findings

Conclusion

Sugar plays an important role in the daily consumption of households, so the government annually stores sugar as a strategic reserve. This stock is equivalent to 90 days of people's consumption and is used to regulate the market. Logically, if the supply and demand of sugar were equal, the surplus stored sugar supply in the warehouses should be equal to the strategic reserve of the government. However, in recent years there has been surplus of sugar supply in warehouses and a few shortages in some exceptional cases. Given that increasing sugar production imposes cost on sugar factories, failure to sell part of the product will increase their costs. In this study, we have tried to determine the role of different quantitative and price factors in generating inventory surplus by simulating the quantitative and price relationships related to sugar production, imports and consumption.

This study results showed that sugar beet price as input and sugar price as product price do not play a decisive role in stock surplus. Therefore, the stock surplus can neither be the result of price policies nor can it be resolved through price policies. Therefore, it seems that the government should adopt other policies instead of using price policies related to sugar and sugar beet prices. The recommendations of this study are as follows:

1- Modifying the timing of the decision on imports: The results of this study showed that imports play an effective role in determining the surplus of inventory. Every year the government tries to import the gap between production and consumption, providing precautionary quantities by estimating the amounts of needed sugar and domestic production. However, the government calculations appear to be insufficiently accurate and each year, the government exceeds the imports than the required amount. It is therefore proposed that the government delay its decision-making time and import sugar with more comprehensive and accurate information.
2- Resolving conflicts between government goals: The findings of this study showed that the growth rate of sugar per capita consumption in Iran was negative and the country's demand for sugar has been declining. At the same time, the government was seeking to increase domestic sugar production by raising the guaranteed purchase price of sugar beet, while importing excessive quantities. Given the decrease in demand and the increase in production, the amount of import should be limited each year and the amount of strategic reserve should be reduced.
3- Providing strategic stocks from domestic production and gradual removal of imports from purchase basket of government: Since domestic sugar prices are higher than its world price, providing strategic stocks from imports is a costly way of regulating the sugar market. However, as the results of this study showed, the problems of sugar surplus and shortages were caused by low planned imports and the continuation of the purchase of imported sugar was a continuation of this problem. Furthermore, these imports increased producers' costs (by not selling part of the product) and impede the growth of domestic production.
4- Supporting domestic sugar factories for equipment upgrades: The results of this study indicated that productivity and technology play a major role in increasing sugar production. Technology improvement results in greater sugar production, improved production quality, or reduced production costs. In all these cases, domestic production has the potential to grow, and the government will effectively counteract the surplus and shortage of the sugar market by substituting it for imported sugar.
5- Government support from sugar beet producers to produce cheaper: One of the ways to support the Iranian sugar industry is to support the agricultural sector, especially sugar beet and sugar cane producers. If producers can sell their crops to sugar factories at a lower price, sugar factories will expand their activity range and sustain farmers income as demand for sugar beet and sugar cane increases. This method can be a good substitute for guaranteed purchase prices and mandatory sugar beet purchase laws. This is because both farmers and sugar factories in the sugar beet market will reach equilibrium.
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References

1- Bonney, M., and M.Y. Jaber. 2011. Environmentally responsible inventory models: Non-classical models for a non-classical era. International Journal of Production Economics, 133(1): 43-53.
2- Clarke, E.M., M. Kohlhase, J. Ouaknine, and K. Sutner. 2003. System description: analytica 2.
3- Lee, S.W., R.A. Gandhi, S.J. Wagle, and A.B. Murty. 2007. r-AnalytiCA: Requirements analytics for certification & accreditation. In 15th IEEE International Requirements Engineering Conference (RE 2007) (pp. 383-384). IEEE.
4- Eden, B. 2001. Inventories and the business cycle: Testing a sequential trading model. Review of Economic

Dynamics, 4(3): 562-574.

5- Farazmand, H, H. Darysawi Bahmanshir, and A. Mansouri. 2015. Estimation of Sugar Demand Function in IRAN Using Econometric Techniques. 7th National Conference on IRANian Sugar Technology.

6- Jha, S., and P.V. Srinivasan. 2001. Food inventory policies under liberalized trade. International Journal of Production Economics, 71(1): 21-29.

7- Kazemnejad, M., A. JIRANi, M. Paloj, A. Gilanpour, A. Nasr Isfahani, and A. Amjadi. 2010. Comparative Advantage and Support Indicators of Sugar Cane and Related Industries in IRAN. First Edition, Publication of Institute for Planning Research, Agricultural Economics and Rural Development.

8- Mestelman, S., D. Welland, and D. Welland. 1987. Advance production in posted offer markets. Journal of Economic Behavior and Organization, 8(2): 249-264.

9- Mateut, S., P. Mizen, and Y. Ziane. 2015. Inventory composition and trade credit. International Review of Financial Analysis, 42: 434-446.

10- Phillips, O.R., D.J. Menkhaus, and J.L. Krogmeier. 2001. Production-to-order or production-to-stock: the endogenous choice of institution in experimental auction markets. Journal of Economic Behavior and Organization, 44(3): 333-345.

11- Prasad, K.N., and R.G. Parkar. 1996. Import related inventory management in Indian economy. International Journal of Production Economics, 45(1): 215-222.

12- Pearce, D.K., and T.O. Wisley. 1983. Sales expectations and inventory changes in retail trade. Journal of Economics and Business, 35(1): 109-121.

13- Wang, H. 2004. Resale price maintenance in an oligopoly with uncertain demand. International Journal of Industrial Organization, 22(3): 389-411.

14- Yan, T., and K.J. Dooley. 2010. Entry timing in a secondary market: When to trade?. International Journal of Production Economics, 124(1): 62-74.

15- Zhong, Y.G., and Y.W. Zhou. 2013. Improving the supply chain's performance through trade credit under inventory-dependent demand and limited storage capacity. International Journal of Production Economics, 143(2): 364-370.

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مقاله پژوهشی

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بررسی عوامل موثر بر مازاد موجودی انبار شکر و راه‌های برون رفت از آن در ایران

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چکیده

به دلیل نقش و اهمیت شکر در مصرف روزانه خانوارها، هر ساله دولت‌ها مبادرت به ذخیره مقادیری شکر به عنوان ذخیره استراتژیک می‌نمایند. از این رو مدیریت و تنظیم موجودی انبار این محصول نقش اساسی در قدرت رقابت آن در بازارها، اصلاح توزیع زمانی و مکانی محصولات و نهاده‌ها تولید در زیربخش‌های اقتصادی را ایفا می کند. در سال‌های اخیرمازاد عرضه شکر در انبارها و در برخی موارد استثنایی کمبود در موجودی انبار را داشته‌ایم. با توجه به این‌که افزایش تولید شکر سبب تحمیل هزینه به کارخانجات تولیدکننده شکر می‌شود، عدم فروش قسمتی از محصول به منزله افزایش هزینه‌های آن‌ها خواهد بود، لذا هدف از این مطالعه بررسی عوامل موثر بر مازاد موجودی شکر و راه‌های برون رفت از آن در ایران می‌باشد. نتایج مطالعه نشان داد، قیمت چغندرقند به عنوان نهاده و قیمت شکر به عنوان قیمت محصول نقش تعیین کننده را در مازاد موجودی انبار بازی نمی‌کنند. بنابراین مازاد موجودی انبار نه می‌تواند نتیجه‌ی سیاست‌های قیمتی باشد و نه از طریق سیاست‌های قیمتی می‌تواند حل شود. از این رو، به نظر می‌رسد که دولت می‌بایست به جای استفاده از سیاست‌های قیمتی مربوط به قیمت شکر و قیمت چغندرقند، از سیاست‌های دیگری نظیراصلاح زمان تصمیم در مورد واردات، حل تعارضات بین اهداف دولت، تامین ذخیرا استراتژیک از تولیدات داخل و حذف تدریجی واردات، حمایت از کارخانجات برای نوسازی و بهسازی تجهیزات و حمایت از تولیدکنندگان چغندرقند برای تولید محصول ارزانتر استفاده نماید.

واژه‌های کلیدی: ایران، شکر، شبیه سازی، موجودی انبار

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Factors Affecting Emission Intensity of Pollutants Emitted from Agricultural Production

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Abstract

Energy products are the main sources of emissions for most of the pollutants in Iran. However, for some pollutants like Methane (CH_4) and Nitrous Oxide (N_2O), the production process, including the agricultural production process, plays a significant role. The aims of this study were to analysis the emissions intensity of the selected pollutants and to introduce the determinants in Iranian agricultural sector. The emission intensity in the agricultural sector was decomposed into its components using decomposition analysis. Then, the regression analysis was applied to investigate the emission intensity determinants. The selected pollutants are Carbon Dioxide (CO_2), CH_4, and N_2O emitted from agricultural production process. The applied data cover 1973-2016. The findings showed that CH_4 emission intensity has been decreasing over the study horizon by 3.9% annually. For N_2O, the corresponding value was 2.6%. Based on the results, output level in agricultural sectors is an important driving factor in the emission intensity. It was found that 1% increase in livestock output level is expected to increase CH_4 emission intensity by 0.9% while it will dampen the N_2O emissions intensity by more than 3.3%. By contrast, the same percentage of increase in the output level of agronomy and horticultural subsector will induce an increase of 3.3% in N_2O emission intensity and will reduce the CH_4 emission intensity more than 0.9%. Macroeconomic variables including urbanization and trade openness failed to affect the agricultural emission intensity significantly. The emission intensity of all pollutants, measured in CO_2 equivalent, has been decreasing over the study period by 3.5% annually. It was also found that, in terms of aggregated emission, output expansion in livestock and forestry sectors may induce higher emission intensity, while agronomy and horticultural output expansion can reduce the emissions intensity. Given that the output level plays a significant role in emission intensity while the macroeconomic variables have nothing to do with emission intensity, the measures taken to reduce the emission intensity in the agricultural sector should be sector-specific. Moreover, the measures should focus on each subsector individually.

Keywords: Agricultural sector, Emissions intensity, Methane, Nitrous oxide

Introduction

Global greenhouse gases emissions have grown by 2.5% annually over 1960-2014, reaching 34.6 billion tons. In other words, these emissions are 3.7 times of those in 1960. These changes may induce irreversible consequences (Manahan, 2010). Economic growth is accompanied by more energy use and more use of fossil fuels will result in higher emission of greenhouse gasses (Taylor *et al.*, 2014). More than 80% of Carbon Dioxide (CO_2) (as the main pollutant) is emitted from the consumption of energy products and the remaining part accounts for production process and final consumption[2]. As for Methane (CH_4), more than

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۲- Energy consumption in Iranian economy has increased 7% annually over 1965-2016 while its GDP has grown by 3.9% (Iran's Energy Balance, 2016). The average energy use for USD 1000 of output is 234.72 Kg oil equivalent while the

84% of the emission accounts for the production process, and the corresponding value for energy is less than 1%. Although, energy products account for most of the pollutants, there are other sources for pollutants emission as well. There are three sources for pollutants emissions, including consumption of energy products, production process, and final consumption. The emissions from production are the part that is emitted in the production process and is not related to the consumption of the energy products[1]. The emissions from final consumption also include emissions from the consumption of the goods and services by households and institutions (Farajzadeh, 2012).

Emissions from production process are significant in some sectors like agriculture in the Iranian economy. The agricultural activities have not accounted for a significant part of energy use and pollution emissions from energy sources. However, they account for a significant part of some of the pollutants emitted from production process[2]. Accordingly, more than 90% of N_2O, around 55% of CO and more than 25% of NO_x emitted from production process. The corresponding value for CO_2 is more than 25% (Farajzadeh, 2012). Agricultural sector accounts for 9.6% of the Iranian GDP, and more than 25% of the population is dependent on agriculture (Central Bank of Iran, 2017). In addition, 4.1 out of 23.4 million active population of Iran are employed in agricultural sector (Central Bank of Iran, 2012; FAO, 2017).

The amount of emission with respect to the production level is measured by a concept known as emission intensity. It measures the emission per unit of production[3]. As literature shows, emissions from production process has not been considered enough due to the dominant role of emissions from energy, while agricultural activities account for a significant part of CH_4 and N_2O emissions. More than 84% of CH_4 emits from the production process and the agricultural sector accounts for around 20%, emitted mainly from livestock and agronomy subsectors. The corresponding values for N_2O are over 58 and 57%, respectively (Farajzadeh, 2012). Thus, as far as CH_4 and N_2O are considered, agricultural sector is important. During the last five decades, the total emissions of theses pollutants, measured in CO_2 equivalent[4], emitted from agronomy and horticultural and livestock subsectors has grown by 2.5 and 0.4%, respectively. The total emissions of the CH_4, N_2O, and CO_2, in terms of CO_2 equivalent, is more than 37 million tons. The corresponding value for the whole of the world is over 5410 million tons. In other words, Iran accounts for around 0.5% of the emissions while the corresponding value for agricultural output share is 1.1% (FAO, 2017). Although, the Iranian agricultural sector is less polluting compared to the world, the attempts to achieve less polluting agricultural output and lowering chemical inputs have been increasing. For instance, pistachio export from Iran to the EU area encountered challenges with respect to health problems (European Commission, 2010). Setting higher standards for agricultural and food products may restrict export. Thus, restricting chemical use and emission of pollutants should be considered.

We focus on intensity decomposition of emission from agricultural production process as well as examine the determinants. Accordingly, emission intensity of the selected pollutants was decomposed into the corresponding components. In addition, based on the current literature, more driving factors were introduced.

In the literature review, we have focused on the driving factors of emissions and emission intensity. However, most of the current literature has examined the emissions from energy products.

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corresponding value for many countries is less than 100 and the global average is around 121 (World Bank, 2016).

۱- Globally, for the most of pollutants, energy products are account for the most part of emissions. Accordingly, 65% of greenhouses gases are assigned to energy consumption or production process (Marrero, 2010).

۲- Agricultural sector share of energy consumption has been decreasing over the decades, accounted for 8.5% and 3.7% in 1967 and 2016, respectively. However, the amount of energy products consumption has been rising, increasing from 4.4 to 50.7 million Barrel of oil equivalent over 1967-2016 with an annual growth of over 5.1% (Iran's Energy Balance, 2016). The reduction in agriculture share results from significant rise in the consumption of energy products in other sectors especially manufacturing activities.

۳- Considering this measure also shows that Iran's situation is not desired. CO_2 emission per income (measured in 2016 PPP$) has been 0.59 while the global average was 0.31 (World Bank, 2016). In other words, in terms of emissions intensity also the Iranian economy is more polluting compared to the world as a whole.

۴- The multiplication factor to aggregate N_2O and CH_4 into CO_2-equivalent are 310 and 21, respectively (United Nations, 2010).

While, the whole of the economy has been considered. Among the driving forces, urbanization has remarkably been at the central focus. For instance, Cramer (Cramer, 2002) showed that increased population is the main driver for air pollution. Some empirical works show that building in the developed countries induces a slowdown in the scale of carbon emissions from energy while it results in higher carbon intensity (Sadorsky, 2013). For example, building construction in the developed Europe may result in lower carbon emissions from energy products consumption (Kasman and Duman, 2015). On the other hand, Barrios *et al.* (Barrios *et al.,* 2006) suggest a significant relationship between rural and urban immigration and pollution in South Africa. Fan *et al.* (2006) believe that the extent of population effect on CO_2 emission depends on the income level of the countries and CO_2 emission is affected negatively in high-income countries, while the positive relation is expected for low-income ones. In the same vein, Shi *et al.* (2003) reported a higher effect of population for developing countries compared to those of the developed ones. Poumanyvong and Kaneko (2010) found the positive effect of population and urbanization on CO_2 emission for different levels of developing process. As for Iran, Behboodi *et al.* (2010) reported a positive relationship between urbanization and CO_2 emission. Shahbaz *et al.* (2016) found that urbanization effect on CO_2 emission depends on level of the emissions such that it dampens the emission primarily but after exceeding a threshold, it leads to higher CO_2 emission. Alam and Fatima (2007) suggested an emissions increasing effect for urbanization. Regarding the divergent findings for the empirical works, this conclusion may be driven; on the one hand, pollution emission may be increased with moving from agriculture-dominant economy to industrial economy. On the other hand, urbanization provides the chance of more efficient use ofinfrastructures, transportation systems, and energy, leading to lower emissions. Thus, the relationship between urbanization and pollution emissions can be positive or negative[1]. The effect of population on emissions is important since Iran has experienced an increasing trend of urbanization over the last decades, increasing from 47% in 1976 to around 75% in 2016 (Central Bank of Iran, 2017).

Production or income, the manufacturing output and trade liberalization are other driving forces considered in the literature. Fan *et al.* (2006) suggested the economic growth as the main driver of CO_2 emission. The same relationship was reported by York *et al.* (2003) for greenhouse gases. The positive effect of production on emissions intensity has been reported in many studies (Wu *et al.,* 2005; Wei *et al.,* 2008; Wang *et al.,* 2005). Lin *et al.* (2009) found that per capita income and population had the greatest effect on the environment, and industrialization was also significant. In Iran, Barghi Oskoei (2008) reported that the effects depend on the income level. He found that trade liberalization and per capita income lead to lower pollution in high and upper-middle-income countries, while those with income lower than average experience higher pollution. Hubler (2009) found that increasing FDI affects emission intensity significantly.

More attention to the pollutants emissions, especially carbon emissions from sources other than energy products, has been paid recently. This review of attention suggests agricultural activities. The corresponding literature can be divided into two groups. Some of them focus on technical aspects and pay more attention to production factors that contain pollutants at farm level. While other empirical works tend to address economic and political factors. From the first group, Li *et al.* (2014) investigated CO_2 emission intensity of Chinese agricultural sector and they determined the components using decomposition analysis. Also, Ma and Feng (2013) using the same approach concluded that in order to achieve low carbon agriculture in China, agricultural sector should decrease using chemical fertilizers and energy and more advanced technology should be applied. Natak *et al.* (2015) believe that to reduce the emission from crop growing activities, managerial attempts are needed. However, for emission from livestock activities the quality of foods and feeding management in pasture has more potential to reduce the emissions. In the agricultural studies, more attention have been paid to chemical fertilizers. Fisher *et al.* (2010), for agronomy activities, have suggested optimization in fertilizer production and improving agricultural production process. Wan *et al.* (2013) pointed out

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١- In the case of positive effect of urbanization on pollution emission Jones (1991) has suggested two mechanisms. First, rising population increases the demand for electricity and transportation, leading to higher emissions of greenhouses gases. Second, higher population intensity increases demand for forestry and its products and leads to changes in forestry use like timber, which may destroy the forests.

increase in use of organic fertilizers and improved production technology of agricultural products in order to dampen CO_2 emissions. Monchuk *et al.* (2010) have investigated more deeply, and they reported the related industries as the sources of high emissions in agricultural sector. They have used Data Envelopment Analysis and concluded that inefficiency in heavy industries such as chemical and petrochemical have lead to increasing emission of CO_2 in agriculture. As mentioned before, the second group of studies addresses economic and political issues. For example, Xu and Lin (2017), while considered the importance of geographical differences in analyzing the emissions intensity of agriculture, suggested that the main driving forces of CO_2 emission in Chinese agriculture are output growth, urbanization and energy intensity. Moyen Uddin (2020), for a group of countries with different income levels showed that output or income is the determinant of CO_2 and CH_4 emission in agriculture; however, its effect is not the same for all countries. In addition, it was found that for some countries the degree of trade openness might result in lower emissions.

As discussed before, agricultural activities, compared to the other activities, play a significant role in pollution emitted from the production process rather than emissions from energy use. This fact has been illustrated in empirical works addressing emissions tax. For instance, Farajzadeh (2018) applying a dynamic CGE model, reported that levying emissions tax induces a rise in the agricultural output which mainly stems from the lower emissions of agricultural sector since it uses energy products much lower than non-agricultural sectors. Findings of Farajzadeh and Bakhshoodeh (2015) also conclude the same implicitly.

The aims of this study were to analysis the trend of selected pollutants emissions from production process in agricultural sector and to determine the driving forces. The distinguishing feature of the study from the current literature is that it examines the emission intensity in production process, while the emission from the consumption of the energy products has mainly been considered by scholars. In addition, the current empirical works have mainly focused on CO_2, while this study addresses N_2O and CH_4 as well. Examining the driving forces of emission intensity may contribute to policymakers to consider the emissions intensity in developing policies.

Method

Many cases of decomposition analysis in the literature apply the Logarithmic Mean Divisia Index (LMDI[1]) to examine the energy intensity. This approach provides an opportunity to determine the driving factors. Indeed, the aggregate emission of a pollutant is decomposed into its components using this method. Following index decomposition method, emission intensity of a pollutant can be presented as follows (Zhang *et al.*, 2019):

$$PI=\frac{\boldsymbol{C}}{\boldsymbol{Y}}=\sum_{\boldsymbol{i}}\frac{\boldsymbol{C_i}}{\boldsymbol{Y_i}}\times\frac{\boldsymbol{Y_i}}{\boldsymbol{Y}} \qquad (1)$$

Where C is the total amount of pollution emissions from production process, $\mathbf{C_i}$ represents the pollution emitted from production process of sector i (including agriculture sectors), $\mathbf{Y_i}$ indicates output (value added) of production sector i, and Y is the total gross domestic production (total output).

Output expansion results from extensive use of resources and productivity growth. Thus, growth in productivity also may affect pollution emissions (Rodríguez and Pena-Boquete, 2017). To incorporate this fact in the analysis, we multiply Eq. 2 by $\frac{\boldsymbol{Y}}{\boldsymbol{L}}\times\frac{\boldsymbol{L}}{\boldsymbol{Y}}$:

$$PI=\frac{C}{Y}=\sum_i\frac{C_i}{Y_i}\times\frac{Y_i}{Y}\times\frac{Y}{L}\times\frac{L}{Y} \qquad (2)$$

Population is another driving force examined in the literature that is expected to influence the emissions intensity. The emissions intensity equation including population (P) can be rearranged as follows:

$$PI=\frac{C}{Y}=\sum_i\frac{C_i}{Y_i}\times\frac{Y_i}{Y}\times\frac{Y}{P}\times\frac{P}{L}\times\frac{L}{Y} \qquad (3)$$

Where $\frac{P}{L}$ is the inverse of employment rate and $\frac{L}{Y}$ is the inverse of labor productivity.

These variables have been applied in Zhang and Hao (Zhang and Hao, 2020) as well as Han *et al.* (2019). Analogue to Eq. 3 we may present the emissions intensity equation as follows:

$$PI=\frac{C}{Y}=\sum_i CY_i\times YY_i\times YP\times PL\times LY \qquad (4)$$

Where i represents agriculture subsectors including agronomy and horticulture, livestock, and forestry and rangeland, which we name them as agricultural sectors. $YY_i\equiv\frac{Y_i}{Y}$ is the output share of sector i. $CY_i\equiv\frac{C_i}{Y_i}$ is the pollution-production factor or emissions intensity which indicates the emissions per unit of output.

1- Logarithmic Mean Divisia Index

Rodríguez and Pena-Boquete (2017) have applied a similar variable for pollution emitted from energy products. We examined different pollutants that have been aggregated into CO_2 equivalent using the multiplication factors. The main pollutants emitted from agricultural activities are N_2O and CH_4 presented in terms of CO_2 equivalent using the corresponding multiplication factors. Also, the emitted CO_2 from forestry and rangeland activities has been added to aggregated emissions of CH_4 and N_2O, forming the total emissions from the agricultural activities.

In the regression analysis applied to examine the driving forces of the emissions intensity in Iranian agriculture activities, in addition to the variables developed in the decomposition analysis (X variables), we further considered variables examined in the literature (Y variables). Thus, the general form of the estimated equation can be presented as follows (5):

$$lnPI_t = \beta_1 + \beta_2 lnX_t + \beta_3 lnY_t + u_t \quad (5)$$

The X-class of the variables includes those that are calculated based on the decomposition analysis (Zhang *et al.*, 2019) technique developed by Ang (2015):

$$\Delta PI = PI^t - PI^0 = \sum_i L_i \cdot ln\frac{CY_{i.t}}{CY_{i.0}}{}_i + \sum_i L_i \cdot ln\frac{YY_{i.t}}{YY_{i.0}} + \sum_i L_i \cdot ln\frac{YP_t}{YP_0} L_i + \sum_i L_i \cdot ln\frac{PL_t}{PL_0} + \sum_i L_i \cdot ln\frac{LY_t}{LY_0} \quad (6)$$

$$L_i = (PI_{i.t} - PI_{i.0})/(lnPI_{i.t} - lnPI_{i.0}) \qquad PI_{i.t} \neq PI_{i.0} \quad (7)$$

$$L_i = PI_{i.t} \; PI_{i.t} = PI_{i.0} \quad (8)$$

Output composition was also applied as determinant of Y-class of the explanatory variables. Zhu and Lin (Xu and Lin, 2017) examined the determinants of emissions intensity in Chinese agriculture using structural variables including energy consumption, urbanization, the population in the agricultural sector, per capita output, and energy intensity. In the same vein, Moyen Uddin (2020) applied agricultural output share, energy consumption, trade openness, and urbanization to examine the pollution emissions through a sample of countries. Regarding the empirical works reviewed, there are some points deserving to be noted. First, to the best of our knowledge, they examined the pollution emitted from the consumption of energy in the agricultural sector. While, emission from the chemical inputs is significant as well. However, due to the data limitation, we used the output level of agronomy and horticultural activities as a proxy for chemical inputs. A significant part of pollution emissions belongs to livestock activities. Thus, the output of these activities was considered in estimation as well. In addition, like the reviewed literature, the output composition and the production structure were taken into consideration using output share of livestock activities in total agricultural output. Moyen Uddin (2020) applied agricultural output share and its quadratic variable, which allow examining the non-linear effect of the variable:

$$lnPI_t = \beta_0 + \sum_{i=1}^{3} \beta_i \, lnCY_i + \beta_4 YYLv + \beta_5 (YYLv)^2 + \beta_6 lnYP + \beta_7 lnPL + \beta_8 lnLY + \beta_9 lnYAg + \beta_{10} lnYLv + \beta_{11} YFo + \beta_{12} U + \beta_{13} TO + u_t \quad (9)$$

In Eq. 9 only livestock output share ($YYLv$) has been included. It is worth noting that the output share of agricultural sectors including livestock and agronomy and horticultural subsectors are highly correlated (-0.98). Thus, we applied only livestock output share in estimated equation. Other explanatory variables are agronomy and horticultural activities output (YAg), livestock output (YLv), forestry and rangeland output (YFo), urbanization (U), and trade openness index (TO). In line with Malakootikhah and Farajzadeh (2020), trade openness was examined using Trade-GDP ratio. In other words, more openness of the economy has been considered as higher trade with respect to the GDP. Rao (2010) suggested a spillover effect for trade that induces technology and productivity improvement, leading to higher economic growth. Eq. 3 was estimated for CH_4, N_2O, and CO_2 equivalent separately.

Data

The applied data are time series of the introduced variables, relating to 1973-2016. The examined pollutants are CH_4, N_2O, and CO_2. The emissions date obtained from the database related to FAO (2017) and the other data are available in database related to the Central Bank of Iran (2017).

Results and Discussion

The results include decomposition analysis of the emission intensity into the components and regression analysis, presented for each pollutant separately. For all specifications, the data stationarity was tested using the Augmented Dickey Fuller test and Durbin-Wu-Hausman test was used to examine the variables erogeneity. Based on the results, all variables were found to be stationary. In addition, the null hypothesis of explanatory variables indigeneity was rejected. It is also worth noting that in all equations the first lag of dependent variable was used to dampen the autocorrelation problem. The lagged-dependent variables are correlated with error terms (Baltagi, 2008) which results in endogeneity problem, thus, the GMM[1] estimation method was applied.

CH_4

Emissions intensity of CH_4 has been decreased by over 3.9% annually. The emissions intensity components are illustrated in Fig. 1. Aggregate (total) emissions intensity has been decreasing over the study horizon, which has mainly been resulted from inverse labor productivity and subsectors emissions intensity. The output composition has contributed to dampen the emission intensity in the early years of the study horizon; however, its contribution has not changed significantly in the following years. Inverse productivity has induced an annual reduction of 1.4%, followed by subsectors' emission intensity by around 0.6% and output composition by 0.3%. Contrary to these components, output scale or per capita output shows a significant intensity increasing effect, leading to 0.75% annual increase in emissions intensity. Inverse employment also illustrates an insignificant but positive effect on emissions intensity. Table 1 presents the regression results for CH_4.

Most of the variables show a statistically significant effect on emissions intensity. Among the applied variables, the coefficients of livestock output share, urbanization and trade openness are not statistically significant. In addition, the non-linear relation for livestock output share was not confirmed.

As expected, an increase in emission intensity in agronomy and horticulture, and livestock induces an increase in aggregate emission intensity. However, there are significant differences in terms of their effects (coefficient). Accordingly, 1% increase in emission intensity of CH_4 in agronomy and horticultural sectors results in higher aggregate emission intensity of agriculture by 0.3% while the corresponding value for livestock sector is 0.8%. It is worth noting that livestock activities account for most of the CH_4 emission of agriculture. This significant role of the livestock activities in CH_4 emission intensity is observed via output level since a 1% rise in livestock activities output is expected to increase the CH_4 emission intensity by over 0.9%.

Inverse employment is another important variable that affects the CH_4 in agriculture significantly and positively. However, its coefficient's absolute value is not considerable. Based on the definition, the higher values for this variable mean higher dependency burden and the pressure imposed by a higher population, which is expected to put more pressure on natural resources and to raise the attempts to increase the output via using more polluting inputs.

As mentioned before, higher output in agronomy and horticultural sector may dampen the CH_4 emissions in agriculture since these activities are less emitting CH_4 compared to the livestock activities and have lower CH_4 emission intensity. According to the coefficient obtained, 1% increase in output of agronomy and horticulture sector is expected to decrease the CH_4 emission intensity of CH_4 in agriculture by over 0.9%. Per capita output also shows an emission intensity dampening effect; however, in terms of the absolute value, its effect is negligible. Higher per capita output may be accompanied by more efficient use of the production factors.

Urbanization and trade openness failed to have a statistically significant effect on the CH_4 emission intensity. In other words, CH_4 emission intensity is mainly derived from the agriculture sector itself. However, the lagged dependent variable also should be considered since it may include the delay effect of the variables. It is worth noting that this variable is applied to dampen the autocorrelation problem (Baltagi, 2008). It should also be noted that this variable may include the measuring errors (McKinnish, 2005), leading to downward bias in the estimated coefficients such that the corresponding value of the coefficient may not be appropriate to calculate the long run effect (Reed and Zhu, 2017).

The diagnostic statistics presented in Table 1 also confirm the appropriateness of the estimated equation. The applied explanatory variables can explain more than 99% of variations in the CH_4 emission intensity. The Ljung–Box Q-statistics also indicate that the residuals are not significantly correlated.

N_2O

N_2O emission intensity has been decreasing slightly over the study period by annual rate of 2.63%, reaching from 1.77 to 0.56 Kg/million Rials. However, the decreasing trend turned to be

1- Generalized Method of Moments

more speeding in the last years and it has decreased by 8.4% annually over 2008-2016. Fig. 2 illustrates the general trend of N_2O emission and the corresponding components. The aggregate (total) emission intensity shows a decreasing trend with insignificant fluctuations. Among the components, inverse of labor productivity, emission intensity of sectors and output composition show negative effects on N_2O emission intensity, while inverse employment and output scale are expected to increase total emission intensity. In terms of the absolute value of the effects, emission intensity of sectors, output composition, and inverse employment rate affect by as low as 0.02% or lower, while the remaining components also have no significant effect since their corresponding values are less than 0.1%. As for CH_4, the most influencing factors of N_2O emission intensity are output scale and labor productivity. The former leads to higher emission intensity and the latter dampens it.

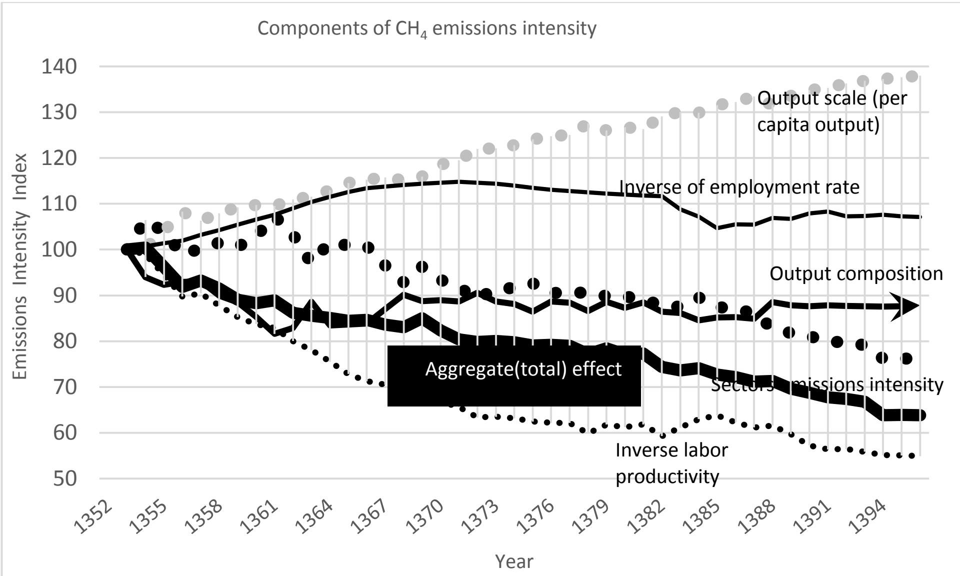

Fig. 1- CH_4 emissions intensity and its components over 1973-2016

Table 1- Regression results for CH_4 emissions intensity model over 1973-2016.

Variable	Coefficient	Standard error	t-statistics	
Constant	0.381	0.887	0.42	
CH_4 emissions intensity in agronomy and horticulture sector	0.257***	0.012	12.20	
CH_4 emissions intensity in livestock sector	0.824***	0.009	86.63	
Output share of livestock sector	-0.057	2.202	-0.026	
Squared of output share of livestock sector	-2.998**	1.136	-2.63	
Agriculture per capita output	-0.055*	0.028	-1.94	
Inverse of employment rate	0.028***	0.005	5.15	
Output of agronomy and horticulture sector	-0.912***	0.330	-2.75	
Output of livestock sector	-0.926***	0.323	2.85	
Urbanization	-0.014	0.060	-0.23	
Trade openness	-0.000	0.005	-0.09	
Lagged dependent variable	-0.017***	0.006	-2.53	
Statistics	Adjusted R^2	J-statistics	Q*(1)	Q(2)
	0.999	7.41(0.59)	).55(٠0.34	).80(٠0.42

The levels of statistical significance are denoted with ***, **, and * for 1%, 5%, and 10%, respectively.

*Q(p) is the significance level of the Ljung –Box statistics in which the first p of the residual autocorrelations is jointly equal to zero.

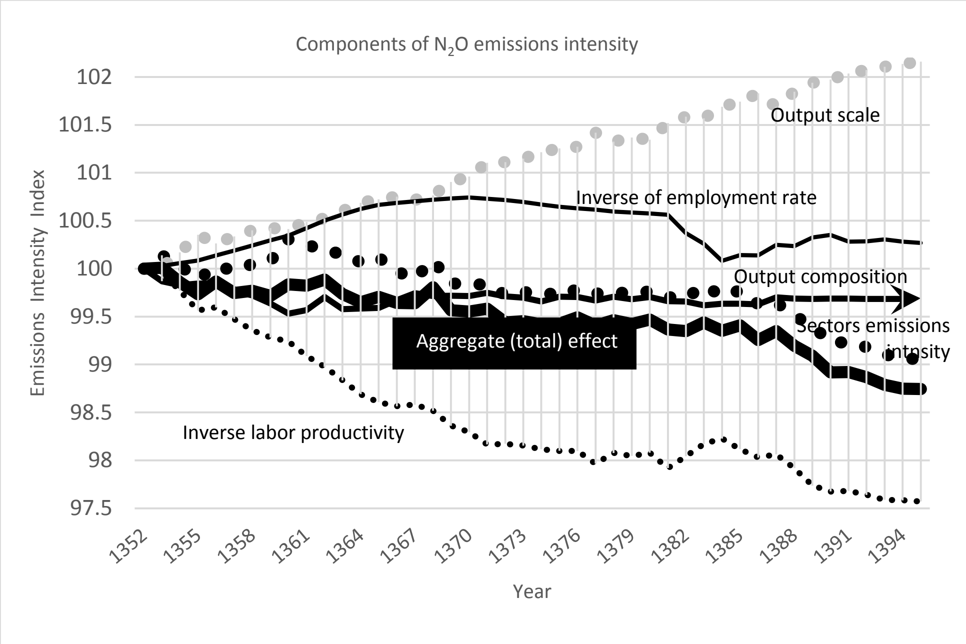

Fig. 2- N_2O emissions intensity and its components over 1973-2016

Agricultural per capita output is the only one that has failed to affect the N_2O emission intensity (Table 2). An inverse U-shaped non-linear relationship was also found between emission intensity and the output share of livestock sector. Based on the relationship, the turning point will occur in the value of 0.77 for emission intensity that regarding the current values of the emission intensity, the emission of N_2O is on the way of climbing up the path.

As the results show, 1% increase in N_2O emission intensity in agronomy and horticulture sector is as strong enough to raise the aggregate (total) emission intensity of agriculture by 0.47%. The corresponding value for livestock sector is around 0.5%. The interesting point is that, while emission intensity and the output share of livestock subsector affect the aggregate emission intensity positively, the corresponding output induces a reduction in emission intensity. Accordingly, 1% increase in livestock activities may reduce the aggregate emission intensity of N_2O by 3.34%. It should be noted that the estimated coefficient for output is interpreted while the effects of other variables are assumed to be unchanged. In other words, output increase in livestock sector should be examined while the output share of this subsector is assumed to be unchanged which is possible if the output of other subsectors increases. On the other hand, agronomy and horticultural sector have an intensity increasing effect and 1% increase in the output is expected to increase the emission intensity by 3.36%. Output expansion via more use of chemical inputs containing this pollutant may increase the N_2O emission intensity dramatically.

Contrary to CH_4, inverse employment has a negative relationship with N_2O emission intensity. In other words, higher dependency burden will dampen the emission intensity. However, its effect is slight. Trade openness reveals a statistically significant effect at 10% with a negligible coefficient. The estimation results showed that urbanization has a negative effect on emission intensity and 1% higher urban population will be accompanied by 0.26% lower emission intensity. However, it is worth noting that the current percentage of urban population is 75 (Central Bank of Iran, 2017), leaving not too much room for higher urbanization. The lagged dependent variable also shows a significant effect with slight value.

Total Agricultural Emissions

The total emission of agriculture including CH_4, N_2O, and CO_2 were aggregated into CO_2-equivalent[1]. As shown in Fig. 3, the general trend is decreasing and like CH_4 and N_2O, output scale plays the most significant role in increasing emission intensity. While, inverse labor productivity has a significant contribution in

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١- The multiplication factor to aggregate N_2O and CH_4 into CO_2-equivalent are 310 and 21, respectively (United Nations, 2010).

lowering emission intensity. The intensity factor of sectors plays the role of intensity reducing effect. However, output composition and inverse employment rate (dependency burden) have no considerable effects

Table 2- Regression results for N_2O emissions intensity model over 1973-2016.

Variable	**Coefficient**	**Standard error**	**t-statistics**	
Constant	-9.804***	3.671	-2.67	
N_2O emissions intensity in agronomy and horticulture sector	0.472***	0.012	40.58	
N_2O emissions intensity in livestock sector	0.503***	0.016	30.72	
Output share of livestock sector	28.079***	9.982	2.81	
Squared of output share of livestock sector	-18.288***	5.297	-3.45	
Agriculture per capita output	-0.016	0.047	-0.34	
Inverse of employment rate	-0.021**	0.010	-2.02	
Output of agronomy and horticulture sector	3.363**	1.418	2.37	
Output of livestock sector	-3.335**	1.422	-2.34	
Urbanization	-0.265***	0.082	-3.22	
Trade openness	-0.012*	0.006	-1.85	
Lagged dependent variable	0.025***	0.006	4.22	
Statistics	Adjusted R^2	J-statistics	Q*(1)	Q(2)
	0.999	3.57(0.89)	0.24(1.37)	0.15(3.70)

The levels of statistical significance are denoted with ***, **, and * for 1%, 5%, and 10% respectively.
*Q(p) is the significance level of the Ljung –Box statistics in which the first p of the residual autocorrelations is jointly equal to zero.

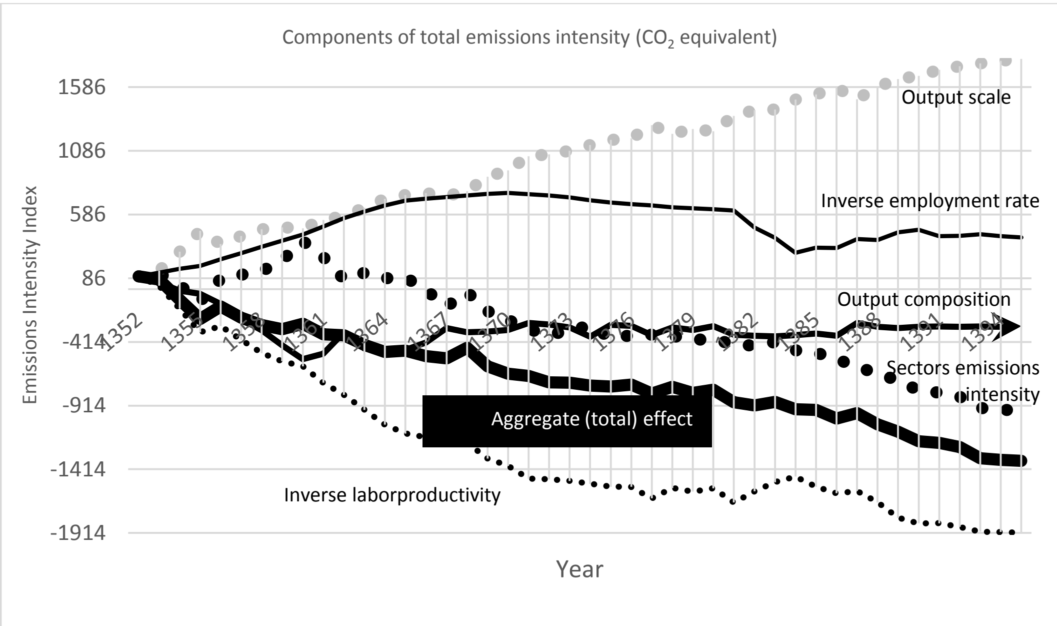

Fig. 3- Total emissions intensity (CO_2 equivalent) and its components over 1973-2016

The results of estimated equation are presented in Table 3. Per capita output is the only variable that has failed to affect emission intensity significantly. Increase in emission intensity of agronomy and horticulture sector by 1% will increase the emission intensity of CO_2 equivalent by around 0.24%. It is worth noting that this variable increases the emission intensity of both CH_4 and N_2O. The corresponding value for livestock sector's emission intensity is 0.6%. The significant contribution of livestock sector to CH_4 emissions is the underlying reason (Table 1). Forestry and rangeland have insignificant role in CO_2 emission. Accordingly, the corresponding coefficient is slight (0.16).

As shown in Table 3, there is an inverted U-shaped non-linear relationship between CO_2 equivalent emission intensity and livestock output share. The turning point value for this variable is 37 percent. Thus, the emission intensity will tend to dampen after approaching this value. The current output share of livestock sector is close to this value.

An increase in the output of agronomy and horticulture sector will induce a reduction in emission intensity, while higher output in livestock and forestry leads to higher emission intensity. This fact for livestock sector stems from its significant role in CH_4 emission. In the same vein, the lower contribution of agronomy and horticulture in CH_4 emission is why this sector induces a reduction in CO_2-equivalent emission intensity.

Among the variables with negative effects on emissions intensity, the inverse employment and trade openness, in terms of the magnitude of the coefficients, have slight effect. In addition, the effect of urbanization is not considerable.

This specification also shows an adjusted-R^2 as high as 99%. In addition, the Ljung–Box Q-statistics indicates that the residuals are not significantly correlated.

Table 3- Regression results for total emissions intensity model over 1973-2016.

Variable	Coefficient	Standard error	t-statistics	
Constant	-0.553***	0.457	-1.21	
Emissions intensity in agronomy and horticulture sector	0.236***	0.008	27.78	
Emissions intensity in livestock sector	0.586***	0.012	48.52	
Emissions intensity in forestry and rangeland sector	0.159***	0.026	6.05	
Output share of livestock sector	1.693***	0.582	2.90	
Squared of output share of livestock sector	-2.289***	0.448	-5.11	
Agriculture per capita output	-0.036	0.037	-0.96	
Inverse of employment rate	-0.040***	0.012	-3.13	
Output of agronomy and horticulture sector	-0.326***	0.090	-3.59	
Output of livestock sector	0.261***	0.082	3.16	
Output of forestry and rangeland sector	0.119***	0.027	4.34	
Urbanization	-0.112*	0.062	-1.79	
Trade openness	-0.014***	0.003	-4.31	
Lagged dependent variable	0.020**	0.008	2.33	
Statistics	Adjusted R^2	J-statistics	Q*(1)	Q(2)
	0.999	8.46(0.67)	)0.26(1.25	)0.41(1.76

The levels of statistical significance are denoted with ***, **, and * for 1%, 5%, and 10% respectively.

*Q(p) is the significance level of the Ljung –Box statistics in which the first p of the residual autocorrelations is jointly equal to zero.

Conclusion

As far as pollution emission has been considered, emission from energy use has received the most attention. However, the emission from production process also shouldn't be ignored. Among the pollutants, agriculture plays a significant role in CH_4 and N_2O emission from production process (Farajzadeh, 2012). This fact has been addressed by the current study in which the emission intensity of the pollutants and the corresponding determinants has been examined. Emission intensity was investigated using decomposition analysis in which the emission intensity of agricultural production process was decomposed into the related components. Then, the role of the components was examined using regression analysis. The considered pollutants are CH_4, N_2O, and CO_2. Livestock activities play significant role in CH_4 emission, while the contribution of agronomy and horticultural output to N_2O emission is more important than other activities (FAO, 2017). Over the study horizon, the emission of the mentioned pollutants has been increasing; however, the emission intensity shows a decreasing trend. In other words, the output of the agricultural activities has been expanded much further compared to the corresponding pollutants emission.

The aggregate emissions of the selected pollutants, measured in terms of CO_2 equivalent, increased by 0.8% annually over the study horizon; however, the emission intensity decreased around 3.5%. Thus, agriculture output has experienced a significant expansion with movement toward less polluting composition. Contrary to these results, there are empirical works showing the increasing emission intensity in Chinese agriculture, which mainly results from intensive use of chemical inputs (Fischer *et al.,* 2010; Li *et al.,* 2014; Nayak *et al.,* 2015). In Iran, chemical inputs also play a significant role in the emission of N_2O in agronomy and horticultural activities. However, livestock activities emit more than two times of agronomy and horticultural activities. Contrary to this fact, emission from livestock and other agricultural activities has not been significantly considered and the attempts are limited to development of strategies to reduce the pollutants emission at the farm level (Zhang *et al.,* 2017). Investigation of the pollutants emission at the sectoral level of agriculture is closely related to the literature at the macroeconomic level. Moyen Uddin (2020) is one of the rare empirical works that applies the macroeconomic variables such as income, urbanization, and trade openness to examine the emission intensity of agricultural activities.

The current study contributes to the literature since it examines the emission from production process. To the best of our knowledge, there are rare works dealing with the pollution emission in Iranian agriculture and some cases like Zibaei and Tarazkar (Zhang *et al.,* 2019) have only addressed the energy consumption in agriculture. Iranian agriculture accounts for only 3.5% of energy consumption, while produces 9% of GDP (Central Bank of Iran, 2017). While most of the current literature addresses the emissions from energy use at the whole of economy, decomposition analysis is useful to take further steps and examine other sources of pollutants emission. The advantage of this approach is that it helps to determine the driving forces of emission intensity (Zhang *et al.,* 2019). Based on this technique, the sectors' emission intensity, output composition, and output level were found to be determinants of emission intensity in agriculture. However, it was revealed that, in terms of the extent of the effect, there are some cases that decomposition analysis shows a slight inconsistency with regression analysis. A similar inconsistency has been reported by Dong *et al.* (Dong *et al.,* 2018). Specificantly, the variable per capita output shows an important increasing role in decomposition analysis, while in the regression analysis it fails to contribute to emission intensity. There are some possible reasons for this inconsistency. First, decomposition analysis applies limited variables compared to the regressions analysis. This point has been suggested as a limitation in Zhang *et al.* (Zhang *et al.,* 2019). In the current study we have used more driving forces like urbanization and trade openness in the regression analysis that are not applicable in the decomposition analysis. The second reason is related to the type of models applied. In the decomposition analysis whole of the dependent variable (emission intensity) changes are assigned to the applied variables, while in the regression analysis, a part of the changes is assigned to residual and constant terms which include those parts of changes that are not explained by explanatory or determinant variables. The third difference relates to the form of the variables applied. For instance, while the output composition factor is applied as an aggregated variable in decomposition analysis, in the regression analysis, a specific variable for each sector is used and three variables for agricultural sectors are defined. In addition, in order to address the possibility of non-linear relationship, some variables are applied in quadratic form in regression analysis. The current study also enjoyed this possibility in which output share of livestock sector was applied in quadratic form and was found to be highly significant. Moyen Uddin (2020) also confirms the contribution of these variables. Thus, it is worth noting that decomposition analysis is powerful in determining the driving forces; however, the variables developed by this technique are not enough necessarily. It assigns the whole of changes to a limited group of variables. However, the determined variables are useful for prediction of the dependent variable. In other words, it is possible to predict the dependent variable using a limited number of variables. The variables developed by decomposition analysis may include the effect of other variables applied in regression analysis. Therefore, we may rely more on regression results, while the contribution of decomposition analysis is also important and helpful especially in developing the driving forces.

Based on the regression results, output level of agricultural sectors is an important variable; however, the direction of their effects on the emission intensity of CH_4 and N_2O is not the same. Output expansion in agronomy and horticulture sector induces an increase in N_2O emission intensity, while it dampens the CH_4 emission intensity. The order is reversed for output rise in livestock sector. In other words, agronomy and horticulture sector is more involved in N_2O emission and livestock activities are more related to CH_4 emission. The sectors emission intensity coefficients also confirm these findings. Changes in output composition more inclined toward agronomy and horticultural (livestock) activities will raise emissions intensity of N_2O (CH_4). Macroeconomic variables like urbanization, trade openness and per capita output didn't reveal significant effects on emission intensity which is in line with findings of Moyen Uddin (2020). Therefore, the strategies developed to reduce the emission intensity can not be the same for livestock and agronomy and horticultural activities. There is a tradeoff between the pollutants emission and relying more on one sector to reduce the emission intensity will raise emission intensity in another sector. Placing restrictions on one sector will lead the production inputs to other sectors, resulting in higher emissions intensity in other sectors.

Based on the findings, the following policy implications are recommended:

1. In order to reduce CH_4 emissions intensity, the strategies should address the livestock activities, while for N_2O, agronomy and horticultural activities are more related. Thus, developing sector- or activity-specific strategies are recommended.
2. Macroeconomic variables have no significant effect on emission intensity of the selected pollutants in agriculture. Therefore, agriculture-specific strategies especially at the farm level are recommended.
3. Although trade openness failed to affect the emission intensity significantly, it is worth noting that it doesn't do with emission increase and trade openness has no more limitation from the emission point of view. This is important since the literature shows a significant potential of gains achievable from international trade.
4. The decomposition analysis and regression analysis are not rivals or substitutes and the weaknesses of decomposition analysis including limited variables and being numerical instead of statistical can be resolved. On the other hand, some estimation problems like the number of observations and multi collinearity bias are not the case in decomposition analysis. Thus, it is recommended to use both techniques simultaneously.

References

1. Alam, S., and A. Fatima. 2007. Sustainable development in Pakistan: the context of energy consumption demands and environmental degradation. Journal of Asian Economics, 18: 825–837.
2. Ang, B.W. 2015. LMDI decomposition approach: A guide for implementation. Energy Policy 86: 233–238.
3. Baltagi, B.H. 2008. Econometric Analysis of Panel Data. Chichester, John Wiley & Sons Ltd.
4. Barghi Oskooi, M.M. 2008. Effects of trade liberalization on emissions (Carbon Dioxide) in the Kuznets environmental curve. Journal of Economic Research, 82: 1-21. (In Persian)
5. Barrios, S., L. Bertinelli, and E. Strobl. 2006. Climatic change and rural–urban migration: The case of sub-Saharan Africa. Journal of Urban Economics, 60: 357-351.
6. Behboodi, D., F. Fallahi, and I. Barghi Golazani. 2010. Economic and social factors affecting the per capita carbon dioxide emissions in Iran (1383-1346). Journal of Economic Research 90: 1-17. (In Persian)
7. Central Bank of Iran. 2017. Available at: http://tsd.cbi.ir/Display/Content.aspx.
8. Cramer, J.C. 2002. Population growth and local air pollution: Methods, models, and results. Population and Development Review, 28(1): 22-52.
9. Dong, F., B. Yu, T. Hadachin, Y. Dai, Y. Wang, S. Zhang, and R. Long. 2018. Drivers of carbon emission intensity change in China. Resources, Conservation and Recycling, 129: 187-201.
10. European Commission. 2010. Food, Farming, Fisheries. Retrieved from https://ec.europa.eu/food/safety/chemical_safety/contaminants/catalogue/aflatoxins_en
11. Fan, Y., L.C. Lui, and G. Wu. 2006. Analyzing impact factors of CO_2 emission using STIRPAT model.

Environmental Impact Assessment Review 4: 377– 395.
12. FAO (Food and Agriculture Organization). 2017. Retrieved from http://www.fao.org/faostat/en/#home
13. Farajzadeh, Z. 2012. Environmental and Welfare Impacts of Trade and Energy Policy Reforms in Iran. Ph.D thesis. Shiraz University, Shiraz, Iran. (In Persian)
14. Farajzadeh, Z. 2018. Emissions tax in Iran: Incorporating pollution disutility in a welfare analysis. Journal of Cleaner Production 186: 618-631.
15. Farajzadeh, Z., and M. Bakhshoodeh. 2015. Economic and environmental analyses of Iranian energy subsidy reform using Computable General Equilibrium (CGE) Model. Energy for Sustainable Development, 27: 147-154.
16. Fischer, G., W. Winiwarter, T. Ermolieva, G. Y. Cao, and H. Qui. 2010. Integrated modeling framework for assessment and mitigation of nitrogen pollution from agriculture: Concept and case study for China. Agriculture, Ecosystem and Environment, 136 (1–2): 116–124.
17. Han, X., T. Cao, and T. Sun. 2019. Analysis on the variation rule and influencing factors of energy consumption carbon emission intensity in China's urbanization construction. Journal of Cleaner Production, 238: 117-958.
18. Hübler, M. 2009. Energy saving technology diffusion via FDI and trade: A CGE model of China. In: Kiel Working Papers 1479. Kiel Institute for the World Economy.
19. Iran’s Energy Balance. 2016. Deputy of Electricity and Energy Affairs, Ministry of Energy. http://pep.moe.org.ir.
20. Jones, D. 1991. How urbanization affects energy-use in developing countries. Energy Policy, 19(7): 621-630.
21. Kasman, A., and Y.S. Duman. 2015. CO_2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. Economic Modeling, 44: 97–103.
22. Li, W., Q.X. Ou, and Y.L. Chen. 2014. Decomposition of China's CO_2 emissions from agriculture utilizing an improved Kaya identity. Environmental Science Pollution Research, 21(22): 13000–13006.
23. Lin, S., D. Zhao, and D. Marinova. 2009. Analysis of the environmental Kuznets curve for CO_2: Evidence from pooled Mean Group. Economic Letters, 82(1): 121-126.
24. Ma, S.Z., and H. Feng. 2013. Will the decline of efficiency in China's agriculture come to an end? An analysis based on opening and convergence. China Economic Review, 27: 179–190.
25. Malakootikhah, Z., and Z. Farajzadeh. 2020. Climate change impact on agriculture value added. Agricultural Economics and Development, 111: 1-30. (In Persian)
26. Manahan, S. 2010. Environmental Chemistry. (9th Ed.). Boca Raton, FL, USA, CRC Press.
27. Marrero, G. 2010. Greenhouse gases emissions, growth and energy mix in Europe. Energy Economics, 32: 1356-1363.
28. McKinnish, T. 2005. Lagged dependent variables and specification bias. Economics Letters, 88(1): 55-59.
29. Monchuk, D. C., Z. Chen, and Y. Bonaparte. 2010. Explaining production inefficiency in China's agriculture using data envelopment analysis and semi-parametric bootstrapping. China Economic Review, 21(2): 346–354.
30. Moyen Uddin, M.M. 2020. What are the dynamic links between agriculture and manufacturing growth and environmental degradation? Evidence from different panel income countries. Environmental and Sustainability Indicators 7: 100041.
31. Nayak, D., E. Saetnan, K. Cheng, W. Wang, and F. Koslowski. 2015. Management opportunities to mitigate greenhouse gas emissions from Chinese agriculture. Agriculture Ecosystem and Environment 209: 108–124.
32. Poumanyvong, P., and S. Kaneko. 2010. Does urbanization lead to less energy use and lower CO_2 emissions? A cross-country analysis. Ecological Economics, 70 (2): 434-444.
33. Rao, B.B. 2010. Estimates of the steady state growth rates for selected Asian countries with an extended Solow model. Economic Modelling, 27: 46–53.
34. Reed, W. R., and M. Zhu. 2017. On estimating long-run effects in models with lagged dependent variables. Economic Modelling, 64: 302-311.
35. Rodríguez, M., and Y. Pena-Boquete. 2017. Carbon intensity changes in the Asian dragons: Lessons for climate policy design. Energy Economics, 66: 17-26.

36. Sadorsky, P. 2013. Do urbanization and industrialization affect energy intensity in developing countries?. Energy Economics, 37: 52-59.
37. Shahbaz, M., S. J. H. Shahzad, N. Ahmad, and S. Alam. 2016. Financial development and environmental quality: The way forward. Energy Policy 98: 353-364.
38. Shi, A. 2003. The impact of pressure on global carbon dioxide emission, 1975-1996, Evidence from pooled cross country data. Ecological Economics, 44: 29 – 42.
39. Taylor, L., A. Rezaei, R. Kumar, N. H. Barbosa-Filho, and L. Carvalho. 2014. Wage increase, transfers, and the socially determined income distribution in the USA. Working papers Series 11, Institute for New Economic Thinking.
40. UNDP (United Nations Development Programme). 2010. Department of Environment. Iran Second National Communication to United Nations Framework Convention on Climate Change (UNFCCC). National Climate Change Office, Department of Environment, Tehran.
41. United Nations. 2010. United Nations Development Program, Department of Environment. Iran second National Communication to United Nations Framework Convention on Climate Change (UNFCCC). National Climate Change Office, Department of Environment, Tehran, Iran.
42. Wan, N. F., X.Y. Ji, J.X. Jiang, H. X. Qiao, and K.H. Huang. 2013. A methodological approach to assess the combined reduction of chemical pesticides and chemical fertilizers for low-carbon agriculture. Ecological Indicator, 24: 344–352
43. Wang, C., J. Chen, and J. Zhou. 2005. Decomposition of energy-related CO_2 emission in China. Energy Economics 30: 73–83.
44. Wei, Y.M., L.C. Liu, Y. Fan, and G. Wu. 2008. China Energy Report: CO_2 Emissions Research. Science Press, Beijing, China.
45. World Bank 2016. Data. Retrieved from https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2014&start=1960
46. Wu, L., S. Kaneko, and S. Matsuoka. 2005. Driving forces behind the stagnancy of China's energy-related CO_2 emissions from 1996 to 1999: The relative importance of structural change, intensity change and scale change. Energy Policy 33: 319–335.
47. Xu, B., and B. Lin. 2017. Factors affecting CO_2 emissions in China’s agriculture sector: Evidence from geographically weighted regression model. Energy Policy, 104: 404-414.
48. York, R., E.A. Rosa, and T. Dietz, 2003. Footprints on the earth: The environmental consequences of modernity. American Sociological Review, 68(2): 279-300.
49. York, R., E.A. Rosa, and T. Dietz. 2003. STIRPAT, IPAT and ImPACT: Analytic tools for unpacking the driving forces of environmental impacts. Ecological Economics, 46(3): 351-365.
50. Zhang, C., B. Su, K. Zhou, and S. Yang. 2019. Decomposition analysis of China's CO_2 emissions (2000–2016) and scenario analysis of its carbon intensity targets in 2020 and 2030. Science of Total Environment 668: 432-442. Y.
51. Zhang, P., and Hao. 2020. Rethinking China's environmental target responsibility system: Province-level convergence analysis of pollutant emission intensities in China. Journal of Cleaner Production, 242: 118472.
52. Zhang, Y., A.L. Collins, P.J. Johnes, and J.I. Jones. 2017. Projected impacts of increased uptake of source control mitigation measures on agricultural diffuse pollution emissions to water and air. Land Use Policy, 62: 185–201.
53. Zibaei, M., and M.H. Tarazkar. 2004. Investigating short-term and long-term relationships between value added and energy consumption in the agricultural sector. Journal of Agricultural Bank, 6: 157-171. (In Persian)

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عوامل مؤثر بر شدت انتشار آلاینده‌های تولید بخش کشاورزی

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چکیده

منشأ اصلی انتشار آلاینده‌ها در ایران حامل‌های انرژی است، اما در مورد اکسیددی‌نیتروژن و متان فرآیند تولید کشاورزی نقش مهمی دارد. در همین راستا، مطالعه حاضر با هدف تحلیل شدت انتشار آلاینده‌های منتخب در بخش کشاورزی و ارزیابی عوامل تعیین‌کننده آن صورت گرفت. برای این منظور ابتدا با استفاده از روش تحلیل تجزیه، شدت انتشار در بخش کشاورزی به اجزای آن تجزیه گردید. سپس با استفاده از تحلیل رگرسیون نقش عوامل تعیین‌کننده در شدت انتشار ارزیابی شد. آلاینده‌های منتخب در بخش کشاورزی شامل متان، اکسیددی‌نیتروزن و دی‌اکسیدکربن منتشرشده از فرآیند تولید و دوره مطالعه شامل ۹۵-۱۳۵۲ می‌باشد. یافته‌ها نشان داد شدت انتشار متان و اکسیددی‌نیتروژن در دوره مطالعه سالانه ۳/۹ و ۲/۶ درصد در حال کاهش بوده است. سطح تولید در زیربخش‌های کشاورزی عامل مهمی در شدت انتشار است. به این ترتیب که انتظار می‌رود یک درصد افزایش در سطح تولید زیربخش دام شدت انتشار متان را ۰/۹ درصد افزایش و شدت انتشار اکسیددی‌نیتروژن را بیش از ۳/۳ درصد کاهش دهد. از سوی دیگر همین میزان افزایش در سطح تولید زیربخش زراعت و باغبانی شدت انتشار متان را ۰/۹ درصد کاهش و شدت انتشار اکسیددی‌نیتروژن را بیش از ۳/۳ درصد افزایش خواهد داد. اثر متغیرهای کلان اقتصاد ایران شامل نرخ شهرنشینی و درجه بازبودن اقتصاد بر شدت انتشار در بخش کشاورزی چندان حایز اهمیت ارزیابی نشد. به این ترتیب سیاست‌های اتخاذشده برای کاهش شدت انتشار باید متمرکز بر متغیرهای بخش کشاورزی و بصورت مجزا در هر زیربخش دنبال شود.

واژه‌های کلیدی: اکسیددی‌نیتروژن، بخش‌کشاورزی، شدت انتشار، متان

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Investigating the Effect of Green Subsidies on Employment, Investment and Value added of Iran's Agricultural Sector Using the CGE Model

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Abstract

One of the most important economic policies in most countries is to support producers or consumers through subsidies. The category of green subsidies has been proposed in the direction of agricultural development, which is in line with the law on targeted subsidies, but in a real way. Green subsidies belong to farmers and are used to boost business and industry in the agricultural sector. The purpose of this study is to investigate the effects of Iran's accession to the World Trade Organization by applying a simulated green subsidy policy on the variables of employment, investment, and value added in the agricultural sector, which is designed in the form of 20%, 50% and 100% scenarios. The model was calibrated using the social accounting matrix of 2011 and the baseline scenario (0% of green subsidies). GAMS software was used to analyze the data in this research. The results show an increase in employment in the agricultural sector during the effects of Iran's accession to the World Trade Organization and by applying the green subsidy simulation policy, in 20, 50 and 100% scenarios. Also, the implementation of green subsidy policy has led to an increase in investment in the agricultural sector.This is due to the increased production in this sector and as a result, increase in the use of intermediate inputs. The results obtained from the mentioned shocks show that value added in the agricultural sector has an upward trend, which is due to the increase in the use of factors of production in this sector.

Keywords: Agriculture section, CGE model, Green Subsidy, World Trade Organization

Introduction

Based on the market economy system, the extent of government presence and intervention in the economy is analyzed based on its advantages and disadvantages (Barton, 2011). One of the most important economic policies in most countries is to support producers or consumers through subsidies. Agricultural subsidies have long been a constant feature of government policies to influence their use (Bellmann, 2019). Supporting theagricultural products has been accepted due to its role in establishing food security and high risk in agricultural production. This is even more important in developing countries where the agricultural sector plays a key role in their economic and social development.Even the World Trade Organization has authorized the use of certain supportive methods by

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governments (Jalali, 2010). In the WTO, all measures and assistance provided by the government or public institutions to agricultural producers so that they can produce and supply agricultural products at more reasonable prices are classified as "internal support". Public services and related support; such as research, pest and disease control, education services, marketing services, infrastructure services, etc. or public storage support to ensure food security, support for farmers' incomes subject to their separation from production, disaster compensation payments. The government has no advantage over farmers in disadvantaged areas. The developments of the last decade in the field of world economy and trade have had a wide reflection on the domestic economies of countries, especially developing countries. One of the most important consequences of these developments is the need to link the process of economic development of countries with the forces and factors of the global economy. The WTO today is one of the foundations of globalization, especially in the field of economics. Countries that are not one of the members of this organization, also try to become a member to achieve economic and industrial development by using the privileges of membership in this international organization (World Trade Organization, 2007). Paying green subsidies to farmers in the agricultural sector is very important in the country's economy. Green subsidies will be paid to support farmers, villagers, and nomads. Green subsidies are given to farmers in three stages before, during, and after production. In this regard pre-production green subsidies include insurance for agricultural products, facilities, and agricultural machinery, and subsidy facilities will be paid to them. Also, subsidies to agricultural inputs and support machinery, including payment of green subsidies during and after production, in the form of conversion and complementary industries, guaranteed purchases, transportation systems, distribution, and export incentives. Iran is now one of the applicants for accession. In Iran, on the one hand, various subsidies are paid directly and indirectly to individuals, firms, and companies, privately and publicly. On the other hand, according to Article 104 of the Fifth Economic, Social and Cultural Development Plan of the Islamic Republic of Iran, the government is obliged to align the laws and regulations of the country's business sector with the laws and regulations of regional and international unions, including the World Trade Organization. Prepare and empower the economic pillars of the country for membership in the World Trade Organization to take legal action (Zare, 2009). The purpose of this study is to investigate the effects of applying a simulated green subsidy policy on the variables of employment, investment, and value added in the agricultural sector. This is the first innovation in Iran. In the world, in this field, because in most countries this policy has been implemented and data is available, econometric methods are applicable in this case. Given that few studies have been performed with the computable general equilibrium model, some of the similar articles will be discussed in the following. Jackson *et al*. (2020) examined the value of the Agriculture Committee in the WTO trade process and found that at least $ 778 billion of WTO trade belongs to the agricultural sector. Ahangari *et al*. (2018) studied the effects of green tax on economic growth and welfare in Iran with a dynamic stochastic general equilibrium approach. The results showed that the application of green tax in the above four scenarios has a little negative impact on economic growth. Lambie (2017) examines the effects of tax reforms, including VAT, in Uruguay using a computable general equilibrium method. The result is that in order to maintain budget neutrality after tax reform, the VAT rate must be reduced. The results of empirical studies showed that participation in normal agricultural policy (CAP) causes positive changes.

Charnowitz (2016) in a study on green subsidies and the WTO, looking at renewable energy, concluded that under the framework of domestic law, international law and world trade law, along with the implementation of the WTO law, a good design of green subsidies can be. Banga (2014) examined the effects of green subsidies on productivity, production and international agricultural trade and used the Agricultural Trade Policy Simulation (ATPSM) model. The results have shown that between 1995 and 2007, green box subsidies increased about 60 percent in the European Union and 40 percent in the United States in agricultural production, leading to substantial gains in developing countries and increasing their export earnings by 55 percent. Lim and Kim (2012) with a CGE model, introduced subsidies to industry R&D as a means of internalizing technological advances in the Korean economy. They found that subsidies (for all groups) to R&D expenditures might increase carbon intensity and real GDP for the Korean economy. Lapka, Kadelinova, Ricon and Lapka (2011) examined the reaction of Czech farmers in a study of rural development in the form of green agricultural subsidies:. Using a computable general equilibrium model, Kling examined the effect of Vietnam's accession to the WTO on income distribution and showed that joining the WTO has been effective on income distribution through job creation. Morley and Poniro (2004) used a general equilibrium model to examine the effect of market access within the framework of the World Trade Organization and the Latin American Rural Free Trade Agreement. Their findings suggest that both the WTO and the Free Trade Agreement will have positive effects on the studied countries in terms of employment and production, and that the WTO has had more positive effects on the agricultural sector. Piri (2016) In a study, the World Trade Organization and Third World countries: A case study examined the process of accession of the Islamic Republic of Iran to the WTO. The results showed that the membership of the World Trade Organization has not been a cure for all political, economic and cultural diseases of any country, but it could be said that it is a big step towards improving the economic structure and economic growth of countries.

Theoretical Foundations and Research Methods

It is well established in the theoretical literature that the channels through which green subsidy payments can affect agricultural production include: (A) The effects of risk were first highlighted by Hennessy (1998) when he argued that green subsidy payments could reduce farmers advancing risks by increasing wealth (wealth effect) and creating less risk-taking. Empirical evidence on the risk effects of green subsidy payments has been provided by many studies including Chavas and Holt (1990), Young and Westcott (2000), Anton (2004), Morrow and Skokai (2006), and Just (2011). Although most studies show that green subsidy payments make farmers production less risky, many believe that the impact may not be very large and can be minimized.

B) Land price effects occur when green subsidy payments become land value. Many studies have modeled this effect and its implications for agricultural production and investment. Debre, Anton and Thompson (2001), Roe, Samuro and Diao (2003), Roberts, Kirvan and Hopkins (2003), Goodwin, Mishra and Ortalo Magne (2003), Kirvan (2009) have have developed models in this area. Hendrix, Johnson, and Deutter (2012) also use a panel data set from Kansas farmers to estimate the dynamic rent equation using the GMM system and show that short-term subsidy capital in agricultural rents increases to 12 cents and the long run to subsidies increase by 37 cents per dollar. C) Credit effects reduce the cost of accessing debt in the event of internal support measures in the Green Fund. Studies have shown that with the presence of incomplete capital markets, including a significant gap between borrowing and lending rates, any agricultural policy, given the availability of credit, will affect farmers' willingness to invest in overproduction in the future. Potentially increases farmers' creditworthiness and liquidity (Roe *et al.,* 2003). D) The effects of labor force participation occur and can affect employment studies show that green subsidy payments make farm families spend more time on the farm, thus increasing employment and agricultural production. These studies include L-Sta, Moshra, and Aharan (2004), Aharan, L-Sta, and Dobre (2006). E) Expectations of green subsidies can affect employment, investment, and value-added production, as farmers may change their production decisions to maximize their future maximum payments from expected policy changes. Banga (2014) also says that green subsidies in agriculture have a significant impact on production and trade. Although in developed countries there has been an attempt for years to separate domestic support from green subsidies in production, the net and natural volume of subsidies provided in some developed countries has led to significant production and trade. These subsidies exist with the decision of the top producer with current production volumes and sales with low production costs, increase their health, reduce their investment risk and create domestic demand for their products. In other words, expectations of subsidies under the green box can affect production, as farmers may change production decisions to maximize their future payments by changing expected policies.

Today, general equilibrium models are widely used in both developed and developing countries and are used in the analysis of various dimensions resulting from the implementation of various economic policies. Among the general equilibrium models, the general equilibrium model can be calculated according to its special advantages and has more practical cases. The most important feature of these models is having micro-principles and optimizing the behavior of households and enterprises, paying attention to the relationships between different economic sectors and the need for low data. On the other hand, considering the specific characteristics of the Iranian economy,enough data is not available or the accuracy of the data is minimum, the use of computable general equilibrium models will be very useful.

In this paper, a computable general equilibrium method is used to investigate the economic effects of the green subsidy simulation policy in Iran agricultural sector. This method is one of the methods of quantitative analysis of policy issues and can provide a comprehensive framework for examining the comprehensive effects of policies. Indeed, one of the greatest advantages of the computable general equilibrium model is its ability to explain the consequences of changes in a particular policy parameter or the characteristics of a sector as a whole (Cardente *et al.,* 2016). Another advantage of the general equilibrium models over econometric models is that they do not dependent on time series data. In addition, the robust microeconomic framework of general equilibrium models fully describes the optimization behavior of economic agents and enables these models to have a stronger analytical basis.In addition to econometric models, these models are preferred over data-output models.. In a computable general equilibrium model, each policy in the model is applied by changing the exogenous parameters. In these patterns, a change in some of the parameters in the model indicates a policy or shock (Naderan and Fooladi, 2005).

Computable general equilibrium models based on Wallace general equilibrium theory are a major general tool for numerical analysis of global public and economic policies. These models are based on the belief that change in one sector of the economy has affected other sectors as well, and that successive effects on other sectors have a significant return on the primary sector. Thus, given the constraints of the economy, the full feedback from all sectors reflects the full effects of policy change or external shocks. As a result, the framework of general equilibrium models describes the complexity of micro-macro two-way interaction more accurately. The CGE model, as an economic model, includes a complete description of the economy and connects the market for goods and factors of production (Muller and Ferrari, 2011). Since CGE general equilibrium models have a more comprehensive view of the components and economic indicators of countries than other theoretical frameworks. They better illustrate the liberalization experience in the form of simulated scenarios (Banooei *et al.*, 2016).

In this model, the equations are generally divided into three parts: zero profit in all sectors, balance in the market of goods and inputs, the balance of the income and costs. Computable general equilibrium models formulate the cyclical flow of income and expenditure of an economy in which producers, factors of production, and consumers are considered. In these models, exchanges are based on the optimization behavior of economic agents, so that consumers maximize their utility function according to the budget level, and thus, the demand side of the model is determined. Manufacturers also seek to maximize their profits, which determines the supply side of the model. Equilibrium market prices provide the necessary conditions for equilibrium. For all goods and services, supply will be equal to demand, and if returns to the scale are constant, the zero profit condition applies to all activities.

In this way, a clear theoretical framework of the implementation of the general equilibrium model will be formed, (Fig. 1). Using the above analytical framework, it is possible to consider various types of economic subsidies; On the factors of production, intermediate inputs and production will be provided for each specific field of activity.

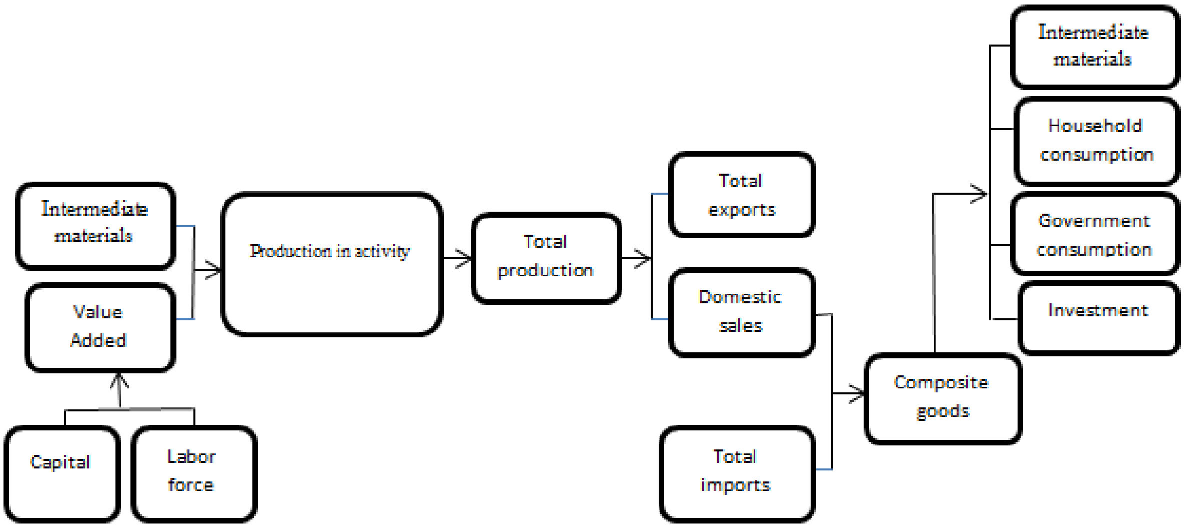

Fig. 1- Computable General Equilibrium Model (CGE) components
Source:(Lafgren *et al.*, 2002)

The model used includes equations related to production, household and government consumption, savings, investment, and foreign trade (Hosoe, 2004). In this model, it is assumed that economic sectors use labor and capital as primary inputs for production. In the reality part of the model, in addition to the primary inputs, it is assumed that the segments also use intermediate inputs for production. For convenience, the production stages are divided into upper and lower stages. At the lower stage, value added (or primary composite factor) is assumed to be obtained by combining labor and capital with Cobb-Douglas production function technology.

$$VA_j = b_j \pi \ FD_{hj}^{\beta_{hj}} \quad (1)$$

In the upper stage, gross output is generated from a combination of value-added and intermediate inputs with Leontief production technology.

$$Y_j = min\left(\frac{X_{ij}}{ax_{ij}}, \frac{VA_j}{ay_j}\right) \quad (2)$$

According to these two steps, each sector maximizes its profit function relative to its production. So finally the following equations are obtained.

$$X_{ij} = ax_{ij}.Y_j \quad (3)$$

$$VA_j = ay_j.Y_j \quad (4)$$

$$FD_{hj} = \frac{\beta_{hj} PN_j}{W_h} VA_j \quad (5)$$

$$PS_j = ay_j.PN_j + \sum ax_{ij}.PQ_i \quad (6)$$

It is assumed that consumers choose their shopping cart in a way that maximizes their usefulness. Their income comes from the supply of labor and capital. The utility of households depends on the amount of consumption of the goods produced in each sector. Here, the utility function is a Cobb-Douglas function, which, given the budget constraint, is equal to the net household income (household income equal to the income derived from the supply of factors of production, from which the direct tax and household savings are deducted). , Net income or available income), will be maximized. Given this, the following equation will be obtained.

$$C_i PQ_i = \lambda_{ci}\left(\sum W_h FS_h - TAX_{dir} - SAV_{hoh}\right) \quad (7)$$

In the case of public sector consumption, it is assumed that the government earns revenue by imposing sales taxes, and direct taxes on household income, import taxes (import tariffs), and oil exports. Government revenue will be spent on expenditures and savings.

$$TAX_{ind,j} = tx_j.PS_j.Y_j \quad (8)$$

$$TAX_{dir} = td.\sum_h W_h\, FS_h \quad (9)$$

$$\text{TARIFF}_j = tx_j.PM_j.M_j \quad (10)$$

$$G_i.PQ_i = \lambda_{gi}\left(TAX_{dir} + \sum TAX_{ind,j} + \sum TARIFF_j + E_{oil} - SAV_g\right) (11)$$

The investment in each sector will be a function of the total investment, which is equal to the total savings (totally private, government, and foreign savings). External savings are assumed to be exogenous variables and therefore the exchange rate establishes the trade balance.

$$SAV_{hoh} = s_{hoh}\sum_h W_h.FS_h \quad (12)$$

$$SAV_g = s_g\left(\sum_i TAX_{ind,i} + \sum_i TARIFF_i + TAX_{dir} + E_{oil}\right) (13)$$

$$SAVING = \left(SAV_h + SAV_{Gov} + SAV_f\right) \quad (14)$$

$$SAVING = INVES \quad (15)$$

$$ID_i.PQ_i = \mu_i.INVEST \quad (16)$$

In the foreign trade sector, it is assumed that there is a small country assumption that the country does not influence international market prices. Therefore, world import and export prices are stable.

$$PE_i = pwe_i.EXR \quad (17)$$

$$PM_i = pwm_i.EXR \quad (18)$$

When considering a model for an open economy, it requires some consideration of substitution between imported, exported and domestically offered goods. In general equilibrium models, there is a difference between imported and domestic goods, as well as between goods produced for export and goods produced for domestic sale. It is assumed that the sum of goods imported and supplied domestically constitutes composite goods (Armington goods). These composite goods are used as intermediate inputs and final uses. Imports are assumed to be an incomplete substitute for domestic production. This means that one unit of imported goods can be replaced by more than one unit of domestic goods. This is known as the Armington hypothesis. The relationship between imports and domestic production is represented as a Constant Elasticity of Substitution (CES).

$$Q_i = \gamma_i\left(\alpha_{mi}.M_i^{\rho mi} + \alpha_{di}.D_i^{\rho mi}\right)^{1/\rho im} \quad (19)$$

Here, Q_i,, D_i, γ_i, α_{di} and α_{mi} represent a composite product, a domestically produced product, ithe efficiency parameter in the composite product function, and the share parameters in the Armington function, respectively. Therefore, $\alpha_{di} + \alpha_{mi} = 1$ and $\alpha_{mi}, \alpha_{di} \geq 0$ and ρ_{mi} The power of the Armington function or the parameter related to the substitution tensile such that and, is the tensile strength of the Armington function, which can be calculated in the form of Equation (20).

$$h_i = \frac{\dfrac{-d\left(\frac{M_i}{D_i}\right)}{M_i/D_i}}{\dfrac{d\left(\frac{PM_i}{PD_i}\right)}{PM_i/PD_i}} \quad (20)$$

According to the problem of maximizing the problem, the demand functions for imports and domestic products will be obtained in the form of equations (21) and (22).

$$M_i = \left(\frac{\gamma_i^{\rho mi}.\alpha_{mi}.PQ_i}{(1+tm_i).PM_i}\right)^{1/1-\rho_{mi}}.Q_i \quad (21)$$

$$D_i = \left(\frac{\gamma_i^{\rho mi}.\alpha_{di}.PQ_i}{PD_i}\right)^{1/1-\rho_{mi}}.Q_i \quad (22)$$

PD_i is the price of domestically produced goods.

It is also assumed that exports can be incompletely converted into domestic production. The relationship between exports and domestic production is also expressed in terms of a transient Constant Elasticity of Transformation (CET).

$$Y_i = \theta_i\left(\beta_{ei}.E_i^{\rho ei} + \beta_{di}.D_i^{\rho ei}\right)^{1/\rho ei} \quad (23)$$

Where E_i is the export value, θ_i is the efficiency parameter of the transfer function, β_{di} and β_{ei} are the share parameters in the transfer function so that $\beta_{ei} + \beta_{di} = 1$ and ρ_{ei} ,β_{di}, $\beta_{ei} \geq 0$ are the transfer functions.

According to the problem of maximization, the supply functions of exports and domestic goods will be obtained in the following relations, respectively:

$$E_i = \left(\frac{\theta_i^{\rho ei}.\beta_{ei}.(tx_i + PS_i)}{PD_i}\right)^{1/1-\rho_{ei}}.Y_i \quad (24)$$

$$D_i = \left(\frac{\theta_i^{\rho ei}.\beta_{di}.(tx_i + PS_i)}{PD_i}\right)^{1/1-\rho_{ei}}.Y_i \quad (25)$$

In order to balance the four markets of labor, capital, composite goods, and foreign currency, the moderating factor for equal supply and demand in each market is the relevant price. Exchange rates are the moderating factors in the following items: the labor market, the wage rates, the capital market, the interest or rent of capital, the composite market, the price of composite goods, and the foreign exchange market,.

$$\sum_j FD_{hj} = FS_h \quad (26)$$

$$Q_i = C_i + G_i + ID_i + \sum_j X_{ij} \quad (27)$$

$$\sum_i pwe_i . E_I + SAV_f = \sum_i pwm_i . M_i \quad (28)$$

There are so many solutions with similar relative prices. The price normalization equation is used to ensure that the equilibrium is the only solution. In this equation, the price index is fixed and changes in other prices relative to this price are measured.

$$PINDEX = \sum_i \omega_i PQ_i \quad (29)$$

Policy variables in these models can also be considered in various forms such as tax rates, subsidy system selection, pricing rules, development strategy selection, trade policies, economic adjustment and stabilization, revenue distribution, government expenditure components, and external shocks. In this study, the policy of paying green subsidies in the part of subsidies paid to farmers has been applied directly and indirectly. Organizing data for use with general equilibrium models is one of the most important first steps in building these models. The social accounting matrix is a good starting point for introducing the basic equations of the general equilibrium model. CGE models establish the relationships between SAM accounts and a set of nonlinear equations simultaneously using modern general equilibrium theory (Can, 2011).

The social accounting matrix is the best setting in which most of the required statistics and data are collected and categorized. This matrix depicts the structural features of the countries economy and clearly shows the channels of transmission of the policies effect from the source to destination. The accounts of this matrix include groups of goods and services, productive activities, factors of production, economic institutions, government tax revenues, and savings and investments.

The SAM matrix somehow describes the resources and uses of society. SAM is technically a square matrix in which each array is linked to a row and a column. Each cell of this matrix represents a payment from column to row. Social accounting matrix includes accounts of activities (agriculture, industry, electricity, transportation and services), goods and services (agriculture, industry, electricity, transportation and services), factors of production (labor and capital) and institutions (households , goverment and the outside world). In this matrix, the last row and column contain the sum of the corresponding items (Zoghipour and Zibaei, 2009).

The method used in this research is that first the relationships between different economic variables are designed in the form of a set of mathematical equations and then to ensure the proper functioning of the model, the accuracy of its production in creating real world data is examined. This is usually done with matrix information for a base year. In this way, based on the information of the social accounting matrix of the economy exogenous variables , the endogenous variables of the model are reproduced and compared with the real world information.

Relying on this information is done to ensure the validity of the model. Model calibration is the process of calculating the transfer and contribution parameters used in the utility and production functions of the CGE model so that solving the equation regains the same original balance of the model data. Then the solution of the calibrated model is used as the basis equilibrium with which the results of the experimental test of the model are compared. The inputs to the calibration process are the CGE model databases, which explain the economy at its initial equilibrium (Berfisher, 2014). Also, one of the main goals in using general equilibrium models is simulation or scenario building. By scenario-making in general equilibrium models, the effects of different policies can be quantified. After ensuring the proper performance of the model, different scenarios are modeled and the results of different policies are predicted based on the designed model.

Results and Discussion

The latest matrix of social accounting in Iran is in 2011, which has been prepared by the Islamic Parliament Research Center (IPRC).In this paper, this matrix has been used as a source of information.This matrix is based on a symmetric data-output table, which has been compiled with a whole-except approach. (Banooei, 2016).

Given that the data used is the social accounting matrix of the year 1990, data were calibrated and updated using the ras method based on 2018 data using the model (Miller and Blair, 2009). The model was used to calculate the initial equilibrium point (Robinson, Kilkenny and Hanson, 1990). GAMS software was used to analyze the data in this research.

From the numerical solution of the computable general equilibrium model, all the reproduced baseline year data , indicate the robustness of the model calibration. The calibrated parameters and the substitution and conversion tensions, respectively, are given in Table 2 of the Armington and Conversion functions, respectively.

The share of intermediate inputs shows the ratio of the amounts of intermediate inputs and factors of production in each unit of product. The share of agricultural intermediate inputs shows that 0.21, 0.38 and 0.01 units of agricultural, industrial and service inputs are required to produce each product unit, respectively.

Table 1- Matrix of macro-social accounting in Iran in 2011 (Million Rial)

	Activities	Factors of production	Institutions
Activities	3744722627		15423275859
Factors of production	6209271377		
Institutions		6233074264	799316040.9
saving			2543162960
The outside world	1412387674	20267641.8	4188335.834
Total	11366381679	6233074264	7431735199

	Investment	The outside world	Total
Activities	2110793327	13599093535	11495605243
Factors of production		23802886.8	6233074264
Institutions		495245.4071	7431735199
saving			26997734860
The outside world	496792564		1935093400
Total	2699734860	1935093400	29795242966

Source: (Islamic Consultative Assembly, 2011)

According to Table 2, the share of capital is 0.711, which is larger than the share of labor by 0.289.This indicates that the agricultural sector is capital-intensive, which meansthe amount of share of capital is more than labor for each unit of product,.

The backlink index is the column sum of the share of intermediate inputs for productive activity. This index shows that the agricultural sector needs 0.28 units of intermediate products per unit of the final product. The latter index of industry and services is 0.12 and 0.11, respectively. Comparing the value of indicators shows that increasing agricultural production has a greater impact on the economy than increasing industrial and service production.

Table 2- Parameters and elasticity model

Function name			Agriculture	Industry	Services
Consumption function	Commodity share		0.6129	0.1224	0.2569
	Marginal propensity to consume of households		0.376	0.060	0.384
Value-added production function (Cobb-Douglas(	Transfer or performance		1.826	1.423	1.903
	Labor force	The share of factors	0.289	0.113	0.343
	Capital		0.711	0.887	0.657
Marginal production function	Agriculture	The share of intermediate inputs	0.211	0.386	0.016
	Industry		0.072	0.283	0.0313
	Services		0.017	0.595	0.076
	The share of value added		0.3014	1.0716	0.606
Armington function)Composite goods(	Elasticity of substitution		1.4	1.4	1.4
	The share of imports		0.032	0.161	0.252
	The transfer		1.642	1.976	1.515
Conversion function	Elasticity of conversion		1.2	1.2	1.2
	The share of exports		0.919	0.479	0.895
	The transfer		3.824	2.002	3.656

Source: Research Findings

One of the main goals in applying general equilibrium models is simulating or scenario building. By scenario-making in general equilibrium models, the effects of different policies can be quantified. Therefore, in order to study the effects of Iran's accession to the World Trade Organization (WTO), the effect of green subsidies in the agricultural sector on the variables of employment, investment and value added has been studied in three scenarios, which are in the form of (base, 20%, 50% and% 100) Designed. The amount of observed change indicates the impact on employment, investment and value added of the agricultural sector in different scenarios in case of the occurrence of a shock or sudden change in the form of green subsidies in the economic system.

Employment Changes

One of the variables that is affected by the application of green subsidies in the agricultural sector is the factors of production. Changes in production typically change the demand for labor and capital stock, and thus affect the application of green employment subsidies.

During the effects of Iran's accession to the World Trade Organization and by applying the green subsidy simulation policy, employment in the agricultural sector is affected. According to the results of Table 3, applying a 20% green subsidy in the agricultural sector will increase employment by 0.19%, and by applying a 50% green subsidy in the agricultural sector, it will be increased by 0.47%. Also, in the 100% scenario, there will be a 0.95% increase in employment. This result contradicts the findings of cling *et al*. (2009). In a study using a computable general equilibrium model, they examined the effect of Vietnam's accession to the World Trade Organization on the income distribution. The results showed that joining this organization was through job creation, especially in the industrial sector.

Since the total amount of capital and labor in the studied model is assumed to be constant, this increase means the transfer of these inputs from other sectors of production to the agricultural sector, and therefore employment in other sectors has decreased.

Table 3- Employment changes

Scenarios / Sections	Scenario 1	Scenario 2	Scenario 3
	20%	50%	100%
Agriculture	0.1911	0.4774	0.9529
Industry	- 0.0256	- 0.0640	- 0.1277
Services	- 0.0936	- 0.2339	- 0.4670

Source: Research Findings

Investment Changes

In the Social Accounting Matrix, the Investment Column Account reports investors purchases of goods and services used (domestic intermediate inputs, imported intermediate inputs) in the future manufacturing activities and the sales tax.

Table 4- Investment changes

Scenarios / Sections	Scenario 1	Scenario 2	Scenario 3
	20%	50%	100%
Agriculture	2.3294	2.5902	2.9788
Industry	- 2.162	- 2.2719	- 2.4061
Services	- 1.5133	- 1.5602	- 1.5713

Source: Research Findings

According to Table 4, the amount of investment in the agricultural sector in Scenario 1 has increased by 2.33% compared to the baseline scenario. In the second and third scenarios, it has increased by 2.59 and 2.98 percent, respectively.

In the industrial sector, in the 20% scenario 2.16, in the 50% scenario 2.27% and in the 100% scenario, 2.41% decrease is observed in investment compared to the basic scenario. Also in the services sector, in scenarios of 20, 50, and 100 percent, there was a decrease of 3.65, 3.84 and 4.04 percent in the amount of investment, respectively. The results of examining the model in the investment sector showed that due to the implementation of green subsidy policy, investment in the agricultural sector will increase. On the other hand, the total investment investment in industry and services is decreasing

Given that the standard model of calculable general equilibrium is a static model (one-period) and the factors of production (labor and capital) are assumed to be constant. As a result, with the application of green subsidy policy in the agricultural sector, the transfer of factors of production from other sectors to the agricultural sector to increase production is observed that this increase in production requires increased use of intermediate inputs, also this transfer reduces production in other sectors and thus Reduction of the use of intermediate inputs in the industry and services sector. As mentioned above, investing in the social accounting matrix is the total payment of the departments for the purchase of intermediate inputs and sales tax. If the full employment of production factors is not established and there is unemployed labor and capital, the increase of production factors in the agricultural sector will be compensated by using the unemployed capacity of production factors. Furthermore, the transfer of production factors from other sectors to this sector will not be observed. The results were consistent with the study of the sun (26). He designed a model for Egypt with an optimization method. His model was used to assess the economic impact of several medium-term scenarios that were dependent on subsidy policies and domestic energy pricing. The results of the model show that in the absence of appropriate policy measures, a reduction effect has been observed in production and investment.

Value-Added Changes

In the social accounting matrix, the total column of payments to labor, capital and tax expenditures constitutes the added value of the economic activity. Value added is a direct function of gross output and demand for factors of production and also directly related to the wages of factors of production.

Table 5- Value added changes

Sourc

Scenarios	Scenario 1	Scenario 2	Scenario 3
Sections	20%	50%	100%
Agriculture	3.2369	3.6622	4.3176
Industry	-3.0215	-3.1519	-3.2753
Services	-4.3765	-4.5791	-4.7853
Total	-2.3099	-2.3492	-2.3341

Source: Research Findings

Given that the standard model of calculable general equilibrium is static (one-period), the factors of production (labor and capital) are assumed to be constant. As a result, with the implementation of a green subsidy policy in the agricultural sector, the transfer of labor and capital from other sectors to the agricultural sector is observed.

In Table 5, the rate of value added increases in the agricultural sector by applying green subsidies with scenarios 1, 2, and 3 by 3.23, 3.66 and 4.31 percent, respectively.

Considering the application of shocks in the form of different rates of green subsidies that entered the general system of the economy in the basic state and the results obtained from these shocks, show an increase in value added in the agricultural sector. Also, the rate of value-added decreases in the industrial sector and is equal to 3.02, 3.15, 3.27.In the service sector, it is equal to 4.38, 4.58 and 4.78, which is higher than the rate of increase in the agricultural sector. Finally, the total changes in value added in scenarios 1, 2, and 3 have been reduced by 2.31, 2.35 and 2.33 percent, respectively.

Due to the transfer of factors of production in agricultural sector from other sectors, the rate of value added in this sector is positive compared to other sectors, Total production and income of the agricultural sector have also increased. In other sectors, the trend of declining income of the factors of production has been achieved, which ultimately reduced the value added of other sectors.

Also, based on the obtained results and the value added changes observed in different production sectors in total, it indicates negative changes in the total value added. The rate of increase in value added in the agricultural sector has been lower than the rate of decrease in other sectors.In general, the total value added variable has been negative compared to the baseline scenario. This negative result is due to the assumption of full employment in the CGE model, and in the absence of this assumption and the transfer of factors of production from other sectors to the agricultural sector and instead attract capital and unemployed labor in this sector, the total value added variable is positive. It becomes.

It is consistent with the findings of Lapka *et al.* (2011). In a study of rural development in the form of green agricultural subsidies, they examined the reaction of Czech farmers. The results of experimental studies showed that participation in normal agricultural policy causes positive changes in the value added of the agricultural sector.

Conclusions and Suggestions

The category of green subsidies has been proposed in the direction of agricultural development, which is in line with the law on targeted subsidies, but in a real way. Green subsidies are for farmers in order to boost business and industry in the agricultural sector and the goals of green subsidies are to mechanize agriculture, improve seeds and soil, insure crops and agriculture, as well as strengthen the manufacturing industry to increase farmers' incomes. In a new classification, green subsidies for developing countries were proposed to develop programs on poverty alleviation, rural development, food security, and diversified agriculture (Banga, 2014).

Green subsidies include subsidies that are exempt from the reduction requirements. These subsidies have minimal effect on production and trade. Funds must be provided by the government, and it is forbidden to ask consumers for higher prices to finance the subsidies. The subsidies in this box do not have any restrictions and can be paid in the required amount in the allowed cases. Other characteristics of this subsidy include the provision of educational, extension, research, pest and disease inspection services, investment in rural and agricultural development infrastructure, food aid, natural disaster compensation aid, and the like, in addition to these protections are considered.

Given the accession of most countries to the World Trade Organization, Iran, as a developing country whose non-oil economy has not played a significant role in the global economy, can not be separated from global developments. Therefore, the main issue of the country is the continuous and focused effort to find a way to make membership possible with the lowest cost and highest benefits. In this way, knowing the exact effects and consequences of membership in this organization will be a great help in going through the process of joining successfully. In this regard, the study of the effects of green subsidies on macro variables in the agricultural sector is a very important issue.

The policy of applying green subsidies in the agricultural sector can increase job opportunities by creating new markets for products and services, providing employment opportunities for more people inside the country. Based on the results obtained from the model, employment in the agricultural sector has increased, and given that the total amount of capital and labor in the model is assumed to be constant, so this increase means the transfer of these inputs from other sectors of production to the agricultural sector and Due to this, employment in industry and services has decreased. Also, with the implementation of the green subsidy policy, investment in agriculture has increased, which is due to increased production in this sector and as a result, increased use of intermediate inputs. The results obtained from the mentioned shocks show that value added in the agricultural sector has an upward trend, which is due to the increase in the use of factors of production in this sector.

Considering that the application of green subsidy policy in Iran's agricultural sector in the form of different scenarios, has created positive changes on macroeconomic variables such as employment, investment and value added, in this type of subsidy management objectives in agriculture, stabilizing and increasing farmers' incomes Encouraging investors to invest, encouraging manufacturers and researching new technology and increasing productivity is followed, so considering that in this study, due to the lack of implementation of this policy and model simulation based on the cost of implementing this policy to the public sector has been done. It is suggested that in the future, with the actual implementation of this policy by the government, the qualitative factors of its implementation can be examined.

Implementation of this policy and accession to the World Trade Organization in the medium and long term, can attract more foreign investment, directly and indirectly, increase the access of domestic companies to financial and credit facilities of international financial institutions, provide the ground for purchasing equipment and advanced technology. Day, removal of marketing barriers in the country's export items.

In the plan to create green subsidies in Iran, we can consider three stages of implementation, which include providing facilities to farmers, farmers share in the profits of the product, and pricing in agricultural products. In order to implement this plan, the government can allocate facilities as subsidies to farmers based on a specific formula every year, especially from the beginning of the cultivation of agricultural products. Part of these facilities can be in the form of loans to mechanize agricultural equipment, including the purchase of tractors, conversion of agricultural land to modern irrigation. Also, an amount of it should be provided for cost research and another amount in line with agricultural insurance and agricultural products insurance to compensate for damages caused by unforeseen events. Providing facilities for the development of the packaging industry and the creation of processing industries, marketing of agricultural products and other items can be considered as other stages of its implementation. It is suggested that part of these facilities be applied for free with a 5 or 6 percent interest rate on bank loans and deposits.

References

1. Ahangari, A., H. Farazmand, A. Montazer Hojjat, and R. Haft Lang. 2018. Effects of Green Tax on Economic Growth and Welfare in Economy of Iran: a Dynamic Stochastic General Equilibrium Approach (DSGE). Quantitative Economics Quarterly, 15(1): 27-61. (In Persian)
2. Ahearn, M.C., H. El-Osta and J. Dewbre. 2006. The Impact of Coupled and Decoupled Government Subsidies on Off-Farm Labor Participation of U.S. Farm Operators. American Journal of Agricultural Economics, 88: 393-408.
3. Banga, R. 2014. Impact of Green Box Subsidies on Agricultural Productivity. Production and International Trade. BACKGROUND PAPER. NO. RVC-11.
4. Banooei, A., A. Elizadeh, N. Sadeghi, M. Mostali Parsa, and H. Mousavi Nick. 2016. Updating the data-output table, social accounting matrix and designing the CGE model and their applications in socio-economic policy. Tehran Islamic Parliament Research Center (IPRC). (In Persian)
5. Barton, A. 2011. Why governments should use the government finance statistics accounting system. Abacus, 47(4): 411- 445.
6. Bellmann, Ch. 2019. Subsidies and Sustainable Agriculture: Mapping the Policy Landscape. Hoffmann Centre for Sustainable Resource Economy. Chatham House.
7. Berfisher, M. 2014. Introduction to computable general equilibrium models. Translated by Bazazan, F. and Soleimani, M. Tehran: Ney Publishing, First Edition. (In Persian)
8. Bellmann, Ch. 2019. Subsidies and Sustainable Agriculture: Mapping the Policy Landscape. Hoffmann Centre for Sustainable Resource Economy, Chatham House.
9. Brady, M., S. Hoggard, E. Kaspersson, and E. Rabinowicz. 2009. The CAP and Future Challenges. SIEPS: European Policy Analysis (11).
10. Can, W. 2011. Scheme of Constructing CGE Model of China. Direct Grain Subsidy Policy. Asian Agricultural

Research Journal 3(7).
11. Cardente, M., F. Sancho, and A. Isabel Gray. 2016. General functional balance. Translated by Morteza Mazaheri Marbari and Behnam Amin Rostamkali, Tehran: Amara Publishing. First Edition. (In Persian)
12. Charnovitz, S. 2016. Green Subsidies and the WTO. Robert Schuman Centre for Advanced Studies Research Paper No. RSCAS 2014/93.
13. Chavas, J.P. and M.T. Holt. 1990. Acreage Decision Under Risk: The Case of Corn and Soybeans. American Journal of Agricultural Economics, 72: 529-538.
14. Cling, J. 2009. The Distributive Impact of Vietnam's Accession to the WTO. Economie Internationale 43-71.
15. Dewbre, J., J. Antòn, and W. Thompson. 2001. The Transfer Efficiency and Trade Effects of Direct Payments. American Journal of Agricultural Economics, 83(5): 1204-1214.
16. El-Osta, H., A.K. Mishra, and M.C. Ahearn. 2004. Labor Supply by Farm Operators Under "Decoupled" Farm Program Payments. Review of Economics of the Household, 2: 367-385.
17. Gohin, A. 2006. Assessing CAP Reform: Sensitivity of Modeling Decoupled Policies. Journal of Agricultural Economics, 57(3): 415-440.
18. Goodwin, B.K., A.K. Mishra, and F.N. Ortalo-Magne. 2003. What's Wrong with Our Models of Agricultural Land Values. American Journal of Agricultural Economics, 85(3): 744-752.
19. Hendricks, N.P., J.P. Janzen, and K.C. Dhuyvetter. 2012. Subsidy Incidence and Inertia in Farmland Rental Markets: Estimates from a Dynamic Panel. Journal of Agricultural and Resource Economics, 37(3): 361-378.
20. Hennessy, D.A. 1998. The production effects of agricultural income support polices under uncertainty. American Journal of Agricultural Economics, 80: 46-57.
21. Hosoe, N. 2004. Computable general equilibrium modeling with GAMS. [online].
22. Islamic Consultative Assembly. 2011. Estimation of social accounting matrix. Parliamentary Research Center. (In Persian)
23. Jackson, L.A., F. Maggi, R. Piermartini, and S. Rubínová. 2020. The value of the Committee on Agriculture: Mapping Q&AS to trade flows. Staff Working Paper ERSD.
24. Jalali, H. 2010. The role of subsidy targeting in the agricultural sector. Monthly specialized agricultural-analytical agriculture of farmers. (In Persian)
25. Just, D.R. 2011. Calibrating the Wealth Effects of Decoupled Payments: Does Decreasing Absolute Risk Aversion Matter. Journal of Econometrics, 162(1): 25-34.
26. Khorshid, M. 2009. An Energy Economy Interaction Model for Egypt. International Conference on Policy Modeling, Canada.
27. Kirwan, B.E. 2009. The Incidence of U.S. Agricultural Subsidies on Farmland Rental Rates. Journal of Political Economy, 117(1): 138-164.
28. Lofgren, H., R.L. Harris, and S.H. Robinson. 2002. A Standard Computable General Equilibrium (CGE) Model in GAMS. Washington D.C: International Food Policy Research Institute.
29. Lambi, C. 2017. Assessing the Impacts of a Major Tax Reform: a CGE-microsimulation analysis for Uruguay. International Journal of Microsimulation, 9(1): 134- 166.
30. Lapka, M., J. Eva Cudlinova, S. Rikoon, M. Pelucha, and V. Kveton. 2011. The rural development contex of agricultural Green subsidies: Czech farmers' responses. Agric. Econ – Czech, 57 (6): 259–271.
31. Lim, J.S. and G.K. Kim. 2012. Combining carbon tax and R&D subsidy for climate change mitigation. Energy Economics, 34: 496-502.
32. Naderan, E. and M. Fooladi. 2005. Provide a general equilibrium model to examine the effects of government spending on output, employment, and household income. Economic Research Journal, 5: 8-45. (In Persian)
33. Miller, R.E. and P.D. Blair. 2009. Input-Output Analysis: Foundations and Extensions. Cambridge University Press, New York.
34. Morely, S. and Pinerio, V. 2004. The Effect of WTO and FTAA on Agriculture and the Rural Sector in Latin America. Washington, *D.C:* International Food Policy Research Institute.
35. Moro, D. and P. Sckokai. 1998. Modeling the CAP reform: degree of decoupling and future scenarios. Working Paper Universita Cattolica de Milano.
36. Muller, M. and E. Ferrari. 2011. Deriving CGE Baselines from Macro-economic Projection. Center for Development Research (ZEF). 53113. Germany.
37. Piri, S. 2016. World Trade Organization and Third World Countries: A Case Study of the Accession Process of the Islamic Republic of Iran to the WTO. Third International Conference on New Approaches in the Humanities.
38. Roberts, M.J., B. Kirwan, and J. Hopkins. 2003. The Incidence of Government Program Payments on Agricultural

Land Rents: The Challenges of Identification. American Journal of Agricultural Economics, 85: 762-769.
39. Robinson, S., M. Kilkenny, and K. Hanson. 1990. The USDA/ERS Computable General Equilibrium (CGE) Model of the United States. Tech. rep USDA/ERS.
40. Roe, T., A. Somwaru, and X. Diao. 2003. Do Direct Payments Have Intertemporal Effects on US Agriculture? In: Moss C. B., Schmitz A., editors. Government Policy and Farmland Markets. Ames, IA: Iowa State Press 115-139.
41. Rude, J. 2000. An Examination of Nearly Green Programs: Case Study for Canada. American Journal of Agricultural Economics, 82 (3): 755-761.
42. Tayybi, K. and S.H. Mesri Nejad. 2006. Methodology of general equilibrium model that can be calculated, theory and application. Quarterly Journal of Economic Studies, 3: 132-103. (In Persian)
43. World Trade Organization. 2007. World Trade Report 2006; exploring The Links between Subsidies, trade and The WTO. Geneva: W.T.O publication.
44. World Trade Organization Website. 2015. Available at WWW.WTO.ORG.
45. Young, E. and P. Westcott. 2000. How decoupled is U.S. decoupled support for major crops. American Journal of Agricultural Economics 82.
46. Zare, M. 2009. Legal requirements for Iran's accession to the World Trade Organization in the field of subsidies. Special Letter W.T.O 11(27). (In Persian)
47. Zoghipour, A. and M. Zibaei. 2009. Investigating the effects of trade liberalization on key variables in Iran's agricultural sector: A computable general equilibrium model. Agricultural Economics Quarterly, 3(4): 67-9. (In Persian)

The attachment

```
Update using the ras method
Set i / 1*3;/
Alias (i,j);
Table a0(i,j) 'known base matrix'
Table z1(i,j) 'unknown industry flows'
Parameter
 x(j)   'observed total output'
 u(i)   'observed row totals'
 v(j)   'observed column totals'
 a1(i,j) 'unknown matrix A;'
u(i) = sum(j, z1(i,j));
v(j) = sum(i, z1(i,j));
a1(i,j) = z1(i,j)/x(j));
display u, v, a1;
 ١ --- *RAS updating
Parameter
 r(i) 'row adjustment'
 s(j) 'column adjustment;'
r(i) = 1;
s(j) = 1;
Parameter oldr, olds, maxdelta;
maxdelta = 1
repeat
 oldr(i)  = r(i);
 olds(j)  = s(j);
r(i)    = r(i)*u(i)/sum(j, r(i)*a0(i,j)*x(j)*s(j));
s(j)    = s(j)*v(j)/sum(i, r(i)*a0(i,j)*x(j)*s(j));
maxdelta = max(smax(i, abs(oldr(i) - r(i))),smax(j, abs(olds(j) - s(j))));
display maxdelta;
until maxdelta < 0.005;
Parameter report(*,i,j) 'summary report;'
option report:3:1:2;
report('A0' ,i,j) = a0(i,j);
report('A1' ,i,j) = a1(i,j);
report('RAS',i,j) = r(i)*a0(i,j)*s(j);
 ٢ --- *Entropy formulation   a*ln(a/a0)
```

```
*The RAS procedure gives the solution to the Entropy formulation
Variable
obj    'objective value'
a(i,j) 'estimated A matrix'
z(i,j) 'estimated Z matrix;'
Positive Variable a, z;
Equation
rowbal(i) 'row totals'
colbal(j) 'column totals'
defobjent 'entropy definition;'
rowbal(i).. sum(j, a(i,j)*x(j)) =e= u(i);
colbal(j).. sum(i, a(i,j)*x(j)) =e= v(j);
defobjent.. obj =e= sum((i,j), x(j)*a(i,j)*log(a(i,j)/a0(i,j)));
Model mEntropy / rowbal, colbal, defobjent;/
*we need to exclude small values to avoid domain violations
a.lo(i,j) = 1e-5;
solve mEntropy using nlp min obj; report('Entropy',i,j) = a.l(i,j);
٣––– *Entropy with flow variable
      *we can balance the flow matrix instead of the A matrix
Variable zv(i,j) 'industry flows;'
Equation
 rowbalz(i) 'row totals'
 colbalz(j) 'column totals tive'
 defobjentz 'entropy objective using flows;'
 rowbalz(i).. sum(j, zv(i,j)) =e= u(i);
 colbalz(j).. sum(i, zv(i,j)) =e= v(j);
Parameter zbar(i,j) 'reference flow;'
zbar(i,j)  = a0(i,j)*x(j);
zv.lo(i,j) = 1;
defobjentz.. obj =e= sum((i,j), zv(i,j)*log(zv(i,j)/zbar(i,j)));
Model mEntropyz / rowbalz, colbalz, defobjentz;/
*turn off detailed outputs
option limRow = 0, limCol = 0, solPrint = off;
solve mEntropyz using nlp min obj; report('EntropyZ',i,j) = zv.l(i,j)/x(j);
۴––– *absolute deviation formulations result in LPs
 *MAD Mean Absolute Deviations
 *MAPE Mean absolute percentage error
 *Linf Infinity norm
Positive Variable
  ap(i,j) 'positive deviation iation'
  an(i,j) 'negative deviation'
  amax    'maximum absilute dev;'
Equation
  defabs(i,j)  'absolute definition'
  defmaxp(i,j) 'max positive'
  defmaxn(i,j) 'max neagtive'
  defmad       'MAD definition'
  defmade      'mean absolute percentage error'
  deflinf      'infinity norm;'
defabs(i,j)..  a(i,j) - a0(i,j) =e= ap(i,j) - an(i,j);
defmaxp(i,j).. a(i,j) - a0(i,j) =l=  amax;
defmaxn(i,j).. a(i,j) - a0(i,j) =g= -amax;
defmad..  obj =e=   1/sqr(card(i))*sum((i,j), ap(i,j) + an(i,j));
defmade.. obj =e= 100/sqr(card(i))*sum((i,j),(ap(i,j) + an(i,j))/a0(i,j));
defLinf.. obj =e= amax;
Model
```

```
  mMAD  / rowbal, colbal, defabs,  defmad/
  mMADE / rowbal, colbal, defabs,  defmade/
  mLinf / rowbal, colbal, defmaxp, defmaxn, deflinf;/
solve mMAD  using lp min obj; report('MAD' ,i,j) = a.l(i,j);
solve mMADe using lp min obj; report('MADE',i,j) = a.l(i,j;(
solve mLinf using lp min obj; report('Linf',i,j) = a.l(i,j);
ܘ --- *Squared Deviations can be solved with powerful QP codes
      *SD     squared deviations
      *RSD    relative squared deviations
Equation defsd, defrsd;
defsd..  obj =e= sum((i,j), sqr(a(i,j) + a0(i,j;)))
defrsd.. obj =e= sum((i,j), sqr(a(i,j) + a0(i,j))/a0(i,j;))
Model
  mSD  / rowbal, colbal, defsd/
  mRSD / rowbal, colbal, defrsd;/
solve mSD  using qcp min obj; report('SD' ,i,j) = a.l(i,j);
solve mRSD using qcp min obj; report('RSD',i,j) = a.l(i,j);
display report;CGE modeling Equilibrium point estimation
Set
   i   'sectors'          / agri    'agriculture                                  'indus   'industries'
                            service 'services       '/
   f   'factors of production'  / labor   'labor'
                                    Capital    'capital   'ins 'institutions'          / labr    'labor'
                               ent     'enterprises     'hh  'household type income'  / hhtrn   'transfer recipients'
                               hhlab   'wage earners'
                               hhcap   'rentiers *        '/the institution names and the factor names "capital"
 *are referred to explicitly below.  if changed, they must also be
 *changed where referenced.
 *the printing of the gnp accounts assume that there is a sector
 *labeled "service".
 *subsets defined below: "define indexes"
   iag(i)  'ag sectors' / agri/
   iagn(i) 'non ag sectors'
   ie(i)   'export sectors'
   ied(i)  'sectors with export demand eqn'
   iedn(i) 'sectors with no export demand eqn'
   ien(i)  'non export sectors'
   im(i)   'import sectors'
   imn(i)  'non import sectors;'
Alias (i,j);
*for sam
Set
   isam 'categories' / commdty,  activity,    valuad
                       insttns,  households, govt
                       kaccount, world,      total/
   isam1(isam)       / total/
   isam2(isam);

Alias (isam2,isam3);
```

```
Parameter sam(isam,isam) 'social accounting matrix;'
isam2(isam) = not isam1(isam);
Parameter
 *read in parameters
 *read in for initialization of variables
  enttax0   'enterprise tax revenue'
  entsav0   'enterprise savings'
  exr0      'exchange rate'
  e0(i)     'exports'
  fbor0     'net foreign borrowing'
  fsav0     'net foreign savings'
  gdtot0    'total volume of government consumption'
  gent0     'payments from government to enterprises'
  govsav0   'government savings'
  hhsav0    'household savings'
  hht0      'household transfers'
  invest0   'total investment'
  m0(i)     'imports'
  mps0(hh)  'household marginal propensity to save'
  pd0(i)    'domestic goods price'
  pe0(i)    'domestic price of exports'
  pindex0   'gnp deflator'
  pm0(i)    'domestic price of imports'
  remit0    'net remittances from abroad'
  sstax0    'social security tax revenue'
  tothhtax0 'household tax revenue'
  xd0(i)    'domestic output'
  volume
 *read in table for initialization of variables (need not be declared)
 *table fctres1(i,f) factor demand by sector
 *table fctry(i,f)   factor income by sector
 *read in parameters as rates, shares, elasticities
  dstr(i)   'ratio of inventory investment to gross output'
  esr       'enterprise savings rate'
  etr       'enterprise tax rate'
  gles(i)   'government consumption shares'
  htax(hh)  'household tax rate'
  itax(i)   'indirect tax rates'
  kish(i)   'shares of investment by sector of destination'
  rhsh(hh)  'household remittance share'
  rhoc(i)   'Armington function exponent'
  rhoe(i)   'export demand price elasticity'
  rhot(i)   'cet function exponent'
  sstr      'social security tax rate'
  te(i)     'export subsidy rates'
  tm(i)     'tariff rates on imports'
  thsh(hh)  'household shares of government transfers'
 *read in table of parameters (need not be declared(
```

```
*table cles(i,hh)      household consumption shares
*table imat(i,j)       capital composition matrix
*table io(i,j)         input-output coefficients
*table sintyh(hh,ins)  household distribution of institutional income
*computed parameters from read in data calibration
*computed parameters for initialization of variables
 fd0(f)      'factor demand, aggregate'
 fs0(f)      'factor supply, aggregate'
 int0(i)     'intermediate input demand'
 netsub0     'export duty revenue'
 p0(i)       'price of composite good'
 pk0(i)      'capital goods price by sector of destination'
 pva0(i)     'value added price by sector'
 pwm(i)      'world market price of imports '
 pwe0(i)     'world price of exports'
 pwse(i)     'world price of export substitutes'
 px0(i)      'average output price'
 var0(i)     'value added rate by sector'
 wfdist(i,f) 'factor price sectoral proportionality constants'
 wf0(f)      'factor price, aggregate average'
 xxd0(i)     'domestic sales, volume'
 x0(i)       'composite good supply, volume'
 yfctr0(f)   'factor income summed over sector'
 yfsect0(i)  'factor income by sector'
 yh0(hh)     'household income'
 yinst0(ins) 'institutional income'

*computed parameters as rates, shares
 ac(i)       'Armington function shift parameter'
 ad(i)       'production function shift parameter'
 alpha(i,f)  'factor share parameter-production function'
 at(i)       'cet function shift parameter'
 delta(i)    'Armington function share parameter'
 econst(i)   'export demand constant'
 gamma(i)    'cet function share parameter'
 pwts(i)     'price index weights'
 qd(i)       'dummy variable for computing ad(i)'
 rmd(i)      'ratio of imports to domestic sales'
 sumsh       'sum of share correction parameter'
 sumhhsh(hh) 'sum of share for hh cles'
 sumimsh(i)  'sum of share for imat'
 tereal(i)   'real export subsidy rate in 1390 '
 tmreal(i)   'real tariff rate in 1390 ';
```

مقاله پژوهشی
جلد ۳۵، شماره ٤، زمستان ۱٤۰۰، ص ۳٦٥-۳٤۹

بررسی اثر اعمال یارانه سبز بر اشتغال، سرمایه‌گذاری و ارزش‌افزوده بخش کشاورزی ایران با استفاده از مدل CGE

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چکیده

یکی از سیاست‌های مهم اقتصادی در اغلب کشورها حمایت از تولیدکننده یا مصرف‌کننده از طریق پرداخت یارانه است. مقوله یارانه سبز در راستای توسعه کشاورزی مطرح شده که هم راستا با قانون هدفمندکردن یارانه‌ها، اما به شکلی واقعی می‌باشد. یارانه سبز ویژه کشاورزان و به منظور رونق کسب و کار و صنعت بخش کشاورزی است. هدف از این تحقیق، بررسی آثار الحاق ایران به سازمان تجارت جهانی، با اعمال سیاست شبیه‌سازی شده یارانه سبز بر روی متغیرهای اشتغال، سرمایه‌گذاری و ارزش‌افزوده در بخش کشاورزی می‌باشد، که در قالب سناریوهای ٪۲۰، ٪۵۰ و ٪۱۰۰ طراحی شده است. کالیبراسیون مدل با بکارگیری ماتریس حسابداری اجتماعی سال ۱۳۹۰ و سناریوی پایه (٪۰ اعمال یارانه سبز) صورت پذیرفت. جهت تجزیه و تحلیل اطلاعات در این تحقیق از نرم‌افزار GAMS استفاده شده است. نتایج نشان می‌دهد که در جریان آثار الحاق ایران به سازمان تجارت جهانی و با اعمال سیاست شبیه‌سازی یارانه سبز، اشتغال در بخش کشاورزی در سناریوهای ۲۰، ۵۰ و ۱۰۰ درصد، افزایش می‌یابد. همچنین با اعمال سیاست یارانه سبز، سرمایه‌گذاری در بخش کشاورزی روند افزایشی دارد، که به دلیل افزایش تولید در این بخش و در نتیجه افزایش استفاده از نهاده‌های واسطه می‌باشد. نتایج بدست آمده از شوک‌های مذکور نشان می‌دهد که ارزش‌افزوده در بخش کشاورزی روندی صعودی دارد، که به دلیل افزایش به‌کارگیری عوامل تولید در این بخش می‌باشد.

واژه‌های کلیدی: بخش کشاورزی، سازمان تجارت جهانی، مدل CGE، یارانه سبز

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Impacts of Climate Change and Water Scarcity on Farmers' Irrigation Decisions in North-Khorasan Province: Major Crops

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Abstract

This paper evaluates the effect of water scarcity and climatic conditions on farmers' irrigation decisions in the production of major crops including wheat, barley, cotton, sugar beet, and alfalfa in North-Khorasan province. Farmers' irrigation decisions are defined with a management model composed of equations of the share of irrigated land, technology adoption, and the irrigation frequencies, which investigated the effect of water scarcity indicators and climatic factors, farm water supply method, land characteristics, and farmers' demographic features. For this purpose, the required data were collected from the 380 questionnaires, completed by farmers in cultivation year of 2017-2018. Then, the equations of the management model were estimated using fractional logit, binomial logit, and OLS methods. The results indicated that economic and physical scarcity of water resources, climatic conditions of temperature and precipitation, severe events of frost and heat, and drought have noticeable impact on farmers' irrigation decisions. Farmers try to reduce the damage caused by climate change and water scarcity by deciding to irrigate their farms and adopting new irrigation technologies. Also, the type of water sources, i.e. surface and groundwater, irrigation method, soil quality of cultivated land, and land size have significant effects on their decisions. In regions without available surface water resource, the cultivation areas of irrigated land are declined. Also, due to water scarcity, farmers are more willing to invest on new technologies to improve irrigation efficiency. In the farms with higher soil quality, improved cropland direction and slope, and resource availability, farmers are more willing to invest on new irrigation methods and increase irrigation frequencies. Therefore, the implementation of policies on improving land quality and cropland integration can increase the acceptance of new technologies, and reduce the water usage. In addition, farmers' demographic characteristics such as experience, tenure, and education influence their decisions for irrigation. Creating suitable conditions for the education and training of farmers will increase farmers' awareness of new agricultural methods and the importance of water resources. Findings of this study provide vision on – how of farmers reaction against crop production systems as well as mitigation policies to confront climate change impacts.

Keywords: Climate change, Fractional logit, Irrigation decisions, Water scarcity

Introduction[1]

Sensitivity of agricultural production against climate change impacts is confirmed by laboratory and experimental studies (Jawid, 2019; Mendelsohn and Dinar, 2003). Increasing temperature and changing precipitation patterns affect the yield and quality of both rainfed and irrigated crops (Siddig *et al.*, 2020). Due to important role of climate conditions in crop production, farmers tend to respond to climate changes by adjusting their methods. Technologies

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and practices already exist for climate change adaptation (Etwire, 2020).

The growing water scarcity and misuse and lack of management of the available water resources are major threats to the sustainable development of various sectors. Today, in most countries suffering from water scarcity, it is important to ask whether the water crisis can be prevented (Hamdy *et al*., 2003). Drought contributes to surface water shortages and groundwater over-abstraction, and damages the agricultural sector (Howitt *et al*., 2014). Therefore, adapting irrigation management is one of the main mechanisms for agriculture to adjust and respond to climate change and water scarcity (Olen *et al*., 2016). One of the most effective ways to reduce water shortage is to increase irrigation efficiency at the water transmission, distribution, and application stages. Water loss can be prevented by using modern irrigation systems.

The agricultural sector has a special place in North-Khorasan province so that it accounted for about 20.7% of GDP and 37.3% of the total employment in 2017 (Statistical Yearbook of North-Khorasan province, 2019). The most important crops produced in this region are cotton, wheat, barley, legumes, vegetables, industrial plants, and fodder. This province had 229984.6 hectares of cultivation area in cultivation year of 2017-2018 which 49.2% and 50.8% was irrigated and rainfed, respectively (Agricultural Jihad Organization of North-Khorasan province, 2017). The climate of the province is arid and semi-arid. Consecutive droughts, population growth, inefficient water resources management, and traditional and low-yield agricultural methods have caused much of the province’s area to suffer severe groundwater depletion. Decreased precipitation and rising temperatures have changed the province’s climate in recent years. Reforming consumption patterns is the only way to overcome the crisis of water scarcity and depletion of water resources (Agricultural Jihad Organization of North-Khorasan province, 2017). Fig. 1 depicts the average precipitation and temperatures for the period of 2006-2018.

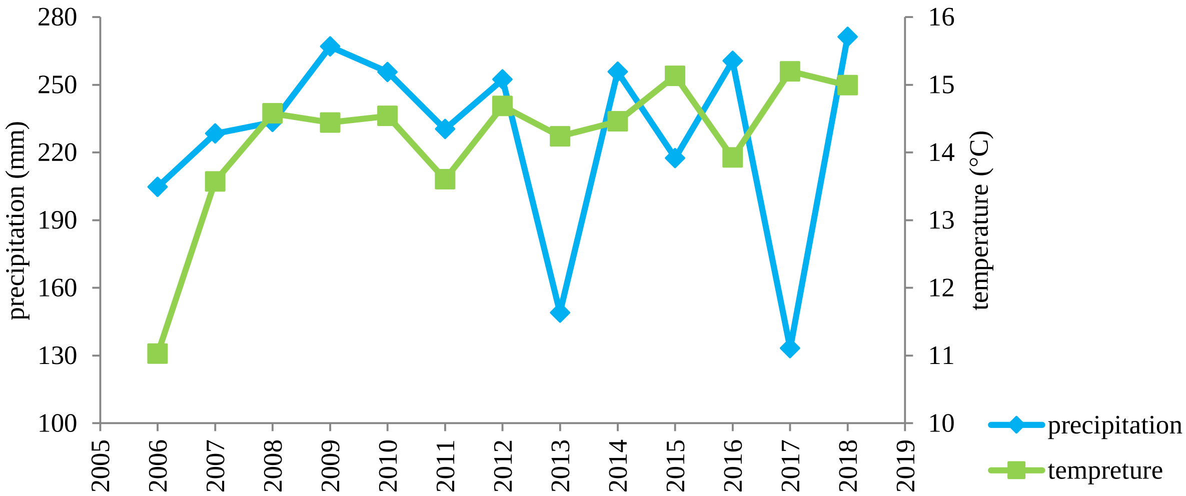

Fig. 1- Annual average precipitation and temperature changes in North-Khorasan province

As can be seen, the precipitation has experienced a decreasing trend in recent years while the temperature has had an increasing trend. These changes are indicative of climate change in the region. The history of precipitation shows that the average annual precipitation in the province has decreased over the past years, implying that the province will be struggling with a water crisis in the coming years. Also, the increasing trend of average annual temperature in the province has directly affected the water requirements of crops. This, along with a decrease in precipitation and a subsequent decrease in water reserves, has aggravated the water crisis.

Several studies have examined the effects of climate change and drought on the agricultural sector. Most studies have focused on the impact of climate change on agricultural production, land, water resources, and farmers' incomes. For instance, Calzadilla *et al*. (2011), Coffel *et al*. (2019), and Dinar *et al*. (2019) have shown that water supply is affected by climate change and water scarcity combined with an increasing demand for food and water for irrigation of agricultural lands due to population growth. So, it requires a careful revision of water use in agriculture. McDonald and Girvetz (2013) predicted the impact of climate changes on both the fraction of agricultural land irrigated and the irrigation rate in the United States. According to the results, during the period of 1985-2005, both quantities have been highly positively correlated with moisture deficit (precipitation), and if the current trend continues, climate change will increase agricultural demand for irrigation in 2090 by 4.5 to 21.9 million hectares. In addition, without significant increases in irrigation efficiency, climate change would increase the average irrigation rate from 7,963 to 8,400–10,415 m^3/ha. The irrigation area has increased the most in humid states, however the irrigation rate has increased the most in arid states.

Sheidaeian *et al*. (2014) showed that decreasing precipitation and increasing temperature would increase evapotranspiration potential and the amount of water used. Khaledi *et al*. (2016) reported that climate change and reduced precipitation have a detrimental effect on agriculture. According to them, farmers' adaptation to climate change is one way to alleviate the effects of this phenomenon. They also showed that lack of financial resources, shortage of water resources, inattention by officials, lack of credit, and cuts in subsidies were the most important obstacles to farmers' adaptation. In a study in Kermanshah province, Iran, Tavakoli *et al*. (2016) showed that crisis management strategies had a positive and significant relationship with the severity and recurrence of farmers’ perceived drought, owned lands, irrigated lands, and farmers’ individual and family characteristics. Parhizkari *et al*. (2017) investigated the impact of climate change by applying precipitation reduction scenarios to available water resources, the economic value of water, and the irrigated area. This study showed that reducing precipitation would reduce the cultivation area and the volume of water used in irrigated farms. Li *et al*. (2020) found that the combined assessment of the impact of water scarcity on economic, social, and environmental aspects and system sustainability could give a more comprehensive picture of efficient water resources management and would contribute to water scarcity remission. They showed that the optimal allocation of water to crops varied in different regions and under different climatic conditions.

In a review of the strategies to face drought and water scarcity, Bressers *et al*. (2019) took the natural circumstances, socio-economic factors, and institutional circumstances in a specific area into account. They argued that factors such as different climatic conditions, access to water resources, water ownership, foresight, and socio-economic conditions of farmers affect the behavior towards water use. This study proposed regulating water supply, saving on water, and recycling water as the strategies towards water supply management. They also recommended the adoption of regulatory measures and financial incentives for water demand management. Zhang *et al*. (2019) also examined farmers’ practices when facing water scarcity based on a field survey in Beijing, China. Based on their results, 53.1% of the farmers adopted water-saving irrigation technologies when facing water scarcity. Factors such as education, farm size, cooperatives, training, groundwater, access to information, and drought-prone areas significantly improved farmers’ adaption to water scarcity, while age, production specialization, and cost had a negative impact on farmers’ adoption of water-saving irrigation technologies.

Some studies such as Rahmani *et al*. (2016), Balali *et al*. (2016), and Movahedi *et al*. (2017) have examined the factors influencing farmers' decision to adopt new irrigation technologies using the logit regression model and questionnaire information. In these research studies, the effect of such variables as age, education, experience, training, land ownership, type of water supply source, etc. has been investigated on the acceptance of farmers. However, few studies have addressed the effects of climate change combined with other factors on farmers' irrigation decisions. For example, Olen *et al*. (2016) estimated the irrigation management model to assess the impact of water scarcity and climate on farmers’ irrigation decisions on the western coast of the United States. Their results showed that economic and physical scarcity of water and climatic factors had significant impact on farmers’ irrigation decisions. Farmers used sprinkler technologies or extra water to reduce the risk of crop damage in extreme climate events. In another study, Frisvold and Bai (2016) examined the effect of climate and other factors on the choice of sprinkler technology in 17 western US states. They revealed that sprinkler irrigation had been adapted to a greater extent in relatively cooler areas with extreme precipitation events and among larger farms with higher water costs and relied more on groundwater.

Research has shown that drought and climate change can have detrimental effects on the agricultural sector and various factors are effective in facing and adapting to climate change. Most studies on the effects of climate change have been conducted for the entire agricultural sector at a national or regional level. Also, studies that have examined the factors influencing irrigation decisions of farmers such as irrigation technology selection, irrigation frequency, etc., have paid less attention to climatic factors and water scarcity. Simultaneous studies of climate change, water scarcity indicators, and other factors affecting farmers' decisions have received less attention. Due to the crisis of water scarcity, drought, reduction of water resources in most plains of North-Khorasan province in recent decades, as well as using more than 69% of the province's water resources by the agricultural sector, it is necessary to reform the water use pattern in this sector. Therefore, recognizing the factors influencing farmers' decisions to irrigate their fields seems necessary, and this study aimed to identify the factors that are effective in farmers' management and irrigation decisions in North-Khorasan province. For this purpose, farmers' irrigation decisions were defined in the context of a management model including the share of irrigated lands, irrigation technology adaptation, and irrigation frequencies. Then, the focus was put on the effect of water scarcity indicators, climatic factors, farmers' land and individual characteristics, water supply sources, etc.

Materials and Methods

Empirical Model

It is assumed that producers make irrigation decisions to maximize farm profit according to climatic conditions (C), water scarcity (S), water supply method (M), land characteristics (L), and demographic characteristics (D). To investigate how these variables influence irrigation decisions, an irrigation management model is estimated for major crops in North-Khorasan province. This management model includes equations of the share of irrigated land (SI), technology adoption (TA), and irrigation frequencies (IF). SI is defined as the share of croplands that are irrigated and takes a value from 0 to 1 (total irrigated croplands to total cultivated croplands). TA is defined as 0 and 1. IF also refers to the total number of irrigations of a crop over the growing season.

$$SI_i = \alpha + \beta_i C_i + \beta_i S_i + \beta_i M_i + \beta_i L_i + \beta_i D_i + \varepsilon_i \quad (1)$$

$$TA_i = \alpha + \beta_i C_i + \beta_i S_i + \beta_i M_i + \beta_i L_i + \beta_i D_i + \varepsilon_i \quad (2)$$

$$IF_{ij} = \alpha + \beta_{ij} C_{ij} + \beta_{ij} S_{ij} + \beta_{ij} M_{ij} + \beta_{ij} L_{ij} + \beta_{ij} D_{ij} + \varepsilon_i \quad (3)$$

where i= 1, …, I represents the farms, and j= 1, …, 5 represents the crop (cotton, barley, sugar beet, wheat, and alfalfa). Climate and weather conditions influencing irrigation decisions are presented by vector C. Farmers have different responses to climate change and drought conditions (Olen *et al*., 2016). The vector C includes the variables of average annual precipitation (mm) and average annual temperature (°C) of the county .Variables indicating whether cold stress has affected farm irrigation in recent years (Yes /No), whether heat stress has affected farm irrigation in recent years (Yes /No), and whether the farm is located in a region with frequent droughts and the irrigation of the farm is affected by these events (Yes /No) are also included in vector C.

Economic and physical indicators of water scarcity are shown in vector S. Water cost (million IRR) per unit area is introduced as an economic water scarcity indicator, and piezometric water level (meters) in the region is introduced as a physical indicator of water scarcity since water shortage increases the cost of pumping groundwater and water supply. So, farmers will be inclined to adopt new technologies to save water (Caswell and Zilberman, 1986). There is, also, greater competition for water in densely populated areas, so the variable of population density is defined as a physical indicator of water scarcity to reflect human demand for water (Calzadilla *et al*., 2011; Coffel *et al*., 2019; Liu *et al*., 2017). North-Khorasan province has eight counties, including Esfarāyen, Bojnourd, Jajarm, Raz and Jargalan, Shirvan, Farooj, Garmeh, and Maneh and Samalqan. In this study, the ratio of the population of the county (people) to its area (km^2) is defined as the variable of population density.

The variables of irrigation water supply source, irrigation method, irrigation frequencies, the number of labor for farm irrigation (day/people), and labor cost for irrigation (million IRR) are denoted by vector M. These variables may affect the volume of water used and irrigation costs of the farm. In the third equation, because the frequency of irrigation is defined as a dependent variable, this variable is removed from vector M. The source of water supply includes rivers, dams, wells, springs, and aqueducts, which are classified into two groups: surface and groundwater. Also, the method of farm irrigation is surface (furrow and basin) or mechanized (drip and sprinkler) depending on crop type.

Vector L represents land characteristics, which includes the variables of land size (hectare) and cropland quality. Potentials and limitations of agricultural land such as soil quality, agricultural land direction and slope, access to water resources and land distance to the water resource, the proximity of agricultural land to required services and easy access to them, and climatic conditions of the region are effective in the quality and valuation of agricultural land. Due to the interaction between crop yield and water availability, the water holding capacity of the land is an important dimension of soil quality (Caswell and Zilberman, 1986) and affects farmers' irrigation decisions. In this study, cropland quality is classified into the three groups of good, medium, and poor based on the farmer's opinion regarding land potentials and limitations.

Vector D examines the effect of farmers' demographic features such as farmer age, experience, tenure, education, and household size. The experiences farmers accumulate over time affect their behaviors (Alam, 2015; Seekao and Pharino, 2016). Experienced farmers are less likely to adopt new management practices as they are approaching retirement (Olen *et al*., 2016; Zhang *et al*., 2019). Tenure (land owned / tenant) influences the producers' decision to choose the type of irrigation methods and accept new irrigation methods. In addition, farmers' educational and training level influences their decisions (Abdulai and Huffman, 2005; Alam, 2015; Cremades *et al*., 2015). In this study, education is classified into illiterate, elementary-school level, intermediate-school level, diploma, associate degree, and bachelor's degree and higher.

Estimation method

The dependent variable of Equation (1), SI, is the share of irrigated land and is defined as a fraction. The fractional logit econometric method is used to estimate this equation. Fractional models were first introduced by Papke and Wooldridge (1996), using the statistical topics of generalized linear models (GLM) and quasi-likelihood literature (QL) method. This model is a kind of generalized linear models whose parameters are estimated using a quasi-verification method. To obtain the fraction model, it is assumed that there are independent and dependent variables {(Xi, Yi): i= 1, 2,…, N} where $0 \le Y_i \le 1$ and N is the sample size that tends to infinity ($N \to \infty$). The following model is also considered for the conditional expectation of the fractional response variable:

$$E\left(y_i \mid x_i\right) = G(x_i\beta) \quad (4)$$

Where G(.) is a known function satisfying $0 < G(z) < 1$ for all Z∈Rs, which ensures that the predicted values of y lie in the interval (0,1). For this purpose, G (.) is typically chosen to be a cumulative distribution function (CDF), with the two most popular examples being $G(z) = \Lambda(z) = \exp(z)/[1 + \exp(z)]$ (the logistic function) and $G(z) = \phi(z)$. Also, β is the vector of model parameters. In Equation (4), there is no assumption about the structure from which the dependent variable is derived, which is one of the advantages of this model.

In this study, the TA equation examines the effect of independent variables on the adoption of irrigation technology. According to the type of dependent variable in the TA equation, the binomial logit model is used for its estimation. The dependent variable of Equation (3), IF, indicates the frequency of irrigation per hectare for each crop. This equation is estimated for each crop separately, using the ordinary least squares (OLS) method.

Data

In this study, farmers who cultivated wheat, barley, cotton, sugar beet, and alfalfa were selected as the statistical population. The selection of this statistical population was based on the highest area of crop cultivation in North-Khorasan province. The required data were collected from the studied statistical population. A cross-sectional survey was conducted using a questionnaire and interviews with farmers in the cultivation year of 2017-18. In this study, to improve the sampling accuracy and incorporate statistical population features, the stratified sampling method was adopted in which the statistical population was divided into different subgroups (county), and then selections were made randomly from each subgroup. Using Cochran's formula, 380 sample sizes of the farmers were gathered out of 38,450 farmers in North-Khorasan province. Then, the sample size of each county was determined using following formula:

$$n_i = \frac{N_i}{N}.n \quad (5)$$

Based on the number of farmers per county where N is the total number of farmers of the selected crops in the province, N_i is the number of farmers of the selected crops in county i, n is the total sample size, and n_i is the samples size of county i. Then, questionnaires were completed based on the cultivation area of each crop in the county.

Table 1- Number of farmers and samples studied in North-Khorasan province

County	Bojnurd	Esfarāyen	Farooj	Garmeh	Jajarm	Maneh-Samalqan	Raz and Jargalan	Shirvan	Total
Statistical population	2762	9437	4102	1427	3570	10245	1537	5334	38450
Sample size	27	93	41	14	35	101	16	53	380

Source: Research Findings

In this study, data on precipitation, temperature, and piezometric water level were collected from Meteorological Organization and the Regional Water Administration of North-Khorasan province. Also, data on the population of the counties were collected from the National Statistics Portal of Iran.

Results and Discussion

This section first presents the descriptive statistics of the data extracted from the questionnaires and the data collected from the relevant departments (Table 2).

Table 2- Descriptive statistics of the variables

Variable	Variable definition	Mean	Median	Min	Max	Std. Dev.
Climatic condition characteristics (C)						
Frost mitigation	Irrigation is used to prevent freeze damage (0/1)	-	0	0	1	0.5
Heat mitigation	Irrigation is used to reduce heat stress (0/1)	-	1	0	1	0.39
Drought	Historic drought region effect on field irrigation (0/1)	-	1	0	1	0.47
Temperature	County average temperature (℃)	14.7	-	12.5	16.1	1.4
Precipitation	County average annual precipitation (mm)	211.7	-	123.4	309	62.9
Water Scarcity (S)						
Water cost	Farm irrigation cost (million IRR)	0.75	-	0.04	4.3	0.51
Water level	Piezometric levels of water in the area (meters)	41.5	-	7.57	101.6	20.5
Population density	City population concentration (population /km^2)	30.7	-	10.5	91.06	25.5
Method of water supply (I)						
Irrigation Source	Farm irrigation source (surface=1 & groundwater=2)	-	2	1	2	0.5
Irrigation method	Farm irrigation method (traditional=1 & mechanized=2)	-	1	1	2	0.36
Labor number	Labor number for farm irrigation during the growing season (Day/people)	5.3	-	0.2	33.3	5.3
Labor cost	Total labor cost for farm irrigation during the growing season (million IRR)	0.25	-	0.005	2	0.26
Land Characteristics (L)						
Land size	Farm size (hectares)	6.2	-	0.25	90	11.7
Cropland quality	Quality of agricultural land (poor=0, medium=1, & good=2)	-	1	0	2	0.63
Characteristics Demographic (D)						
Age	Farmer age (years)	46.2	-	19	74	12.4
Experience	experience operating the current farm (years)	25.9	-	1	58	13.6
Tenure	Type of land ownership (tenant=0 & land owned=1)	-	1	0	1	0.43
Education	Education (1/2/3/4/5)	-	2	0	5	1.3
Household size	Household size	-	5	1	10	1.5
Share of irrigated land	Share of Farmer Irrigated Land [1,0]	0.73	-	0.05	1	0.29
Technology Adoption	Adoption of field irrigation technology (0,1)	-	0	0	1	0.37
Irrigation Frequencies	Frequent irrigation of the field during the growing season	-	6	1	18	3.32

Source: Research Findings

Then, farmers' decision-making equations (the share of irrigated lands, the irrigation technology adoption, and irrigation frequencies) are estimated and their results are reported and analyzed.

Share of irrigated land

The equation for the share of irrigated lands is estimated using the fractional logit method whose results are presented in Table 3. According to Wald Chi2 (17), this method is highly efficient in estimating the model. Wald Chi2 showed that there is a significant relationship (P < 0.01) between the share of irrigated land and explanatory variables. The results of the marginal effects indicate that climatic variables have the greatest impact on the share of irrigated lands.

Table 3- Results of estimating the factors affecting on the share of irrigated land

Variable	Coefficient	Z-Statistic	Marginal effect	Z-Statistic	Elasticities at mean
Temperature	0.146***	2.06	0.024**	2.08	0.445**
Precipitation	0.003*	1.89	0.001**	1.91	0.145**
Frost mitigation	0.297*	1.88	0.045**	1.9	0.03**
Heat mitigation	-0.363*	-1.65	-0.06*	-1.65	-0.062*
Drought	0.293*	1.81	0.049*	1.81	0.04*
Water cost	0.073	0.42	0.012	0.43	0.011
Water level	-0.008**	-2.01	-0.001**	-2	-0.072**
Population density	-0.001	-0.2	-0.0001	-0.2	-0.004
Irrigation Source	-0.3*	-1.73	-0.05*	-1.74	-0.095*
Irrigation method	0.5**	2.13	0.083**	2.12	0.119**
Irrigation frequencies	-0.014	-0.44	-0.002	-0.43	-0.018
Labor cost	-0.64**	-1.73	-0.106*	-1.73	-0.032*
Cropland quality	0.264*	1.91	0.044**	1.91	0.06**
Land size	0.041	1.23	0.007	1.24	0.048
Experience	0.017**	2.08	0.003**	2.09	0.088**
Tenure	-0.31*	-1.63	-0.05	-1.62	-0.049
Education	0.215***	2.49	0.036***	2.51	0.096***
Constant	-2.27*	-1.47	-	-	-
Wald chi2(17) = 66.59 (0.00)	Log pseudo likelihood = -177.98				

Note: (*), (**), (***) denotes significance at the level of 10, 5 and 1% (p <0.10, p <0.5, p <0.01), respectively. Source: Research Findings

The temperature has a positive and significant relationship with SI and the marginal effect of temperature is equal to 0.024, which indicates that if the temperature increases by 1ºC, the share of irrigated land will increase by 0.024 units. Moreover, as the estimation of elasticity at mean shows, 1% increases in temperature increases the share of irrigated lands by 0.445%. Increasing the temperature causes the amount of precipitation not to be enough for crop growth, therefore farmers have to increase the area of irrigated lands to cultivate the crop and irrigate the farm to compensate for the crop's water needs. According to the Findings, the precipitation variable is directly associated with SI, so that 1 mm increase in precipitation increases the share of irrigated lands by 0.001 units. Due to the fact that climate change is generally associated with reduced precipitation, changing the climatic conditions of the region and reducing the volume of precipitation increases the need for irrigation and reduces the volume of water available for irrigation. Eventually, the farmers will be forced to reduce their share of irrigated lands. Dashti *et al*. (2017) and Parhizkari *et al*. (2017) have confirmed the effect of reduced precipitation on the reduction of irrigated cultivation.

One way to reduce the effects of cold temperatures on farms is irrigation because water has a high heat capacity and releases a lot of energy before freezing. For this reason, frost damage is reduced at high humidity (Khaledi, 2004). So, if producers can irrigate their farms to reduce frost damage, the share of the irrigated lands will be 0.03% higher. This result is consistent with the findings of Olen *et al*. (2016). In addition, increasing the air temperature increases the crop's irrigation requirement and due to the available water volume, increasing heat and creating stress will reduce the cultivated area of the irrigated crops. Increased drought in recent years has also had a positive and significant effect on SI so that the share of the irrigated lands has been increased by 0.04%. Rising temperatures and droughts in recent years have led to an increase in water abstraction from the province's groundwater resources so that farmers have drilled authorized and unauthorized wells and have pumped more groundwater to supply irrigation water. This has led to a sharp decline in groundwater resources in some plains of the province (Velayati, 2006).

The irrigation method and water resource have a significant effect on SI. Improving the irrigation method and the use of new technologies will increase the share of farmers' irrigated lands by 0.12%. Also, due to the negative impact of the irrigation resource on SI, surface water shortage and withdrawal of groundwater resources reduce SI by 0.05 units. The results revealed that with the increase in labor costs and, consequently, the increase in farm irrigation costs, the share of irrigated land decreases. On the other hand, water depth has a negative and significant relationship with SI, which indicates that a one-unit increase in water depth (meters) will reduce SI by 0.072%. Caswell and Zilberman (1986) pointed out that increasing the depth of well water (piezometric level of water) would reduce the volume of available water and increase the final cost of pumping groundwater. As a result, increasing irrigation costs, rendering it uneconomic, makes farmers reluctant to irrigate the farm. The effect of improving the quality of agricultural lands on SI shows that farmers increase the share of irrigated lands if there are no restrictions on irrigation. Lichtenberg (1989) mentioned that improving the quality of cropland increases the fertility of the land and reduces the need for irrigation, so the farm profit will increase and farmers will be more interested in irrigated cultivation.

Farmer's experience and education have a positive and substantial effect on SI. In general, farmers who have been engaged in agriculture for many years have lands with more access to water recourse and higher quality. As Paltasingh and Goyari (2018) have shown, education increases farm productivity and leads farmers to use new technologies. Therefore, if more literate farmers use more modern irrigation methods, they can irrigate more croplands with a certain volume of water, thereby expanding their share of irrigated lands.

Irrigation Technology Adoption (TA)

The equation of irrigation technology adoption has been estimated using the binomial logit model and the results are reported in Table 4. Based on the LR chi2 statistics, the model estimated is significant at the $P < 0.01$ level, and according to the value of R^2, the independent variables account for 58% of the changes in the dependent variable. Based on the significance of the variables in the logit model, only the variables of water cost, water level, population density, and farmer tenure are not considerable, and other variables are significant.

Table 4- Results of estimating the factors affecting on the irrigation technology adoption

Variable	Coefficient	Z-Statistic	Marginal effect	Z-Statistic	Elasticities at mean
Temperature	-0.406*	-1.76	-0.02*	-1.81	-5.92*
Precipitation	0.009*	1.67	0.004*	1.7	1.88*
Frost mitigation	1.3**	2.25	0.064**	2.35	0.616**
Heat mitigation	-1.16*	-1.73	-0.058**	-.176	-0.947**
Drought	-2.16***	-2.75	-0.108***	-2.92	-1.96***
Water cost	-0.278	-0.44	-0.014	-.045	-0.207
Water level	0.009	0.67	0.0004	0.67	0.369
Population density	-0.013	-0.73	-0.0006	-0.74	-0.393
Irrigation Source	1.31**	2.3	0.065**	2.41	2.001**
Irrigation frequencies	0.569***	4.7	0.028***	5.79	3.56***
Labor number	-1.45***	-4.75	-0.072***	-5.91	-7.77***
Labor cost	16.2***	3.45	0.807***	3.86	4.03***
Cropland quality	2.17***	4.1	0.108***	4.62	2.37***
Land size	0.074***	2.86	0.004***	3.07	0.439***
Experience	0.11***	3.94	0.005***	4.53	2.84***
Tenure	0.148	0.23	0.007	0.23	0.112
Education	0.81***	2.9	0.04***	3.11	1.74***
Household size	0.73***	3.38	0.036***	3.67	3.42***
Constant	-11.29**	-2.13	-	-	-
LR chi2(18)= 164(0.00)	Log likelihood= -6.035		pseudo $R^2 = 0.58$		

Note: (*), (**), (***) denotes significance at the level of 10, 5 and 1% ($p < 0.10$, $p < 0.5$, $p < 0.01$), respectively. Source: Research Findings

According to the results, rising temperatures and frequent droughts in the region reduce the likelihood of technology adoption, and new irrigation technologies are less likely to be adopted in warmer regions. Rising temperatures and frequent droughts directly affect crop yields, so the decline in farm yields and incomes will reduce the farmer's financial ability to adopt new technologies so that farmers will not be able to invest in the farm. In interviews with farmers, one of the reasons for not accepting new technologies was their lack of financial ability, which is exacerbated by the drought. Furthermore, rising temperatures and drought can increase evaporative losses from sprinkler spray, so this irrigation method can be an inappropriate technology (Finkel and Nir, 1983; Olen *et al*., 2016). The results showed that increasing temperatures and drought reduce the likelihood of technology adoption by 5.92% and 1.96%, respectively. This result is consistent with the findings of Frisvold and Bai (2016), which concluded that the adoption of modern irrigation methods is less likely in warmer climates and under drier climate change scenarios, so other adaptation strategies may be more appropriate to pursue in hot and arid regions.

Based on results, 1% increase in precipitation increases the likelihood of technology adoption by 1.88%. One explanation is that careful irrigation can reduce water stress. Crops are sensitive to water stress caused by heavy and frequent rains due to their shallow roots. Increased precipitation leads to enhancing soil moisture, thereby reducing the depth of root activity and spreading the roots superficially. In this case, the plant will be justifiably vulnerable to sudden stress. The results indicated that producers who have used irrigation to reduce heat stress on the farm are 0.947% less likely to adopt the technology. In fact, farmers whose irrigation has been affected by heat stress do not have careful planning in farm management and are generally less willing to adopt new irrigation and farming methods. Also, farmers who irrigate their farms in the face of cold stress are 0.616% more likely to adopt the technology than farmers who do not.

The results demonstrated that the type of water supply has a positive and significant effect on technology adoption. It shows that the probability of technology adoption for groundwater resources is 2.001% higher than that of surface water resources. This result is consistent with the findings of Zarifian *et al*. (2020). In fact, farmers in areas with less available surface water have to use groundwater to supply the plant with water, and owing to fewer water resources, they are more inclined to use irrigation technologies to manage and save available water. Besides, at farms with more irrigation frequencies, the probability of adopting technology is 3.56% higher and farmers are more interested in modern technologies to reduce irrigation costs and manage water used. At farms where irrigation technologies are less likely to be adopted, more labor is used for irrigation. In fact, modern technologies require fewer laborers to irrigate the farm, and this is due to the negative relationship between the labor number and the technology adoption. Also, increasing the cost of the labor directly increases the cost of irrigating the farm and reduces the farmer's profit. Therefore, the probability of technology adoption increases by 4.03% with one unit of increase in labor cost.

Land quality and size have a positive and remarkable relationship with the acceptance of technology. If the land quality improves, farmers will be more willing to invest in the farm and improve irrigation and cultivation methods. Adopting new technologies for croplands with higher quality will be 2.37% higher than for those with lower quality. Increasing the farm size will also enhance the economic efficiency of investing in the farm. Based on the findings, the probability of technology adoption will be 0.439% higher with a 1% increase in land size. Finally, experienced and revenue-generating farmers are likely to be more inclined to adopt the technology and the probability of technology adoption increases by 2.84%.

With the increase in farmers' education, the probability of irrigation technology adoption increases by 1.74%. In fact, higher education increases farmers' awareness of new farming methods and new technologies. The household size has a positive and significant relationship with the adoption of irrigation technology, so it can be concluded that increasing the number of households creates a sense of collective support and synergy to improve agricultural conditions through using new technologies. Indeed, family members are a kind of support for the farmer and the farmer will feel less risky in adopting new technologies and cultivation methods. This result is consistent with the findings of Karppien (2005) and Behbahani Motlagh *et al*. (2017).

Irrigation frequencies (IF)

The results of estimating the irrigation frequencies equations using the OLS method are reported in Table 5. According to the F-stat statistic, all equations are significant, and the independent variables capture 63-94% of the variance in the dependent variable. It can be concluded from the results that the variables of the temperature and irrigation resource are quite significant in all equations.

Table 5- Estimation results for the irrigation frequencies in the farm

Variable	Estimated coefficient				
	Alfalfa	**Barley**	**Cotton**	**Sugar beet**	**Wheat**
Temperature	1.14***	0.32***	0.7**	0.49*	0.4***
Precipitation	-0.01**	-0.02***	-0.002	0.01**	-0.02***
Frost mitigation	-0.43**	-0.21	-0.28	1.24**	-0.33**
Heat mitigation	-2.84**	-0.4**	1.93***	0.32	0.36**
Drought	-1.4	0.7***	1.4*	-2.43***	0.1
Water cost	1.6***	0.75**	-3.19**	-0.22	-0.58***
Water level	-0.02	-0.004	0.02*	0.1***	-1.3E-05
Population density	0.03***	-0.02***	0.015	0.04***	-0.01
Irrigation Source	0.85*	0.41**	-0.71*	-1.5***	-0.34*
Irrigation method	-0.72	-0.71	-2.42*	-2.08***	0.46*
Cropland quality	0.61	0.33*	1.61***	1.18***	0.03***
Land size	0.03*	0.07*	0.017	0.14**	-0.02***
Experience	-0.04*	-0.008	-0.05**	-0.03	0.01
Tenure	-1.1**	-0.06	-1.11**	-1.42**	-1.09***
Education	0.35	-0..006	-0.35	1.06***	0.35***
Constant	-3.93	1.87	2.16	-2.8	3.29**
R^2	0.94	0.77	0.63	0.82	0.83
D-W stat	1.92	1.59	1.62	2.55	1.67
F-statistic	25.4(0.00)	13.9(0.00)	3.4(0.00)	7.26(0.00)	27.5(0.00)

Note: (*), (**), (***) denotes significance at the level of 10, 5 and 1% (p <0.10, p <0.5, p <0.01), respectively. Source: Research Findings

The results showed that weather and climate are important factors determining irrigation frequencies at the farm and almost all weather variables are significant. According to the results, increasing the temperature has a positive and meaningful effect on the irrigation frequency of all selected crops. One unit of increase in the temperature increases the average irrigation frequency per hectare of cotton, barley, sugar beet, wheat, and alfalfa crops by 0.7%, 0.32%, 0.49%, 0.4%, and 1.14%, respectively. Increasing the temperature cause more evapotranspiration of the crop and consequently, increase the water required by the plant. Therefore, the frequency of farm irrigation is increased to meet the water needs of the plant, which is a reason for the positive relationship between temperature rise and IF.

Based on the results, increasing the precipitation leads to higher IF in sugar beet farms, while decreases it at barley, wheat, and alfalfa farms. Increased precipitation enhances the volume of water available for farm irrigation, so farmers have less restriction on farm irrigation and can increase the frequency of on-farm irrigation. Due to the high water requirement and long growing period of sugar beet, irrigation helps its proper growth and development, so with increasing the volume of available water, the frequency of irrigation increases (Zarski *et al*., 2020). On the other hand, as Olen *et al*. (2016) pointed out, the impact of precipitation on irrigation decisions has crop-specific thresholds, above which farmers respond very differently to climate changes. Only when precipitation is above thresholds, an increase in precipitation will lead to less irrigation frequency. With increasing precipitation, most of the water needed by the plant is supplied, hence the need for field irrigation is reduced, which caused decreasing the frequency of irrigation.

The exposure of wheat and sugar beet crops to cold stress has a negative and positive effect on IF, respectively, but this effect is insignificant on IF for other crops. In order to decline the damages caused by early cold in autumn and late cold in spring, farmers need to make appropriate decisions depending on crop type, time of stress, and plant growth stage. In North-Khorasan province, sugar beet is generally cultivated when it germinates and emerges during low temperatures. After germination, there is a possibility of late spring frosts and damage. At some farms, irrigation can reduce the effect of cold by increasing the temperature. As a result, the frequency of irrigation increases with the increase in the probability of cold. Wheat frosting may occur in two periods: before and after winter. Generally, most damage occurs due to late spring frosts, and the earlier the plant is in the growing stage, the lower the probability of damage is. Therefore, the probability of cold occurrence reduces the irrigation frequency. Agricultural experts also suggest refraining from irrigating wheat farms to prevent autumn frosts.

According to the findings, the occurrence of heat stress and the use of irrigation to reduce the stress increase irrigation frequency at cotton and wheat farms and reduce it at barley and alfalfa farms. Various factors affect a plant's heat tolerance. In general, the temperature that causes damage to the plant is different depending on type of the plant and the region of plant growth. The highest area of cotton and wheat is in Maneh and Samalqan. The water resources of this county are in a better situation than other counties, as the average annual precipitation of this county is higher than the province-wide average, so in facing heat stress, farmers have less restriction on irrigating their farms. Therefore, with the occurrence of heat stress, the average irrigation frequency of the province at wheat and cotton farms will increase by 1.93% and 0.36%, respectively. Also, due to the higher average annual temperature of this county than the average of the province, the probability of heat stress is higher in this county. So, farmers respond to heat stress by increasing irrigation frequencies. Frequent droughts increase the average irrigation frequency at cotton and barley farms by 1.4% and 0.7% and decrease it at sugar beet and alfalfa farms by 2.43% and 1.4%, respectively.

Farmers increase water volume and frequency of farm irrigation in arid areas with frequent droughts to meet crop water requirements. In the studied province, 66% of the cotton acreage is in Maneh and Samalqan county and 40% of the barley acreage is in Esfarāyen county. Also, based on the reports of the Jihad Agricultural Organization of North-Khorasan Province, the counties of Maneh and Samalqan and Esfarāyen have had the highest areas affected by drought in recent years. Therefore, drought has increased the irrigation frequencies of these crops. On the other hand, restrictions on access to water resources as a result of drought and changes in drought-resistant crops have reduced the irrigation frequencies of sugar beet and alfalfa. Water scarcity occurs more in areas where precipitation decreases and air temperature increases, and the water required for the irrigation is supplied more from groundwater resources. Also, with increasing water scarcity, the cost of pumping and water supply to the farm increases. Since most of the areas cultivated by barley and alfalfa in North-Khorasan province are located in regions with lower average precipitation and higher temperatures, the need for farm irrigation to meet the crop water requirements increases due to higher evaporation and transpiration of the plant. Therefore, this is a reason for the positive relationship between higher water costs and higher irrigation frequencies.

Also, according to the findings, increasing the piezometric level of water in the region leads to increasing irrigation frequency at cotton and sugar beet farms. Increasing water depth means more water scarcity and drought in the region. Crops like cotton and sugar beet that have high water needs should be irrigated more frequently to meet their water demands, so farmers increase the irrigation frequencies on their farms. In addition, in North-Khorasan province, cotton is mostly cultivated in areas where surface water is available. Therefore, with increasing water scarcity, farmers extract groundwater to supply farm water. Also, the variable of population density has a positive and meaningful effect on irrigation frequency at sugar beet and alfalfa farms and has a negative effect at barley farms. There is greater competition for water in densely populated areas, which is more likely to lead to limited agricultural water deliveries or the voluntary transfer of agricultural water to higher-value uses (Burke *et al*., 2004). As the demand for water increases, the amount of water available to irrigate the farm decreases, which results in reducing the frequency of irrigation. However, based on the results, the positive effect of population density can be explained by the fact that the increase in population in a region leads to higher volume of livestock, and due to the need to provide livestock fodder, the area under cultivation and the irrigation frequencies of alfalfa farms increase for further harvesting. Although barley is also a livestock feed, farmers will be less willing to cultivate it and use water for its irrigation under water-scarce conditions due to the low benefit of barley farms.

The results revealed that the type of irrigation source has a negative and significant effect on irrigation frequency at cotton, wheat, and sugar beet farms. In other words, if water for farm irrigation is supplied more from groundwater sources, irrigation frequencies will be reduced. In fact, groundwater is mostly used for agriculture in areas where surface water is not available and the volume of water available is less, thus the irrigation frequency is reduced. On the other hand, irrigation source has a positive and significant effect on barley and alfalfa crops. The highest cultivation area of these crops is in Esfarāyen county, whose temperature is higher than the average temperature of the province. Also, it had the second-lowest annual precipitation after Jajarm in the province in 2018-2019. Besides, most of the water needed for agriculture in this county is supplied from groundwater sources, so more irrigation frequencies are taken to meet the water needs of the crop. The irrigation method at cotton and sugar beet farms has a negative and meaningful effect on irrigation frequencies, while its effect is positive and significant at wheat farms. Also, the irrigation method has no significant effect on irrigation frequency at barley and alfalfa farms where irrigation frequency is determined independently of the type of irrigation method.

Based on the results, the mechanized irrigation method reduces the average irrigation frequency at cotton and sugar beet farms by 2.42% and 2.08%, respectively and increases it at wheat farms by 0.46%. According to the comprehensive report of agricultural water productivity (Comprehensive report on agricultural water productivity, 2017) in the province, the adoption of new irrigation technologies reduces the volume of water used to irrigate farms. The volume of water used during the cultivation period is reduced through the reduction of the volume of water used in each irrigation or the reduction of irrigation frequency. At cotton and sugar beet farms, in addition to reducing the volume of water used, the frequency of irrigation has also been decreased. However, the irrigation frequency at wheat farms has increased as a result of the adoption of new technologies, and with the application of management practices to the water used in each irrigation, the total volume of the water used during the growing period has decreased. The results showed that improving the cropland quality increases the irrigation frequency at cotton, barley, sugar beet, and wheat farms. In fact, the type of soil texture, direction, slope, and farm position affect the need for irrigation, so changing the cropland quality changes the amount of irrigation requirement of the farm. In addition, improving the cropland quality affects the profitability of the crop grown in the farm, and farmers may have to spend more on the land to improve it and harvest more.

Based on findings, increasing the land size has a positive and significant effect on irrigation frequency at barley, sugar beet, and alfalfa farms and has a negative and meaningful effect on irrigation frequency at wheat farms. Considering that barley, sugar beet, and alfalfa have the highest area of cultivation in Esfarāyen and Jajarm counties and a higher percentage of agricultural water supply in these counties is from groundwater sources, so increasing the land size reduces irrigation frequency due to the limited water resources. Also, due to limited water resources, better management for farm irrigation is done in larger lands. The highest irrigated area of wheat is in Maneh and Samalqan County, where a higher percentage of irrigation water is supplied from surface resources. Furthermore, large farmers generally have less restriction on water supply with more access to water resources, so they apply more irrigations (along with efficient management in water used) for more production and profit.

Finding of the study demonstrated that farmers' demographic characteristics affect irrigation frequencies, too. Farmers' experience and tenure have a negative effect on irrigation frequencies. Since experience is related to the farmer age, older farmers are not motivated to use irrigation even if they have access to water resources due to the smaller household size (reduction of average household size and separation of children from families with increasing the farmer's age) and prefer to avoid laborious irrigation work. Wakeyo and Gardebroek (2017) have also mentioned this point in their study.

Conclusion

In this paper, farmers' irrigation decisions to produce major crops of wheat, barley, cotton, sugar beet, and alfalfa in North-Khorasan province were analyzed using econometric models. For this purpose, the effects of climatic and weather factors, water scarcity, irrigation method and source, land characteristics, and demographics were studied on the share of irrigated land, technology adoption, and irrigation frequencies. The climate of the province is semi-arid with cold winters and hot summers. The results provide useful information about how farmers react and adapt to climate change in crop production systems.

It can be concluded from the results that climatic factors of temperature, precipitation, severe frost, heat, and drought, and economic-physical indicators of water scarcity have a significant impact on farmers’ irrigation decisions. Farmers try to reduce the damage caused by climate change and weather factors by deciding on irrigating their farms. The results indicated that farmers are more responsive to temperature changes than to other climatic factors. In areas with drought and warmer climates, the share of irrigated land increases and the likelihood of adopting technology decreases. Also, with increasing air temperature, the irrigation frequency of farms increases. Precipitation is positively related to the share of irrigated lands and the likelihood of adopting irrigation technology. According to the research results, the occurrences of drought and reduced precipitation in recent years have reduced the tendency to adopt new irrigation methods. This might be due to the reduced farm profitability and farmers' unwillingness to invest in farms. Therefore, to increase the efficiency of water used, it is suggested that the government formulate and implement support and incentive policies in this regard.

As the results showed, changes in the piezometer level of water significantly influence farmers’ irrigation decisions. Therefore, sustainable groundwater management can provide an important signal for producers to use irrigation methods to save groundwater. Moreover, the type of irrigation source (surface and groundwater), irrigation method, cropland quality, and land size have notable effects on farmers' decisions. In regions where surface water is not available, the share of irrigated land declines, and due to water scarcity, farmers are more willing to invest in new technologies. In higher-quality farms, farmers are more willing to invest in new irrigation methods and the frequencies of farms irrigation are increased. So, policymakers can increase the penetration of new technologies by improving land quality and integration. By creating production cooperatives, production resources and factors can be provided to farmers at a lower cost, agricultural lands can be rehabilitated, farmers can be connected to government centers, and mechanization can be developed.

Given that weather, climatic, and water scarcity indicators, type of crop grown, and water supply method on the farm have significant impacts on farmers' irrigation decisions, the government should pay special attention to these factors in adopting water management and optimal water use policies (including water pricing and quotas). The government should also make policies according to the climatic situation of the region. The climatic conditions themselves sometimes lead farmers towards new technologies and the implementation of policies such as pricing only imposes additional costs on farmers and discourages them.

Based on the results, farmers’ demographic characteristics such as education and experience influence their irrigation decisions. Increasing farmers’ experience and educational level increase the likelihood of accepting new irrigation methods, so creating suitable conditions for the education and training of farmers will pave the way for technology acceptance. It is also necessary to motivate the young and educated generation to enter the agricultural sector to develop and adopt appropriate technologies.

Reference

1. Abdulai, A., and W. E. Huffman. 2005. The diffusion of new agricultural technologies: the case of crossbred-cow technology in Tanzania. American Journal of Agricultural Economics 87: 645-659.
2. Agricultural Jihad Organization of North-Khorasan Province. 2017. Soil and Water Management and Engineering Technical Affairs. (In Persian)
3. Alam, K. 2015. Farmers’ adaptation to water scarcity in drought-prone environments: a case study of Rajshahi District, Bangladesh. Agricultural Water Management, 148: 196-206.
4. Balali, H., H. Saadi, and R. Vahdat Adab. 2016. Economic and social factors affecting the adoption of pressurized irrigation technology in wheat fields of Hamadan city. Agricultural Education Management Research, 37: 85-96. (In Persian)
5. Behbahani Motlagh, M., M.S. Sharifzadeh, G. Abdollahzadeh, and M.R. Mahboobi. 2017. Farmers' Adoption Behavior of Pressurized Irrigation Technology in Dashtestan County. Iran Agricultural Extension and Education Journal, 13 (1): 89-103. (In Persian)
6. Bressers, H., N. Bressers, and S. Kuks. 2019. Strategies and instruments to face drought and water scarcity. Chapter 14 in book, Facing Hydro meteorological Extreme Events: A Governance Issue, First Edition, Edited by Jeunesse, I.L. and C. Larrue.
7. Burke, S.M., R.M. Adams, and W.W. Wallender. 2004. Water Banks and Environmental Water

Demands: Case of the Klamath Project. Water Resources Research, 40 (W09S02): 1–9.
8. Calzadilla, A., K. Rehdanz, and R.S.J. Tol. 2011. Water scarcity and the impact of improved irrigation management: a computable general equilibrium analysis. Agricultural Economics 42: 305-323.
9. Caswell, M.F., and D. Zilberman. 1986. The effects of well depth and land quality on the choice of irrigation technology. American Journal of Agricultural Economics, 68: 798-811.
10. Coffel, E. D., B. Keith, C. Lesk, R.M. Horton, E. Bower, J. Lee, and J. S. Mankin. 2019. Future hot and dry years worsen Nile basin water scarcity despite projected precipitation increases. Earth's Future, 7(8): 967-977.
11. Comprehensive report on agricultural water productivity. 2017. Agricultural Jihad Organization of North-Khorasan Province. (In Persian)
12. Cremades, R., J. Wang, and J. Morris. 2015. Policies, economic incentives and the adoption of modern irrigation technology in China. Earth System Dynamic, 6: 399-410.
13. Dashti, Gh., Kh. Olphi, M. Ghahremanzade. 2017. Investigating the effects of climatic variables on land allocation between groups of annual crops in the country. Journal of Agricultural Economics and Development, 30(4): 297-307. (In Persian)
14. Dinar, A., A. Tieu, and H. Huynh. 2019. Water scarcity impacts on global food production. Global Food Security, 23: 212-226.
15. Etwire, P.M. 2020. The impact of climate change on farming system selection in Ghana. Agricultural System 179: 102773.
16. Finkel, H. J., and D. Nir. 1983. Criteria for the Choice of Irrigation Method. In Handbook of Irrigation Technology Volume II, ed. H. J. Finkel. Boca Raton, FL: CRC Press.
17. Frisvold, G., and T. Bai 2016. Irrigation technology choice as adaptation to climate change in the Western United States. Journal of Contemporary Water Research & Education, 158: 62-77.
18. Hamdy, A., R. Ragab, and E. Scarascia-Mugnozza. 2003. Coping with water scarcity: water saving and increasing water productivity. Irrigation and Drainage, 52: 3-20.
19. Howitt, R., J. Medellin-Azuara, D. MacEwan, J. Lund, and D. Summer 2014. Economic analysis of the 2014 drought for California agricultural. Center for Watershed Sciences University of California, Davis UC Agricultural Issues Center ERA Economics, Davis, Calif.
20. Jawid, A. 2019. A ricardian analysis of the economic impact of climate change on agriculture: evidence from the farms in the Central Highlands of Afghanistan. Journal of Asian Economics, ASIECO 101177.
21. Karppien, H. 2005. Forest owners' choice of reforestation method: An application of the theory of planned behavior. Forest policy and Economics 7 (3): 393-409.
22. Khaledi, F., K. Zarafshan, A. Mirakzadeh, and l. Sharafi. 2016. Analysis of adaptability of wheat farmers in Sarpol-e-Zahab city against climate change. Iranian Agricultural Extension and Education Science 12 (2): 169-182. (In Persian).
23. Khaledi, S. 2004. Investigation of frost phenomenon and its effects in horticulture of Marand city. Journal of Applied researches in Geographical Sciences 2 (2): 29-50. (In Persian).
24. Li, M., Y. Xu, Q. Fu, V. P. Singh, D. Liu, and T. Li. 2020. Efficient irrigation water allocation and its impact on agricultural sustainability and water scarcity under uncertainty. Journal of Hydrology 586: 124888.
25. Lichtenberg, E. 1989. Land quality irrigation development, and cropping patterns in the northern high plains. American Agricultural Economics Association 71 (1): 187-194.
26. Liu, J., H. Yang, S. Gosling, M. Kummu, M. Flörke, S. Pfister, N. Hanasaki, Y. Wada, X. Zhang, C. Zheng, J. Alcamo, and T. Oki. 2017. Water scarcity assessments in the past, present and future. Earth's Future 5 (6): 545-559.
27. McDonald, R.I., and E. H. Girvetz. 2013. Two challenges for U.S. irrigation due to climate change: increasing irrigated area in Wet States and increasing irrigation rates in dry states. PloS One, 8(6): e65589.
28. Mendelsohn, R., and A. Dinar. 2003. Climate, Water and Agriculture. Land Economics, 79(3): 328-341.
29. Movahedi, R., N. Izadi, and R. Vahdat Adab. 2017. Investigating the effective factors on the acceptance of pressurized irrigation technology among farmers in Asadabad city. Journal of Water Research in Agriculture, 31(2): 287-300. (In Persian)
30. Olen, B., J. Wu, and C. Langpap. 2016. Irrigation decisions for major west coast crops: water scarcity and climatic determinants. American Journal of Agricultural Economics, 98(1): 254-275.

31. Paltasingh, K.R., and P. Goyari. 2018. Impact of farmer education on farm productivity under varying technologies: case of paddy growers in India. Agricultural and Food Economics, 6(7): 1-19.
32. Papke, L.E., and J.M. Wooldrige. 1996. Econometric methods for fractional response variables with an application to 401 (K) plan participation rates. Journal of Applied Econometrics, 11: 619-632.
33. Parhizkari, A., A. Mahmoudi, and M. Shokat Fadai. 2017. Assessing the effects of climate change on available water resources and agricultural production in the Shahroud watershed. Agricultural Economics Research, 9(1): 23-50. (In Persian)
34. Rahmani, S., S. Yazdani, A. Mahmoudi, M. Shokat Fadai, and A. Souri. 2016. Investigating the factors affecting the acceptance and development of pressurized irrigation cultivation level using Logit model (Case study: Ardabil province). Journal of Economic Growth and Development Research, 6(23): 13-26. (In Persian)
35. Seekao, C., and C. Pharino. 2016. Key factors affecting the flood vulnerability and adaptation of the shrimp farming sector in Thailand. International Journal of Disaster Risk Reduction, 17: 161-172.
36. Sheidaeian, M., M. Ziatabar Ahmadi, and R. Fazlavali. 2014. The effect of climate change on irrigation net requirement and rice yield (Case study: Tajan plain). Journal of Water and Soil (Agricultural Sciences and Industries), 28(6): 1284-1297. (In Persian)
37. Siddig, K., D. Stepanyan, M.Wiebelt, H. Grethe, and T. Zhu. 2020. Climate change and agriculture in the Sudan: Impact pathways beyond changes in mean rainfall and temperature. Ecological Economics, 169: 106566.
38. Statistical Yearbook of North-Khorasan province. 2019. Statistical Center of Iran. (In Persian)
39. Tavakoli, J., H. Almasi, and P. Ghoochi. 2016. Investigation and analysis of farmers' adaptation strategies to drought in Kermanshah province. Rural Research, 7(1): 217-242. (In Persian)
40. Velayati, S. 2006. Investigation of water crisis in Khorasan province. Modarres Human Sciences, 10(48): 213-234. (In Persian)
41. Wakeyo, M. B., and C. Gardebroek. 2017. Share of irrigated land and farm size in rainwater harvesting irrigation in Ethiopia. Journal of Arid Environments, 139: 85-94.
42. Zarifian, S., J. Rostami, and E. Pishbahar. 2020. Factors affecting the use of modern irrigation systems for Sustainable Agricultural Development (Case Study: Rural Areas of Bostan Abad City of East-Azerbayjan Province Iran). Journal of Agricultural Knowledge and Sustainable Production, 30(3): 217-229. (In Persian)
43. Zarski, J., R. Kuśmierek-Tomaszewska, and S. Dudek. 2020. Impact of Irrigation and Fertigation on the Yield and Quality of Sugar Beet (Beta vulgaris L.) in a Moderate Climate. Agronomy, 10(2): 166.
44. Zhang, B., Z. Fu, J. Wang, and L. Zhang. 2019. Farmers’ adoption of water-saving irrigation technology alleviates water scarcity in metropolis suburbs: A case study of Beijing, China. Agricultural Water Management, 212: 349-357.

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تأثیر تغییرات اقلیم و کمبود آب بر تصمیم‌های آبیاری کشاورزان استان خراسان شمالی: محصولات عمده زراعی

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چکیده

در این مقاله، اثر کمبود آب و شرایط اقلیمی بر تصمیمات آبیاری کشاورزان در تولید محصولات عمده زراعی گندم، جو، پنبه، چغندرقند و یونجه در استان خراسان شمالی ارزیابی شده است. تصمیم‌های آبیاری کشاورزان در قالب یک مدل مدیریت شامل معادلات سهم اراضی آبی، پذیرش تکنولوژی آبیاری و دفعات آبیاری مزرعه تعریف شده است و اثر شاخص‌های کمبود آب و عوامل اقلیمی، روش تأمین آب مزرعه، ویژگی‌های اراضی و جمعیتی کشاورز مورد بررسی قرار گرفتند. برای این منظور از طریق تکمیل پرسشنامه توسط ۳۸۰ کشاورز اطلاعات مورد نیاز جمع‌آوری و سپس با استفاده از روش‌های لاجیت کسری، لاجیت دوگانه و OLS معادلات مدل مدیریت برآورد شده‌اند. نتایج نشان داد که کمبود اقتصادی و فیزیکی منابع آب، شرایط اقلیمی دما و بارندگی و رخدادهای شدید سرمازدگی و گرمازدگی محصول و خشکسالی، تأثیر قابل توجهی بر تصمیم‌های آبیاری کشاورزان دارند. کشاورزان از طریق تصمیم به آبیاری مزرعه و اتخاذ تکنولوژی‌های جدید سعی می‌کنند خسارت ناشی از تغییر اقلیم و کمبود آب را کاهش دهند. همچنین نوع منبع آبیاری سطحی و زیرزمینی، روش آبیاری، کیفیت و مقیاس مزرعه بر تصمیمات کشاورز تأثیر معنادار دارد. در مناطقی که آب سطحی در دسترس نیست، سطح اراضی آبی کاهش می‌یابد و به دلیل کمبود آب، کشاورزان رغبت بیشتری برای سرمایه‌گذاری در فناوری‌های جدید دارند. مزارعی که از نظر جنس خاک مزرعه، جهت و شیب زمین زراعی و دسترسی به منابع از کیفیت بالاتری برخوردار هستند، کشاورزان تمایل بیشتری برای سرمایه‌گذاری در روش‌های نوین آبیاری دارند و دفعات آبیاری را در مزارع افزایش می‌دهند. لذا، اعمال سیاست‌هایی جهت بهبود کیفیت و یکپارچه‌سازی اراضی، میزان گسترش تکنولوژی را افزایش و حجم آب مصرفی در مزرعه را کاهش می‌دهد. همچنین، ویژگی‌های جمعیتی کشاورز از قبیل تجربه، مالکیت، تحصیلات بر تصمیماتی که کشاورز برای آبیاری مزرعه می‌گیرد تأثیرگذار هستند. ایجاد بستر تحصیل و آموزش کشاورزان، میزان آگاهی کشاورزان را نسبت به روش‌های نوین کشاورزی و اهمیت منابع آب افزایش می‌دهد. نتایج این تحقیق اطلاعات ارزشمندی در مورد چگونگی واکنش کشاورزان در سیستم‌های تولید و انطباق با تغییرات اقلیمی و اتخاذ سیاست‌های اثربخش فراهم می‌کند.

واژه‌های کلیدی: تصمیم‌های آبیاری، تغییر اقلیم، کمبود آب، لاجیت کسری

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Determining the Optimal Stock Portfolio of Agricultural Companies in Tehran Stock Exchange

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Abstract

Efficient Asset allocation and investment portfolio selection are among the most critical and challenging issues in investment management and a continuous concern for investors. When investors invest in the capital market, they expect their portfolio to perform well. Therefore, this study determines the optimal stock portfolio of agricultural companies in the Tehran Stock Exchange (TSE). Thirty-two most important agriculture companies in the (TSE), with monthly data from 2014-2020, were selected from Iran's two most essential agriculture industries, the food and beverage industries, and the sugar industry. Two portfolios for the food and beverage industry and sugar industry goals: minimizing portfolio variance and maximizing portfolio return using the Markowitz model with two different scenarios and applying two minimum investment constraints of 1% and optimized maximum investment of 20% without considering these two constraints. The efficiency, variance, and Sharp ratios are also calculated. The results showed that both food and beverage industry portfolios and the sugar industry portfolios became more efficient when optimized to maximize portfolio returns. The result also indicates the food and beverage industry was more efficient than the portfolio of the sugar industry. In this portfolio, the amount of investment for the shares of Salmin Company was 86.7% and for Mehram Company was 13.3%.

Keywords: Markowitz Model, Optimization, Portfolio Return, Risk, Sharp Ratio

Introduction

As one of the pillars of the Iran economy, it has an essential role in attracting small savings and financial resources and allocating them to finance large economic projects. There is no doubt that economic growth, development of welfare and social justice, and expansion of financing mechanisms depend on the growth of the capital market in proportion to other components of the economic system (Sadeghi, 2014). Iran is one of the countries whose traditional part of the agricultural market, due to economic inefficiency, does not meet the country's needs. Still, economic conditions have caused many problems for farmers, consumers, and even traders of agricultural products. Astray capital in the society can invest in the farming sector through the Tehran Stock Exchange, which creates a boom in agriculture production in the farming sector and creates for the shareholders of this sector to profit from the investment. Agricultural companies in the farming industry are essential in the growth and development of the country's agricultural industry in the conversion and processing of raw materials in the farming industry. In Iran, the industries related to this sector are financially weak and have not been able to grow and develop like developed

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countries; As a result, they need financing their investment in various ways. Therefore, the stock market provides the required capital for the companies in question and contributes to the country's economic growth. This is possible when the investor's profit from this investment is not ignored. Therefore, the main problems faced by investors are selecting securities for investment and creating an optimal portfolio of stocks (Hoseini Kasgari *et al*., 2017). Thus, this study provides a way to identify the stock risk of companies in these industries, which investors can use to maximize profits and reduce investment risk; in other words, determine the optimal stock portfolio of companies related to these industries. Each agricultural company in the (TSE) market has different risks and returns (Alipoor Leili, 2018). In order to invest in these companies, it is essential to examine the risk and return of each TES stock to identify the optimal portfolio for investment.

There are 43 agriculture industries in the Tehran Stock Exchange. Five sectors are classified as agriculture, textiles, wood products, sugar, and food and beverage industries related to the agricultural sector. Table 1 shows the correlation coefficients between the returns of agricultural industries. As it can be seen, there is no complete correlation between the returns of the agricultural industries under study, and the process of their returns is not entirely in line with each other. Therefore, we can diversify our portfolio by including different companies from each industry, thereby reducing the variance of the portfolio and optimizing the portfolio.

Table 1- Correlation coefficients between the returns of agricultural industries

Industry	The correlation coefficient
Food – sugar	0.58
Food – Agriculture	0.48
Food – Textiles	0.27
Food- Wooden	0.31
Sugar – Agriculture	0.36
Sugar – Textiles	0.10
Sugar – wood	0.25
Agriculture – Textiles	0.15
Agriculture – wood	0.25
Textiles – wood	0.03

Source: Research findings

Based on economic theories, it is assumed that investors are always looking to maximize their desirability while investors are investing in terms of risk and return. In other words, the basis of investment decisions is the relationship between risk and return. Investors always pay attention to two factors of risk and return to determine the optimal portfolio of their stocks. Empirical studies have demonstrated that unsystematic risk can be virtually eliminated in 30 to 40 randomly selected stocks portfolios. Of course, if investments are made in closely related industries, more securities are required to eradicate the unsystematic risk. The investors inhabiting this hypothetical world are assumed to be risk-averse. This notion, which agrees for once with the world most of us know, implies that investors demand compensation for taking on risk. In financial markets dominated by risk-averse investors, higher-risk securities are priced to yield higher expected returns than lower-risk securities.

Each investment has its own risk and return, and the combination of these two factors influences the investor's decision to choose the optimal portfolio. Depending on their degree of risk aversion, they choose the investment portfolio with the lowest risk and maximum return (Joonz, 1943). Therefore, according to the presented materials, this research identifies the optimal portfolios of agricultural companies in the Tehran Stock Exchange, and the most efficient portfolio is selected.

Hosseini Kasgari *et al*. (2017) studied to provide a method for selecting the optimal portfolio of stocks of food industry companies in the Tehran Stock Exchange using the model of mean skewness variance with six objective functions. In their research, to select the optimal stock portfolio, first, the stock price was predicted, and then two methods of mean variance-skewness and mean variance pattern were used, and the optimal stock portfolio was determined. Mousavi *et al*. (2016) optimized the portfolio of Sepah Bank Investment Company using the combined model of

Markowitz and GARV multivariate. The main purpose of their research paper was to optimize the portfolio of Sepah Bank Investment Company using the risk minimization method compared to the expected return. They considering the expected return, the optimal risk of the investment portfolio containing four industries has been calculated. Findings showed that whenever there is less risk in each industry, their share in the investment portfolio is higher. In addition, among these four industries, the highest average share is related to the non-metallic mineral extraction industry, and the metal mineral extraction industries, large multidisciplinary companies, and the chemical materials and products industry are in the positions, respectively. Therefore, it is appropriate for Sepah Investment Company to consider such prioritization in order to minimize its risk at all times as well as to achieve the expected return. Ghadiri Moghaddam and Rafiei Darani (2010), in their research, have examined and determined the optimal stock portfolio of companies active in the food industry of the Tehran Stock Exchange based on the value at risk index (VaR).

Table 2- Companies active in the food and beverage industry in the Tehran Stock Exchange

Industry	Sub-industry	Company
Food and beverage products other than sugar	Growing and preserving fruits, vegetables	1- Murghab plain
		2- Piazer cultivation and industry
		3- Iranian nectar
		4- Noush Mazandaran
		5- Pure Martyrs of Khorasan
	Production of animal and vegetable oils	6- Nili Sanat Kerman Production Complex
		7- Margarine
		8- Behshahr Industrial
		9-Development of Behshahr industries
		10-Behpak Industrial
	Dairy production	11-Kalber Dairy
		12- Pak Dairy
		13-Pegah of East Azarbaijan
		14-Pegah of Azerbaijan
		15-Pegah Fars
		16-Pasteurized milk of Pegah Khorasan
		17-Isfahan Pegah pasteurized milk
		18-Pasteurized milk of Pegah Golpayegan
		19-Pegah Golestan pasteurized milk
	Production of starch and related food products	20-Glokozan
	Production of ready-made animal feed	21-Pars livestock feed
	production of bread and related products	22-Georgian biscuits
		23-Salmin
		24-Vitana
		25-Saturn
	Production of cocoa, chocolate, and sweets	26-Pars Minoo
		27-Minoo Industrial (Khorramdareh)
		28-Self-sufficiency of freedmen
		29-Shokopars
		30-Minoo Shargh Food Industries
		31-Gaz Coin
	Other food products	32- China Agriculture and Industry China
		33-Produced by Mehram
		34-Behshahr Industries Development (Holding)
		35-Congratulations
		36-Noush Pooneh Mashhad
		37-Agriculture and industry of Khorasan spring flowers
	Production of barley and beer	38-Behnoosh Iran
	Soft drinks and mineral water	39-Pakdis

Source: Tehran Stock Exchange 2019

The main purpose of their study was to determine and study the optimal portfolio of stocks of companies active in the food industry of the stock exchange based on the value-at-risk index, which is used mathematical planning with integers. Abroad, Basuki *et al*. (2019) have used linear algebra equations to determine the optimal portfolio in an article. The results of their studies have shown that it is suitable for determining the optimal portfolio by linear algebra method. Poor Nima and Ramesh (2016) chose the optimal portfolio with the help of the Sharp single index model and using risk-return analysis in the automotive and pharmaceutical sectors. Campbell *et al*. (2001) determined the optimal stock portfolio by maximizing the expected return with limited value at risk. The problem of portfolio selection therefore remains to maximize the expected returns, however, while minimizing the downside risk taken by the risk-taking value, and using this approach allows a very general framework for create a portfolio selection. Therefore, by reviewing the other research to determine the optimal portfolio stock of agricultural companies In Tehran Stock Exchange it is necessary to use the Markowitz optimal portfolio method.

One of the industries related to the agricultural sector in the Tehran Stock Exchange is the food and beverage industry. This industry is non-periodic; There is a constant demand for products in all seasons and different economic situations (Shirzad, 2016). Table 2 shows the names of companies active in the food and beverage industry separately.

Another industry related to the agricultural sector that operates on the stock exchange is the sugar industry. As a nutrient needed by the body and the primary sweetener and its high consumption in the daily basket of the household, sugar has the highest consumption in industries such as beverage, canned and compote, sweets, and chocolate. In addition to its nutritional importance, it has always been considered a strategically important material politically and economically. Therefore, most countries try to supply and produce it and meet their domestic needs as much as possible, and several countries earn a significant share of their revenues from the export of this product. In Iran, the primary uses of sugar are households, confectionery factories, cakes and chocolates, beverage and beverage factories, pharmaceutical factories, and livestock and poultry industries. Still, the most important are households and factories. The name of the sugar industry is shown in Table 3.

Table 3- The name of Companies in the sugar industry on the Tehran Stock Exchange

Industry	Sub-industry	Company
Sugar	Sugar production	1-Isfahan Sugar 2-Qazvin sugar factories 3-Hegmatan Sugar 4- Nectar 5-Lorestan Sugar 6-Marvdasht Sugar 7-Neyshabur Sugar 8-Food and sugar products of Piranshahr 9-Fixed sugar of Khorasan 10-Shahroud Sugar 11-Torbat Jam sugar 12-Sugar Shirvan Quchan 13-Khorasan sweet sugar 14-The role of sugar in the world 15-Food products and Chaharmahal sugar

Source: Tehran Stock Exchange 2019

Fluctuations in stock returns of agricultural industries, one of the criteria for measuring risk in the capital market, have been studied in graphs to indicate the possibility of risk in stocks of these industries due to changes in stock returns. These fluctuations from 2014 to 2020 have been studied for different agricultural industries. Figure 1 shows the trend of stock returns of the food and beverage industry during the years 1993 to 1998. The stock return of this industry had the lowest value of -0.12 in 2014, and this amount reached its highest level, 1.9 in 2020. Figure 2 also shows the trend of stock returns in the sugar industry. In 2014 the industry started its lowest stock return with -0.62, and in 1998, it reached its highest level of 1.41.

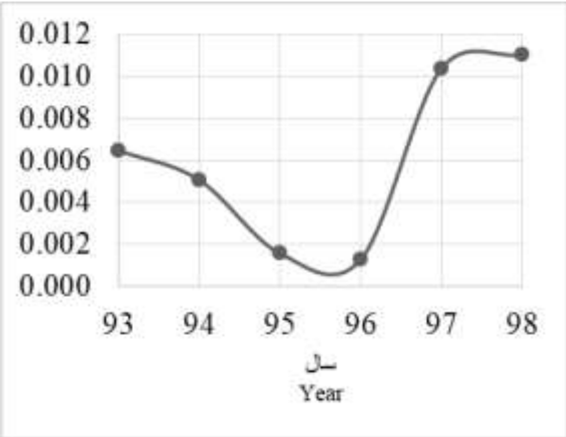

Fig. 2- Trend of stock returns of sugar industry

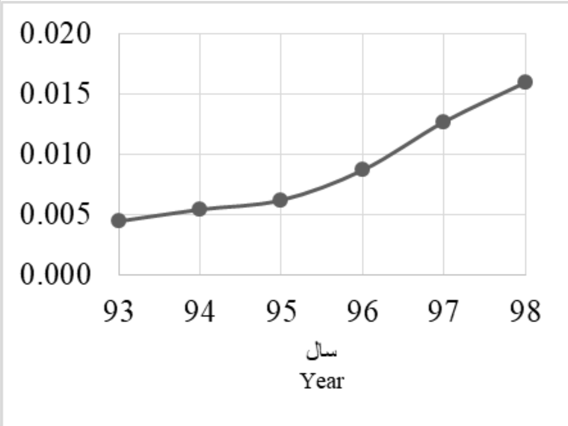

Fig. 1- Trend of stock returns of food and beverage industry

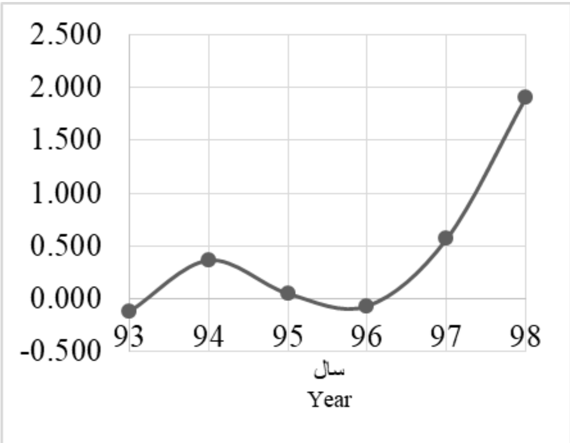

Fig. 3- Risk of food and beverage industry stocks

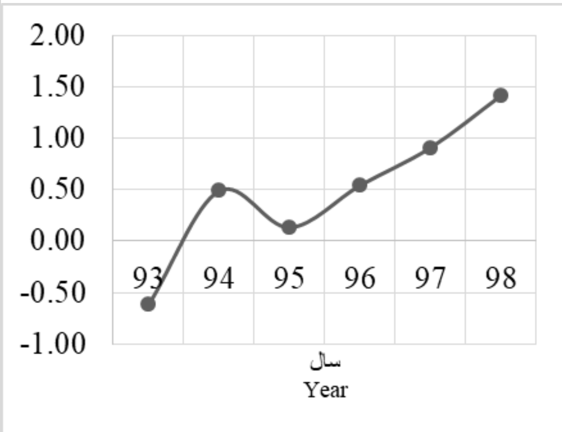

Fig. 4- Risk of Sugar industry stock

Figure 3 shows the stock risk of the food and beverage industry. In 2014, the stock risk of this industry was 0.006, which in 1996 reached its lowest level of 0.001, and in 1998 its highest level of 0.011. The stock risk of the sugar industry is shown in Figure 4. In 2014, this industry had its lowest risk amount of 0.004, which had an upward trend until 1998, and this year has reached its highest level of 0.016.

Research Methodology

The term portfolio, in simple terms, refers to a combination of assets formed by an investor to invest. This investor can be an individual or an institution. In other words, a portfolio includes a set of real assets invested by an investor. In this study, our emphasis is on financial assets. Financial assets include various securities such as equity securities, common stock, preferred stock, and financial derivatives (Joonz, 1943). But in this study, our financial assets are stock of agriculture companies. The modern portfolio theory was proposed in 1952 by Harry Markowitz. This theory states that part of the risk can be eliminated or at least reduced by diversifying securities. In 1959, Markowitz was the first to introduce variance or standard deviation as a measure of risk. He stated that decision-makers in portfolio selection minimize the return variance to a certain level of expected return or maximize the expected return to a certain level of variance. This approach provides an efficient boundary that portfolios on the efficient frontier (Figure 5) show the minimum risk per return (Salim Odloo, 2017).

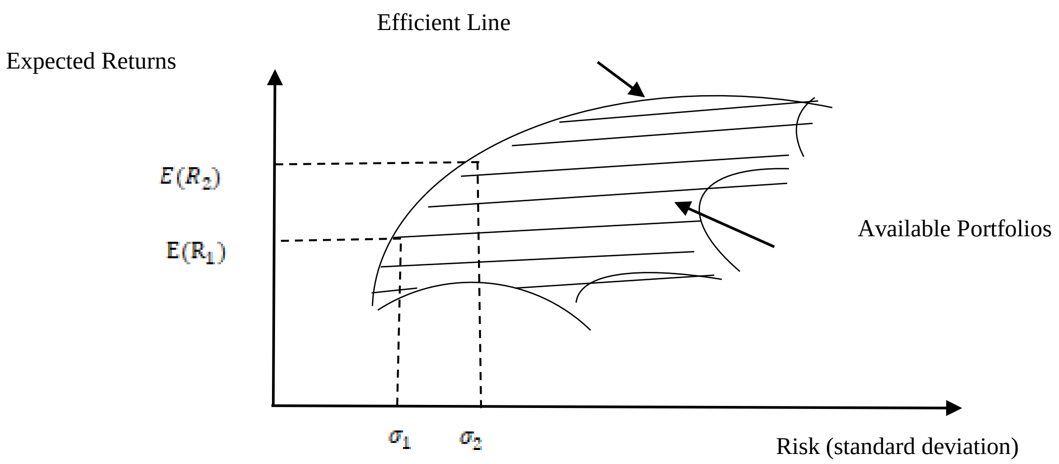

Fig. 5- Markowitz efficient frontier

A portfolio is a set of two or more activities that Markowitz (1959) formulated portfolio theory in this way. The investor should consider different efficient combinations of standard deviation and expected returns and choose his portfolio based on his preferences and degree of risk aversion. Portfolio theory states that a variety of two stocks whose returns are not fully correlated provides a combination whose fluctuations are less than the fluctuations of individual stocks. Modern portfolio theory shows that specific risks can be removed or at least mitigated through the diversification of a portfolio. The trouble is that diversification still does not solve the problem of systematic risk; even a portfolio holding all the shares in the stock market cannot eliminate that risk. Therefore, when calculating a deserved return, systematic risk most plagues investors.

Hence the investor tries to reduce changes through some less correlated stocks or negatively correlated with each other. The advantage of this theory is that it considers stock returns and risk together. Return on a portfolio is the weighted average return on the portfolio of stocks in which the weight of each stock is the share of those stocks in the portfolio (Equation 1).

$$E(R_p) = \sum_{i=1}^{N} W_i R_i \tag{1}$$

In this regard, $E(R_p)$ is the total return on the portfolio, W_i is the stock weight i, R_i is the stock return i, and N is the number of companies in the portfolio. And the stock returns of each company in a portfolio are obtained using (Equation 2) (6).

$$R_{it} = \frac{P_{it} - P_{it-1} + D_{it}}{P_{it-1}} * 100 \tag{2}$$

R_{it} is i's stock rate of return in period t, P_{it} is the i-share price at the end of the period, P_{it-1} is the stock price i at the beginning of the period. D_{it} is a dividend cash dividend in period t.

The dividend is the amount a company pays to investors from dividends made. The variance of the portfolio also depends on the covariance between the stocks, which, if there is no complete positive correlation between them, reduces the variance of the entire portfolio to (Equation 4). The variance of shares of each company is also obtained from (Equation 3).

$$\sigma_i^{\,2} = \sum_{i=1}^{N} (R_i - E(R_i))^2 \Pr_i \tag{3}$$

$$\sigma_p = \sqrt{\sigma_p^2} = \sqrt{\sum_{i=1}^{N} w_i^{\,2} \sigma_i^2 + \sum_{i=1}^{N} \sum_{j=1}^{N} \operatorname{cov}(R_i, R_j)} \tag{4}$$

$$\operatorname{cov}(R_i, R_j) = r_{ij} \sigma_i \sigma_j \tag{5}$$

In these two relations, (Equations 4 and 5), σ_i^2 is the stock variance i, pr_i is the probability of occurrence of any rate of return for a company i , σ_p^2 is the total variance of the portfolio, cov (R_i, R_j) is the covariance of the return between shares i and j, r_{ij} is the correlation coefficient between the returns of companies i and j, σ_i is the standard deviation of a company i and σ_j is the standard deviation of company j. The selection of the optimal point of each person on the efficient boundary is based on the tangent point of each individual's utility function and the efficient frontier.

Mean-Variance Analysis is a technique that investors use to make decisions about financial instruments to invest in, based on the amount of risk they are willing to accept (risk tolerance). Ideally, investors expect to earn higher returns when investing in riskier assets. When measuring the level of risk, investors consider the potential variance (the volatility of returns produced by an asset) against the expected returns of that asset. The mean-variance analysis essentially looks at the average variance in the expected return from an investment. The mean-variance analysis is a component of modern portfolio theory. This theory assumes that investors make rational decisions when they possess sufficient information. One of the theory's assumptions is that investors enter the market to maximize their returns while at the same time avoiding unnecessary risk.

When choosing a financial asset to invest in, investors prefer the asset with lower variance when given choosing between two otherwise identical investments. An investor can achieve diversification by investing in securities with varied variances and expected returns. Proper diversification creates a portfolio where a loss in one security is counter-balanced by again in another. The mean-variance analysis is comprised of two main components, as follows:

Variance measures how distant or spread the numbers in a data set are from the mean or average. A large variance indicates that the numbers are further spread out. A small variance indicates a small spread of numbers from the mean. The variance may also be zero, which indicates no deviation from the mean. When analyzing an investment portfolio, variance can show how a security's returns are spread out during a given period.

The second component of the mean-variance analysis is the expected return. This is the estimated return that security is expected to produce. Since it is based on historical data, the expected rate of return is not 100% guaranteed. If two securities offer the same expected rate of return, but one comes with a lower variance, most investors prefer that security.

Similarly, if two securities show the same variance, but one of the securities offers a higher expected return, investors opt for the security with the higher return. When trading multiple securities, an investor can choose securities with different variances and expected returns.

The E-V standard performance set can be achieved using appropriate mathematical programming techniques or linear programming such as Linear Programming-Risk simulator (LP-RS). The general form of this approach is expressed in the form of (Equation 6 and 7) (Narayan, 1990).

$$MinV_p = \sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i=1}^{N}\sum_{j=1}^{N} \text{cov}(R_i, R_j) \tag{6}$$

S.t

$$\sum_{i=1}^{N} w_i E(R_i) \geq E$$

$$\sum_{i=1}^{N} w_i = 1$$

$$w_i \geq 0 \quad \text{for i=1, 2,…,N}$$

In this case, E is the minimum expected return level. The goal in this model is to minimize portfolio variance for a given level of return. The first limitation also states that the return on the portfolio must be such that it is greater than or equal to the minimum expected return. The second constraint, the primary investment constraint, states that the total amount invested in each stock equals one. The third constraint says that each company's share in the portfolio is zero or greater.

$$MaxE(R_p) = \sum_{i=1}^{N} W_i E(R_i)$$

S.t

$$\sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i=1}^{N}\sum_{j=1}^{N} \text{cov}(R_i, R_j) \leq V \tag{7}$$

$$\sum_{i=1}^{N} w_i = 1$$

$$w_i \geq 0 \quad \text{for i=1, 2,…,N}$$

In this regard, variable V is the maximum level of variance accepted. The goal of this model is to maximize portfolio returns for a given level of variance. The first limitation also states that the variance of the portfolio must be such that it is less than or equal to the maximum level of variance expected. The second and third constraints are repeated as in the previous model. Finally, solving these models gives us the share of each company in the optimal stock portfolio. Different metrics can be used to evaluate portfolio performance. The Sharp ratio or return to variability ratio is one of the criteria developed by Sharp (1996) to measure portfolio performance. The Sharp ratio is obtained by dividing the portfolio's excess returns by the standard portfolio deviation. In fact, by using this ratio, we are looking to calculate the monetary amount that an investor receives to bear the entire risk. The Sharp ratio is calculated using equation (8):

$$Sh_p = \frac{E(R_p) - R_f}{\sigma_p} \qquad (8)$$

In this regard, $E(R_p)$ is the return on the portfolio, σ_p is the standard deviation of the portfolio, and R_f is the rate of return on the risk-free investment (Luenberger, 1997).

The data used in this study include the monthly returns of 32 companies listed on the Tehran Stock Exchange, the data of which existed monthly from 1993 to 1999. These companies are in the two sectors industries of food and beverage and sugar industry and are in the agriculture sector.

Results and Discussion

In order to determine the optimal portfolio of shares of agricultural companies, the results of using the Markowitz model to optimize the two portfolios of the food and beverage industry and sugar industry with two objectives of minimizing variance and maximizing portfolio returns are shown in Tables 4, and 5, respectively.

As it is shown in Table 4, in the second column, portfolio optimization has been done with two restrictions: minimum investment and maximum investment, and in the third column, optimization has been done without considering these two restrictions. In the second column, the minimum investment on each company is 1%, and the maximum investment on the shares of each company is 20%. In this paper, we compare the portfolio optimization of the food and beverage industry with two goals of minimizing variance and maximizing the portfolio's expected return, considering the two constraints of minimum and maximum investment. Due to the increasing share of some companies such as Pars Mino, Pegah Azerbaijan, Pegah Isfahan, and Salmin in this industry's portfolio, we conclude that these companies have maximized the return of the portfolio a good return. The companies are Georgian Biscuit, Behshahr Industrial Development, Murghab Plain, Behpak Industrial, Glucosane, Margarine, and Cultivation and China's industry has lower returns. The results of portfolio optimization of this industry, without considering the two constraints of minimum investment and maximum investment, also show that when we optimized the portfolio intending to maximize returns, the participation of companies in the portfolio decreased, and the portfolio share towards Salamin and Mehram companies is gone. The Sharp ratios also show that a portfolio is more efficient when optimizing a portfolio intending to maximize returns.

Also, in Table 5, the portfolio of the sugar industry has been optimized with the two objectives of minimizing variance and maximizing portfolio returns. In the second column, portfolio optimization has been done with two restrictions of minimum investment and maximum investment. In the third column, optimization has been done without considering these two restrictions. In the second column, the minimum investment in each company is 1%. The maximum investment on the shares of each company is 20% as a result of comparing the portfolio optimization of the sugar industry with two goals of minimizing variance and maximizing the expected return of the portfolio by considering the two constraints of minimum investment and maximum investment. It shows that when we maximize the portfolio return, we can say that these companies have excellent returns due to increasing the share of some companies such as Isfahan and Qazvin, and Marvdasht sugar companies. The Nectar, food products and Chaharmahal sugar companies, Khorasan fixed sugar, and Lorestan sugar has lower returns. The results of portfolio optimization of this industry, without considering the two constraints of minimum investment and maximum investment, also show that when we optimized the portfolio intending to maximize returns, the companies' participation in the portfolio decreased, and the whole portfolio was allocated only to Piranshahr Sugar Company. The resulting Sharp ratios also show that a portfolio is more efficient when optimizing a portfolio intending to maximize returns.

Table 4- Results of food and beverage industry portfolio optimization with two objectives of minimizing variance and maximizing portfolio efficiency

Company	The percentage share of each company with two constraints of minimum and maximum amount of investment on the shares of each company		Percentage share of each company without two constraints of the minimum and maximum amount of investment on the shares of each company	
	Minimize portfolio variance	Maximize portfolio returns	Minimize portfolio variance	Maximize portfolio returns
Behnoush	1	1	0	0
Georgian Biscuits	12.9	1	14	0
Pars Minoo	1	6	0	0
Pegah of Azerbaijan	3.9	20	4.2	0
Pegah Isfahan	6.2	20	6	0
Pegah Khorasan	1	1	0	0
Behshahr Industries Development	10.3	1	10.9	0
Plain Morghab	3.6	1	2.3	0
Salmin	5.9	20	6.2	86.7
Minoo Shargh Food Industries	1.2	1	0	0
Behpak Industrial	4.1	1	4.4	0
Behshahr Industrial	1	1	0	0
Minoo Industrial (Khorramdareh)	1	1	0	0
Glokozan	7.9	1	7.6	0
Pak Dairy	1.2	1	1.9	0
Kalber Dairy	1	1	0	0
Margarine	5	1	5.8	0
Mahram	20	20	23.8	13.3
China Agro-industry China	11.9	1	12.2	0
Monthly Portfolio Returns	2.4	4	2.5	5.8
Monthly Portfolio Variance	0.006	0.008	0.006	2
Sharp 1.25%	14.5	30.8	17.1	31.9
Ratio 1.83%	6.8	24.3	9.3	27.8

Source: Research findings

Table 6 shows the participation of companies in optimal portfolios. The stocks of companies in the food and beverage industry and the sugar industry do not have the power to attract investors whose expected return on companies' stocks is high. Investors with high expected returns do not spend their money buying stocks of companies related to these two industries. The difference between these companies' risk (variance) is more minor, and their risk is closer to each other than their return.

Food industry companies have a high multiplication rate in creating employment and added value, effectively increasing revenue, reducing waste, improving the quality of products, stimulating increased demand for agricultural products, presence in global markets, and business prosperity. The small share of the food industry in the production of 90 million tons of Iranian agricultural products and the closure of activity of less than the capacity of some food industry companies, along with the high volume of food imports, shows the importance of investing in this field and the presence of more food companies in the stock market. It is the stock of Tehran. Many food companies need low-cost banking facilities to raise their working capital. Due to high inflation and consequently high-interest rates, it is practically impossible for them to receive this capital, and their competitiveness does not increase. Therefore, the following suggestions are based on the results obtained in this study.

Comparing the optimization results of the two portfolios of the food and beverage industry and the sugar industry, considering the two constraints of minimum investment and maximum investment was obtained when the return of the portfolio is maximized when the variance is minimized. The share of some companies increased, and the share of others decreased. Due to this increase and decrease in share, the companies in each of the two portfolios were divided into low-yield and high-yield groups, which are given in Table 7. Also, the optimization results of these two portfolios, without considering the two constraints of minimum investment and maximum investment, show when the portfolios were optimized to maximize returns, the companies' participation in the portfolio decreased, and the entire portfolio was allocated to only three companies, indicating that these companies differed from each other in terms of high returns. Salmin and Mehram companies are the most profitable companies in the food and beverage industry, and Piranshahr sugar company is the most profitable company in the sugar and sugar industry. In the last row of Table 7, these companies are listed in each of the two portfolios.

Table 5 - Results of portfolio optimization of sugar industry with two objectives of minimizing variance and maximizing portfolio return

Company	The percentage share of each company with two constraints of minimum and maximum amount of investment on the shares of each company		percentage share of each company without two constraints on the minimum and maximum amount of investment on the shares of each company	
	Minimize portfolio variance	Maximize portfolio returns	Minimize portfolio variance	Maximize portfolio returns
Nectar	8.3	1	11.2	0
Sugar of Shahroud	1	1	0	0
Food Products and Chaharmahal Sugar	11.7	1	12	0
Isfahan Sugar	19.5	20	3.4	0
Piranshahr Sugar	20	20	42.	100
Torbat Jam Sugar	1	1	0	0
Khorasan Fixed Sugar	5.1	1	8.3	0
Shirvan Quchan Sugar	1	1	0	0
Qazvin Sugar	1	20	0	0
Lorestan Sugar	9.4	1	10.2	0
Marvdasht Sugar	1	12	0	0
Neyshabur Sugar	1	1	0	0
Hegmatan Sugar	20	20	12.8	0
Monthly Portfolio Returns	2	2/9	2	3.6
Monthly Portfolio Variance	1.2	1.4	1.1	1.5
Sharp 1.25%	6.9	13.8	7.2	18.8
Ratio 1.83%	1.5	8.9	1.6	14

Source: Research findings

Table 6- The level of participation of companies in the optimal portfolio

Portfolio	The level of participation of companies in the optimal portfolio	
	Minimize portfolio variance	Maximize portfolio returns
Food and beverage industry portfolio	63%	10%
Sugar industry portfolio	53%	7%

Source: Research findings

Table 7- Classification of companies according to the results of portfolio optimization

Rate of return	Food and beverage industry portfolio	Sugar portfolio
Low return	Georgian Biscuits, Behshahr Industries Development, Murghab Plain, Behpak Industry, Glucosan, Margarine and China China	Nectar, food products and Chaharmahal sugar, Khorasan fixed sugar, Lorestan sugar
High return	Salmin, Mehram, Pars Minoo, Pegah Azerbaijan, Pegah Isfahan	Piranshahr sugar, Isfahan sugar, Qazvin sugar and Marvdasht sugar
The most return	Salmin, Mehram	Piranshahr Sugar

Source: Research findings

The main result of this study is the use of the Markowitz portfolio model and for a set of two or more activities that suggest an optimal portfolio for investors with different goals of minimizing risk and maximizing returns that can be achieved at different levels of risk for industries as well as the entire stock market. Given that in both the food and beverage industry portfolios and the sugar industry, the Sharp ratios obtained when maximizing returns have increased relative to when the variance has been minimized, investors are advised to increase investor's behavior of risk aversion.

As a result of comparing the results of portfolio optimization of the food and beverage industry with two goals of minimizing variance and maximizing the expected return of the portfolio, it is suggested to investors in the agricultural sector that the share of some companies such as Pars Mino, Pegah Azerbaijan, Pegah Isfahan and Salemin in the portfolio of this industry, which have good returns, in their investment portfolio.

Optimize the portfolio to maximize returns because this study has shown that this method is more efficient. Given that the results of portfolio optimization of the food and beverage industry to maximize the portfolio's expected return have been the most efficient, investors are advised to buy shares resulting from this portfolio's optimization. Considering the importance of the food and beverage industries and sugar industry in Iran's agricultural sector, it is recommended in future studies to identify risks and policies to reduce risk and create incentives to increase investment in these two industries. The model used in the research is suggested to be solved with other optimization models, including the algorithms mentioned in the research background (shrimp batch meta-algorithm, genetic algorithm, etc.). It is also suggested that in future studies, in proportion to the amount of capital or investment brought by investors, they should consider their amount of money as a constraint in the model used (Markowitz model) and optimize their portfolio according to the amount of capital.

References

1- Alipoor Leili, V. 2018. Investigating the Relationship between Rate of Return and Risk in the Sugar Group in Tehran Stock Exchange. Master thesis, Tehran University. (In Persian)

2- Basuki, B., S. Sukono, D. Sofyan, S.S. Madio, and N. Puspitasari. 2019 Linear Algebra on investment portfolio optimization model. In a presentation at the 4th Annual Conference" Applied Science and Engineering." 2019 December.

3- Campbell, R., R. Huisman, and K. Koedijk. 2001. Optimal portfolio selection in a Value-at-Risk framework. Journal of Banking and Finance, 25(9): 1789-1804.

4- Ghadiri Moghadam, A., and H. Rafie Darani. 2010. Investigating and Determining the Optimal Stock Portfolio of Companies Active in the Food Industry of the Tehran Stock Exchange. Journal of Agricultural Economics and Development, 24(3): 304-309. (In Persian)

5- Hoseini Kasgari, H., A. Hoseini Yekani, and S. Abedi. 2017. Optimal Portfolio Selection of Stocks of Food Industry Companies in Tehran Stock Exchange Using the Combined Forecasting Method: Application of Mean-Variance-Skew Pattern. Agricultural Economics, 11(4): 81-105. (In Persian)

6- Joonz, CH. 1943. Investment Management, Translation of Tehrani, R and Noorbakhsh, A. Knowledge Look Publications: 1-500.

7- Luenberger, D.G. 1997. Investment Science. OUP Catalogue.

8- Moosavi, Y., A. Gholami, and S. Samei. 2016. Optimizing the Investment Portfolio of Sepah Bank Investment Company using the combined Markowitz and Garch Multivariate Model. Applied Economics, 18: 1-14. (In Persian with English abstract)

9- Narayan, P. 1990. Farm Planning Under Risk: An Application of the Captial Asset Pricing Model to New Zealand Agriculture. Doctoral dissertation, Lincoln University.

10- Poornima, S., and A.P. Remesh. 2016. Construction of Optimal Portfolio Using Sharpe's Single Index Model: A Study with Reference to Automobiles and Pharmaceutical Sector. International Journal of Applied Research, 1(13): 21-24.

11- Sadeghi, M. 2014. Comparative study of Iran Stock Exchange with other stock exchanges in the world and the reasons for its strengths and weaknesses. Journal of Accounting Research, 3(12): 167-193. (In

Persian)
12- Salim Odloo, A. 2017. Determining the Relationship Between Crop Risk and their Prices in Iran by Provinces. Master thesis, Tehran University. (In Persian)
13- Shirzad, S. 2016. Investigating the Factors Affecting the Stock Market of Agricultural Industries in Tehran Stock Exchange. Master thesis, Tehran University. (In Persian)
14- Tehran Stock Exchange, 2019. https://www.tse.ir/.

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تعیین انتخاب سبد بهینه سهام شرکت‌های کشاورزی در بورس اوراق بهادار تهران

امیرحسین چیذری[1]، کیمیا وزیریان

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چکیده

تخصیص دارایی و انتخاب سبد سرمایه‌گذاری، یکی از مهم ترین و پرچالش ترین مباحث در مدیریت سرمایه‌گذاری و نیز یکی از دغدغه‌های همیشگی سرمایه‌گذاران به‌شمار می‌رود. هنگامی که سرمایه‌گذاران در بازار سرمایه اقدام به سرمایه‌گذاری می‌نمایند، انتظار دارند سبد منتخب آن‌ها از کارایی مناسبی برخوردار باشد. لذا هدف از این پژوهش، تعیین سبد بهینه سهام شرکت‌های کشاورزی در بورس اوراق بهادار تهران می‌باشد. بدین منظور ابتدا ۳۲ شرکت از کل شرکت‌های بخش کشاورزی در بورس اوراق بهادار تهران که داده‌های آن‌ها از سال ۱۳۹۹ الی ۱۳۹۳ به صورت ماهانه وجود داشت از دو صنعت غذایی و آشامیدنی و صنعت قند و شکر انتخاب شدند. سپس دو پرتفویی صنعت غذایی و آشامیدنی و صنعت قند و شکر با دو هدف حداقل سازی واریانس پرتفویی و حداکثرسازی بازده پرتفویی بااستفاده از مدل مارکوویتز با دو سناریوی متفاوت یک‌بار با اعمال دو محدودیت حداقل سرمایه‌گذاری به میزان ۱ درصد و حداکثر سرمایه‌گذاری به میزان ۲۰ درصد و یک‌بار بدون در نظر گرفتن این دو محدودیت بهینه سازی شدند و بازده، واریانس و نسبت‌های شارپ برای آن‌ها محاسبه شد. نتایج نشان داد هر دو پرتفویی صنعت غذایی و آشامیدنی و صنعت قند و شکر زمانی که با هدف حداکثر سازی بازده پرتفویی بهینه سازی شدند، از کارایی بیشتری برخوردار شدند. هم‌چنین پرتفویی صنعت غذایی و آشامیدنی نسبت به پرتفویی صنعت قند و شکر از کارایی بیشتری برخوردار شد. در این پرتفویی میزان سرمایه‌گذاری برای سهام شرکت سالمین ۸۶/۷ درصد و برای شرکت مهرام ۱۳/۳ درصد به‌دست آمد.

واژه‌های کلیدی: بازده، پرتفوی، کارایی، مدل مارکوویتز، نسبت شارپ

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Iran's Export Competitiveness in the Supply Chain of Tomato Paste in the Target Markets

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Abstract

Agricultural and food industry exports are one of the strategies for export development and sustainable economic growth in developing countries. Since Iran has been among the top ten countries in the export of tomatoes and tomato paste in recent years, the purpose of this article was to compare the global market structure of these two products as two links in the tomato supply chain and calculate the revealed comparative advantage of their exports in the world and the target countries. According to the results, the global market structure of both products in the period 2010-2018, despite the high share of the top four market powers, has been an open oligopoly for most of the years, which indicates a small share of the most competitors and high competition between them. However, due to the large share and stability of market leadership, it is unlikely that small countries will be able to capture the share of large countries. Therefore, it is suggested that Iran, with an average share of 1.61 percent in the tomato market and 5.30 percent in the paste market, prioritize a number of markets in which it has more competitiveness for market penetration, market development, and branding. On average, exports of tomatoes and tomato paste to Turkmenistan, Iraq, and Afghanistan have had the greatest comparative advantage for Iran. It is proposed to prioritize competition, market development, and branding in a number of markets in which it has competitiveness and stability based on the revealed comparative advantage index, including Turkmenistan and Afghanistan. It is worth mentioning that due to the higher comparative advantage of tomato paste compared to tomato, its higher added value, more branding, and storage and transportation capabilities, it is recommended, with the development of investment in food processing industries and the completion of supply chain and marketing. Development of the export market of tomato paste should be a priority of the country.

Keywords: Export Target Market, Revealed Symmetric Comparative Advantage, Tomato paste, World Market Structure

Introduction

Foreign trade and export are so important in the economies of countries that its expansion is one of the main goals of economic programs of developing countries. The importance and position of foreign trade in the economic growth and development of countries is such that economists refer to it as the engine of economic development; because trade improves competitiveness, creates employment, and increases foreign exchange earnings in the country (Mehrparvar Hosseini, 2013). One of the main goals of developing countries is to achieve sustainable economic growth and development which the exports expansion can be a direct factor for economic growth. Hence, these countries are always looking to expand their exports to benefit from opportunities, financial resources, earnings, and other advantages (Behzadnia *et al*., 2019). So that in many developing countries such as Iran, the export leap is defined as a development strategy (Rafiee *et al*., 2018). One of the most important features of Iran's

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economy is its strong dependence on oil revenues (Ahmadi and Kiani rad, 2016). The dependence of the economies of Iran and other oil-producer countries on oil revenues and the impression of these revenues from political and economic issues has made the economies of these countries vulnerable. Therefore, any fluctuation in oil prices will lead to a deficit in their balance of payments (Mehrparvar Hosseini, 2013). One of the ways to face this challenge is to develop products that, while improving the domestic economy, increase non-oil exports. Therefore, it is necessary to expand the export of non-oil products and diversify the country's foreign exchange earnings which encouraging non-oil exports, including agricultural goods and conversion industries, can be a good alternative (Ahmadi and Kiani rad, 2016). Export development in the agricultural sector requires the recognition of potential export products and global markets (Palouj, 2018). The export of goods to foreign markets is done with the aim of making continuous profit and income with the satisfaction of consumers. In situations where markets are competitive, in addition to the facilities and capabilities of each country in the production and export of goods, knowledge of export markets and target markets is essential. One of the effective factors in determining the appropriate strategy in the economic development of any country, under the title of export development strategy, is to have a comparative advantage in production and exports. The market structure also represents the organizational characteristics of the market, which can be used to determine the relationship between market components, competition, and the nature of pricing in it (Mahmoudi and Vali Beigi, 2004).

Food processing industries as industries related to agricultural products are among the most important industrial groups that can play an important role in the economic development of countries. The creation and development of these industries can have a special effect on increasing the added value of agricultural products and increase the export value of this sector, which brings more foreign exchange earnings compared to the sale of raw materials (Turkmani and Zoghipour, 2008).

Iranian tomatoes are among the agricultural products that are exported fresh and processed to countries around the world, and increasing its exports is very important in the development of non-oil exports (Modarresi *et al*., 2020). According to the International Trade Center, in 2018, Iran's share in the world tomato export market was 2% and the foreign exchange earnings from the export of this product in the same year was about $ 245,000 and ranked 10th, while Iran's share in the export market of tomato paste was 4.5 percent and the foreign exchange income from it was $ 141,000 and it was in the seventh place. As shown in the maps of Fig. 1 and 2, the situation of Iran's tomato and paste exports in 2018, the target markets of these two products for Iran are different, and although the most important target markets of both products are Iran's neighboring countries, tomato paste is exported to more countries in the five continents of the world, which can be considered as the reason for the longer shelf life of this product and the possibility of exporting to countries in farther geographical distances. Due to the higher price and more foreign exchange earnings of the processed products of this agricultural product, including tomato paste compared to the raw product, completing the supply chain of this product in target market countries as a trading strategy can strengthen the country's export revenues and efficient use of production resources. So that in countries where Iran has a good position in terms of competitiveness in the tomato market, branding and market development of the tomato paste should be on the agenda. For this purpose, it is necessary to study and compare the competitive market structure of these two products and the comparative advantage of Iran in the whole market and each of the target markets of this country.

Therefore, the purpose of this article is to study and compare the exporting market structure and Iran's position in the global tomato and tomato paste market during 2010-2018 and also to evaluate Iran's comparative advantages in the export target markets of these two products in order to better understand the market and formulate more efficient competitive strategies. For this purpose, in the following, some previous researches on market structure and comparative advantages are going to be discussed.

Farajzadeh and Bakhshudeh (2011) studied the pistachio global market structure with emphasis on the strength of the Iran market power that the results showed, the structure of the pistachio market structure is a closed oligopoly. Also, Mehrparvar Hosseini *et al*. (2013) in their research using the indicators of concentration ratio and Herfindahl Hirschman, import and export comparative advantages examined the trade model and market structure of dates in Iran and the world in the period 1992-2011. The results demonstrated the market structure of dates for the world and Iran's target market have become more competitive during this period and contrary to the reduction of Iran's revealed comparative advantage index, still this country has competitive power in the world market. Khodavardizadeh and Mohammadi (2017), in their research, determined the comparative advantage and analyzed the global market structure of medicinal plants in the period 2000-2011, which showed the comparative advantage of Iran's exports was not stable and fluctuated during the studied years. Also, the global export market of medicinal plants during this period follows three types of monopolistic competition, open oligopoly, and close oligopoly. In the study of Ahmadi and Kiani Rad (2016), using the export comparative advantage and Herfindahl-Hirschman indices, Iran's competitive power in exporting tomato paste was investigated, which based on the results obtained during the period 2014-2001, Iran's exports did not have an advantage and had many fluctuations. Meanwhile, all major exporting countries (China, Italy, United States of America, Spain, Portugal, and Turkey) have had a stable export trend. Other studies in this field include Aminizadeh *et al*. (2014), Ferto and Hubbard (2003), Gajurel and Pradhan (2012), Ishchukova and Smutka (2013), and Mirbagheri *et al*. (2019) who have studied the market structure and competitiveness in the market of various products.

Fig. 1- Map of Iran's tomato export to the world in 2018

Source: International Trade Center

Fig. 2- Map of Iran's tomato paste export to the world in 2018

Source: International Trade Center

The purpose of this study is to investigate and compare the global market structure and Iran's revealed comparative advantages in its target markets of tomato supply chain rings. In this regard, after expressing the research method, the results and suggestions are going to be presented.

Materials and Methods

According to international trade theories, in order to develop exports in any country, proceedings are needed that include identifying comparative advantages, prioritizing advantageous industries, and investing in the development of these activities export (Mahmoudi, And Vali Beigi, 2004). The law of comparative advantage in trade means that if a country can export goods at a lower cost than other countries, it has a comparative advantage in exports compared to other countries, and by entering the world trade market, it can benefit more from the export of goods in which it has a comparative advantage (Mehrparvar Hosseini *et al*, 2013).

The market structure represents the organizational characteristics of the market that can be used to determine the relationship between market components, competition, and the nature of pricing in it (Gajurel and Pradhan, 2012). The most well-known indicators of market structure are the Concentration Ratio Index (CR_n) and the Herfindahl-Hirschman Index (HHI). Therefore, in this research, in order to study the global market structure of tomato paste and tomato, the two mentioned indicators have been used, which are introduced in the following.

1- Concentration ratio (CR_n): The concentration ratio of top n the largest firms in the market, indicates the total ratio of market sales to total market size by these firms. This index can be presented as Equation (1) (Khodaverdizadeh and Mohammadi, 2017):

$$CR_n = \sum_{i=1}^{n} S_i \qquad (1)$$

In this equation, n is the number of large countries (usually the top four exporting countries) active in the tomato paste and tomato markets, S_i is the market share of the i^{th} country and CR_n is the concentration ratio of top n large countries.

2- Herfindahl-Hirschman Index (HHI): Herfindahl-Hirschmann Index is calculated from the sum of the quadratic power of the market share of all countries active in the market. This index is obtained from Equation (2) (Gajurel, and Pradhan, 2012).

$$\mathrm{HHI} = \sum_{i=1}^{k} S_i^{\,2} \qquad (2)$$

Based on Table (1), this index is between two numbers, zero and one. If this number approaches zero, the product market will move towards competitiveness (less concentration) and if it approaches number one, the market will move towards monopolization (more concentration).

Table 1- Kinds of market structure and its characteristics

The main feature of the market	Herfinahl-Hirschman Index	Concentration ratio	Market structure
There are more than 50 competitors without a significant market share.	$HHI \to 0$	$CR_1 \to 0$	Perfect Competition
None of the competing firms has more than 10% of the market.	$(1/HHI) \to 10$	$CR_1 < 10$	Monopolistic Competition
4 companies have up to 40% of the market.	$6 < (1/HHI) \leq 10$	$CR_4 < 40$	Open Oligopoly
4 companies have at least 60% of the market.	$3 < (1/HHI) \leq 6$	$CR_4 > 60$	Close Oligopoly
More than 50% of the market is owned by one firm.	$1 < (1/HHI) \leq 3$	$CR_1 \geq 50$	Dominant firm
One firm monopolizes the entire market.	$HHI \to 1$	$CR_1 \to 100$	Monopoly

Source: Maddala *et al*. (1995)

Based on the theoretical literature, the revealed comparative advantage index is a measure of export competitiveness (Salami and Pishbahar, 2001), which has been used in many studies as seen in the previous section. This index is obtained from Equation (Amirnejad *et al*., 2015):

$$RCA_{ij} = \frac{\frac{X_{ij}}{\sum_i X_{ij}}}{\frac{\sum_j X_{ij}}{\sum_i \sum_j X_{ij}}} \qquad (3)$$

In this equation, X_{ij} is the value of exports of goods i by country j, $\sum_i X_{ij}$ is the total value of exports of the country under study, $\sum_j X_{ij}$ is the value of exports of the goods i in the world and $\sum_i \sum_j X_{ij}$ is the total value of world exports. In other words, the numerator of fraction is the share of export goods i from the total exports of the country under study and the denominator is the deduction of the share of global exports of goods i from the total exports of the world. The value of the RCA_{ij} index in the range of zero to one indicates a lack of advantage and in the range of one to infinity illustrates the existence of comparative advantage and the move towards trade specialization (Mehrparvar Hosseini *et al*., 2013). The growing trend of this index demonstrates the improvement of a country's competitive position in the global market of that product. In addition, large fluctuations in this index over time can be considered a measure of instability in a country's trading system. Changes in comparative advantage may be due to reasons such as changes in the relative cost of producing goods, exchange rates, domestic trade barriers, or countries that want those goods (Salami and Pishbahar, 2001).

In this article, the revealed comparative advantage for exporting tomatoes and tomato paste to the target countries of Iran is also calculated. Thus, using Equation (3), this time for X_{ij} the value of Iran's exports of goods i to country j, for $\sum_i X_{ij}$ the total value of Iran's exports of goods i, for $\sum_j X_{ij}$ the value of exports of goods i from all over the world to country j, and for $\sum_i \sum_j X_{ij}$ is the total value of exports of goods i in the world.

Considering that in the revealed comparative advantage index for export, the absence of comparative advantage in the range of zero to one and the existence of comparative advantage in the range of one to infinity are defined, to symmetrize this interval, the revealed symmetric comparative advantage index can be used next to this index, which is calculated from Equation (4) (Aminizadeh *et al.*, 2014).

$$RSCA_{ij} = \frac{RCA_{ij} - 1}{RCA_{ij} + 1} \quad (4)$$

The range of changes in this index is between negative one and positive one. If the RSCA is between negative one and zero, it represents that there is no comparative advantage, and if it is between zero and positive one, it indicates the relative advantage.

In this study, the data required to calculate the comparative advantage and investigation the market structure has been extracted from the website of the International Trade Center for the years 2010-2018 and Excel 2019 software has been used to compute the indicators.

Result and discussion

The most important export target markets for Iranian tomatoes and tomato paste in the years studied in this article (2010-2018) are Iraq, Russia, United Arab Emirates, Afghanistan, Turkmenistan, Oman, Kazakhstan, Azerbaijan, Armenia, Pakistan, Georgia, Qatar, Kuwait, Turkey and Ukraine, which most of them are neighboring countries of and Central Asia region. For this goal, first, the indicators of the market structure were calculated based on the literature, which the results can be seen in Tables (2) and (3).

Table 2- Tomato market structure & Iran's situation in it in 2010-2018

Year	Leaders of market	CR1	CR4	HHI	1/HHI	Market structure	Iran's share	Iran's level
2010	Netherlands, Mexico, Spain, Turkey	21	59	0.11	8.71	Open Oligopoly	1.80	13
2011	Mexico, Netherlands, Spain, Morocco	23	61	0.13	7.92	Open Oligopoly	1.20	12
2012	Netherlands, Mexico, Spain, Morocco	21	61	0.12	8.19	Open Oligopoly	1.60	13
2013	Netherlands, Mexico, Spain, Morocco	20	60	0.12	8.37	Open Oligopoly	0.90	14
2014	Netherlands, Mexico, Spain, Morocco	21	59	0.11	8.74	Open Oligopoly	1.80	12
2015	Netherlands, Mexico, Spain, Morocco	21	61	0.12	8.32	Open Oligopoly	1.50	13
2016	Mexico, Netherlands, Spain, Morocco	24	62	0.13	7.87	Open Oligopoly	1.50	13
2017	Mexico, Netherlands, Spain, Morocco	21	62	0.12	8.12	Open Oligopoly	1.70	13
2018	Mexico, Netherlands, Spain, Morocco	24	63	0.13	7.91	Open Oligopoly	2.50	10
Average		22	61	0.13	8.23	Open Oligopoly	1.61	12
Minimum		21	59	0.11	7.87	Open Oligopoly	0.90	10
Maximum		24	63	0.13	8.74	Open Oligopoly	2.50	14
Coefficient of variation		0.06	0.02	0.18	0.03		0.575	0.09

Source: Research findings

According to the Herfindahl index, the tomato market structure has been open oligopoly on average in the period of years 2010-2018, however, the share of the top four competitors was more than 60%, which demonstrated a tendency to the closed oligopoly structure, and in fact, it states that the top four countries have a significant market share and other competitors are competing with each other with their small shares (Tables 2, 3). Leading countries in the tomato market for most of the year are the Netherlands, Mexico, Spain, and Morocco, and in the tomato paste market are Italy, China, Spain, and the United States, indicating that

Spain has market power in both chains. Iran's average ranking in the period 2010-2018 in the tomato and paste market was 12 and 6, respectively, and Iran's share was 1.61 and 5.30 percent, which in the tomato market showed more fluctuations compared to tomato paste.

Table 3- Tomato paste market structure & Iran’s situation in it in 2010-2018

Year	Leaders of market	CR1	CR4	HHI	1/HHI	Market structure	Iran’s share	Iran’s level
2010	China, Italy, Spain, USA	27	69	0.16	6.09	Open Oligopoly	3.70	7
2011	China, Italy, USA, Spain	29	70	0.17	5.88	Closed Oligopoly	5.00	6
2012	China, Italy, USA, Spain	29	68	0.16	6.14	Open Oligopoly	6.10	6
2013	China, Italy, USA, Spain	27	69	0.16	6.29	Open Oligopoly	4.90	6
2014	China, Italy, USA, Spain	26	68	0.15	6.65	Open Oligopoly	5.50	6
2015	China, Italy, USA, Spain	26	68	0.15	6.70	Open Oligopoly	5.80	6
2016	Italy, China, USA, Spain	23	65	0.14	7.31	Open Oligopoly	6.40	6
2017	Italy, China, USA, Spain	22	64	0.13	7.54	Open Oligopoly	6.20	6
2018	Italy, China, USA, Spain	23	65	0.14	7.32	Open Oligopoly	4.50	7
Average		26	67	0.15	6.66	Open Oligopoly	5.30	6
Minimum		22	64	0.13	5.88	Closed Oligopoly	3.70	6
Maximum		29	70	0.17	7.54	Open Oligopoly	6.40	7
Coefficient of variation		0.10	0.03	0.09	0.09		0.17	0.07

Source: Research findings

Table 4 shows the results related to the revealed comparative advantage index for tomato and tomato paste export of Iran, which Iran had a comparative advantage in the export of both products in the period 2010 to 2018. But the export of tomato paste has had a much greater comparative advantage for Iran, which illustrates that this processed product has had more competitive compared to fresh Iranian tomatoes in the supply chain.

Table 4- Iran's comparative advantage for export in the global markets of tomatoes and tomato paste in the period 2010-2018

	Tomato		Tomato paste	
Year	Revealed comparative advantages	Revealed symmetric comparative advantages	Revealed comparative advantages	Revealed symmetric comparative advantages
2010	3.98	0.60	7.96	0.77
2011	2.92	0.50	12.27	0.84
2012	3.81	0.58	13.99	0.86
2013	2.74	0.47	13.70	0.86
2014	3.98	0.60	12.18	0.84
2015	3.50	0.56	13.11	0.85
2016	3.50	0.56	14.04	0.86
2017	3.98	0.60	14.62	0.87
2018	6.35	0.73	11.27	0.83
Average	3.87	0.57	12.57	0.84
Minimum	2.74	0.47	7.96	0.77
Maximum	6.35	0.73	14.6	0.87
Coefficient of variation	0.26	0.12	0.16	0.03

Source: Research findings

Tables 5 and 6 show Iran's revealed export advantage for tomato and its paste in the most important target markets of Iran, most of which are neighboring countries. Among the target countries, tomato exports to Turkmenistan had the highest advantage on average, and the growing trend of this index, regardless of its fluctuations, represents an improvement in Iran's competitive position in the market of this country. Iran in Afghanistan's tomato paste market, with an average of 16.89 RCA, has the most competitive power among other competitors in the market of this country. Also, Iraq is in the third place of target markets in terms of comparative advantage, contrary to the high volume of imports of this product from Iran, compared to other target markets of Iran. That is, despite the large volume of tomato paste exports to Iraq, Iran's competitiveness in this market is less compared to its power in Afghanistan and Turkmenistan. A number greater than one for RCA in Afghanistan, Turkmenistan, Iraq, Pakistan, and the United Arab Emirates shows a comparative advantage in exporting tomato paste to these countries.

Table 5- Revealed comparative advantage for exporting tomatoes to Iran's target export countries in 2010-2018

Year	Iraq	Russia	United Arab Emirates	Afghanistan	Turkmenistan	Oman	Kazakhstan	Azerbaijan	Armenia	Pakistan	Georgia	Qatar
2010	27.9	0.2	0.4	43.4	36.6		0.4	15.7	0.3	0.8	0.17	0.1
2011	54.2	0.1	0.1	23.0	74.6		0.6	24.4	4.5	2.0		
2012	42.9	0.1	0.1	36.8	58.7		1.8	17.4	10.2	0.2	0.24	
2013	53.2	0.2	1.7	74.9	91.5	0.2	1.5	31.3	4.5	0.6	0.10	
2014	33.3	0.1	0.8	38.3	52.4	0.1	1.1	40.8	1.8	0.2	0.07	
2015	50.1	0.2	1.4	46.8	64.4	0.4	0.7	48.1	2.8	0.3	0.11	
2016	47.7	0.8	2.9	32.8	62.7	0.7	2.0	14.3	3.9	0.1	0.07	
2017	44.8	1.0	3.1	56.5	58.3	1.7	1.4	6.3	26.3	22.0	0.08	14.6
2018	33.7	1.4	7.0	25.2	38.6	3.4	1.2	29.0	8.2	0.3	0.49	11.0
Average	43.1	0.4	2.0	42.0	59.9	0.7	1.2	25.3	7.0	2.9	0.1	2.9
Maximum	54.2	1.4	7.0	74.9	91.5	3.4	2.0	48.1	26.3	22.0	0.5	14.6
Minimum	27.9	0.1	0.1	23.0	36.6	0.1	0.4	6.3	0.3	0.1	0.1	0.1
Coefficient of variation	0.21	1.1	1.1	0.4	0.3	1.6	0.5	0.5	1.1	2.4	1.0	2.0

Source: Research findings

As mentioned in the previous section, large fluctuations in the RCA index over time can be considered a measure of instability in a country's trading system (Salami and Pishbahar, 2001). Based on the number obtained for the coefficient of variance, the revealed comparative advantage of Iran's exports of tomatoes and tomato paste to Turkmenistan and Afghanistan, respectively, had the least volatility, which indicates stability in these two markets, while being competitive. Therefore, penetration in these two markets can be a priority for Iran, and also this country can develop the market of other products in the tomato supply chain, due to its branding and position in these two markets. It is noteworthy that Iran's competitiveness in the tomato paste market of Turkmenistan has had a decreasing trend, despite the improvement of the competitive situation in the tomato market of this country, which necessitates attention to progress the marketing activities of tomato paste with emphasis on the Iranian tomato brand.

Table 6- Revealed comparative advantage for exporting tomato paste to Iran's target export countries in 2010-2018

Year	Iraq	Afghanistan	Russia	Pakistan	Kuwait	Kazakhstan	Qatar	Turkey	United Arab Emirates	Turkmenistan	Azerbaijan	Ukraine
2010	12.61	22.51	0.61	6.74	0.45	0.33	0.75	0.01	1.67	22.70	0.04	0.17
2011	10.94	16.98	0.82	5.06	0.23	0.14	0.01		0.16	16.28	0.01	0.09
2012	9.33	14.45	1.09	0.59	0.28	0.09	0.27	0.03	0.23	13.05	0.01	
2013	9.92	18.05	0.89	1.62	0.39	0.25	0.04	0.05	0.40	11.47	0.01	0.03
2014	7.89	15.48	1.28	1.69	0.22	0.90	0.10	0.17	3.87	8.19	0.06	
2015	9.44	16.00	0.72	1.79	0.83	0.60	0.06	0.10	1.90	4.44	0.05	0.16
2016	8.40	14.38	0.72	2.12	1.12	1.56	0.03		1.85	5.95	0.01	0.10
2017	8.42	14.89	0.63	3.13	1.10	0.58	0.51	0.75	1.40	14.26	0.02	0.95
2018	7.40	19.29	0.45	3.26	0.89	0.36	1.02	0.51	0.09	9.96	0.02	0.48
Average	9.37	16.89	0.80	2.89	0.61	0.54	0.31	0.18	1.28	11.81	0.03	0.22
Maximum	12.61	22.51	1.28	6.74	1.12	1.56	1.02	0.75	3.87	22.70	0.06	0.95
Minimum	7.40	14.38	0.45	0.59	0.22	0.09	0.01	0.01	0.09	4.44	0.01	0.03
Coefficient of variation	0.17	0.16	0.32	0.67	0.61	0.86	1.19	1.48	0.96	0.47	0.70	1.41

Source: Research findings

selection of target markets, Iran's export advantages in its important target markets for both products were examined and the results demonstrated, the export of Iranian tomatoes and tomato paste to Turkmenistan and Afghanistan, respectively, have had the highest advantage and the lowest fluctuation in the export advantage index, which indicates competitiveness and stability in these two markets. Therefore, penetration in the markets of these two countries can be a priority for Iran and according to the branding and the position of the country in these two markets, the market of other related products in the Iranian tomato supply chain can also be developed in them. Due to the declining trend of Iran's competitiveness in the tomato paste market of Turkmenistan, contrary to the improvement of the competitive situation in the tomato market of this country, it is recommended to pay attention to the improvement of marketing activities of tomato paste with emphasis on the Iranian tomato brand. Also, due to the higher comparative advantage of tomato paste compared to tomatoes, its higher added value, the possibility of more branding and capability of storage

Conclusion

Considering the role of non-oil exports, agriculture and food processing industries in the country's foreign exchange earnings, the objectives of this study were to compare the global market structure of tomato and tomato paste as two links in the tomato supply chain and to calculate the revealed comparative advantage of the export of these two products in the world and the target countries of Iran. Based on the results, the open oligopoly structure of tomato and tomato paste global markets in the most years of the period 2010-2018, despite the high share of the top four market powers, illustrates a slight share of more competitors and more competition between them. But given the large share and stability of market leadership, it is unlikely that small competitors will be able to capture large countries of markets. Therefore, it is suggested that Iran, with an average share of 1.61 percent in the tomato market and 5.30 percent in the paste market, prioritize a number of markets in which it has more competitiveness for market penetration, market development and branding. In this article, in order to create a clear picture for the priority to use the country's domestic production resources such as water and energy and subsidies allocated to it in an efficient system by producing the most added value and foreign exchange revenue.

and transportation, it is suggested, with the development of investment in food processing industries and the completion of supply chain and marketing, development of the export market of tomato paste should be given

References

1- Ahmadi, A., A. Kiani Rad. 2016. Assesment of Competitive Power of Iran in Global Market of Tomato Paste, The first national conference on new approaches in accounting and management, Mianeh, Iran. (In Persian).

2- Aminizadeh, M., H. Rafiee, A. Riahi, E. Mehrparvar Hosseini. 2014. Pattern of Competitiveness of Pistachios World Premier Exporters in Iran's Importers Market. Agricultural Economics 8(2): 41-68. (In Persian).

3- Amirnejad, H., S. Shahabi, H. Navidi. 2015. The Investigation of Trade Dimensions of Iran’s Raisins. Agricultral Economics and Development (23): 217-245. (In Persian).

4- Behzadnia, P., N. Senobar, S. Hosseini. 2019. The Impact of Export Incentive Programs on Export Performance: The Role of the Attractiveness of Foreign Markets and Export Capabilities. Journal of International Business Administration 2(3): 63-85. (In Persian).

5- Farajzadeh, Z., M. Bakhshoodeh. 2011. Studying Pistachio World Market Structure with Emphasis on Iranian Market Power. Agricultral Economics and Development (73): 125-145 (In Persian).

6- Ferto, I., L. Hubbard. 2003. Revealed Comparative Advantage and Competitiveness in Hungarian. The World Economy, 26: 247-259.

7- Gajurel, D.P., R.S. Pradhan. 2012. Concentration and Competition in Nepalese Banking, Journal of Business, Economics & Finance, 1: 5-16.

8- International Trade Center. 2020. https://www.trademap.org/Index.aspx

9- Ishchukova, N., L. Smutka. 2013. Revealed comparative advantage of Russian agricultural exports. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 4.

10- Khodaverdizadeh, M., S. Mohammadi. 2017. Comparative Advantages and Analysis of International Market Structure of Medicinal Plants: Case Study of Anise, Badin, Fennel and Coriander (In Persian).

11- Maddala, G.C., S. Dobson, E. Millen. 1995. Microeconomics, The Regulation of Monopoly, Mc Grawhill Book Company Press.

12- Mahmoudi, A., H. Vali Beigi. 2004. Analysis of comparative advantages and prioritization of target markets for the export of Iranian dairy products, Ninth Conference on the Development of Non-Oil Exports, Tabriz Chamber of Commerce, Industries and Mines, Iran: 159-194 (In Persian).

13- Mehrparvar Hosseini, E. 2013. Factors Affecting Iran's Agricultural Trade Balance Behavior, M.Sc. Thesis, University of Tehran, Tehran. (In Persian).

14- Mehrparvar Hosseini, E., M. Aminizadeh, H. Rafiee, A. Riahi, M. Bastani. 2013. Designing of Iranian Dates Trade Model; Application of Trade Advantages and Theory of Market Structure. Agricultural Economics 7(2): 19-46. (In Persian).

15- Modarresi, M., S. Afrasiabi, H. Bagheri Garbollagh, and F. Khani. 2020. Prioritizing Export Target Markets of Tomato Iran Using Numerical Taxonomy Analysis (In Persian).

16- Microsoft Excel. 2019. Microsoft, LA, USA

17- Mirbagheri, S.SH., H. Rafiee, and H. Akbarpour. 2019. Market structure analysis and export pattern of Iranian saffron. Iranian Journal of Medicinal and Aromatic Plants 35(5): 802-818. (In Persian).

18- Palouj, M. 2018. Pathology of the Agro-industrial Exploitation System and Its Development Strategies. Iranian Agricultral Extension and Education Journal 14(2): 201-217 (In Persian).

19- Rafiee, H., S. Mirbagheri, H. Akbarpour, E. Jalili. 2018. Investigating the structure and compilation of the selection model for Iranian export markets. Business strategies Shahed University 25(12):66-76. (In Persian).

20- Salami, H., and E. Pishbahar. 2001. Changes in the Comparative Advantage Pattern of Agricultural Products in Iran: An Applied Analysis Using Expressed Comparative Advantage Indicators, Agricultural economics and development, 9 (34): 67-99. (In Persian).

21- Turkamani, J., and A. Zoghipour. 2008. Factors affecting the export supply of Iranian food industry products. Agricultural Economics, 2 (1), 23-33. (In Persian).

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مقاله پژوهشی

جلد ۳۵، شماره ٤، زمستان ١٤٠٠، ص ٤٠٦-٣٩٧

رقابت‌پذیری صادراتی ایران در زنجیرۀ عرضۀ رب گوجه‌فرنگی در بازارهای هدف

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چکیده

صادرات محصولات کشاورزی و صنایع تبدیلی از راهبردهای توسعه صادرات و رشد پایدار اقتصادی در کشورهای در حال توسعه به شمار می‌رود. از آنجا که ایران در صادرات گوجه‌فرنگی و رب گوجه در سال‌های اخیر در بین ده کشور برتر جهان جای داشته است، هدف این مطالعه مقایسه ساختار بازار جهانی این دو محصول به عنوان دو حلقه از زنجیره عرضه گوجه‌فرنگی و محاسبه مزیت نسبی آشکار شده صادرات آنها در جهان و کشورهای هدف ایران تعیین شد. براساس نتایج، ساختار بازار جهانی هر دو محصول در دوره ۲۰۱۸-۲۰۱۰ با وجود سهم بالای چهار قدرت برتر بازار، در بیشتر سال‌ها انحصار چندجانبه باز بوده است که بیانگر سهم اندک بیشتر رقبا و رقابت زیاد بین آنها است. اما با توجه به سهم زیاد و ثبات رهبری بازار، امکان گرفتن سهم کشورهای بزرگ برای رقبای کوچک، اندک است. از این رو، پیشنهاد می‌شود، ایران با متوسط سهم ۱/۶۱ درصدی در بازار گوجه و ۵/۳۰ درصد در بازار رب، تعدادی از بازارها را که در آنها از قدرت رقابت‌پذیری بیشتری برخوردار است، برای نفوذ، توسعه بازار و برندسازی در اولویت قرار دهد. به طور میانگین صادرات گوجه‌فرنگی به کشورهای ترکمنستان، عراق و افغانستان برای ایران بیشترین مزیت نسبی را داشته و همچنین صادرات رب گوجه‌فرنگی نیز به کشورهای ذکر شده دارای بیشترین مزیت نسبی برای ایران بوده است که پیشنهاد می‌شود، تعدادی از بازارها را که در آنها براساس شاخص مزیت نسبی آشکار شده از قدرت رقابت‌پذیری و پایداری برخوردار است، از جمله بازارهای ترکمنستان و افغانستان را در اولویت نفوذ، توسعه بازار و برندسازی قرار دهد. شایان ذکر است، با توجه به مزیت نسبی بالاتر رب گوجه در مقایسه با گوجه‌فرنگی، ارزش افزوده بالاتر آن، امکان برندسازی بیشتر و قابلیت نگهداری و حمل و نقل، توصیه می‌شود، با توسعۀ سرمایه‌گذاری در صنایع تبدیلی و تکمیل زنجیرۀ عرضه و بازاریابی، توسعه بازار صادراتی رب گوجه‌فرنگی در اولویت کشور قرار گیرد.

واژه‌های کلیدی: بازار هدف صادراتی، رب گوجه‌فرنگی، ساختار بازار جهانی، مزیت نسبی متقارن آشکارشده

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Cropping Pattern Optimization in the Context of Climate-Smart Agriculture: A Case Study for Doroodzan Irrigation Network- Iran

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Abstract

Modern irrigation systems are considered as a way to both respond to the effects of climate changes and improve the water security. Applying such systems, save the water used in farming activities and consequently made some environmental challenges in terms of increasing energy consumption and greenhouse gas emissions. Although some recent studies analyzed the relationship between water and energy in the agricultural irrigation systems, considering the objectives on productivity, adaptation, and mitigation in a cropping pattern optimization problem is necessary. Climate-Smart agriculture as a strong programming concept, addresses these three objectives and has created the potential for a "triple-win" solution. This study is an effort to fill the study gap on triple-win solution in modern irrigation by developing an integrated economic-hydrological-environmental model called WECSAM at the basin level using a hydrological model called WEAP. For this purpose, a multi-objective optimization model has been developed with the concepts of water footprint, energy footprint, and the greenhouse gas emissions in the context of CSA. We applied the model to the northern region of Bakhtegan basin called Doroodzan irrigation network located in Iran. The result of the WECSAM model indicated that by simultaneously optimizing the conflicting objectives of maximizing profit and minimizing water footprint, energy footprint, and CO_2 emissions, as compared to the single-objective model of maximizing economic profit, the water footprint decreases by 8.2%, Energy footprint decreases by 21.2%, CO_2 emissions decreases by 6.9% and profit decreases by 7.4%. The share of each system in irrigating the water-smart, energy-smart, and climate-smart cropping pattern is as follow: 54% for drip system, 26% for semi-permanent sprinkler system, 11% for surface systems, 8% for center-pivot, and <1% for classic permanent sprinkler system.

Keywords: Cropping Pattern, Climate-Smart Agriculture, CO_2 Emission, Irrigation Systems, Multi-objective Optimization, Water Footprint

Introduction

Increasing world population and consequently expanding demand for agricultural crops associated with the pressure on water resources caused by climate change, has made a major challenge for agriculture to ensure food security of communities (Escriva-Bou *et al*., 2018; Wang *et al*, 2017; Galan-Martin *et al*., 2017). In recent decades, one of the main adaptation strategies to respond to food security challenge is the development of irrigated agriculture and improving the water use efficiency (García *et al*., 2014; Tarjuelo *et al*., 2015; Hardy *et al*., 2012; Daccache *et al*., 2014; Schwabe *et al*., 2017; Hanjra & Qureshi, 2010). Irrigation cultivation area worldwide has increased from 161,148,000 ha in 1961 to 338,710,000 ha in 2018. More than 70% of the surface and groundwater are have been applied for the agricultural application (Dehghanipour *et*

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al., 2020) while 90% of this amount is consumed in arid and semi-arid regions (Tarjuelo *et al*., 2015; Molden, 2013). Development of modern irrigation infrastructure and pressurized irrigation systems, as a strategy to improve both water and food security through increasing crop yield and reducing irrigation water use, plays a substantial role in intensifying the production of agricultural crops in arid and semi-arid areas (Fouial *et al*., 2016).

The modern irrigation technologies are considered as a way to manage the effects of climate change as well as to improve the water security. Nevertheless, although some modern irrigation technologies may save the water consumption volume (Playán & Mateos, 2006), employing such systems as a single strategy to respond to rising food demand contains a serious challenge in terms of increasing Energy consumption as well as greenhouse gas (GHG) emissions, and even economic challenges (Mushtaq *et al*., 2013; Schwabe *et al*., 2017). so recently, many researchers has been paid attention to study the performance of these systems (Rodríguez-Díaz *et al*., 2007; Fernández García *et al*., 2014; Daccache *et al*., 2014; Hardy and Garrido, 2012; Levidow *et al*., 2014; Mushtaq *et al*., 2013; Rodríguez-Díaz *et al*., 2012; Carrillo Cobo *et al*., 2014; Zhao *et al*., 2020; Tarjuelo *et al*., 2015; Mateos *et al*., 2018; Espinosa-Tasón *et al.,* 2020). In this matter, world statistics indicate that about 23-48% of the world's agricultural energy is directly consumed by the irrigation pumps (Mushtaq *et al*., 2013; Zhao *et al*., 2020). A study conducted by Fernández García *et al*. (2014) revealed that with the development of modern irrigation systems, the water consumption has decreased by 23%, while the water costs have increased by 52%, mainly due to higher energy requirements. Espinosa-Tason *et al*. (2020), by creating "energized-water" term, showed that the conversion of the furrow irrigation system to drip and sprinkler irrigation systems in Spain, generated 600% increase in the energy consumption, tripled the cultivation area in the 1950–2017 period, and also doubled the water consumption for some periods. They indicated the importance of paying attention to choosing the irrigation methods in the management of agricultural systems.

Although some recent studies provided valuable analyses of the relationship between water and energy in the agricultural irrigation systems, and also highlighted the importance of extending these studies in water-scarce areas, but a significant number of them have resulted that there are some gaps in this field that required to be supplemented with more efforts. In this regard, Rodríguez Díaz *et al*. (2011) by developing a water and energy consumption assessment method in the pressurized irrigation networks in 10 sub-basins of representative Andalusian, concluded that there is a high requirement for energy to implement these irrigation systems. Accordingly, they suggested that water and energy should be optimized simultaneously. Mushtaq *et al*. (2013) using an integrated economic-environmental model, surveyed the trade-off between water storage, energy consumption, greenhouse gas emissions, and economic benefits in sprinkler, drip and surface irrigation systems. By emphasizing the complexity of exploring the effectiveness of modern irrigation systems to achieve the irrigation efficiency on farms, they showed that in order to optimize investment in new irrigation technologies, items that should be considered simultaneously in the crop system are adaptation, and mitigation measures. In this way it's possible to achieve the most economic benefits, manage the effects of climate change, and also minimize negative effects on the environment.

Thus, to deal with the existing challenges, three factors of productivity, adaptation, and mitigation should be synthesized in management of agricultural systems. The concept of climate-smart agriculture (CSA) as a strong programming concept has been able to solve these three objectives simultaneously, which has created the potential for a "triple-win" solution (Long *et al*., 2016; Neufeldt *et al*., 2013). Here, the CSA is resistant to the climate change by improving productivity, sustaining farm incomes, increasing the water use productivity, and reducing the GHGs emissions. Water-smart, energy-smart, carbon-smart and knowledge-smart technologies can significantly, directly or indirectly, improve productivity, increase flexibility, and decrease the GHGs (Imran *et al*., 2019). It should be noted that **CSA** contains a wide range of technologies and practices, in which water and energy management are the most important (Palombi & Sessa, 2013; Olayide *et al*., 2016; Streimikis *et al*., 2020; Bogdanski, 2012). Nonetheless, having in mind the location-specific property of CSA (Palombi & Sessa, 2013), the technologies and practices employing in each region should be investigated to confirm its accordance with the CSA objectives.

In recent years, irrigation of many crops has been shifted towards modern irrigation systems and the level of irrigated cultivation area has increased in types of:

- Classical permanent sprinkler irrigation system;
- Semi-portable sprinkler irrigation system;
- Center-pivot irrigation system;
- Drip irrigation system.

Supporting farmer's livelihood, and, simultaneously, decreasing in river inflow as well as available water shrinkage, highlighted the importance of the integrated agricultural management.

It can be clearly concluded that regardless of the technical factors, the selection of irrigation systems in a region can meet the objectives of adaptation, mitigation, and productivity simultaneously only if its optimization take place alongside with cropping pattern in the context of CSA objectives. Although the importance of this problem has been highlighted in many studies, but in our knowledge, no study by now has presented the problem to optimize the cropping pattern and irrigation system based on CSA objectives. This study is looking to fill the study gap by developing an integrated economic-hydrological-environmental model at the basin level using a hydrological model called WEAP[1], which is a multi-objective optimization model synthesizied with the concepts of water footprint, energy footprint, and the GHGs emissions in the context of CSA. We are trying to answer questions on the necessity of converting to modern irrigation systems for all crops in order to achieve the objectives of CSA and what combination of crops and irrigation systems can be acceptable to obtain a smart farming system.

Methodology

The water supply challenges, by maximizing the farmers' profits while ensuring the sustainability of the natural ecosystem, require the use of multi-objective optimization models (Giupponi, 2007). In this study, in order to meet the objectives of CSA to determine the optimal cropping pattern and irrigation systems, these following objectives are considered:

- Maximizing economic profit
- Minimizing water footprint
- Minimizing energy consumption
- Minimizing CO_2 emissions

One of the most important parts of these components is the water resource available in the basin, which should be allocated among urban, industry and agriculture sectors using different policy priorities and also between different crops. In some studies, fuzzy methods have been applied to deal with this uncertainty (Li *et al*., 2019; Mardani Najafabadi *et al*, 2019). However, in some other studies, it is suggested that basin simulation models can be applied to facilitate decisions related to complex irrigation systems that depend on various variables, parameters, processes, and uncertainties (Escriva -Bou, 2018; Mirzaei & Zibaei, 2020). In this study, we utilized the WEAP-MABIA model to determine the amount of available water as well as simulating the yield and water requirements of crops in the study area. Likewise, by calculating the effective evapotranspiration by WEAP, the water footprint index was considered instead of the usual physical requirement. Compared to physical water, the water footprint is a more useful tool to achieve cleaner production in real-world agricultural water management practices (Dai *et al*., 2021). A complete description of the general framework of the model, the WEAP-MABIA model, multi-objective mathematical model for obtaining water and energy footprints, and CO_2 emissions are described in the following sections.

Integrated Model Context

The general framework of the model is provided in Fig. 2. In the first step, by entering the climate data, land use, soil, water resources, plant information, irrigation, and agricultural, city, industry, and environmental demand sites and their approved priorities in the region, finally calibrating the WEAP model, we were able to simulate the actual measures of water resources, water requirement, and crop yield. Besides, with the use of effective evapotranspiration, and reference transpiration obtained from the WEAP model, the water footprint index of the selected crops is calculated in the region. The energy footprint per hectare has been calculated for different irrigation crops and systems by using information on the irrigation systems and energy, water consumption, and crops yield. Meanwhile, using the emission data described in the section data, the emission amount of each crop was assessed in different irrigation systems. After these calculations, a multi-objective hydrologic-economic-environmental model was set. By solving the multi-objective model using the genetic algorithm (GA) method, we obtained the Pareto frontier function. Then, by giving the same weights to our

1- Water Evaluation And Planning System (WEAP) four objectives in TOPSIS method, the most effective crop pattern irrigated with the best combinations of irrigation systems was chosen as well.

Water Evaluation and Planning System (WEAP)

The Water Evaluation and Planning System (WEAP) is a useful and practical tool for the comprehensive water management (Esteve *et al*., 2015; Blanco-Gutiérrez *et al*., 2013), which was developed by the Stockholm Environment Institute (SEI). WEAP, in addition to being a tool for forecasting and policy analysis, by considering the supply and demand sides of water resources, can provide a comprehensive delineation of the current state of water supply resources as well as demand side of the basin (Yates *et al*., 2005). By employing the MABIA method in WEAP, the processes of evapotranspiration, runoff**,** infiltration, and irrigation requirements at the basin can be simulated. The MABIA method is a daily simulation of evapotranspiration, irrigation and planed requirements, crop growth and yield, which includes some modules to estimate reference evapotranspiration and soil water capacity (Jabloun & Sahli, 2012).

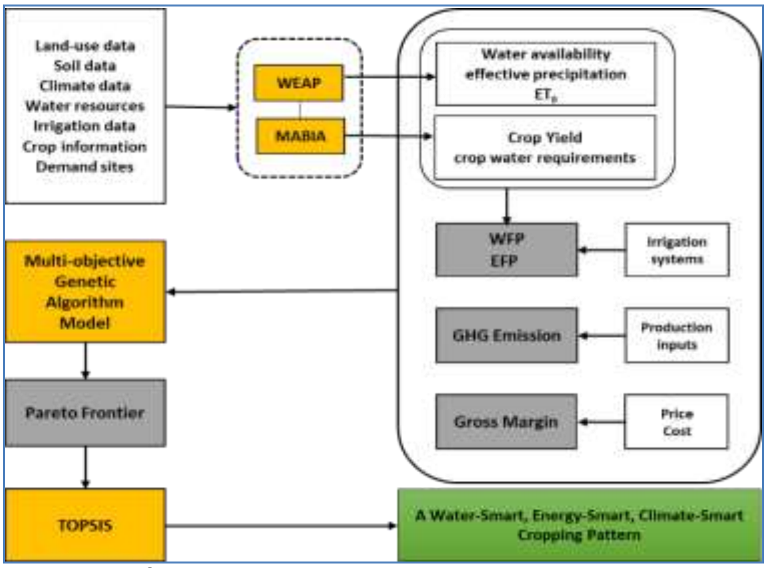


Fig. 1- Framework of the Water-Energy-Climate Smart Agriculture Model (WECSAM)

Table 1- Cropping pattern of the study area

Catchment	Area (ha)	Crop pattern
Main & Abarj	9317	Wheat (67.5%), Barley (1.8%), Tomato (6.7%), Rice (17.2%), Corn (3.1%)
Left side	14481	Wheat (64.6%), Barley (3.9%), Tomato (6.7%), Rice (2.6%), Corn (20.6%)
Ordibehesht	6015	Wheat (76.2%), Barley (4.2%), Tomato (2.4%), Rice (1.6%), Corn (9.3%)
Hamoon	16078	Wheat (74.6%), Barley (18.2%), Rice (1.1%), Corn (1.1%)
Continue of the left	7714	Wheat (64.2%), Barley (17.4%), Tomato (1.9), Corn (7.3%)
Continue of the right	3240	Wheat (88.9%), Barley (11.1%)
Total	56845	Wheat (70.5%), Barley (90%), Tomato (3.3%), Rice (4.0%), Corn (8.0%), Others (4.3%)

In order to simulate evapotranspiration, effective rainfall, water requirements of crops, yield, and water available for agriculture in this study, city demand node with priority 1, industrial demand node with priority 2, and agricultural catchments and the environmental demand of Bakhtegan wetland with priority 3 were defined. Since Doroodzan irrigation network is divided into 6 regions, 6 agricultural catchments are defined so that available water resources and cultivation areas and other information can be carefully entered into the model. However, as the decisions are made for the multi-objective model at the level of the irrigation network, the whole area has been aggregated. Information on the cultivated areas are reported in Table 1.

The model was calibrated by comparing the observed and simulated values of variables like river flow, yield and water requirement. Plant parameter including basal crop coefficient were used for calibration, and the values of calibrated water need and yield is presented in Table 2. Model accuracy is measured using the standardized bias score that showed a good level of accuracy with a bias of less than 20% (see Esteve *et al*. (2015)).

Table 2- WEAP calibration parameters

Parameter	Barley	Forage crop	Rice	Tomato	Wheat
'basal' crop coefficient, K_{cb}*	0.50	0.67	0.92	0.68	0.55
Net water requirement** (m^3)	2759.93	3113.49	11333.55	8889.42	3332.16
Yield (tons)	2.88	58.44	5.35	67.72	4.55

*Average of three stages of plant growth
** Weighted average of irrigated catchments

then were included in the proposed model. In the following, the objectives and constraints of the model are described and also the definition of the symbols used in the model are available in table 3.

The profit of the agricultural system. The most important criterion that many decision makers consider to choose the cropping pattern at different scales from a farm to region, is the profit obtained from the agricultural activity, which reflects both economic development (at regional scale) and farmers' livelihoods and income (on a farm scale) (Li *et al*., 2019). The profit function is explained using Eq. (1).

$$Profit^{max} = \sum_s \sum_c (Income_{cs} - Cost_{cs}) \times x_{cs} \quad (1)$$

$$Income_{cs} = P_c * Y_{cs} \quad (2)$$

$$Cost_{cs} = (WN_c/eff_s) \times CW + QE_{cs} \times CE + CSYS_{cs} + OIC_c \quad (3)$$

Water footprints. In this study, instead of minimizing the physical volume of water consumption, minimizing water footprint per hectare was considered. By minimizing the water footprint index, several objectives can be achieved simultaneously: decreasing water consumption, increasing water efficiency, and reducing pollution per unit of crop (Hoekstra, & Chapagain, 2011; Hoekstra *et al*., 2009).

$$WFP^{min} = \sum_s \sum_c WF_{cs} \times x_{cs} \quad (4)$$

Energy footprint. The energy footprint index is calculated with the aim of determining the amount of energy consumed (Li *et al*., 2015). Due to the importance of reducing energy consumption in applying modern irrigation systems, minimizing the energy consumption (energy footprint) per hectare, was entered in the proposed model as an objective:

$$EFP^{min} = \sum_s \sum_c EF_{cs} \times x_{cs} \quad (5)$$

CO_2 emission. The energy used for pumping and irrigation emits the significant carbon emissions, which accelerates the process of climate change and global warming. As such, this is one of three scopes of CSA to reduce or eliminate the greenhouse gas emissions in the agricultural sector. Thus, minimizing CO_2 emissions was considered

Water Footprint

To effectively manage water resources as well as to minimize the water consumption, it is essential to define appropriate criteria and integrate them into support tools and decision-making models. The concept of water footprint, first was introduced by Hoekstra as a quantitative measure of the water volume consumed per unit of crop as well as the volume of water required to dilute pollution (Hoekstra and Chapagain, 2011). Green, blue, gray, and white water footprints for wheat, rice, tomato, barley, and forage corn in the study area were estimated using the proposed framework developed by Ababaei & Etedali (2014). The green water footprints represent part of the total evaporative flow allocated to human purposes, whereas the blue water footprints represent the volume of groundwater and surface water consumed for the human requirements. Besides, the volume of water required to dilute wasted manure (using runoff or deep infiltration) indicates a gray water footprint. In this study, following most studies, the gray water footprint was calculated only for nitrogen fertilizers as the most important source of agricultural land pollution in Iran (Ashktorab & Zibaei, 2021). At the end, the white water footprint was also calculated based on the proposed method by Ababaei & Etedali (1).

Multi-objective Model

A multi-objective optimization model was developed to determine a Water-Energy-Climate Smart Agriculture Model called 'WECSAM'. For this purpose, some conflicting but vital objectives were set for the smart allocation of water and land resources between wheat, barley, rice, tomato, and forage corn in the study area. In this model, the system profit, water footprint, CO_2 emissions, and energy footprint can be optimized with regard to water and land resources constraint in different irrigated water seasons. Each crop was entered into the model in six separate activities, depending on the irrigation system. Besides, the technical coefficients and available resources for water and land inputs were calculated by planting season, and reproductive process of genetic algorithm was described by the following steps: producing a population of chromosomes, evaluation of the fitness, forming a loop to generate new population, repeating the process of selection, crossover, mutation, and accepting until the population is completed, running the algorithm using new generation, evaluation of stopping criteria (Khoshnevisan *et al*., 2015). MATLAB optimization program finds the minimum of each objective function when it solves an optimization problem. So, objective functions ought to be maximized should be multiplied by (−1) (Elsoragaby *et al*., 2020). More details about GA can be found in the literature (Collette & Siarry, 2004).

TOPSIS

After solving the multi-objective model and achieving the optimal Pareto frontier, the most effective Pareto solution can be chosen based on the different attitudes of decision makers and stakeholders, which is implemented in the TOPSIS method. This is an easy way to rank available options based on different criteria. Mentioned method that chooses the shortest distance from the ideal point as the best alternative, is one of the compromise methods (Mirzaei & Zibaei, 2020).

as another objective of this study:

$$CE^{min} = \sum_s \sum_c CO_{cs} \cdot x_{cs} \quad (6)$$

$$CO_{cs} = CEF \cdot QF_c + CEP \cdot QP_c + CEPD \cdot QPD_c + CEI \cdot QEI_c + COI \quad (7)$$

Constraints. Due to the differences in the planting season in the cultivation pattern of the region, the constraints of water and land resources were defined in different planting seasons (eq.8-eq.13). Eq. 12 is the constraint of economic output to guarantee the livelihood of farmers and economic development.

$$\sum_s \sum_c LANDS1_{cs} \times x_{cs} \leq TLS1 \quad (8)$$

$$\sum_s \sum_c LANDS2_{cs} \times x_{cs} \leq TLS1 \quad (9)$$

$$\sum_s \sum_c WATS1_{cs} \times x_{cs} \leq (SWS1 + GWS1) \quad (10)$$

$$\sum_s \sum_c WATS2_{cs} \times x_{cs} \leq (SWS1 + GWS1) \quad (11)$$

$$\sum_s \sum_c GM_{cs} \times x_{cs} \geq Prof^{min} \quad (12)$$

$$x_{csys} \geq 0$$

Genetic algorithm

Multi-objective economic-hydrologic-environmental problem solved by Genetic Algorithm (GA) method using MATLAB toolbox. Collette & Siarry (2004) refer to genetic algorithm as a "comprehensive heuristic search" that often solves complex problems that are not possible to be solved with conventional methods. The

Table 3- The nomenclature of the parameters and variables used in WECSAM model

Symbol	Definition
Indices	
c	Index of crop
s	Index of irrigation system
Max	Superscript for maximum
Min	Superscript for minimum
Decision variable	
X_{cs}	Land use allocation to crop c irrigated with system s (ha)
Objective functions	
$Profit^{max}$	Maximum system profit (10 Rials)
WFP^{min}	Minimum water footprint (m^3/ha)
EFP^{min}	Minimum energy footprint (Kw.h/ha)
CE^{min}	Minimum CO_2 emission (kg)
Parameters	
$Income_{cs}$	Income of crop c irrigated with system s (10 Rials)
$Cost_{csys}$	Costs of crop c irrigated with system s (10 Rials)
P_c	Price of crop c (10 Rials)
Y_{cs}	Yield of crop c irrigated with system s (tons)
WN_c	Water required for crop c (m^3/ha)
Eff_s	Efficiency of irrigation system s
CW	Costs of water utilization (10 Rials)
QE_{cs}	Quantity of energy use for crop c irrigated with system s (kw.h/ha)
CE	Costs of electricity utilization (10 Rials)
$CSYS_{cs}$	Costs of system for system s implemented for crop c (10 Rials/ha)
OIC_c	Other inputs costs for crop c (10 Rials)
WF_{cs}	Total water footprint of crop c irrigated with system s (m^3/ha)
EF_{cs}	Energy used per ha for crop c irrigated with system s (kw.h/ha)
CO_{cs}	CO_2 emissions of crop c irrigated with system s (kg co_2/ha)
CEF	Carbon emission coefficient of fertilizer utilization for crop c (kg co_2/kg)
QF_c	Fertilizer utilization amount per unit area of crop c (kg/ha)

CEP	Carbon emission coefficient of pesticide utilization for crop c (kg co_2/kg)
QP_c	Pesticide utilization amount per unit area of crop c (kg/ha)
CED	Carbon emission coefficient of diesel oil utilization for crop c (kg co_2/L)
QD_c	Diesel oil utilization amount per unit area of crop c (L/ha)
CEI	Carbon emission coefficient of electricity (kg co_2/kw.h)
QEI_c	Electricity utilization amount per unit area of crop c (kw.h/ha)
CI	Carbon emission coefficient of irrigation area (kg co_2/ha)
$LANDS1_{cs}$	Land coefficient for winter crops irrigated with system s (ha)
TLS1	Total land available for winter crops (ha)
$LANDS2_{cs}$	Land coefficient for summer crops irrigated with system s (ha)
TLS2	Total land available for summer crops (ha)
$WATS1_{cs}$	Water need of winter crops irrigated with system s (m^3/ha)
SWS	Total surface water available for winter crops (ha)
GWS	Total ground water available for winter crops (ha)
TWATS1	Total water available for winter crops (ha)
$WATS2_{cs}$	Water need of summer crops irrigated with system s (m^3/ha)
TWATS2	Total water available for summer crops (ha)
GM_{cs}	Gross margin of crop c irrigated with system s (10 Rials /ha)
$Prof^{min}$	Minimum expected profit (10 Rials)
$Area_c^{min}$	Approved minimum area allocated for crop c (ha)

Data collection and processing

The data needed to implement the WECSAM model were collected from a variety of sources, including local specialist organization, statistical yearbooks, interview with farmers and experts, and the experimental studies. The data required for the WEAP model, including climatic information of the region (maximum and minimum temperature, precipitation, relative humidity, wind speed and sunny hours) were collected from the information of Doroodzan and Zarghan synoptic stations (Meteorology Organization of Iran (IRIMO), 2020). Land use and water consumption for agriculture, industry and urban, and also soil types and groundwater resources were extracted from the reports of Fars Regional Water Organization (Regional Water Company of Fars, 2020). Information on planting and harvesting dates, irrigation and potential yield of the region was obtained from interviews with farmers and specialists of the regional agriculture department. The minimum area under cultivation for each crop is an amount approved by the Agriculture-Jahad Organization for this region, which is set at 2160 for barley, 3200 for forage corn, 2000 for rice, 960 for tomatoes, and 14400 for wheat.

The energy required to extract one cubic meter of water in different irrigation systems in the study area and the cost of each irrigation system per hectare were calculated and updated from the results of a research project conducted by Liaqat *et al*. (2012). Distribution and transfer efficiencies of the region and on-farm application efficiencies by different irrigation systems were extracted from the reports of Fars Regional Water Organization (Regional Water Company of Fars, 2020) and from the study of Abbasi *et al*. (2014), respectively. Information on prices and production costs of products was obtained from the Database of the Ministry of Agriculture-Jahad (MAJ, 2020). The amount of CO2 emissions for each product was calculated based on the study conducted by Li *et al*. (2019) which were equal to 0.9 $kgCO_2$/kg for chemical fertilizer, 4.93 $kgCO_2$/kg for pesticide, 2.73 $kgCO_2$/L for diesel oil, 0.85 $kgCO_2$/kW·h for electricity, and 740 $kgCO_2$/ha for irrigation.

Study area

The study area, irrigation network and drainage of Doroodzan, include six construction units located in the north of Bakhtegan basin on the Kor River and its gross area is 78553 hectares (as illustrated in Fig. 2).

More than 90% of the cultivation area in this region is allocated to wheat and barley crops in winter and rice, tomatoes and forage corn in summer. Fig. 1 depicts the geographical location of the study area.

Results

Irrigation systems, CO_2 emissions, water footprints and energy footprints

Table 4 reports the values of efficiencies for different irrigation systems. In Doroodzan region, transfer and distribution efficiencies are 0.88 and 0.78, respectively, but the application efficiency at farm level varies depending on the irrigation system used in the field. The efficiency of the surface irrigation system in this area is calculated 0.58, whereas it is equal to 0.71 for the drip irrigation system, and is equal to 0.52 for the classic permanent sprinkler irrigation system. Semi-portable and center-pivot sprinkler irrigation systems are 0.65. In the improved surface irrigation system, due to the improvement of distribution efficiency up to 90%, the total irrigation efficiency could reach at 0.46, known as the highest efficiency among different systems after drip irrigation. The amount of electricity consumption per cubic meter of water in each of the different irrigation systems is provided in the last column of Table 4.

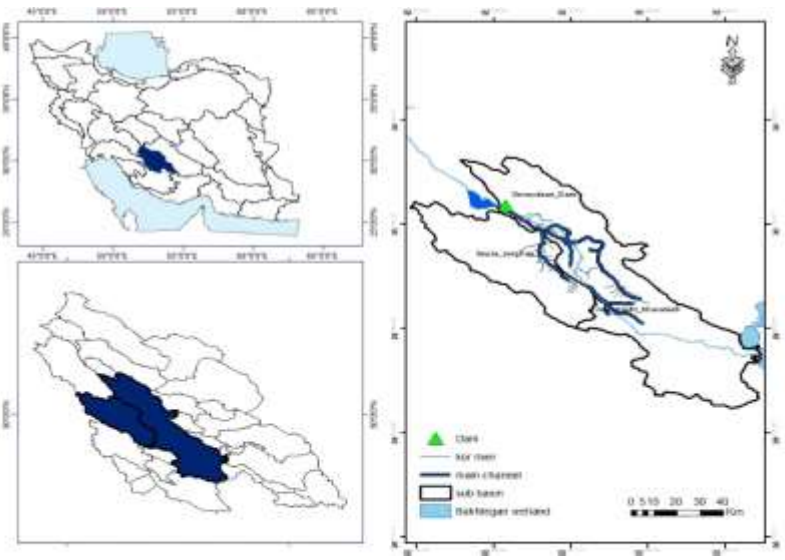


Fig. 2- Location of study area

Table 4- Transfer, distribution, farm irrigation and total efficiency and energy use of per m3 water extraction

	Irrigation systems	Transfer	Distribution	Farm	Total	Energy (kw.h)
Sys1	Surface	0.88	0.78	0.58	0.40	0.30
Sys2	Surface-improved	0.88	0.90	0.58	0.46	0.30
Sys3	Drip	0.88	0.78	0.71	0.49	0.70
Sys4	Sprinkler-permanent	0.88	0.78	0.52	0.36	1.33
Sys5	Sprinkler-semi permanent	0.88	0.78	0.65	0.45	1.09
Sys6	Sprinkler-center pivot	0.88	0.78	0.65	0.45	0.89

Source: Regional water Company of Fars

The highest energy consumption is related to the classical fixed sprinkler irrigation system, followed by semi-portable sprinkler irrigation. Moreover, the lowest energy consumption is related to the surface irrigation system that is considered 0.4 less than drip irrigation system, based on literature (Zhao *et al*., 2020).

In Table 5, the total water footprint per ha calculated for each crop and each system. The highest and lowest amount of water footprint were obtained for rice and barley, respectively. Tomato was ranked the second in terms of water footprint. Comparison of water footprints between crops and irrigation systems shows that the highest water footprint was obtained in the surface irrigation system, whereas the lowest one was for drip irrigation system. Regarding that both the yield and the amount of water consumption were involved to calculate the water footprint, we could expect that the drip irrigation system potentially has the lowest amount of water footprint among different crops.

The results of energy footprint per ha are listed in Table 6. The rice and barley contained the highest and the lowest energy footprint per ha respectively.

Table 5- Total water footprint of selected crops by different irrigation systems (m3/ha)

	Irrigation systems	Barley	Forage corn	Rice	Tomato	Wheat
Sys1	Surface	8866.25	9754.34	30401.95	24262.63	10303.61
Sys2	Surface-improved	7941.91	6780.05	24674.64	19353.89	7256.08
Sys3	Drip	5657.40	6381.86	23299.66	18291.49	6904.39
Sys4	Sprinkler-permanent	7794.24	8782.90	31768.71	25007.10	9467.31
Sys5	Sprinkler-semi permanent	6345.07	7138.74	25591.14	20104.54	9416.43
Sys6	Sprinkler-center pivot	8131.89	8925.56	27377.96	21891.36	9416.43

Source: Research Findings

Table 6- Energy footprint of selected crops under different irrigation systems (Kwh/ha)

	Irrigation systems	Barley	Forage corn	Rice	Tomato	Wheat
Sys1	Surface	2079.77	2346.19	8540.48	6698.68	2510.97
Sys2	Surface-improved	1802.47	4744.53	17270.74	13546.22	5077.75
Sys3	Drip	3958.68	4465.80	30886.65	24225.79	9080.94
Sys4	Sprinkler-permanent	10264.45	11579.36	42150.50	33060.53	12392.61
Sys5	Sprinkler-semi permanent	8240.02	9295.61	33837.31	26540.12	6657.24
Sys6	Sprinkler-center pivot	5514.00	6220.37	22643.01	17759.93	6657.24

Source: Research findings

Table 7- CO_2 emission of selected crops under different irrigation systems ($kgCO_2/ha$)

	Irrigation systems	Barley	Forage corn	Rice	Tomato	Wheat
Sys1	Surface	3058.58	3641.68	8601.83	7266.48	3500.45
Sys2	Surface-improved	2822.87	5680.26	16022.56	13086.89	5682.21
Sys3	Drip	4655.65	5443.35	27596.09	22164.53	9084.93
Sys4	Sprinkler-permanent	10015.55	11489.87	37170.36	29674.06	11899.85
Sys5	Sprinkler-semi permanent	8294.80	9548.68	30104.14	24131.71	7024.78
Sys6	Sprinkler-center pivot	5977.68	6934.73	20588.99	16668.55	7024.78

Source: Research findings

The results for CO_2 emission per hectare for crops with different irrigation systems are reported in Table 7. A comparison between the emission of per hectare of different crops shows that rice has the highest and barley has the lowest amount. However, all crops reach their maximum emission amount when irrigated with the permanent sprinkler irrigation, and the use of improved surface irrigation diffuses the lowest emission compared to other irrigation systems.

Results of single-objective models

Four objective functions were considered to determine the optimal cropping pattern, which simultaneously involved the choice of irrigation method. To obtain a clearer analysis, we first implemented four single-objective model in GAMS software separately. The results of single-objective models are depicted in Table 8. As can be observed, if the cropping pattern of this region is determined only with the objective of maximizing economic profit then products like barley, forage corn, and rice will enter the pattern at the minimum approved cultivation area for the region, and therefore only tomato and wheat compete with each other in allocation of the cropping area. The results indicate that in order to maximize profit, the total cultivation area of the selected crops will be 54,295 hectares, in which 4% will be allocated to barley, 5.9% to forage corn, 3.7% to rice, 11.2% to tomatoes, and 75.2% to wheat. To irrigate this pattern, 3.7% improved surface irrigation system, 21.1% the drip irrigation, and 75.2% the semi-portable sprinkler irrigation would be utilized. The rice will be irrigated with the improved surface irrigation, whereas barley, forage corn, and tomatoes will be irrigated with the drip irrigation, and finally wheat will be irrigated with semi-portable sprinkler irrigation.

If the objective of cropping pattern selection in the study area, is to minimize the greenhouse gas emissions, then 2160 hectares of barley with the improved surface irrigation system, 13298 hectares of forage corn, 200 hectares of rice with surface irrigation system, 960 hectares of tomatoes with the drip irrigation system, and 34281 hectares of wheat with the surface irrigation system are included in the cropping pattern. As such, in this case, most of the cultivation area is irrigated using a surface irrigation system. In this case, 52698.8 hectares of the region's arable lands are cultivated with the selected crops, in which 68.8% are irrigated with the traditional surface irrigation system, 4.1% with the improved surface irrigation system, and 27.1% with the drip irrigation system. Wheat includes for 65.1% of the cultivation area, followed by forage corn (25.2%), barley (4.1%), rice (3.8%) and tomatoes (1.8%). Another very important objective in the current situation of the world and also study area is to minimize the water consumption. In this regard, if the cropping pattern is determined only by minimizing the water footprint, 2160 hectares of barley, 9339 hectares of forage corn, 2000 hectares of rice, 3302 hectares of tomatoes, and 14400 hectares of wheat will be included in the pattern. However, all crops except rice are irrigated using the drip irrigation system, whereas only rice enters the pattern using the improved surface irrigation system. In this case, the total cultivation area of these crops will be 31201.3 hectares, in which wheat contains the highest share with 46.2%, whereas rice with 6.4% obtains the lowest share in the cropping pattern. Besides, 29.9% of this area is forage corn, 10.6% is tomato, and 6.9% is barley.

The fourth considered objective is to minimize the energy consumption in the selected cropping pattern of Doroodzan region. To do so, the problem is solved with the aim of minimizing the energy consumption and water and land restrictions, as well as the constraint of minimum economic profit. The cropping pattern to meet this objective for cultivation includes 28,667 hectares of barley with the improved surface irrigation, 12822 hectares of forage corn with the drip irrigation, and 2000, 960, 19468 hectares of rice, tomato and wheat crops with the traditional surface irrigation, respectively. In this cropping pattern, a total area of 63,916.6 hectares is allocated to cultivate these crops, in which 48,135 hectares are allocated to winter crops including wheat and barley, while 15,781.6 hectares to summer crops including forage corn and rice. The share of surface, improved surface and drip systems will be 35.1, 44.9, and 20.1 percent, respectively. As a result, the sprinkler irrigation systems are not proposed to minimize the energy consumption.

Table 8- Optimized cropping pattern in single objective models

		sys1	sys2	sys3	sys4	sys5	sys6
Model 1: Profit Maximizing	Barley	-	-	2160.0	-	-	-
	Forage corn	-	-	3200.0	-	-	-
	Rice	-	2000.0	-	-	-	-
	Tomato	-	-	6094.6	-	-	-
	Wheat	-	-	-	-	40840.4	-
Model 2: Emission Minimizing	Barley	-	2160.0	-	-	-	-
	Forage corn	-	-	13298.3	-	-	-
	Rice	2000.0	-	-	-	-	-
	Tomato	-	-	960.0	-	-	-
	Wheat	34280.7	-	-	-	-	-
Model 3: WFP Minimizing	Barley	-	-	2160.0	-	-	-
	Forage corn	-	-	9339.2	-	-	-
	Rice	-	2000.0		-	-	-
	Tomato	-	-	3302.1	-	-	-
	Wheat	-	-	14400.0	-	-	-
Model 4: EFP Minimizing	Barley	-	28666.7	-	-	-	-
	Forage corn	-	-	12821.6	-	-	-
	Rice	2000.0	-	-	-	-	-
	Tomato	960.0	-	-	-	-	-
	Wheat	19468.3	-	-	-	-	-

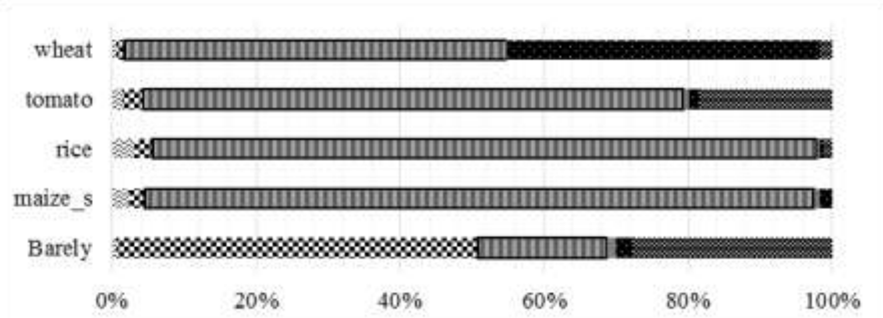
Source: Research Findings

Results of Multi-objective WECSAM Model

After comparing the results of four single-objective models, we considered the results of multi-objective models obtaining from the GA implementation. By running this model in MATLAB, the Pareto frontier curve was obtained with 70 solutions, in which the most effective Pareto solution was selected using the TOPSIS method and equal weighting of each objective as criteria (Fig. 3).

The energy-smart, water-smart, and climate-smart cropping pattern was obtained for Doroodzan region contains 59% wheat, 11.6% tomatoes, 4.7% rice, 7.5% forage corn, and 17.2% barley. The results of WECSAM model suggest that only 54.5% of the arable lands in Doroodzan region should be irrigated with the drip irrigation system. After the drip irrigation, the semi-portable sprinkler irrigation contains the largest share of the irrigation area in the region. The improved surface irrigation system will irrigate 10%, whereas the center-pivot sprinkler will irrigate 8% of the cultivation area.

At the meantime, the traditional irrigation system and the permanent sprinkler irrigation will contribute less than one percent to the irrigation of the cultivation area. A general comparison between the obtained results indicates that the most selective irrigation system is the drip irrigation system, which is the predominant irrigation method for forage corn, rice, tomato, and wheat crops, while the predominant irrigation method for barley is the improved surface irrigation system. On the other hand, the predominant irrigation method after the drip irrigation is the semi-portable sprinkler system for wheat. Besides, the center-pivot irrigation system is the second choice for irrigation for barley and tomatoes. Overall, the drip irrigation system, semi-portable sprinkler irrigation system, and the improved surface irrigation system obtain the highest cultivation area, respectively. In addition, the classical fixed sprinkler irrigation system, the surface irrigation system, and the center pivot sprinkler system obtain the least share in the irrigation of the chosen cultivation pattern.



	Barely	maize_s	rice	tomato	wheat
sys1	44.98	80.88	65.07	72.75	129.78
sys2	3978.99	71.13	55.12	157.36	306.51
sys3	1415.57	3233.26	2003.88	4021.89	14441.19
sys4	105.49	28.56	9.27	43.98	50.04
sys5	176.89	46.34	7.97	73.66	11771.12
sys6	2200.19	10.42	27.33	987.10	483.79

Fig. 3- Allocated land to selected crops under different irrigation systems in WECSAM

Comparing the values of different objective functions in four single-objective models can provide a trade-off analysis between different objectives (Fig. 4). Obviously, the highest economic benefits are obtained in Model 1, whereas in other models, the objectives are to minimize the water and energy footprints and CO_2 emissions, the solution is determined in such a way that can provide the minimum profit constraint, because the increase in profit is the result of increasing levels of agricultural activity, which is not possible except at the cost of more water and energy consumption, and more CO_2 emissions.

Regarding the amount of CO_2 emissions, the highest value is related to the profit maximization model, whereas the lowest one is related to the emission minimization model. In models 3 and 4, the amount of emission is near to the model 2, but in the case where the objective is to minimize the water footprint, the emission is higher than the case of the energy minimization. Thus, it can be concluded that water footprint and CO_2 emission are inversely related to each other.

The highest amount of water footprint belongs to model 4, followed by models 1, 2 and 3, respectively, so that the difference between the amounts of water footprint in model 3 with other models is very large. Eventually, the amount of energy consumed was the highest in Model 1 and the lowest in Model 4. It can be seen that after model 1, the highest energy consumption is in the case where our objective is to minimize the water footprint. Accordingly, achieving the minimization of the objectives of water footprint and energy footprint can move against each other.

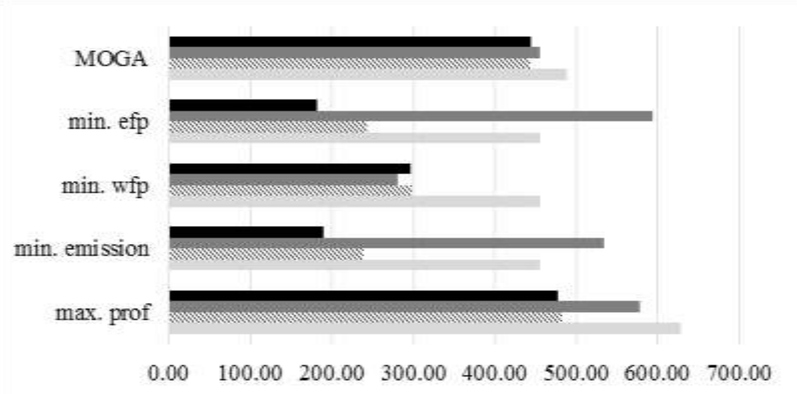
Conclusion

An integrated hydrological-economic-environmental model so-called WECSAM was developed to ensure the obtaining a climate-smart, water-smart and energy-smart cropping pattern. This model included the WEAP hydrological model as a basin database, a multi-objective model in the context of CSA for simultaneous optimization of profits, CO2 emissions, water and energy footprint, and a multi-criteria model called TOPSIS .This model contains the following advantages:

- Simultaneous optimization of cropping pattern and irrigation system so that it includes adaptation, mitigation, and productivity strategies, simultaneously.
- The use of a hydrological simulation model for a basin to more accurately calculate uncertain parameters, including available water, water requirements, and crop yield.
- Applying the concept of water footprint instead of the physical amount of water in order to achieve multiple objectives (decreasing water consumption, increasing water efficiency, and reducing pollution per unit of crop) by minimizing one objective.
- Determining the allowable limit for the

development of new irrigation methods so that the benefits of improving efficiency and the disadvantages of increasing energy consumption, and CO_2 emissions are adjusted.

- Balancing the consumption of water, energy, and land resources in the agricultural system in different growing seasons
- The possibility of trade-off analysis between four objectives of the model.



	max. prof	min. emission	min. wfp	min. efp	MOGA
■ efp	476.91	189.70	295.56	181.33	444.23
■ wfp	578.04	533.60	280.99	594.18	455.41
▨ emission	481.50	236.96	296.95	243.04	442.01
■ profit	628.42	455.56	455.56	455.56	488.99

Fig. 4- Comparison of objective values in single-objective and multi-objective models

the conflicting manner of the proposed objectives. This result is in accordance with ones obtained by Daccache *et al*. (2014) and Jacobs (2006). The result of the WECSAM multi-objective model indicates that by simultaneously optimizing the conflicting objectives of maximizing profit and minimizing water, energy, and CO_2 emissions, as compared to the single-objective model of maximizing economic profit, the water footprint decreases by 8.2%, Energy footprint decreases by 21.2%, CO_2 emissions by 6.9%, and profit decreases by 7.4%. In this pattern, the share of drip systems is 54.5%, and for semi-permanent sprinkler system it is 26.2%, whereas the classic permanent sprinkler system contains less than one percent of the irrigation of the chosen cropping pattern. The selection of irrigation systems resulted from WECSAM model is in accordance with the results of the study conducted by Mushtaq *et al*. (2015). Thus, deciding based on an integrated WECSAM model can well support the decision to adopt more efficient irrigation technologies at basin level and to manage it in a way that the potential negative effects (such as CO_2 emissions and more energy consumption) along with positive effects (reducing water footprints) be considered.

The WECSAM model was implemented for the northern region of Bakhtegan basin called Doroodzan irrigation network. First, the water footprint was calculated for different crops using the results of the simulation of the WEAP-MABIA model for the region. In the surface irrigation system, the highest amount of the water footprint per hectare is for rice and then tomatoes, in which the barley crop contains the lowest amount of the water footprint per hectare. The obtained results for the water footprint of the crops are in accordance with the results of Ashktorab & Zibaei (2019). Comparing the water footprint of each crop in different irrigation systems, the results indicate that the lowest amount of this index is attained for all crops in the drip irrigation system, which is due to higher yield and less water consumption in this system. This result of the effect of the drip irrigation system on reducing the water footprint is in accordance with the study of Nouri et al. (Nouri et al., 2016).

Trade-off analysis between objectives using a comparison of the results of single-objective models reveal that the values of the energy footprint and water footprint in the respective models change against each other and this appears such as rice and tomatoes are very rare to grow using a sprinkler irrigation system. Hence, the justification for this choice using a mathematical model lacks any technical support. In an experimental analysis, it can be explained that in the area of maximum allowable cultivation area using mentioned irrigation methods that can be allocated to these crops, will be equal to these values. Nevertheless, it can be recommended that in future studies, technical principles for choosing the appropriate irrigation system for each crop should be included in the model.

The results of WECSAM show that achieving the climate-smart agriculture goals in the Doroodzan irrigation network is not necessarily possible by changing the irrigation technology of all crops to the modern irrigation system, but by optimizing cropping patterns under different irrigation systems and determining allowable limits to develop modern irrigation systems at the basin level can achieve the goals of climate-smart agriculture.

As can be observed, the GA selects the cropping pattern in such a way that all crops enter the pattern using all irrigation systems. Some crops

References

1. Ababaei, B., and H.R. Etedali. 2014. Estimation of water footprint components of Iran's wheat production: Comparison of global and national scale estimates. Environmental Processes, 1(3): 193-205.
2. Abbasi, F., F. Sohrab, and N. Abbasi. 2015. Irrigation efficiencies: Temporal and spatial changes in Iran. Agricultural Technical and Engineering Research Institute, Iran. (In Persian)
3. Ashktorab, N. and M. Zibaei. 2019. Virtual Water Transfer through Iranian Interprovincial Cereals Trade. Journal of Agricultural Economics and Development, 33(1): 55-74. (In Persian with English abstract)
4. Blanco-Gutiérrez, I., C. Varela-Ortega, and D.R. Purkey. 2013. Integrated assessment of policy interventions for promoting sustainable irrigation in semi-arid environments: A hydro-economic modeling approach. Journal of Environmental Management, 128: 144-160.
5. Bodenhofer, U. 2003. Genetic algorithms: theory and applications. Lecture notes, Fuzzy Logic Laboratorium Linz-Hagenberg, Winter, 2004.
6. Bogdanski, A. 2012. Integrated food–energy systems for climate-smart agriculture. Agriculture and Food Security, 1(1): 1-10.
7. Carrillo Cobo, M., E.C. Poyato, P. Montesinos, and J.R. Díaz. 2014. New model for sustainable management of pressurized irrigation networks. Application to Bembézar MD irrigation district (Spain). Science of the Total Environment: 473: 1-8.
8. Collette, Y., and P. Siarry. 2004. Multi-objective optimization: principles and case studies. Springer Science and Business Media.
9. Daccache, A., J.S. Ciurana, J.R. Diaz, and J.W. Knox. 2014. Water and energy footprint of irrigated agriculture in the Mediterranean region. Environmental Research Letters, 9(12): 124014.
10. Dai, C., X.S. Qin, and W. T. Lu. 2020. A fuzzy fractional programming model for optimizing water footprint of crop planting and trading in the Hai River Basin, China. Journal of Cleaner Production, 278: 123196.
11. Dehghanipour, A.H., G. Schoups, B. Zahabiyoun, and H. Babazadeh. 2020. Meeting agricultural and environmental water demand in endorheic irrigated river basins: A simulation-optimization approach applied to the Urmia Lake basin in Iran. Agricultural Water Management, 241: 106353.
12. Díaz, J.R., P. Montesinos, and E.C. Poyato. 2012. Detecting critical points in on-demand irrigation pressurized networks–a new methodology. Water Resources Management, 26(6): 1693-1713.
13. Elsoragaby, S., A. Yahya, M.R. Mahadi, N.M. Nawi, M. Mairghany, S.M.M. Elhassan, and A. Kheiralla. F. 2020. Applying multi-objective genetic algorithm (MOGA) to optimize the energy inputs and greenhouse gas emissions (GHG) in wetland rice production. Energy Reports, 6: 2988-2998.
14. Escriva-Bou, A., J.R. Lund, M. Pulido-Velazquez, R. Hui, and J. Medellín-Azuara. 2018. Developing a water-energy-GHG emissions modeling framework: Insights from an application to California's water system. Environmental Modelling and Software, 109: 54-65.
15. Espinosa-Tasón, J., J. Berbel, and C. Gutiérrez-Martín. 2020. Energized water: Evolution of water-energy nexus in the Spanish irrigated agriculture, 1950–2017. Agricultural Water Management, 233: 106073.
16. Esteve, P., C. Varela-Ortega, I. Blanco-Gutiérrez, and T.E. Downing. 2015. A hydro-economic model

for the assessment of climate change impacts and adaptation in irrigated agriculture. Ecological Economics, 120: 49-58.

17. Fouial, A., R. Khadra, A. Daccache, and N. Lamaddalena. 2016. Modelling the impact of climate change on pressurised irrigation distribution systems: Use of a new tool for adaptation strategy implementation. Biosystems Engineering, 150: 182-190.
18. Galan-Martin, A., P. Vaskan, A. Anton, L.J. Esteller, and G. Guillen-Gosalbez. 2017. Multi-objective optimization of rainfed and irrigated agricultural areas considering production and environmental criteria: a case study of wheat production in Spain. Journal of Cleaner Production. 140: 816-830.
19. García, I.F., J.R. Díaz, E.C. Poyato, P. Montesinos, and J. Berbel. 2014. Effects of modernization and medium-term perspectives on water and energy use in irrigation districts. Agricultural Systems, 131: 56-63.
20. Giupponi, C. 2007. Decision support systems for implementing the European water framework directive: the MULINO approach. Environmental Modelling and Software, 22: 248–258.
21. Hanjra, M.A., and M.E. Qureshi. 2010. Global water crisis and future food security in an era of climate change. Food Policy, 35(5): 365-377.
22. Hardy, L., A. Garrido, and L. Juana. 2012. Evaluation of Spain's water-energy nexus. International Journal of Water Resources Development, 28(1): 151-170.
23. Hoekstra, A.Y., and A.K. Chapagain. 2011. Globalization of water: Sharing the planet's freshwater resources. John Wiley & Sons.
24. Hoekstra, A.Y., A. Chapagain, M. Martinez-Aldaya, and M. Mekonnen. 2009. Water footprint manual: State of the art 2009.
25. Imran, M.A., A. Ali, M. Ashfaq, S. Hassan, R. Culas, and C. Ma. 2019. Impact of climate smart agriculture (CSA) through sustainable irrigation management on Resource use efficiency: A sustainable production alternative for cotton. Land Use Policy, 88: 104113.
26. Jabloun, M., and A. Sahli. 2012. WEAP-MABIA tutorial: a collection of stand-alone chapters to aid in learning the WEAP-MABIA module. Federal Institute for Geosciences and Natural Resources, Hannover, Germany.
27. Jacobs, S. 2006. Comparison of life cycle energy consumption of alternative irrigation systems.
28. Khoshnevisan, B., E. Bolandnazar, S. Shamshirband, H.M. Shariati, N.B. Anuar, and M.L.M. Kiah. 2015. Decreasing environmental impacts of cropping systems using life cycle assessment (LCA) and multi-objective genetic algorithm. Journal of Cleaner Production, 86: 67-77.
29. Levidow, L., D. Zaccaria, Maia, R., Vivas, E., Todorovic, M., and Scardigno, A. 2014. Improving water-efficient irrigation: Prospects and difficulties of innovative practices. Agricultural Water Management 146: 84-94.
30. Levidow, L., D. Zaccaria, R. Maia, E. Vivas, M. Todorovic, and A. Scardigno. 2014. Improving water-efficient irrigation: Prospects and difficulties of innovative practices. Agricultural Water Management, 146: 84-94.
31. Li, M., Q. Fu, V.P. Singh, Y. Ji, D. Liu, C. Zhang, and T. Li. 2019. An optimal modelling approach for managing agricultural water-energy-food nexus under uncertainty. Science of the Total Environment, 651: 1416-1434.
32. Liaqat, A.M., B. Nazarai, H.A. Alizadeh, M. Ghadirianfar, and Z. Sarayshad. 2012. Analysis of energy consumption in pressurized irrigation systems and presentation of methodology for studying energy consumption in the process of design and development of systems. Ministry of Agriculture Jihad, Iran. (In Persian)
33. Long, T.B., V. Blok, and I. Coninx. 2016. Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: evidence from the Netherlands, France, Switzerland and Italy. Journal of Cleaner Production, 112: 9-21.
34. Mango, N., C. Makate, L. Tamene, P. Mponela, and G. Ndengu. 2018. Adoption of small-scale irrigation farming as a climate-smart agriculture practice and its influence on household income in the Chinyanja Triangle, Southern Africa. Land, 7(2): 49.
35. Mardani Najafabadi, M., S. Ziaee, A. Nikouei, and M.A. Borazjani. 2019. Mathematical programming model (MMP) for optimization of regional cropping patterns decisions: A case study. Agricultural Systems, 173: 218-232.
36. Mateos, L., A.C. dos Santos Almeida, J.A. Frizzone, and S.C.R.V. Lima. 2018. Performance assessment

of smallholder irrigation based on an energy-water-yield nexus approach. Agricultural Water Management, 206: 176-186.

37. Mirzaei, A., and M. Zibaei. 2020. Water Conflict Management between Agriculture and Wetland under Climate Change: Application of Economic-Hydrological-Behavioral Modelling. Water Resources Management, 35(1): 1-21.
38. Molden, D. (Ed.). 2013. Water for food water for life: A comprehensive assessment of water management in agriculture. Routledge.
39. Mushtaq, S., T.N. Maraseni, and K. Reardon-Smith. 2013. Climate change and water security: estimating the greenhouse gas costs of achieving water security through investments in modern irrigation technology. Agricultural Systems, 117: 78-89.
40. Neufeldt, H., M. Jahn, B.M. Campbell, J.R. Beddington, F. DeClerck, A. De Pinto, and D. LeZaks. 2013. Beyond climate-smart agriculture: toward safe operating spaces for global food systems. Agriculture and Food Security, 2(1): 1-6.
41. Nouri, H., B. Stokvis, A. Galindo, M. Blatchford, and A.Y. Hoekstra. 2019. Water scarcity alleviation through water footprint reduction in agriculture: the effect of soil mulching and drip irrigation. Science of the Total Environment, 653: 241-252.
42. Olayide, O.E., I.K. Tetteh, and L. Popoola. 2016. Differential impacts of rainfall and irrigation on agricultural production in Nigeria: Any lessons for climate-smart agriculture?. Agricultural Water Management, 178: 30-36.
43. Palombi, L., and R. Sessa. 2013. Climate-smart agriculture: sourcebook. Climate-smart agriculture: sourcebook.
44. Playán, E., and L. Mateos. 2006. Modernization and optimization of irrigation systems to increase water productivity. Agricultural Water Management, 80(1-3): 100-116.
45. Pourmohamad, Y., A. Alizadeh, M.M. Baygi, M. Gebremichael, A.N. Ziaei, and M. Bannayan. 2019. Optimizing cropping area by proposing a combined water-energy productivity function for Neyshabur Basin, Iran. Agricultural Water Management, 217: 131-140.
46. Rodríguez Díaz, J.A., E. Camacho Poyato, and M. Blanco Pérez. 2011. Evaluation of water and energy use in pressurized irrigation networks in Southern Spain. Journal of Irrigation and Drainage Engineering, 137(10): 644-650.
47. Rodríguez-Díaz, J.A. 2012. More 'crop per drop'–the energy trade-off in Spanish irrigated agriculture.
48. Schwabe, K., K. Knapp, and I. Luviano. 2017. The Water–Energy Nexus and Irrigated Agriculture in the United States: Trends and Analyses. In Competition for Water Resources (pp 80-104). Elsevier.
49. Singh, H., D. Mishra, and N.M. Nahar. 2002. Energy use pattern in production agriculture of a typical village in arid zone, India—part I. Energy Conversion and Management, 43(16): 2275-2286.
50. Streimikis, J., Z. Miao, and T. Balezentis. 2020. Creation of climate-smart and energy-efficient agriculture in the European Union: Pathways based on the frontier analysis. Business Strategy and the Environment, 30(1): 576-589.
51. Tarjuelo, J.M., J.A. Rodriguez-Diaz, R. Abadía, E. Camacho, C. Rocamora, and M.A. Moreno. 2015. Efficient water and energy use in irrigation modernization: Lessons from Spanish case studies. Agricultural Water Management, 162: 67-77.
52. Wang, Y.B., D. Liu, X.C. Cao, Z.Y. Yang, J.F. Song, D.Y. Chen, and S.K. Sun. 2017. Agricultural water rights trading and virtual water export compensation coupling model: a case study of an irrigation district in China. Agricultural Water Management, 180: 99-106.
53. Yates, D., J. Sieber, D. Purkey, and A. Huber-Lee. 2005. WEAP21—A demand-, priority-, and preference-driven water planning model: part 1: model characteristics. Water International, 30(4): 487-500.
54. Zhao, Y., Q. Wang, S. Jiang, J. Zhai, J. Wang, H. Guohua, and Y. Zhu. 2020. Irrigation water and energy saving in well irrigation district from a water-energy nexus perspective. Journal of Cleaner Production, 122058.

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بهینه‌سازی الگوی کشت در چارچوب اهداف کشاورزی اقلیم-هوشمند: مطالعه موردی شبکه آبیاری درودزن- ایران

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چکیده

سیستم‌های نوین آبیاری به عنوان یک راهبرد انطباقی برای مدیریت اثرات تغییر اقلیم و بهبود امنیت آب در نظر گرفته می‌شود. استفاده از چنین سیستم‌هایی علاوه بر صرفه‌جویی در مصرف آب، چالش‌هایی را در زمینه افزایش مصرف انرژی و انتشار گازهای گلخانه‌ای ایجاد کرده است. اگرچه برخی از مطالعات اخیر تحلیل‌های ارزنده‌ای از رابطه بین آب و انرژی در سیستم‌های آبیاری کشاورزی ارائه کرده‌اند، اما توجه همزمان به بهره‌وری، سازگاری و کاهش اثرات مخرب محیط زیستی در بهینه‌سازی الگوی کشت یک سیستم کشاورزی به عنوان یک ضرورت اساسی کمتر مورد توجه قرار گرفته است. کشاورزی اقلیم-هوشمند به عنوان یک مفهوم برنامه‌ای قوی که به این سه هدف می‌پردازد، پتانسیل یک راه‌حل برد سه‌جانبه را ایجاد کرده است. این مطالعه با توسعه یک مدل یکپارچه اقتصادی-هیدرولوژیکی-محیطزیستی به نام WECSAM در سطح حوضه، متشکل از یک مدل هیدرولوژیکی به نام WEAP و یک مدل بهینه‌سازی چند-هدفه و ترکیب آن با مفاهیم ردپای آب، ردپای انرژی و انتشار گازهای گلخانه‌ای در چارچوب کشاورزی اقلیم-هوشمند، در جهت پر کردن این خلأ است. این مدل برای منطقه شمالی حوضه آبریز بختگان به نام شبکه آبیاری درودزن اجرا شد. نتایج مدل WECSAM نشان داد که با بهینه‌سازی همزمان اهداف متناقض حداکثرسازی سود اقتصادی و حداقل‌سازی ردپای آب، ردپای انرژی و انتشار دی‌اکسید کربن، در مقایسه با مدل تک-هدفه حداکثرسازی سود، باعث کاهش ۸/۲ درصد ردپای آب، کاهش ۲۱/۲ درصد ردپای انرژی، کاهش ۶/۹ درصد انتشار انتشار دی اکسید کربن و کاهش ۷/۴ درصد سود اقتصادی می‌شود. سهم سیستم قطره‌ای در آبیاری الگوی کشت آب-هوشمند، انرژی-هوشمند و اقلیم-هوشمند ۵۴/۵ درصد و برای سیستم بارانی نیمه متحرک ۲۶/۲ درصد است، در حالی که سیستم بارانی کلاسیک ثابت کمتر از یک درصد از آبیاری الگوی کشت بهینه را به خود اختصاص می‌دهد.

واژه‌های کلیدی: سیستم‌های آبیاری، الگوی کشت، کشاورزی اقلیم-هوشمند، بهینه‌سازی چندهدفه، رد پای آب، انتشار CO_2

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