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On the Effect of Rainfall Variations on Economic Variables: The Application of General Equilibrium Model

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Abstract

The economy of Iran is dependent on many variables that play a role in its growth and development. On the other hand, rainfall is one of the important factors of climate change that has affected economic strategic programs including those of the agricultural sector. Rainfall variations impact many economic variables, some of which are explored here. The aim of this study was to evaluate rainfall shocks on some economic variables using a general equilibrium model that included the best scenario representing the highest rainfall, the worst scenario representing the lowest rainfall, and normal scenario considering average rainfall. To check the effect of these changes on the agricultural sector, a set of commodities produced by this section is considered separately, and other sections are considered in general. The results showed that the production of these commodities has been increased by about 14% in the best rainfall scenario. All commodities have been faced with reduced consumption from 0.3% to 10.3% in the worst rainfall scenario; this was the greatest loss of products related to the agricultural commodities. Rainfall increased the price of all commodities by 0.25-28.7%, except for industry. Both private and public investments were influenced by rainfall change.

Keywords:
agricultural sector, economics variables, general equilibrium model, rainfall

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INTRODUCTION

Rainfall changes are one of the important factors of climate change that is of higher importance in developing countries where agriculture is rain-fed is important (Sassi & Cardaci, 2013). In Iran, the acreage of the crops amounts to 12.2 million hectares in which 52.1% is irrigated and 47.9% is rain-fed. As can be seen, it is of more importance in development countries where rain-fed farming is more important, rainfall has a strong effect on economic variables, like GDP, price, and import-export (Alijani et al., 2011). Rainfall changes affect all economic sectors, such as agriculture, because the water used in the agricultural sector is mostly supplied by rainfall. In the agricultural sector, rainfall variations mainly influences the agricultural productions (Cabral, 2014). This study has simulated and evaluated the impact of rainfall shocks on some economic variables. After the economy of a country reaches a relative balance, the shocks may lead to changes in the economic variables.

Extensive research has evaluated the effects of rainfall on sectorial and economic growth, some of which are reviewed in this section. There are different views on rainfall variations and computable general equilibrium (CGE) model in Iran and around the world. Some of these views are mentioned below.

Using global data for 1950-2004, Bernauer et al. (2012) showed that the impact of climate change on economic growth is not as huge as the variations in climate change indexes and samples. However, the moving average-based evaluation of temperature for Africa implies negative effects – though only at 10 percent level.

Ali (2012) employed a co-integration analysis in Ethiopia and found an adverse impact on growth. He specifically observed that change in rainfall value and variability has a long-term drag-effect on growth.

Cabral (2014) evaluated the effects of rainfall shocks on poverty in Burkina Faso and Senegal using a CGE model. The results showed that Senegal would experience a decline in poverty due to an increase projected in future rainfall trends. By contrast, Burkina Faso would experience an aggravation of poverty as future rainfall was predicted to decline. However, relieving policies tend to alleviate the rate of this decrease. In summary, future rainfall is expected to have positive effects on poverty in Senegal and negative effects in Burkina Faso.

In a study on the impact of climate change on agriculture and food security, Fallah Shojaee et al. (2012) estimated the effect of climate change on food security. They reported that food security and climate change are in an interaction. These variations may pose risks to food safety at different stages from farm to fork. Henseler et al. (2009) employed a mathematical model, positive mathematical programming (PMP), to evaluate the effects of climate change on agricultural land use on the fringes of the Danube River in Austria and Germany. They confirmed the unique capability of mathematical programming models in linking the economic components of the biophysical and ecological aspects. This study addresses two states of climate change and socio-economic changes. Changes in the climate directly or indirectly affect the activities of the agricultural sector. The consequence is the significant loss of production potential and yield in seasons with low rainfall and in dry regions, particularly for rain-fed crops (whose water requirement cannot be met by through irrigation), and this can even be a major threat to the economic sustainability of these lands. Sultana et al. (2009) evaluated vulnerability and adaptation of wheat production to climate change in four climatic regions of Pakistan and concluded that rising temperature will lead to a reduction in crop yield in arid, semi-arid and sub-humid areas, but with the current rate of gradual increase in temperature, i.e. 1°C, wheat yield is expected to increase in wet area.

This study aimed to evaluate the effect of rainfall variations on some economic variables in Iran using a CGE model. The review of the literature shows that the agricultural sector of Iran has not been subjected to this kind of research using the general equilibrium model. This is despite the fact that the agricultural sector is of crucial importance for Iran, making it imperative to conduct the present study.

METHODOLOGY

General equilibrium models comprehensively describe the entire sectors of an economy and their interactions at the same time. These models describe the behavior of production units that maximize efficiency and the behavior of consumers that maximize utility (Lofgren, 2003). As was noted, the general equilibrium model of this study has been developed on the basis of the general equilibrium model with some adjustments like what has been done in research in Iran and parts of the world. Some of these adjustments were structural, but the others were partial. These adjustments were to make the model appropriate and flexible so that it can be used in similar studies on Iran's economy. Major changes include adding variables such as rainfall variation and food security, defining new equations, choosing specific functional forms using standard forms and designing rainfall change scenarios and their impact on different economic variables.

General equilibrium model equations are as follows:

Price block

Price blocks are divided into different prices such as import price, export price, demand price of domestic non-traded goods, absorption, domestic output value, activity price, value-added Price, etc. All price equations are in the same form in general equilibrium models.

Production and commodity block

This block includes domestic production and input equations, the allocation of domestic production to domestic consumption, domestic market and export that shows total domestic supply. All the equations are the same in general equilibrium models, except value-added equation that was changed in this study. The original function is as below:

$$QVA_a = a_a^{va}\left(\sum_{f\in F}\delta_{fa}^{va}\cdot QF_{fa}^{-\rho_a^{va}}\right)^{-\frac{1}{\rho_a^{va}}} \qquad (1)$$

where Q_{ct} is crop productivity, RF_t is rainfall, T_t is trend variable, μ_t is error, and α, β, γ are parameters to be estimated (Sassi & Cardaci, 2013).

Also, QVA_a is the quantity of aggregate value-added, a_a^{va} is the efficiency parameter and δ_{fa}^{va} is the share parameter for factor *f* in activity a, ρ_a^{va} is the CES value-added function exponent (that is a transformation of the elasticity of substitution), and QF_{fa} is the quantity demanded of factor *f* from activity *a*.

Literature concludes according to the literature, it can be said that market price and family income are two factors that influence economic food availability represented by the variable of consumption. In this framework, stochastic component is introduced by Rainfall effect on the value added; then, standard general equilibrium model is modified as follows:

$$QVA_a = (rf_a^s.a_a^{va})\left(\sum_{f\in F}\delta_{fa}^{va}\cdot QF_{fa}^{-\rho_a^{va}}\right)^{-\frac{1}{\rho_a^{va}}} \qquad (2)$$

where rf_a^s is variable of rainfall shock (Sassi & Cardaci, 2013).

In addition to the change in value-added equation, one equation for crop productivity as below is added to the equations, too.

$$Q_{ct} = \alpha RF_t + \beta RF_t^2 + \gamma T_t + \mu_t \qquad (3)$$

where Qc_t is crop productivity, RF_t is rainfall, T_t is trend variable, μ_t is error, and α, β, γ are parameters that must be estimated (Sassi & Cardaci, 2013).

Institution block

Institutions block considers the transfer between institutions such as government, households, firms, and foreigners. In this section, we discuss the transfer of any of these entities. Equations of this block determine the expenditure and income of government, households, and firms.

System constraint block

System constraint block includes constraints related to market factors, commodities, foreign sector, government and investment-savings. In this block, some equations impose equality between the total quantity demanded and total quantity supplied and some equations determine the balance between income and expenditure in each institution (Thomas et al., 2016).

Data and other required information

The input-output table of each section is shown once in rows and once in the columns. This section is in the row as a manufacturer or seller of goods or services and in the column as a consumer or buyer of goods or services. SAM matrix shows the relationship between the production activities, income distribution from these activities among the factors of production, and the income distribution among social institutions. Furthermore, SAM matrix explains how to use income socio-economic institutions in the structure of the economy.

RESULTS AND DISCUSSION

To apply three shocks of rainfall change on economic variables, the first variable considered is the production of goods. In average rainfall scenario, the lowest and highest rainfall changes in the supply of the materials were observed in domestic markets. Results of imposed rainfall changes scenarios on the production of goods are expressed in Table 1. As can be seen, rainfall changes have the greatest impact on rain-fed wheat production in the best rainfall scenario. This scenario has increased production of this commodity by about 14%. As is evident in Tables 1 and 2, all activities have been decreased in the supply and domestic consumption in average rainfall scenario. This decrease in supply is in the range of -0.25% and -2.1% which is the highest for rain-fed wheat.

Table 2 shows the percentage change in supply and demand of goods in the worst rainfall scenario. In this scenario, all goods have been faced with reduced consumption ranging from 0.3% to 10.3%. The greatest reduction was related to the agricultural products. Rain-fed wheat had the greatest reduction of 10.3% in supply and demand and this shows that rain-fed wheat is sensitive to reduced rainfall. Table 2 presents the changes in supply and demand of goods under the best scenario. As you can see, all goods have been faced with increased consumption in that the increase in the consumption of agricultural products is higher than that in other goods. This increase in production and usage can be explained by the fact that one of the important factors affecting agricultural production is water whilst water is mainly provided by rainfall. Among them, rain-fed wheat has had the highest increase in supply and consumption because it has the highest acreage. According to Table 2, it can be understood that amount of change in imports is not in balance with a domestic supply of goods. Decreasing

Table 1
The Results Imposed Rainfall Scenarios on the Production of Goods

Goods	Best rainfall	Average rainfall	Worst rainfall
Rain-fed wheat	12.1	-2.1	-10.3
Other rain-fed grains	10.3	-1.1	-9.7
Irrigated wheat	9.1	-0.9	-7.1
Other irrigated grains	8.8	-0.4	-7
Other agricultural goods	8.3	-0.4	-6.6
Other sectors	3.2	-0.4	-3.6

Table 2
The Change in the Supply and Consumption of Domestic Goods

Goods	Best rainfall	Average rainfall	Worst rainfall
Rain-fed wheat	13.8	-10.7	-2.1
Other rain-fed grains	4.4	-7.9	-1.2
Irrigated wheat	9.1	-1.5	1.1
Other irrigated grains	3.1	-2.7	2.2
Other agricultural goods	9.3	-7.5	0.3
Other sectors	2.7	-1.5	0.6

Table 3
Changes in Prices of Domestic Demand

Goods	Best rainfall	Average rainfall	Worst rainfall
Rain-fed wheat	-10.1	1	19.8
Other rain-fed grains	-10.8	0.7	28.7
Irrigated wheat	-8.7	0.6	10.6
Other irrigated grains	-9.3	0.3	12
Other agricultural goods	-9.3	0.4	8.9
Other sectors	-2.9	0.2	2.7

Table 4
Changes in Imports of Goods

Goods	Best rainfall	Average rainfall	Worst rainfall
Rain-fed wheat	1.1	10.7	-9.1
Other rain-fed grains	0.8	15.4	-9.8
Irrigated wheat	1	8.6	-7.2
Other irrigated grains	0.9	9.1	-6.4
Other agricultural goods	0.9	7.6	-5.8
Other sectors	0.6	6.1	-5.2

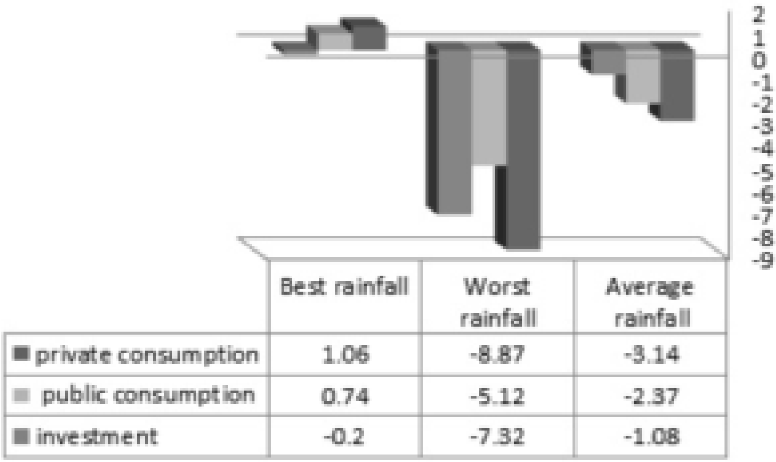

Figure1. Rainfall changes, consumption and investment

rainfall leads to reduced cropping area and impairs the overall efficiency of products. In addition, crop production is reduced with similar rate in the average

Prices in Table 3 reveal that in average rainfall scenario, we are faced with a slight increase in price for all goods except industry. In the worst scenario, rainfall increased the price of all goods, except for industry and these increases are in the range of 0.25% to 28.7%. The highest increase in prices is related to the agricultural commodities among which the highest is in other rain-fed crops and the second highest is for the rain-fed wheat.

According to Table 4, the amount of change in imports is not equal to changes in domestic supply of goods. Reduced rainfalls, in fact, lead to reduced acreage and the loss of the overall efficiency of products and crops are lost with the same amount under moderate rainfall. In average rainfall scenario, the imports of all goods are increased. Obviously, an increase in imports is in proportion to the decrease in supply. This increase is in the range of 0.35 and 1.1. The import of wheat shows the largest increase. Table 4, also, presents the changes in the imports under the worst rainfall scenario. As you can see in this scenario, the imports of all commodities are increased in range of 6.1 and 15.4. The results for the best rainfall scenario show that import of all commodities is declined. The reduction ranges from -5.2 to -9.8 and the highest decline is in the import of other rain-fed grains.

As seen, the shocks by rainfall scenarios have been effective on consumption and agricultural production. Since there are backward or forward links between variables and economic sectors, it can be concluded that rainfall scenarios have been effective on macroeconomic variables, too. Commodities, especially wheat and other rain-fed grains in average rainfall and worst rainfall scenarios, were faced with inflationary pressure. This inflationary pressure has been effective on private consumption and public consumption, and investment influences them. In the worst and average rainfall scenarios, public and private consumption is reduced. While this is one of the factors that influence GDP and results in its reduction. Investment has declined in all scenarios, too.

CONCLUSION AND IMPLICATIONS

Rainfall changes have the greatest impact on wheat production. The greatest increase in the production of rain-fed wheat has seen in the best rainfall scenario. Percent change in supply and domestic consumption of goods in different rainfall scenarios showed that these scenarios are faced with changes in supply and domestic consumption. In the worst rainfall scenario, the greatest reduction of products was related to agricultural products and among of the goods, rain-fed wheat had the highest percentage reduction in supply and demand.

After simulation of three applied scenarios, some changes were made in imports. The highest import was devoted to agricultural commodities among which ‘other rain-fed grains’ and then, ‘rain-fed’ wheat exhibited the highest variations in the worst scenario. In the best scenario, the importation of all commodities was decreased, and the greatest decrease was related to ‘other rain-fed grains’.

Given most food requirement is satisfied by grains. In periods of rainfall reduction, the domestic production fails to meet people’s demand. Thus, policies should be applied to satisfy the food requirement of the society with the minimum costs.

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REFERENCES

Ali, S. (2012). Climate change and economic growth In a Rain-fed Economy: How much does rainfall variability cost Ethiopia? *Econometric & Statistical Methods, 46*, 30-68.

Alijani, F., Karbasi, A.R. & Mozafari Mosanan, M. (2011). The effect of temperature and rainfall on yield of winter wheat in Iran. *Economics and Development, 76*, 47-23.

Bernauer, T., Böhmelt, T., & Koubi, V. (2012). Environmental changes and violent conflict. *Environment Research Letters, 7*, 560-601.

Fallah Shojaee, M., Mazlom, S., & Sadeghi Mahonak, A.R. (2012). *The effect of climate change on agriculture and food security.* Second Seminar on Food Security, 17-18 October (50-68), Savadkuh, Azad University Branch of Savadkuh.

Cabral, F.J. (2014). Rainfall and economic growth and poverty: Evidence from Senegal and Burkina Faso. *African Growth and Development Policy, 8*(3), 1-34.

Henseler, M., Wirsig, A., Herrmann, S.T., & Krimlyand Dabbert, S. (2009). Modeling the impact of global change on regional agricultural land use through an activity-based non-linear programming approach. *Agricultural Systems, 100*, 31-42.

Lofgren, H. (2003). *Exercise in general equilibrium modeling using GAMS. International Food Policy Research Istitute, Washengton DC, 18*, 120-130.

Sassi, M., & Cardaci, A. (2013). Impact of rainfall pattern on cereal market and food security in Sudan: Stochastic approach and CGE model. *Food Policy, 43,* 321–331.

Sultana, H., Ali, N., Iqbal, M.M., & Khan, A. M. (2009). Vulnerability and adaptability of wheat production in different climatic zones of Pakistan under climate change scenarios. *Climatic Change, 94,* 123-142.

Thomas, O., Ochuodho, V., Lantz, A., & Olale, E. (2016). Economic impacts of climate change considering individual, additive, and simultaneous changes in forest and agriculture sectors in Canada: A dynamic, multi-regional CGE model analysis. *Forest Policy and Economics, 63,* 43-51.

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