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Climate Change and Crop Yields in Iran and Other OIC Countries

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Abstract:

Climate change is the main phenomenon that directly affects the world environment, and changes in the environment affect economic sectors differently. The most important impacts of climate change would be on enhancing the average global temperature and the decrease in precipitation. The agricultural sector is the first and most affected sector in the climate change. We examined the impact of temperature and precipitation variables on the agricultural yield for three common products namely fruits, rice and corn in 14 OIC[3] countries including Iran.

The share of employment in the agricultural sector as compared to the total employed is a control variable. By estimating the model using the panel data method over the years 1992 and 2015, the results indicate a negative effect of temperature on the agricultural sector. Precipitation has a positive effect and the share of employment in agriculture has a negative effect.

1.Introduction

Climate change is associated with the variations in the average global temperature and the increase in the frequency of extreme weather happening, changes in precipitation, and rising sea levels. By weather extremes we mean unexpected, unusual, unanticipated, intense and non-seasonal weather, and the climate is in high variation seasonally.

Evidence suggests that the basic objective of economic life in the future would be "to adapt economic production to environmental conditions" (Azimi, 1992: p. 29). We are heading the decades that the environment plays a crucial role in the growth and development.

In fact, climate change directly impact the world environment. The science of climate change is based on two centuries of theory and evidences. The basic idea on greenhouse gases was emerged in the the 19th century by Jane Baptist Faurier

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and John Tindal. Faurier argued that something prevent energy from escaping, and Tindal identified gases in practice. In the early 20th century, Arhenius discussed the relationship between emissions from fossil fuels and greenhouse gases. In the mid-20th century, with the advent of quantum theory, the mechanism of the fluctuating greenhouse gases was identified. As a matter of fact, this part of physics and chemistry of the atmosphere identified the mechanism of greenhouse gases.

There is a widespread agreement that the emission of greenhouse gases is a key stimulant of climate change, and its ongoing process will impose further warming and long-term damage to the climate system. Human activities through the extraction and combustion of fossil fuels, deforestation, or agricultural activities to emit greenhouse gases. Increasing greenhouse gases leads to its increase in the atmosphere, and also increase the amount of energy consumed in the atmosphere. With increasing warmth, the average temperature of earth and the world's water rises. Increasing temperature and energy, give rise to the intensity and diversity of the climate system which in turn causes fluctuations and change local and regional climate patterns. (Stern & Fankhauser, 2016: p. 6).

In traditional growth models, long-term growth is due to the exogenous technological changes (Solow, 1956; Swan, 1956; Ramsey, 1928; Cass, 1966; Koopmans, 1965), Saving, Human Capital and R & D. (Lucas, 1988; Romer 1986; Romer, 1990; Jones, 1995; Nelson and Phelps, 1966).

On the other hand, the climate is considered as the primary condition of economies, which only has a superficial effect on income (Mankiw, Romer & Wille, 1992). There are two points that justify incorporating climatic conditions such as changes in rainfall and temperature in growth models. In the first place, precipitation-dependent developing economies may experience irregular changes in rainfall. Such instability is capable of shaping the long-term economic pathway.

Second, if climate change happens soon, then there will be more than a superficial effect on the economy, because such a change is a process and different from periodic shocks (Seid Nuru, 2012: p. 4).

One of the most important features of climate change is inclusiveness. Therefore no country is immune from its harm. In the developing countries, along with overcoming poverty and improving economic growth, additional burden of climate change will be added to their problems, and climate change will weaken development perspectives for these countries. Scientific studies have indicated that carbon dioxide released from burning fossil fuels, along with the release of other greenhouse gases from human activities, leads to higher temperatures on the planet and global climate change. The average temperature in the world will increase from 2 to 3 degree Celsius in the next 50 years.

The most important consequences of climate change include melting glaciers, reducing product yields, rising sea levels, and consequently increasing annual floods, droughts and biodiversity loss (Stern, 2006: p. 56). The range of implications and impact on different parts of human life and well-being, makes climate change a special phenomenon and transcends it beyond an environmental issue. On the other hand, the economic aspect of this phenomenon is very high due to its effects on growth, development and poverty. According to the studies and reports in recent years, climate change has had the greatest impact on poor and developing economies and their ability to grow. Therefore warm countries became poorer with decreasing in national income of 8.5% per centigrade global warming between 1950 and 2000. (Dell et al., 2009: p. 5).

Models estimate that the temperature growth by the year 2100 in a scenario of unmitigated climate change leads to considerable economic losses for most underdeveloped countries. Under the presumption that weather shocks have constant impacts on the level, rather than the growth rate of per capita output, models show that the per capita GDP of an underdeveloped country would be 9 percent lower in 2100 than it would have been without temperature increase.(Acevedo et al., 2018: p.5).

The developing and poor economies are located more in hot and cold regions of the world, they are therefore more vulnerable to climate shocks and are more affected by inadequate infrastructure. We know that sustained economic growth and climate change are not compatible with one another, because sustainable development is a development that "fulfills the needs of the present generation without compromising the ability of future generations to meet their needs." Obviously, the nature of climate change is so effective that the next generation will be affected.

The poor people in Africa, Asia, and other regions are struggling with disruptive aspects of product shortages, reducing agricultural productivity and increasing hunger, malnutrition and disease due to climate change. Farming productivity, even with changes in agricultural practices, is likely to decrease globally, especially in tropical areas and more than 3 million people could die from malnutrition annually.

Agricultural crop yield is a determinant in the vulnerability of developing countries. In the North Europe and North America, the productivity of products and the growth of forests may increase under some extent of warming. But in China and Japan, the yield of rice, the world's high-consumption product, will decrease, while the yield of wheat, corn and rice will be hit, especially in Central and South Asia. The outlook for agricultural products and livestock in rain-fed areas in Sub-Saharan Africa are also disappointing, even when warming reaches 2-2.5 ° C above temperature level before industrial revolution.

The slowdown in the productivity of rice production in India after 1980 was not only related to the decline in rice prices and the deterioration of the irrigation infrastructure, but also to the adverse impacts of climate change as a result of pollution and global warming. Based on climate change impacts on agricultural products, it is expected that the output of main agricultural products in India will decline between 4.5 to 9 percent in the next three decades, even with short-term adjustments. (World Bank, 2010: pp. 5 and 40).

2. Literature Review

Tokunaga et al (2015) in "Dynamic Panel Data Analysis of the Impacts of Climate Change on agricultural Production in Japan" examined the issue in eight regions of Japan for the period 1995-2006. Relying on the evaluation of the static and dynamic panel data model of production function, when mean annual temperature increases 1C, rice production decreases in the short run, by 5.8%, and 3.9%, in the long run.

Exenberger et al (2014) examined the impact of climate change on agricultural production and considering technological differences, in a panel of 127 countries from 1961 to 2002. In high income countries, climate change hasn't significant impact on agricultural production, but has significant adverse impacts on low and middle income countries. These adverse effects implies a moderate negative effect of temperature increase on agricultural production. For low income countries, the adverse impacts include the reduction in precipitation and the increase in the frequency of drought events which both are strong in sub-Saharan Africa.

Guiteras (2007) examined the impacts of Climate Change on Agriculture in India. The impact of annual changes in climate on agricultural production estimated by using a 40 year panel data set for 200 Indian districts. In India, the impact in the medium-run is adverse and significant. The projected climate change for 2010 to 2039, implies decreases in the main crop yields by 4.5% to 9 %, but the long-run impact (2070-2099) is expected to reduce the yields by 25% or more with no long-run adaptation. Results indicate that climate change will impose huge costs on the agriculture in India, unless Indian agriculture adapt to climate change.

Roberts et al. (2008), examined the impact of Climate Change on crop yields and indicated the significance of temperature impacts in the US, using Panel data analysis. The yield increases in temperature until a threshold for corn, soybeans, cotton, but temperatures above the limits would be harmful.

Based on aforementioned empirical findings, we examine the impact of climate change on the selected agricultural products in 14 OIC countries including Iran.

3.Climate Change in Iran

The climate of Iran with arid and semi-arid areas has extreme situations. In some areas, temperatures above 50 degrees Celsius are reported in the summer and in the winter, part of the country is facing a temperature of minus 20 degree

Celsius or lower. The amount of rainfall in the country is based on its location and distribution with extreme states.

For example, rainfall in central deserts and southern regions is less than 50 mm, while in the Northern provinces and western highlands, it is about 1600 mm. Depending on the duration and distribution of rainfall, there is also an unfavorable situation, as most rainfall in arid and semi-arid areas is a storm that lasts for only few days. Weather coverage in Iran's regions is 35.5% very dry, 29.2% Dry, 20.1% Mediterranean and 10% Wet (Cold Mountain). The following diagram indicates temperature and precipitation dispersion over the years 1992 to 2015 in Iran.

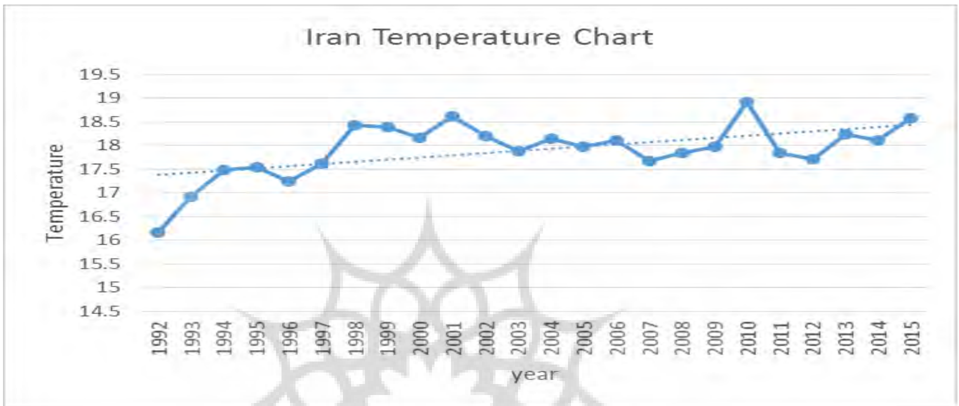

Figure 1: Iran Temperature Chart (1992-2015)

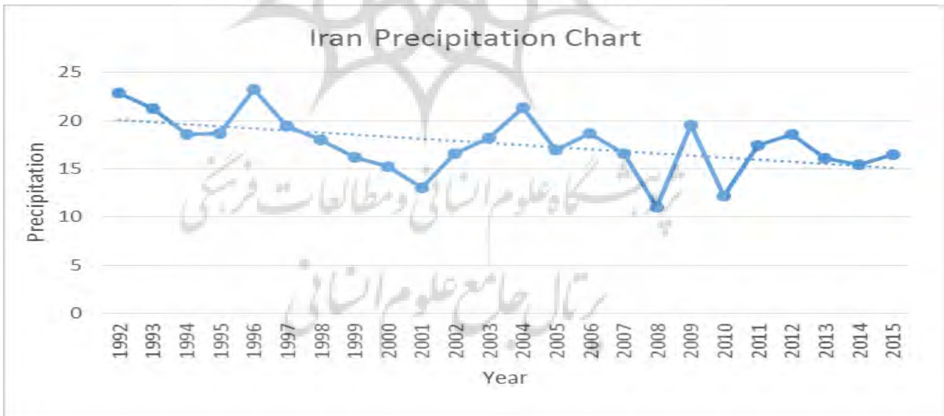

Figure 2: Iran precipitation Chart (1992-2015)

Given the trend, the average temperature during these years has undergone an incremental increase, and the average rainfall is also decreasing. For a country which, even without climate change, is faced with rising temperatures and water shortages, due to its geographical circumstances, climate change will be a major challenge to economic growth, especially in the agricultural sector. In this study, to illustrate the effects of climate change on the yield of agricultural crop in Iran, dummy variables is used in the model.

4. Methodology

The relationship between temperature and economic activities has been quantified in two ways. The first approach emphasizes on development and growth and examines the relationship between the average temperature and the macro-economic variables in the countries. However, many argue that this may lead to spurious correlation of temperature with national features such as institutional quality.

The second approach emphasizes on micro-evidences to quantify the impact of climate change. Then summing up these evidences to realize the impact on national income. This approach has used Integrated Assessment Models (IAMs), which are widely used to model the interaction of climate and the economy. The basic challenge for this approach is its complication. (Dell et al., 2012: p. 2).

We examined the impact of climatic variables such as precipitation and temperature on agricultural yield of fruits , rice and corn in Algeria, Bangladesh, Benin, Indonesia, Iraq, Iran, Malaysia, Mauritania, Mozambique, Nigeria, Pakistan, Philippines, Senegal and Turkey, for the period 1992 to 2015, using logarithmic function. Then a 1 percent change in the explanatory variables will affect the yield on the product.

Data for temperature and precipitation extracted from the World Bank's historical climate data[1] for each country, and for the yield, it was extracted from FAO[2] data of selected products. In the end, for the data on the share of agricultural employment to total employment of countries, it also extracted from the World Bank data series.

5. Empirical Results

We first tested variables' stationary by using Im, Pearson and Shin (IPS) test. The IPS test is done based on the average unit root statistic (for each one separately). In this test, the null hypothesis is that individual time series contains a single root and the H1 hypothesis is that each time series is stationary (Mehregan and Ashrafzadeh, 2014: 131). Table 1 indicates the results of IPS test and all variables are stationary.

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[1] http://sdwebx.worldbank.org/climateportal/index.cfm?page=downscaled_data_download&menu=historical

[2] http://www.fao.org/faostat/en/#data

Table 1, Stationary Test Results

Variable	Statistic	P-value	Result
Agricultural Output Yield	-6.1171	0.0000	stationary
Average Annual Temperature	-7.4684	0.0000	stationary
Average Annual Precipitation	-8.3367	0.0000	stationary
Agricultural Employment Over Total Employment	-2.2787	0.0113	stationary

Source: Research calculations

The F Limer test is conducted for choosing between panel data and Pooling data methods. In the F test, H0 hypothesis is the equalization of the intercept (the need to use pooling data) against the H1 hypothesis, non-equalization of intercept (the need to use panel data). (Mehregan and Daliri, 2010: pp. 159-160). Table 2 indicates the results of F Limer test results.

Table 2, F Limer Test Results

Variable	Statistic	P-value	Result
F Limer Test	61.67	0.0000	Panel Data

Source: Research calculations

Hausman's test is used to determine the estimation method in the panel data method. In this test, the null hypothesis is the random method and H1 hypothesis is the fixed effect method. Table 3 indicates Hausman test results.

Table 3, Hausman Test Results

Variable	Statistic	P-value	Result
Hausman Test	7.41	0.1920	Random Effect Method

Source: Research calculations

In principle, collinearity means the existence of a complete or accurate linear relationship between all or some of the explanatory variables of the regression model. One way to identify co-linearity is through correlation coefficients. If for a regression equation, the correlation coefficient between explanatory variables is greater than the R2 value, then it is an intense co-linearity. (Souri, 2013: 239).

Based on Hausman's test, the null hypothesis for the choice of random method is not rejected. Therefore, using the Brousch-Pagan test, we choose between the Pooling data method and the random effects. In this test, the null hypothesis indicates the method of pooling and the H1 hypothesis describes the random effects. Given the result of table 4, the null hypothesis is rejected and the random effects method is selected.

Table 4, Breush and Pagan Test Results

Variable	Statistic	P-Value	Results
Breusch and Pagan Lagrangian Multiplier Test	1753.82	0.0000	Random Effects Method

Source: Research calculations

$\sqrt{R2}$ calculated in the model is 0.66 and based on the following results we can ignore the collinearity between the explanatory variables.

Table 5, Collinearity Test Results

Variable	lnT	lnP	lnE
lnT	1.0000		
lnP	-0.2051	1.0000	
lnE	-0.1762	-0.0361	1.0000

Source: Research calculations

The other way to identify collinearity is Variance Inflation factor (VIF), which indicates how variance is inflated. We know that when variance coefficients increase (inflate), there is collinearity. This quantity is derived from the following equation:

$VIF = 1/1-R2$

If the value is equal to one, then it indicates lack of correlation. The general rule is that when VIF passes through 10, there are serious indications for complete collinearity. Table 5 indicates VIF test results.

Table 6, VIF Collinearity Test Results

Variable	lnT	lnP	lnE
VIF	1.22	1.16	1.10

Source: Research calculations

Based on Hausman test results and the random effects method, LR test is used to test variance heterogeneity. This statistic has a $\chi 2$ distribution. The LR test results of the model implies the existence of variance heterogeneity (table 7).

Table 7, LR Test Results

Variable	Statistic	P-value	Result
Heterogeneity Test of Random Effects	288.26	0.0000	Variance Heterogeneity

Source: Research calculations

To test the auto-correlation, we conducted the Wooldridge test. The null hypothesis in this test is lack of autocorrelation, which based on the statistic of the model, the null hypothesis has been rejected and have first order autocorrelation.

Table 8, Wooldridge Test Results

Variable	Statistic	P-value	Result
Wooldridge Test	30.617	0.0001	It has autocorrelation

Source: Research calculations

6. Model Estimation

The ordinary least squares method does not use information that indicates the variability of the inequality of the independent variable, and attach importance to each observation, but the estimator known as the generalized least squares (GLS) consider these information (such as heterogeneity or autocorrelation), and thus able to be the best linear unbiased estimator (BLUE). The method of transforming the main variables in such a way that convert variables, satisfy the assumptions of classic model and then apply the OLS method, known as the Generalized Least Squares (GLS) method. In short, GLS is the same as OLS for converted variables that satisfy OLS standard assumptions; therefore, estimators are known as GLS estimator that are BLUE (Gujarati, 1999: p. 473 and 524).

The estimated model is as follows:

$$\mathbf{lnCropYield = \alpha_1\ \alpha\alpha_2 D_i + \beta_1 lnT_{it} + \beta_2 DlnT_{it} + \beta_3 lnP_{it} + \beta_4 DlnP_{it} + \beta_5 lnE_{it} + \beta_6 DlnE_{it} + u_{it}}$$

In which:

$\mathbf{T_{it}}$**:** Average Temperature — $\mathbf{DT_{it}}$**:** Dummy of Average Temperature

$\mathbf{P_{it}}$**:** Average Precipitation — $\mathbf{DP_{it}}$**:** Dummy of Average Precipitation

$\mathbf{E_{it}}$**:** Share of Employment in Agriculture — $\mathbf{DE_{it}}$**:** Dummy of Share of Employment in Agriculture

Based on the tests and the discovery of variance heterogeneity and auto correlation in the variables of the model, the GLS estimator is BLUE with minimum variance. Therefore, the model is estimated using GLS method considering variance heterogeneity and auto-correlation (Table 7). It is worth recalling that all variables estimated are logarithmic.

"Table 9, Model Estimation Using GLS"

Explanatory Variable	Abbreviation	Coefficient	Standard Error	Probability	Z Statistics
Average Temperature	lnT	-0.55292	-0.08691	0.0000	-6.36
Dummy of Average Temperature	DlnT	0.69922	0.50045	0.162	1.40
Average Precipitation	lnP	0.03629	0.01670	0.030	2.17
Dummy of Average Precipitation	DlnP	-0.06003	0.06412	0.349	-0.94
Share of Employment in Agriculture	lnE	-0.24507	0.03677	0.0000	-6.66
Dummy of Share of Employment in Agriculture	DlnE	0.06073	0.24465	0.804	0.25
Intercept	_cons	14.11322	0.29041	0.0000	48.60
Dummy variable	D	-2.22444	1.75920	0.206	-1.26
Number of Groups	14				
Number of Observations	336				

Source: Research calculations

The impact of temperature coefficient on the yield of the product is negative and significant. Therefore, one-percent increase in temperature would reduce the yield of fruit, rice and corn in the selected countries by 0.55 percent. The precipitation coefficient is positive and significant. One percent increase in the precipitation, the yield increases by 0.036 percent. The final explanatory variable is the share of employment in the agricultural sector, which has a negative and significant coefficient. One percent increase in agricultural employment will reduce the yield by 0.24 percent.

Using dummy variables, the effect of climate change on Iran's agricultural crop yield is also estimated. The coefficients of dummy variables for Iran are not significantly different from the other countries. Therefore, the effect of the climate change on agricultural product of Iran is similar to that of other OIC countries.

7. Conclusion

We examined the impact of climate variables namely temperature and precipitation on the yield of fruits, rice and corn in 14 selected OIC countries (Algeria, Bangladesh, Benin, Indonesia, Iraq, Iran, Malaysia, Mauritania, Mozambique, Nigeria, Pakistan, Philippines, Senegal and Turkey) for 24 years (1992 to 2015). As expected, rising temperatures would reduce the returns on these products, and countries will face serious problems with global warming and more increased temperature in the future. Another impact of the climate variable, namely, precipitation on the yield of the product, as expected, is positive. Reducing precipitation as a result of climate change will reduce agricultural products especially since most of these countries are in semi-arid and arid regions, and even without climate change, water shortage in some of these countries is as serious as in Iran.

Another variable, the share of employment in the agricultural sector over the total employment, has a negative and significant effect. It can be argued that due to the limitations of agricultural lands, increasing employment will reduce productivity. On the other hand, with the economic growth, the number of workers in the industrial sector will increase and workers in the agricultural sector will decline.

The use of traditional carbon technologies will further emit more greenhouse gases, thus accelerating global warming and climate change. For the governments to tackle this phenomenon is to adapt and mitigate its impacts. Developing countries need to evolve in agricultural production, energy, transportation, and urban systems.

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تغییر اقلیم و بازدهی کشاورزی در ایران و دیگر کشورهای عضو سازمان همکاری اسلامی[1]

چکیده:

تغییر اقلیم اصلی‌ترین پدیده‌ای است که به طور مستقیم محیط زیست را در سراسر دنیا تحت تأثیر خود قرار می‌دهد و تغییرات در محیط زیست بخش‌های اقتصادی را به میزان متفاوت تحت تأثیر خود قرار می‌دهد. از مهم‌ترین اثرات تغییر اقلیم می‌توان به بالا رفتن متوسط دمای جهانی و کاهش در بارش اشاره کرد. بدون شک، اولین و مهم‌ترین بخشی که از تغییر اقلیم اثر می‌پذیرد، بخش کشاورزی است. در مطالعه پیش رو، اثر متغیرهای اقلیمی دما و بارش بر بازدهی کشاورزی سه محصول مشترک میوه‌جات، برنج و ذرت در 14 کشور منتخب عضو سازمان همکاری اسلامی به همراه ایران در نظر گرفته شده است. سهم اشتغال در بخش کشاورزی نسبت به کل شاغلین در بخش کشاورزی نیز متغیر کنترلی مدل می‌باشد. با تخمین مدل با استفاده از روش پانل دیتا طی سال‌های 1992 تا 0015، نتایج حاکی از اثر منفی دما بر بخش کشاورزی است. بارش دارای اثر مثبت و سهم اشتغال در کشاورزی اثری منفی دارد.

[1] Organization of Islamic Cooperation (OIC)