Vizyoner Dergisi

Süleyman Demirel Üniversitesi Vizyoner Dergisi, Yıl: 2020, Cilt: 11, Sayı: 28, 665-679.
Süleyman Demirel University Visionary Journal, Year: 2020, Volume: 11, No: 28, 665-679.

ISSN: 1308-9552

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

CLIMATIC CHANGE: THE EFFECT OF RAINFALL ON ECONOMIC GROWTH*

İKLİM DEĞİŞİKLİĞİ: YAĞIŞLARIN EKONOMİK BÜYÜME ÜZERİNE ETKİSİ

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ABSTRACT

The variation in rainfall amount is found to be more forceful in poorer or agriculture-dependent countries and seems to be less effective for industrial economies. As Turkey is a newly industrialised country with a growing service economy, it is categorized as an emerging economy in the world. However, agricultural industry still plays a significant role in the economy especially in terms of the level of employment. The aim of the study is to examine the impact of rainfall on economy through economic outcomes of drought on agricultural industry. There seems to be a positive correlation between rainfall and agricultural industry in over the investigated period. As the growth in agricultural industry is highly correlated, similarly rainfall and overall economic growth appear to be coinciding and moving together. When there is drought in the country, economic crises follow this pattern. Besides rainfall, another variable, temperature, is allowed to identify whether it has any effect on the growth. Contrary to rain, temperature has no influence on agricultural output. The descriptive figures note that while agricultural industry involves a small share of the whole economy, the results of the study imply rainfall amount in Turkey has more impacts on economic growth than thought.

Keywords: Drought, Rainfall, Economic Growth, Agriculture, Climate Change.

JEL Classification Codes: E00, O13, Q10, Q54.

ÖZ

Yağış miktarındaki değişimin gelişmemiş veya tarıma bağımlı ülkelerde daha güçlü olduğu ve sanayi ekonomileri için daha az etkili olduğu görülmüştür. Türkiye, büyüyen hizmet ekonomisine sahip yeni sanayileşmiş bir ülke olduğundan, dünya ulusları arasında yükselen bir ekonomi olarak sınıflandırılmaktadır. Ancak, tarım endüstrisi özellikle istihdam düzeyinde ekonomide önemli bir rol oynamaktadır. Bu makalenin amacı kuraklığın tarım sektörü üzerindeki ekonomik sonuçları ve bunun dolaylı olarak genel ekonomi üzerindeki etkisi incelenmiştir. İncelenen dönem boyunca yağış ve tarımsal sanayi arasında pozitif bir korelasyonun olduğu görülmektedir. Tarım sektöründeki büyüme, genel ekonomik büyüme ile yüksek derecede korelasyona sahip olduğu ve yine ülkedeki yağış trendi ile genel ekonomik büyüme arasında bir ilişkinin olduğu bulunmuştur. Türkiye'de kuraklığın egemen olduğu yıllarda ekonomik krizlerin bu dönemleri izlediği gözlemlenmiştir. Yağışın yanı sıra, bir başka değişken olan sıcaklık verisi de analize konu edilmiştir. Yağışların aksine, sıcaklığın tarımsal üretim üzerinde bir etkisi bulunmamıştır. İstatistikî rakamlar, tarım endüstrisinin tüm ekonominin küçük bir kısmını içermekte olduğunu gösterse de, makalenin sonuçlarına göre Türkiye'de yağış miktarının ekonomik büyüme üzerinde düşünüldüğünden daha fazla etkisi olduğunu göstermektedir.

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* This article was also presented at the ICOAEF 2019 Conference.

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Makale Geliş Tarihi / Received : 24.02.2020
Makale Kabul Tarihi / Accepted : 30.07.2020

DOI: 10.21076/vizyoner.693363

Süleyman Demirel Üniversitesi Vizyoner Dergisi, Yıl: 2020, Cilt: 11, Sayı: 28, 665-679.
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ISSN: 1308-9552

Anahtar Kelimeler: Kuraklık, Yağış, Ekonomik Büyüme, Tarım, İklim Değişikliği.

JEL Sınıflandırma Kodları: E00, O13, Q10, Q54.

1. INTRODUCTION

The issue of climate change has become a hot spot in 2018 when hot temperatures rise to record levels around the world especially in Europe. Climate changes are felt in several types. It can either be in the form of severe drought, or it can also show up as the form of extreme weather conditions such as floods, typhoon or global warming. Nasa Global Climate Change, a web site of Earth Science Communications Team has introduced several facts with reference to how climatic change has implications on earth. Global temperature has increased 1.8 Fahrenheit since 1880, Arctic ice level decreased to its lowest degree in 2012, global average sea level is increasing 3.2 millimeters each year over the past 100 years. All these facts demonstrate the global climate change that our universe is now experiencing in a negative way.

The effect of climate change will not only be physical changes on earth, but also considerable consequences on economic progress and living standards. In a report in Financial Times newspaper, The United Nations secretary-general Antonio Guterres claims that hot weather can have an adverse effect on productivity of economies by 2030. The secretary-general estimates the cost of this productivity loss to be at about 2 trillion US Dollars by 2030 for the entire global economy. In their analysis Mani, Bandyopadhyay, Chonabayashi, Markandya and Mosier (2018), believe that rising hot temperatures will have significant impact on reducing living standards in South Asia in the long term. The influence of climate change in South Asia is claimed to have serious consequences on household consumption, road network, and weakening markets. Such that, for instance, according to a report by Global Economic Prospects, the economic growth estimation for South Asian countries was lowered in the year 2012 as result of shortage of monsoon rains, electricity shortages and other macro-economic imbalances.

Recently, the main economists stream suggest that alongside physical and human capital accumulation, the variation of prosperity of the world is contributed by other several factors such as good institution, healthy democracy, rule of law (Acemoglu, Johnson and Robinson, 2001), geography (that determines climate), integration and institutions (Rodrik, Subramanian and Trebbi, 2004) are also important to explain changes in economic growth around the world. Rodrik et al. (2004) suggest that when measuring geography, distance from equator, percentage land located in tropics or average temperature used as proxies. While the role of climate change discussed on the side of economics, this impact has also been examined for financial sector. Batten, Sowerbutts and Tanaka (2019) argue that climate change risks can affect central banks' policy decisions through transmission channels and further believe that climate change could be used in modelling for monetary policies.

This research is partly similar to the one that investigated the direct role of precipitation and temperature on growth of a group of countries by Dell et al. (2012). In this paper, using econometric modelling to see the effect of precipitation (rainfall amount) and temperature on Turkish economic growth in the short run, the attention is also given to the relation between rainfall and some other variables such as agricultural output, employment in agricultural sector and wheat production level. Dell et al. (2012) also consider transmission channels that how climatic change affects economic growth. The authors state that for instance, higher temperatures may lead to political instability by causing people expose to an uprising with likely effect on economic output. Or, short of rainfall may reduce agricultural yields, which in turn may reduce the GDP of countries. Bearing this in mind, the focus will be on the effect of rainfall and temperature on agricultural output and using this simple transmission mechanism to see the likely outcome of rainfall and temperature on overall economic growth for Turkey.

While agricultural output seems to be dominating a small share of the total economy of Turkey, which stands at about 6%, the employment level in agriculture controls about 20% of total workforce of the country. This means that the consumption of households from rural part of the country will be affected badly when output of agriculture is lower due to short of rainfall.

Assuming that the agricultural industry plays a crucial role in one country's economy, then the rainfall amount in a year considered to be an important exogenousvariable besides macro-economic determinants such as capital stock, labor workforce, interest rate, money supply and exchange rates. In agriculture productivity, two conditions may come to the fore. The first is that if a country's arable lands are enough to have irrigated systems and underground reservoirs, then it could be said that the agricultural crop yield will not be affected too much from the scarce of

falling rain or drought. The same issue was also raised by Gilmont et al. (2018) for Indian states' agricultural productivity that to some extent irrigation has the influence on reducing output variation, but when irrigation is applied by using underground water rather than surface water, the influence becomes smaller. However, if the second situation exists, that is, if a country cannot have enough arable lands to be irrigated, and then the short of rainfall should have severe impact on crop yield in that time. Further, excessive irrigation will reduce underground reservoir if rainfall is not enough to feed reservoir in the long run. Another aspect is that the rainfall amount affects not only crops, but also has influence on land under permanent meadows and pastures which is very important for sheep and cattle breeding as these lands provide natural and cheap feedstuff. Not to mention water necessities for humankind! Though, it only counts for 1% of water available worldwide (Evans and Sadler, 2008).

Figure 1 indicates the trend in rainfall in Turkey between 1980 and 2018. It seems that the trend in rain were downward over the years. It is highly likely that the fall of rainfall amount is due to climate change as suggested by many researches. For example the work of Arnell et al. (2014)analysed the impact of climate change on some region and food products in the future. The author found that crop productivity in the region of Middle East and North Africa would be the most affected parts. As Turkey is located in Mediterranean basin, due to climatic changes recently, there exists an extreme rain or extreme drought in Turkey (Turkes, 2012). The author also points that such changes in climate of Turkey began to berealisedfrom 1990s with number of snowy days decreasing and number of hot days increasing.

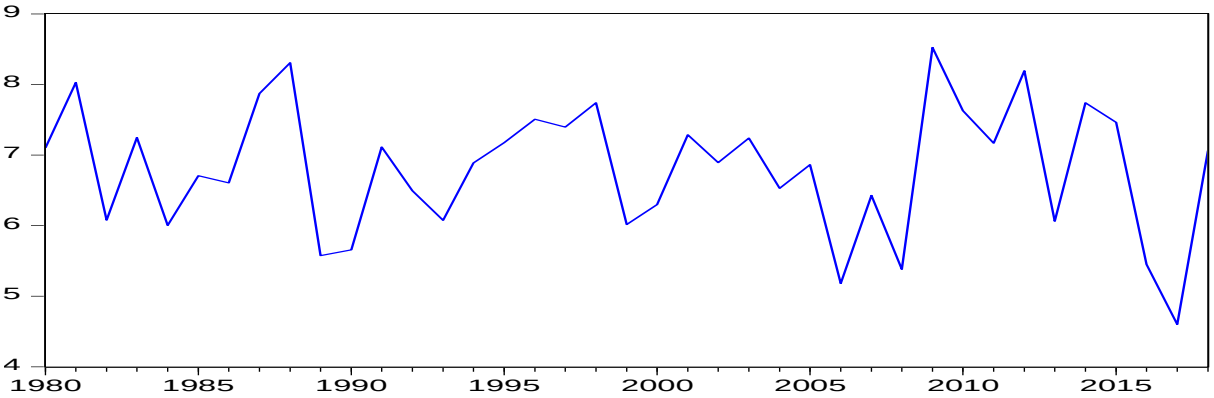

Figure 1. Rainfall amount in Turkey between 1998 and 2018

Source: (Turkish State Meteorological Service, 2019).

With respect to decreasing rainfall, when looking at Turkey's arable land statistics, there seems to be a decline in the amount of arable lands from about 25 million hectares in 1988 to about 20 million hectares in 2015, a 20% fall. The decrease in arable lands speeds up especially after 2000 (See Table 1).

Table 1. Total Arable Lands in Turkey

Years	Total Arable Land in Hectare
1988	24,786,000
2000	23,768,000
2015	20,651,000

Source: (Turkish Statistical Institute, 2019).

The reason for the fall of arable lands in Turkeyis due to policies of liberalisation of the economy started at the beginning of 1980, when politic interests intentionally planned to scale down emphasis on agricultural industry with the aim of boosting manufacturing sector. Else, the workforce from agriculture flight continued at the beginning of the new millennium. The reason for this may be that the scarce of rainfall that occurs during the beginning of 2000 and after 2011. The speed of increasing urbanization is also one of the reason behind the falling work force in agriculture. When Turkish economy picked up after its worst economic crisis of 2001, the industrial production grew significantly up until 2007. As industrial production increased, the need for more workforces required. As it is mentioned that the scarce of rainfall, at the beginning of 2000 and after 2011, made people who

rely on agriculture to leave their own business and migrate to cities for better job opportunities. So that, the amount of arable lands left empty increased as a result with the negative contribution of declining rainfall.

For instance, when the amount of rainfall and workforce in agriculture industry is compared between 2000 and 2018, the below figure imply that as the rainfall amount decreases the labour workforce in agriculture industry also falls or vis a vis. Figure 2 shows that labour workforce in agricultural industry is in decline in Turkey. Declining workforce in agricultural industry looks reasonable as Turkey is an emerging country with its developing manufacturing and service industries.

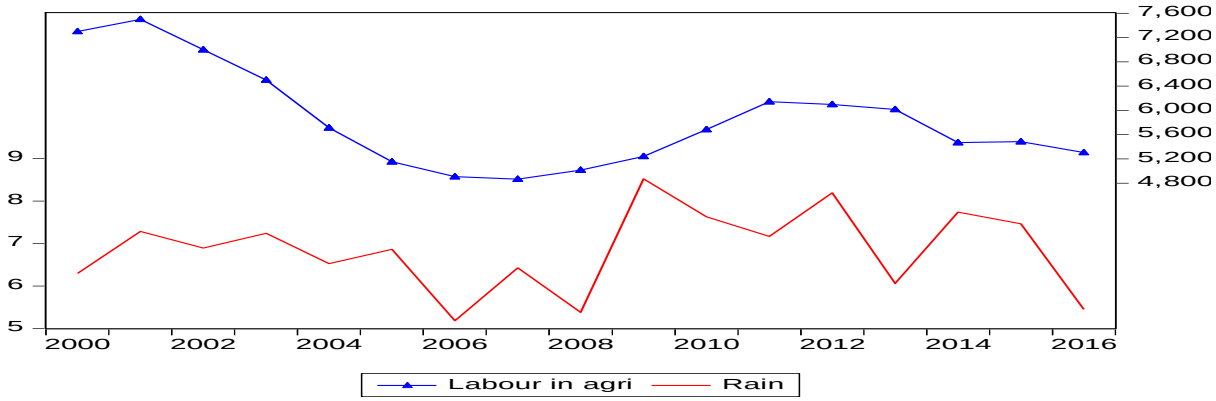

Figure 2. Rainfall and Labor Workforce in Agriculture between 2000 and 2016

Source: (Turkish Statistical Institute, 2019; Turkish State Meteorological Service, 2019).

Looking at the situation of arable lands where the irrigation is possible to grow crops in Turkey, the approximate irrigated area is 5.9 million hectares out of about 20 million of arable lands as of 2016 according to General Directorate of State Hydrolic Works of Turkey statistics. However this number has been increasing over the couples of decade with the support of the government subsidies and technological improvement. This picture can be interpreted as almost three quarter of the arable lands are deprived of irrigation system in Turkey. Hence, the crop yields should mainly be depending on rainfall amount in Turkey. Nevertheless, when looking at the wheat output[3] figures, despite a fall in arable lands the crop yield output seems to be steady over the years[4] (See Figure 3). From the statistics, we see that if there is drought, the irrigated areas' productivity also fall due to drought. Because without enough rain, the soil becomes salinated with underground water and cause decline of soil quality (Evans and Sadler, 2008). It means that relying only on irrigation will not last long in the long run.

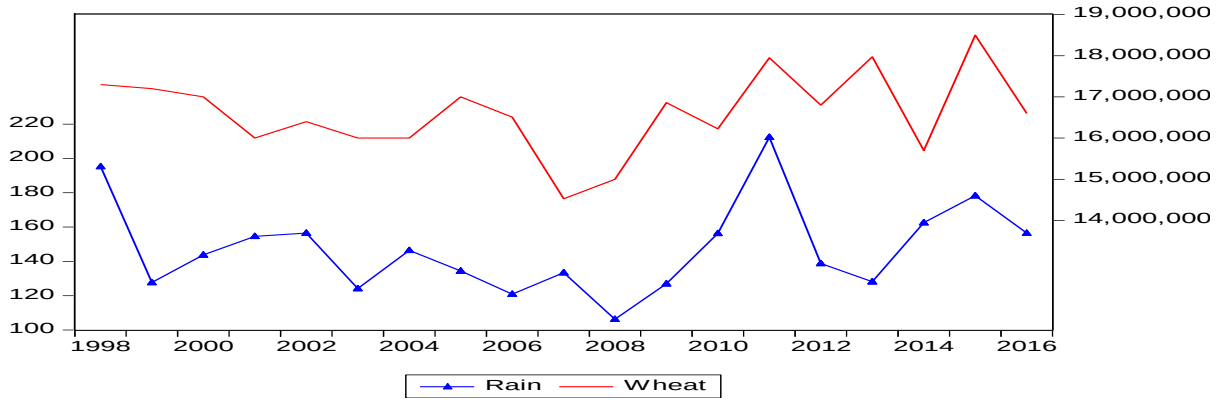

Figure 3. Comparison of Rain and Wheat Output between 2000 and 2015

Source: (Turkish Statistical Institute, 2019).

[3] Wheat is selected among the crops grown in Turkey due to being the most cultivated product.

[4] Appendix 1for comparison of yield between irrigated and non-irrigated land.

Figure 3 releases the fact that despite falling arable lands, the output of wheat crop stay steady in some level and then rising[5] and the main trend of wheat output level is depend on rainfall amount. This is due to for several reasons. The first reason is thought to be that, as mentioned above, the area which irrigation systems applied are increasing over the years. By irrigating arable lands, the output of crops will positively be affected. The second reason may be the case that technological improvements have been used by the farmers, such as using effective fertilizers and more advanced equipments or perhaps, as Masters and Wiebe (2000) point out a result of productivity of modern scientific research which may be applied by the Turkish producer. A Stanford University research reveals that modern agricultural technology not only increase crop yields but also help to reduce greenhouse-gas emissions. While these developments occurs, if the country takes enough rainfall for each year, then the output of crops could be expected to be even higher according to above results taking account the positive correlation between rainfall and wheat output level[6].

2. AGRICULTURAL INDUSTRY IN TURKISH ECONOMY

Having stated some information about agricultural lands in Turkey in regards to rainfall, in this section of the study, few materials are provided on the position of agricultural industry in Turkish economy.

Agricultural industry is as important as manufacturing and service industries. The world population is growing and the need for food and water is increasing too. Therefore, many countries are putting emphasis on this industry, especially the richest. For instance, European Commission, Statistical Factsheet (2016) suggests while the U.S. spends over 38 Billion U.S. Dollar to support agriculture industry as of 2015, Turkey spends 11 Billion U.S. Dollar and the 28 Countries of European Union spends about 50 Billion Euro as of 2014. The reason for subsidising this industry is to stimulate improvement of countries by increasing agricultural output, investment and employment (Gulati and Sharma, 1995).

With the economic liberalisation of Turkish economy in 1980, the state embarked new policies to reform its economy towards a liberal legacy. What the governments of Turkey wanted at that time was to stress expanding manufacturing industry and improve its export capabilities. Since, agricultural industry played a bigger role in the economy, the governments, then tried to weaken this industry and reduced subsidies which is a factor that cause agricultural output variation significantly (Masters and Wiebe, 2000). Ever since, the workforce in this industry has been falling in Turkey.

However, at the beginning of 2000s, Turkey has launched new strategies on agriculture industry with the aim of reforming to increase output and export level. The figure of 2015 shows how the government of Turkey supports this industry by spending 11 Billion US Dollar when compared the US spending amount. Turkish spending is much higher than the U.S. in terms of their GDPs.

According to report released by the Ministry of Food Agriculture and Livestock of Turkey (2013), the followings are introduced to the industry: (Just some important reforms are given below)

- Interest rate free loans issued for irrigation investment and cooperatives.
- R&D support provided for private sector and universities.
- Agriculture and Rural Development SupportInstitution (IPARD Agency)"was established.
- Good Agricultural Practices were supported.
- Agricultural Basins Model was clarified.

The above reforms show how Turkish government put emphasis on agricultural industry. By having applied reforms on the industry, the contribution of the industry to the national income was rose 2,6 fold from 2002 to 2012. Also, according to Ministry of Food Agriculture and Livestock of Turkey (2013) figures export of agriculture output rose from 4 billion USD in 2002 to 16 Billion USD in 2012.

When looking at employment level in overall economy, agricultural industry occupies still a significant position, even though the number is falling since 2005 from 25% to 19.5% of total employed workforce as of 2016 (See

[5] We found that there is negative correlation (-0.186) between cultivated area and wheat output level.

[6] We also found a positive correlation (+0.21) between rainfall and wheat output level.

Table 2). Due to new statistical calculation, more data prior to 2005 could not be used in the analysis. However, the previous old data shows that employment in agriculture were higher prior to 2005. According to statistics by Bugra (2010), the employment rate of agricultural industry in overall economy was at 45% and 36% in 1985 and 2000 respectively in Turkey.

Table 2. Percentage of Employment by Industries between 2005 and 2016.

Years	Agriculture	Manufacturing	Construction	Services
2005	25.5	21.6	5.6	47.3
2006	23.3	21.9	6.0	48.8
2007	22.5	21.8	6.1	49.6
2008	22.4	22.0	6.0	49.5
2009	23.1	20.3	6.3	50.4
2010	23.3	21.1	6.6	49.1
2011	23.3	20.8	7.2	48.7
2012	22.1	20.5	7.2	50.2
2013	21.2	20.7	7.2	50.9
2014	21.1	20.5	7.4	51.0
2015	20.6	20.0	7.2	52.2
2016	19.5	19.4	7.6	53.6

Source: (Turkish Statistical Institute, 2019).

Today, this figure is quite high when compared to developed countries where, employment in agriculture as a percentage of total employment stand at some average of 3% for European Union, 1.6% for the U.S. Still, Turkey's numbers also higher than its peer countries which are also classified as developing countries, such as Russia, Brazil, Mexico, Poland and Hungary (See Appendix 2).The higher agricultural employment rate means higher dependency of agricultural output for Turkey concerning the overall population, and if the output fall as a result of drought or short of rainfall, it is believed that there will be a negative shock to the overall economy.

Similar to employment of agricultural industry in the whole economy, the GDP level of agricultural output is also declining its share of GDP in the whole economy. The Figure 4 displays that while the share of agriculture in GDP was about 10% in 1998, this number falls to almost 6.2% at the end of 2018.

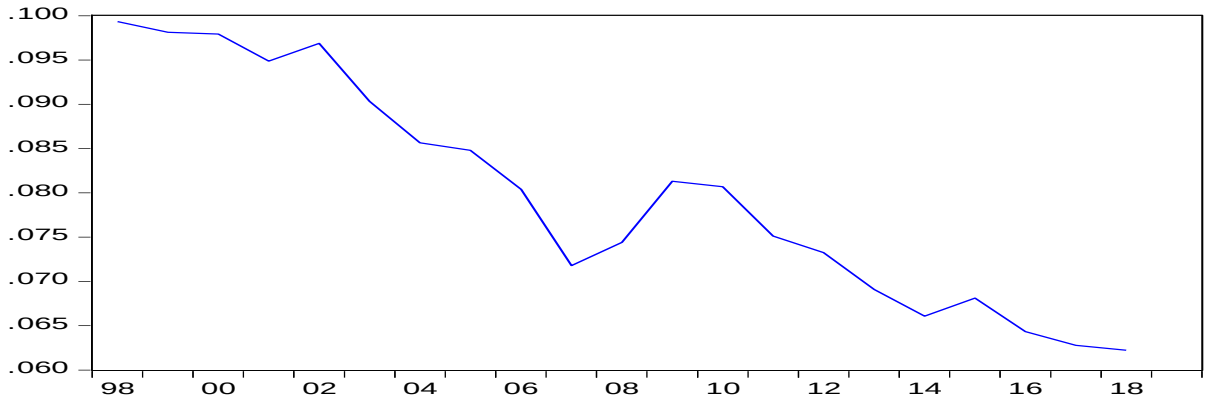

Figure 4. The Share of Turkish Agricultural Output in GDP between 1998 and 2018.

Source: (Central Bank of Turkey, 2019).

On the other hand, the Figure 5 indicates how agricultural output's annual variation is hand in hand with overall economic growth. Granger causality test is run to see which output volume causes which. The results are summarised in empirical section of the study. The results suggest uni-directional causality from agricultural industry to the total GDP. Further, the correlation between agricultural GDP and total GDP is found to be about 98.2%.

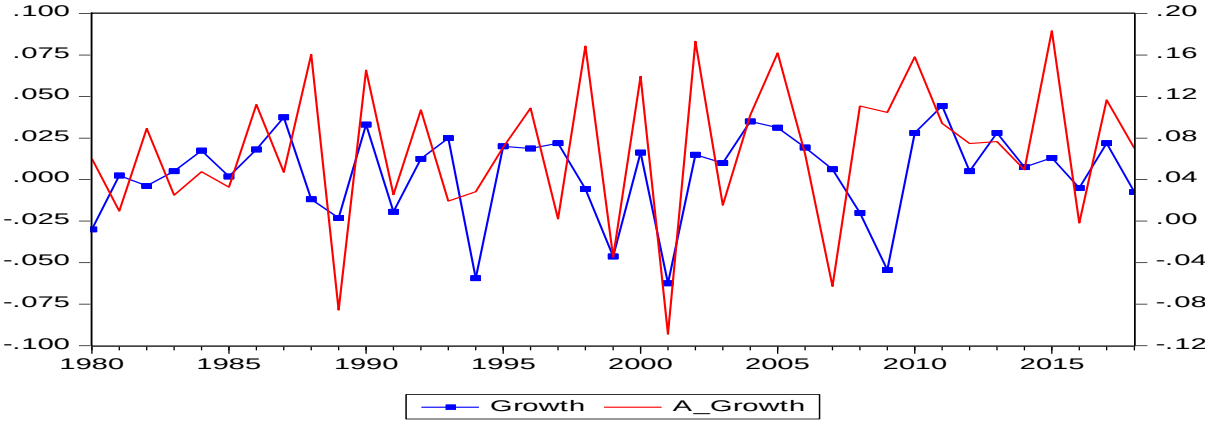

Figure 5. Agricultural Growth and Overall Economic Growth Rate of Turkey between 1980 - 2018

Source: (Central Bank of Turkey, 2019).

When looking at consumption level of households in Turkey, there seems to be a clear differentiating point from rural consumption to urban consumption. Rural consumption growth is smaller than the urban. This may be reasonable. However the rural consumption looks decreasing at the time of less rain in Turkey, for instance in the year of 2006 (See Figure 6). The theory suggest that the falling consumption will drag the economic growth down. One can ask the question that the effect of rural consumption is lower on the overall economy. However, in Turkish context, as noted above, the work force in agriculture still have a great importance in overall work force. Which means that when drought takes place, the number of people that are going to be affected will be higher, which lower their consumption and investment level, hence the nationwide economy will perform poor. This information only account for the years between 2002 and 2013 as there is no available data before and after these dates. Nonetheless, we believe that the rural consumption should fall in post 2013 as the rainfall amount decreased in the following years.

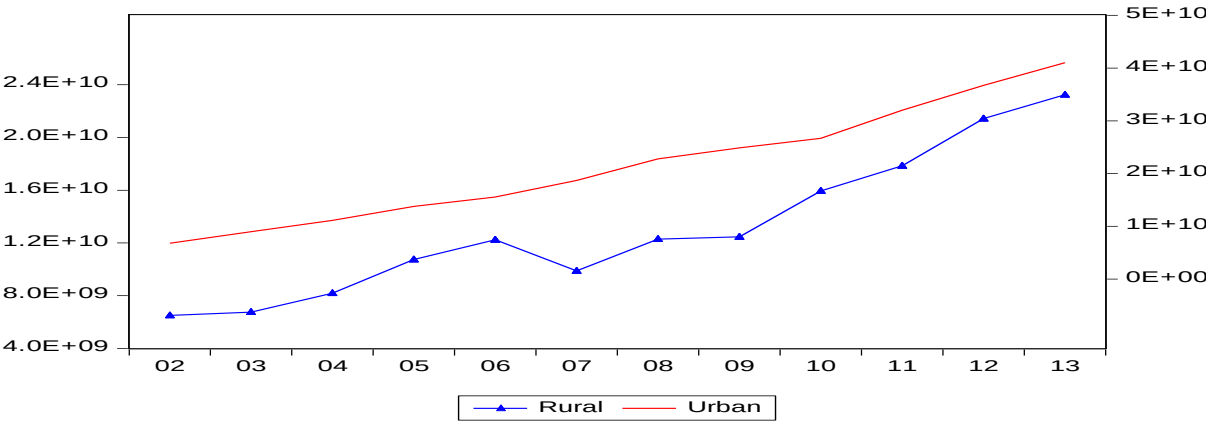

Figure 6. Household Consumption for Rural and Urban, 2002 and 2013.

Source: (Turkish Statistical Institute, 2019).

3. LITERATURE REVIEW

Although there are not many studies on this topic, several researches emerge to be engaged in examining the relationship between rainfall, or weather condition, and economic growth and agricultural output in several countries. The studies are focused on agricultural industry intensive countries such as Sub-Saharan Countries, Morocco, Iran (Barrios, Bertinelli and Strobl, 2010; Mansuri, 2004; Salami, Shahnooshi and Thomson, 2009), and in several case in the United States (Rosenzweig, Tubiello, Goldberg, Mills and Bloomfield, 2002) where the effects of rain on specific crops have been examined. For instance, the research by Dell et al. (2014) uses specific

weather conditions, such as temperature, precipitation and windstorm variation, to see contemporary effect on agricultural output, industrial output, labor productivity, energy demand, health, conflict, and economic growth. They found that especially temperature is important in affecting agricultural output, industrial output, energy demand, labor productivity and political stability, but no effect of rainfall.

One of the most recent research about the relation between rainfall and economic growth is carried out by Gilmont et al. (2018) who investigated the effect of rainfall in India in state level. The authors argue that the states where relation between rainfall and economic growth are stronger generally seems to be performing better in economic terms than other states in which the correlation between rain and economic growth are weak. Over all, the others suggest that while economic diversification occurs in Indian economy, there is still economic dependency on rainfall variation directly or indirectly.

In their work, Borgomeo et.al (2018) first estimated direct effects of rainfall shocks on Ethiopian agricultural industry and then by using Computable General Equilibrium model they try to see how rainfall shocks transmits to the wider economy in a specific basin in Ethiopia. A downward shock of rainfall scenario causes the GDP of the basin by 5%. And the authors further argue that all sectors benefit from increasing the amount of rainfall.

Rodrik et.al. (2004) found climatic changes, which determined by geography, had strong indirect effect on institutions and agricultural development, the quality of human resources and technological exchange.

For instance, in their paper, Barrios et al. (2010) investigated the effect of rainfall on economies of developing of Sub-Saharan African and Non-African developing economies. By using panel data, they found a significant effect of short of rainfall on African countries but no significant result for other developing countries.

Masters and Wiebe (2000) examined the determinants of agricultural input and output with respect to climate conditions and found that seasonal frost is an important variable for output level beside investments in researches.

In another paper, which measures drought in Morocco by cereal yield per hectare is examined byMansouri (2004). For example, he found the impact of drought on real consumption to be negative in Morocco, as agricultural shocks are determinants of the growth in the country.

Iran is also agricultural dependent country where the workforce in agricultural industry is about 20% in 2010. Salami et al. (2009) tried to find empirical results of the cost of drought on agricultural sector and an indirect cost on overall economy in Iran by using linear econometric modelling. They found that the drought of 1999 and 2000 had an effect of -1.6 billion U.S Dollar on agricultural industry and reduced its sub-section of other agriculture related economies such livestock and forestry. As a result of drought, the overall Iranian manufacturing fell about 7.8% and service industry down about 3.7% in investigated period.

In the case of Turkey, there is no studies that are focused on the direct effect of rainfall on economic growth. However, a paper which explores the effect of drought only on Turkish agricultural industry in a qualitative method is reported by Kapluhan (2013). The author state that at the time of scarcity of rain, agricultural products which are grown in non-irrigated area are negatively affected.

Another study by Bayrac and Dogan (2016) examines the effect of climate change on Turkish agricultural industry. The author uses rainfall amount, temperature, agricultural productivity and CO_2 emission to estimate agriculture GDP in Turkey. They found a positive correlation between agricultural productivity and rainfall. The variables CO_2 emission and temperature are negatively correlated with the agricultural productivity.

In their work, Ertunga and Unalmis (2014) searched for the relation between drought and hydro electric power generation in Turkey. The authors found that as the amount rain fall, the power generation from hydro system also fall and the shortfall of power is compensated by the supply of coal and natural gas.

4. DATA AND ECONOMETRIC METHODOLOGY

4.1. Data

Rainfall and temperature data were collected from Turkish State Meteorological Service. Daily data for each city were then converted into quarterly and then into annual data. We first considered to use weighted average of rainfall according to province size. However, the outcome of this turnout to be the same as normal country level

rainfall average. Therefore, country level average rainfall amount is used. Data start from 1980 to 2018. Economic growth rate, agricultural growth rate data were gathered from Central Bank of Turkey and other agriculture related statistics from Turkish Statistical Institute.Growth rates are calculated from constant prices.

4.2. Empirical Theory and Method

Dell et al. (2014) introduce the impact of climate change on economic outcomes through the following functional relationship:

$$\boldsymbol{y} = f(\boldsymbol{C}, \boldsymbol{X}) \quad (1)$$

The authors describe ($\boldsymbol{C}$) as vector of climatic variables and ($\boldsymbol{X}$) as vector of outcomes of $\boldsymbol{y}$. They show that this climatic variables could consist of temperature, precipitation, and extreme weather. X variable is a dependent variable which may include national income, agricultural output, industrial output, labour productivity, political stability, energy use, health, and migration, among others. The authors also state that X could be any characteristics correlating with C, which affect the outcomes of interest possibly by conditioning the climate response.

Same as the equation (1) above, to explore the relationship between rainfall and temperature on agricultural economic growth and overall economic growth in Turkey, Ordinary Least Square (OLS) estimation of an autoregressive distributed lag (ADL) method will be employed to see the relationship. This method allows us to determine what the effects are of a change in variables over time (Chen, Y.Y) and to control for business cycle affect (Bond, Leblebicioglu and Schiantarelli, 2007).

Two models were built. First, rainfall and temperature were considered as sole explanatory variables to see theirlinkage to the agricultural industry growth. The second model will see the effect of agricultural growth on overall economic growth in Turkey. In all models both agricultural economic growth and overall economic growth will be dependent variable. The ADL estimation equation will look like this:

Model 1:

$$Agri_{Growth_t} = \beta_0 + \beta_1 agri_{growth_{t-1}} + \ldots + \beta_p agri_{growth_{t-p}} + \delta_1 rain_t + \delta_2 rain_{t-1} + \cdots + \delta_q rain_{t-q} + \gamma_1 temp_t + \gamma_2 temp_{t-1} + \cdots + \gamma_q temp_{t-q} \varepsilon_t \quad (2)$$

Model 2:

$$Growth_t = \beta_0 + \beta_1 growth_{t-1} + \ldots + \beta_p growth_{t-p} + \delta_1 agri_{growth_t} + \delta_2 agri_{growth_{t-1}} + \cdots + \delta_q agri_{growth_{t-q}} + \varepsilon_t \quad (3)$$

In above equation (2),*t* indicate time unit (where *t* = 1, 2,…,21),*Agri_Growth* shows economic growth of agricultural industry, *rain* representsrainfall amount and *temp* indicates temperature level.βs, δs and γsare coefficients of parameters.While in equation (2), *Growth* expresses overall economic growth of Turkey beside parameters coefficients of βs and δs. Finally ε indicate error term.

Before proceeding further to see the statistical assessment of the variables, it is necessary to check whether the variables are stationary or not. For instance, for the case of time series, Sarı, Hammoudeh and Ewing (2007) suggest that the characters of time series can be determined by applying robust unit root estimators that will suit the model. Variables in time series analysis, must be stationary in order to avoid spurious regression. In other words, the traditional values of t, F and R^2 tend to be biased, the regression output may give a wrong result, even though the regression may contain higher value, despite this higher value these variables may not be related at all (Brooks, 2004). By having stationary variables, the likelihood of spurious regression will be removed and also the significance of regression will be higher (MacKinnon, 1991).

Hence, among the variables GDP and agricultural GDP non-stationary in their levels. For this reason, the first difference of both variables were taken into the models as growth rate. Their first difference were taken because as Bond et al. (2007) suggest and recommendthat first-differencing can be used to avert the cointegration hypothesis descriptions. Because taking log of GDP will cause non-stationary on left side of the equation and variables on the right hand side. Rainfall and temperature series are stationary at their levels.

4.3. Empirical Findings

Since our aim is to find relation between rainfall and economic growth, in this part of the empirical study, an OLS estimation of ADL method which includes distributed lagsof independent variables and lags of dependent variable (Auto-regressive) to the equation. This method has some advantages. By using distributed lags, the effect of independent variables can be found overtime on dependent variable (Parker). For instance, in our case, we believe that the effect of rain will not be immediately felt by the economy rather the effect will be felt at least one or two quarters or one year after it happens. In autoregressive form, the lags of dependent variable also affect its own behavior in the coming periods. We should also note that our two variables fulfill the necessity for OLS regression in terms of being stationary that are shown in unit root test results.

When running ADL estimation for Model 1, the results of findings are as below:

Table 3. OLS Estimation by ADL

Regression on Agricultural Growth			
Variables	Coefficients	Std. Errors	P-values
Agricultural growth(-1)	-0.69572	0.123378	0.0000
Rain	0.01451	0.005928	0.0200
Rain(-1)	0.01072	0.005817	0.0746
Temperature	-0.01372	0.009347	0.1517
C	-0.00168	0.122486	0.9891
@trend	0.00212	0.000696	0.0046

The numbers in the parenthesis indicate lag numbers. Lags were selected automatically by (AIC).

The above results (See Table 3) show that the rainfall amount contemporaneously affects agricultural growth in a positive way. This outcome is sensible as agricultural output respond to country's climate conditions. Increase in rainfall in a year will contribute to boost crop yield in a given year. However, it appears that temperature has no relation with the agricultural growth in Turkey over the investigated period. When looking at Figure 7, the shaded areas display that years when rainfall amount falls, agricultural output follow the same pattern. One thing is noticeable from the below figure that agricultural output in Turkey fluctuating extremely. And the answer for this could be perhaps the changing climatic conditions such as occurring drought for some years.

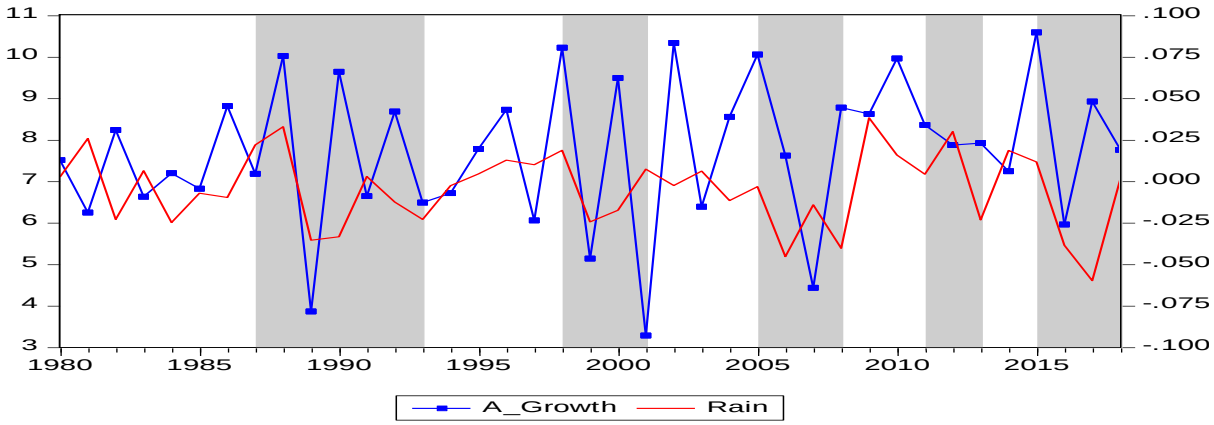

Figure 7: Relationship between Agricultural Growth and Rainfall in Turkey, 1980-2018.

The first model found a positive and significant relation between rainfall and agricultural output. And now through transmission mechanism as pointed out by Dell et al. (2012), in which it is believed that as the climate conditions are good, then agricultural growth will positively be affected and in turn, as the agricultural industry grow the overall economic growth will benefit from this expansion or contraction when agricultural output fell.

Overall economic growth is dependent variable and agricultural growth is independent variable in the second model when running OLS estimation of ADL method. See Table 4 for the estimation results.

Table 4. OLS Estimation by ADL

Regression on Agricultural Growth			
Variables	Coefficients	Std. Errors	P-values
Growth(-1)	-0.69572	0.123378	0.0000
Agricultural Growth	0.01451	0.005928	0.0200
Agricultural Growth(-1)	0.01072	0.005817	0.0746
Agricultural Growth(-2)	-0.01372	0.009347	0.1517
C	-0.00168	0.122486	0.9891

The numbers in the parenthesis indicate lag numbers. Lags were selected automatically by (AIC).

The above figures show that there is a significant and positive correlation between agricultural growth and overall growth contemporaneously. The figures also imply that two lags of agricultural growth also has positive impact on economic growth in Turkey.

Figure 8 also illustrates graphically how rainfall amount and economic growth are closely related to each other from 1980 to 2018. The shaded areas also indicate somehow interesting points. For instance, Turkey experienced severe economic crisis in 1994, 1998, 2008 and the last in 2018. All economic downturns coincide when there are rainfall shortage or drought in the country. Figure 7 also implies that rainfall shortages occur before economic downturns and following this fall, economic growth appears to be declining too.

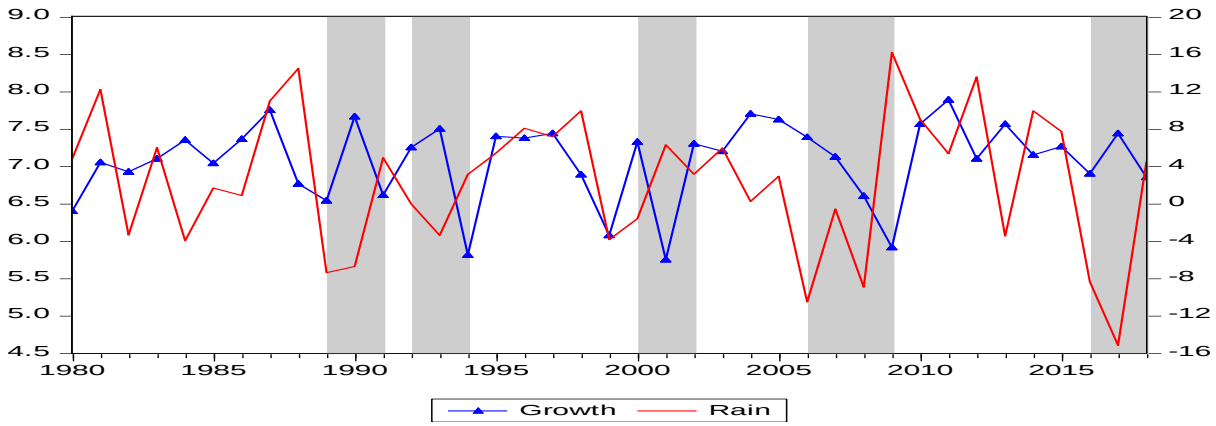

Figure 8. Relationship between GDP Growth and Rainfall in Turkey, 1980-2018.

4.3.1. Causality Test

When looking at causality between agricultural output and GDP figures, there seems to be uni-directional Granger cause between both variables. It seems that agricultural growth granger cause overall economic growth while p-value is significant for the hypothesis (See Table 5).

Table 5. Granger Causality Test Results

Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
AGRI_GROWTH does not Granger Cause GROWTH		4.3869	0.0207
GROWTH does not Granger Cause AGRI_GROWTH		0.1668	0.8470

Lag selection were chosen according to VAR model.

5. CONCLUSION

In this paper we investigated whether rainfall amount in Turkey has any effect on Turkish economic growth by OLS estimation of ADL for the short run. Firstly, an overview of relation between rainfall and arable lands, agricultural labor workforce and wheat output in Turkey were provided. As the rainfall increases in the country,

agricultural labor workforce and wheat output increases together over the investigated period. Secondly, The paper analysed the relation between rainfall and agricultural output. The results suggest that agricultural growth is positively affected by the rainfall amount Turkey. Then, the focus was given on the relation between agricultural output and overall economic growth, and found that through transmission mechanism, rainfall could positively have the effect on the economic growth. As mentioned above, for instance, the economic crisis that Turkey experienced in 1994, 1998, 2008 and 2018 are all coincide with that when there is shortage of rain or drought in the country during those times. The other variable, tempreture is found to be insignificant on both agricultural industry and general economy. This finding is also in line with the literature (Dell, Jones and Olken, 2012; Sangkhaphan and Shu, 2019).

Turkish economy generally performs well in the second and third quarter of each year. Similarly, agricultural industry performs well especially in the third quarter of each year. This indicates that agricultural industry supports the whole economy specifically in the third quarter, if it takes enough rainfall in the second quarter. (See illustration of a graph in Appendix 3, that shows trend in second quarter of rain and third quarter of economic growth. The correlation between the two appears to be +34%).

Several arguments can be built to justify how rainfall amount affect economic growth. The most important indicator is employed labor work force in agriculture sector in Turkey. As it is mentioned above, while the share of agriculture in the economy stand at about 6%, the work force that employed in agriculture is as high as 20% in Turkey. This can be interpreted that still a quite large proportion of population relies on agricultural industry when compared other advanced and developing countries. In the case of drought, the crops' output level will fall and hence, the income of those will fall. The figure of consumption level displays that the rural consumption level is well below urban one. The figure also indicates that rural consumption is decreasing at the time of less rain in the country. The causality tests again provide the causality from agricultural economy to the whole economy.

As rainfall is found to be positively related with the overall economic growth in Turkey, this variable may be used in explaining and examining economic growth in Turkey for the coming researches beside other conventional macro-economic and financial indicators as the recent studies suggest. This study may give some base intuition for future researches on the issue of rainfall, drought and economic growth.

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Süleyman Demirel Üniversitesi Vizyoner Dergisi, Yıl: 2020, Cilt: 11, Sayı: 28, 665-679.
Süleyman Demirel University Visionary Journal, Year: 2020, Volume: 11, No: 28, 665-679.
ISSN: 1308-9552

Appendix 1. The Comparison of Yield between Irrigated and Non-Irrigated Land

Years	Irrigated	Non-irrigated
2012	380	232
2013	401	241
2014	337	211
2015	412	244

The abobe table shows the comparison of wheat yield per decare in irrigated land and non-irrigated land between 2012 and 2015. There is no available data prior to 2012.

Appendix 2. Employment in Agriculture (% of Total Employment)

Panel A	%
European Union	3.0
U.S.A	1.6
Japan	3.7
Canada	2.2
Panel B	
Turkey	21.2
Russia	7.0
Brasil	14.5
India	49.7
Hungary	4.7
Poland	11.7
Mexico	13.4

Source: (World Bank Data).

Appendix 3. Second Quarter Rainfall and Third Quarter Economic Growth, 1998-2016.