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Assessing the Role of Agriculture and Energy Use on Environmental Sustainability: Evidence from RALS Cointegration Technique

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ABSTRACT

This study is relevant towards determining the ability of Turkey in mitigating environmental degradation which is one of the major areas of concern. Therefore, we aimed to examine the linkage among agriculture, energy use, economic performance and FDI with environmental sustainability. To this end, ecological footprint has been considered as a more comprehensive and reliable indicator to measure the level of environmental degradation. This relationship has been investigated with different approaches such as the Residual Augmented Least Squares Augmented Dickey-Fuller (RALS-ADF), Residual Augmented Least Squares Engle and Granger (RALS-EG) and leveraged bootstrap causality test for the period from 1970 to 2017. The RALS procedure was utilized to analyze the stationarity level of each variable and their cointegration relationship. The findings confirmed that all the variables investigated have cointegration relationship and have positive and statistically significant effect on environmental degradation in Turkey. The results of leveraged bootstrap causality test showed that there are bidirectional causal relationships of environmental sustainability with agriculture sector as well as FDI and economic performance. Moreover, the unidirectional causal relationship runs from environmental degradation to energy use and from FDI to economic performance and agriculture sector. The other unidirectional causal relationship running from agriculture sector to energy use and from economic performance to energy use. Also, our findings confirmed the inverted U-shaped EKC hypothesis for the relationship of economic performance and environmental sustainability. Therefore, our findings provide insights for policymakers to consider investigated variables as a surest way to have environmental sustainability.

Keywords: Agriculture, FDI, Energy Consumption, RALS Cointegration, Turkey
JEL Classifications: Q43. F64. C32

1. INTRODUCTION

Environmental and ecological degradation is a significant problem globally. This is one of the major areas of concerns in Turkey due to its ambitious economic expansion program which aim to place it as one of the ten largest economies globally by the year 2023. According to the European Environmental Agency (EEA), Turkey is the twentieth largest emitter of greenhouse gases (GHGs) mainly from its industrial, agricultural, and waste sectors. In other to its targets, the country uses environmentally friendly and traditional technologies in its agricultural sub-sectors. These activities harm environmental quality through machinery use, unethical waste disposal, climate change issues, (rainfall and temperature), deforestation, and soil degradation. Turkey is witnessing environmental degradation influenced by human activities from past to present due to its agricultural practices. Presently, the country is experiencing a myriad of environmental problems due to its massive agricultural production which often releases harmful substances such as methane (CH_4), nitrous dioxide (N_2O), and carbon dioxide (CO_2) through the practice of fertilization and the use of pesticides to increase output. Additionally, tillage and desertification affect land, soil, air, and water quality (Čirjak, 2020).

Agriculture is an important sector for both developing and emerging economies. It has the propensity to engender higher-income generation, provide food and raw material to non-agricultural sectors, export, and reduce unemployment/poverty especially for labor abundant countries, such as Turkey. Turkey is among the leading economies of the Middle-East and Mediterranean region in terms of population and productive land. It is also one of the 20 largest economies globally and 7th largest producer and exporter of agricultural products. Turkey's agricultural sector plays a primary role in its economy by contributing majorly to income, export, employment rate, and rural growth (FAO, 2021). The agricultural sector covers 23% of the country's economy with 1000 square meters of farm size. The government validates that the National Agricultural Project intends to improve agricultural productivity in the county thereby making it one of the five major producers by 2023.

Additionally, the increased demand for energy by the rapidly growing population in the country over the years necessitated the use of traditional sources such as fossil fuel and coal which are high GHG emitters. According to Bekun and Agboola (2019), energy production/consumption leads to the improvement in productivity and economic growth of any economy. Consequently, these increases result in environmental destruction by releasing harmful emissions. According to the world resources institute (2020), the energy sector is the major emitter of GHG with 73% of emissions. However, Turkey's energy supply is more of imports which are unfavorable to the environment given to the rise in emission. Several works of literature on the energy-environment nexus have highlighted the adverse consequences of energy use on the environment. For example, Oguz et al. (2020) and Sharif et al. (2020), asserted in their work that increase in energy use raises ecological footprint in Turkey. Furthermore, Tong et al. (2020), Adedoyin et al. (2020), and Cetin et al. (2018), Khan et al. (2020), also indicated the inverse relationship of energy use on the environment in their studies. However, some of the studies revealed the positive effect of energy consumption as per emission reduction on the environment (Sinha and Shabaz, 2018; Balsalobre-Lorente et al., 2018; Etokakpan et al., 2020).

Turkey is one of the fastest-growing economies in the world open to economic development (Akadiri et al., 2019). Foreign direct investment (FDI) takes part in the improvement in the growth rate and living standard of the country's economy, giving that in February 2021 FDI increased by 975USD mn. This shows that FDI which is one of the major sources of economic growth in Turkey (Katircioglu, 2009; Aga, 2014), could affect the environment positively or negatively. The positive impact of FDI inflows on the environmental quality has considered FDI as an additional indicator to environmental quality. Before now, existing literature which carefully examined the significant nexus between FDI and environmental quality concluded with different directions. For instance, Joshua et al. (2020) and Shahbaz et al. (2019), stated in their paper that FDI inflows influence the environment positively. On the contrary, some of the researchers found that FDI influences the environment negatively by increasing carbon dioxide emission (Seker et al., 2015; Malik et al., 2020; Sarkodie and Strezor, 2019; and Udemba, 2020), while others found out that FDI has no statistically significant impact on the environment (Haug and Ucal, 2019). However, to the best knowledge of the authors, there are no significant number of studies carried out to examine the relationship among FDI and ecological footprint to capture the overall effect of FDI on the environment.

A number of environmental literatures have observed the Environmental Kuznets Curve (EKC) hypothesis, which was first observed by Grossman and Krueger (1991) for the linkage between economic growth and environmental degradation. Thus, the EKC reflect that environmental quality reduces due to the increase in economic growth. This indicates that environmental damages increase first and later reduces with improvement in economic growth. The first phase impact of the curve shows that environmental quality deteriorates gradually with increase in growth from resources that trigger environmental degradation. As economic growth continues to rise, environmental damages surges in the same manner, showing an inverted U-shaped relation. Udemba (2020) revealed the positive linkage between economic performance and ecological footprint. A group of authors have implemented and affirmed the EKC hypothesis for different economies. Katircioğlu and Katircioğlu (2018) for Turkey, Tiwari et al. (2013) for India, Shahbaz et al. (2012) for Pakistan, Balcilar et al. (2010) for G-7 countries. However, others such as Richmond and Kaufmann (2006), and Agras and Chapman (1999) did not find any affirmation of the EKC hypothesis.

In the literature, some scholars applied CO_2 as proxy to environmental degradation to analyze the EKC hypothesis. Pata (2018) investigated the EKC hypothesis for Turkey indicating an inverted U-shaped relationship between economic performance and CO_2 emission. In addition, the EKC hypothesis was confirmed by Bulut (2021), Sharif et al. (2020), Agboola and Bekun (2019), Dogan (2018), Shahbaz et al. (2018), Pata (2018), Aslan et al. (2018), and Ozcan et al. (2018) Katircioglu (2017), Katircioglu and Taspinar (2017), Seker et al. (2015), using CO_2 emission as a factor of environmental degradation. On the contrary, some studies cannot support the cogency of EKC hypothesis (Alola and Donve, 2021; Akbostanci et al., 2009). However, others such as Ozcan et al. (2018) and Malik (2021) did not confirm the EKC hypothesis for Turkey. Recently, some studies by Bulut (2021), Selim and Rivas (2020), Godil (2020), and Fakher (2019) applied the Ecological Footprint (EF) as proxy to environmental degradation to scrutinize the EKC hypothesis. The studies affirmed the validity of the U-shaped relationship between the ecological footprint and economic performance in Turkey. In the contrary, Köksal et al. (2020) and Ozcan et al. (2018) indicates that EKC hypothesis is not valid in Turkey. However, our study utilizes ecological footprint as proxy to environmental problem.

This study aims to examine Turkish's engagement in minimizing environmental degradation to promote environmental quality by examining the influence of agriculture, energy use and FDI on environmental degradation. To the best of our knowledge, there are scanty number of studies examining the effect of agricultural productivity on environmental degradation and none of the researches have examined the effect of agriculture, energy use, and FDI on ecological footprint using the new econometric technique, RALS analysis for Turkey. Ecological footprint has been used as a proxy to environmental sustainability compared to other researchers who mostly used CO_2 emission. Therefore, in this study, the residual augmented least squares (RALS) procedure which was developed by Im and Schmidt (2008) was utilized to analyze the stationarity level of each variable and their cointegration relationship. This model was used since it particularly allows us to obtain the information from nonnormal errors in estimations. Moreover, by using nonnormally distributed errors, both the RALS unit root test and RALS-EG cointegration test give more powerful results compared to traditional models. This can be assumed as one of our contributions to the existing literature. Moreover, the EKC hypothesis was examined by means of ecological footprint as a measure of environmental damage. Several recommendations can be provided for Turkey from the results of this research work.

This section is followed by literature reviews (2) while section (3) gives information about data and methodology and followed by empirical results (4). Section (5) concludes the study and gives policy recommendations.

2. LITERATURE REVIEW

Past studies have emphasized the effect of agriculture, energy, FDI, and economic growth on the environment of different nations. Excessive agricultural production and energy consumption have, however, necessitated the release of excessive greenhouse gas emissions. Table 1 shows notable trend of agriculture, energy, and FDI on environmental degradation of different economies especially that of Turkey. Turkey recently has become more vulnerable to environmental changes leading to a rise in emission. Although, policies are already adopted to control the problems of the environment and climate change to achieve environmental sustainability. Most of the econometric models shown in Table 1 have strived to extend the analysis of the growth-energy-environmental degradation relationship with applicable variables. Nevertheless, there is still no consensus in the literature about the effect of the variables. Many studies have examined the EKC hypothesis in Turkey with conflicting results. Some of the studies validate the EKC hypothesis while others do not support the validity of the EKC hypothesis. Hence, the present study conveys the EKC hypothesis and examines the nexus among the variables using the RALS model. Several reviews on the role of agriculture, energy consumption and environmental quality. Recently, many studies investigated the nexus among agriculture, total energy with environmental degradation. For example, Dogan (2016) examined the relationship between agricultural performance and environmental pollution for Turkey and indicated a significant negative effect on environmental pollution. An increase in agricultural production improves the quality level of the environment and confirmed the EKC hypothesis. In Turkey, Bas et al. (2021) inspected the environmental effect of agriculture, export, and energy utilization using data from 1991-2019, applying the Fully Modified Ordinary Least Squares and Autoregressive Distributed Lag models (FMOLS and ARDL measure). The outcome of the study revealed that agriculture value-added and export alleviate environmental problems, increase in energy utilization influence carbon emission. The environmental Kuznets Curve (EKC) hypothesis is validated for agriculture value-added and carbon emission linkage. In another study, Udemba (2020) explore the link among agriculture, FDI and EF for India from 1975 to 2016, using the linear and nonlinear ARDL. They concluded that the agricultural sector influences the environment negatively with a positive significant connection. Similarly, Ullah et al. (2018) applied the annual data from 1972 to 2014 to inspect the causal linkage between agricultural practice and environmental degradation in Pakistan and revealed that agricultural ecosystem has a positive effect on environmental pollution thereby showing that any rise in agricultural practices results in a similar rise in CO_2 emission. In addition, Chandio et al. (2020) examined the cereal production response to CO_2 emissions from 1968 to 2014 in Turkey, using the ARDL model. The results reveal that CO_2 emissions harm agricultural production affecting cereal yield negatively in Turkey. These papers mostly used CO_2 emissions as an indicator for environmental degradation, however, there are scanty number of studies investigating this relationship by using ecological footprint.

3. DATA AND METHODOLOGY

3.1. Data

This study examines the long-run effect of agriculture sector on environmental sustainability incorporating with energy use, foreign direct investment and economic performance in Turkey. Data covered for this study is on annual basis from 1970 to 2017. Accordingly, the descriptions of investigated variables with their assertion of measurements and sources are given in Table 2 The data, except ecological footprint (EFP), obtained from World Bank World Development Indicators. Global Footprint Network official website was used to obtain Ecological footprint data.

3.2. Methodology

To investigate specified relationship among investigated variables, the model was constructed for the study given below.

$$\text{In } EFP_t=\alpha_0+\beta_1 \text{ In } AGRI_t+\beta_3 \text{ In } EUt+\beta_3 \text{ In } FDIt+\beta_4 \text{ In } Yt+\beta_5 \text{ In } Y_t^2+\varepsilon_t \quad (1)$$

Where ε_t represents error term in the model at t=1970, 1971,…2017; β's are the coefficients of the explanatory variables and show the magnitude of the nexus among explanatory variables and environmental sustainability. α_0 is used for the intercept. All the variables are in their logarithmic forms in order to stabilize the variance of a series.

Turkey prioritizes the economic growth to environmental sustainability for previous decades. Besides being an energy-import-dependent country and using traditional energy sources in its production process, its fragile financial market is sensitive to fluctuations in foreign capital flows. Therefore, in this study, the coefficients of all investigated variables are expected to

Table 1: Summary of past literature on agriculture, energy consumption, foreign direct investment, and the environmental quality

Authors	Dates	Country	Variables	Method	Results
Akbostanci et al. (2009)	1968-2003	Turkey	CO_2, GDP	Time series model	The results do not confirm the EKC hypothesis
Halicioglu (2009)	1960-2005	Turkey	GDP, CO_2, EC, foreign trade	Bound test	Economic growth increases carbon emission
Ozturk and Acaravci (2010)	1968-2005	Turkey	$C0_2$, GDP, EC, employment	ARDL model and Granger causality	EC increases CO_2 emission
Jebli and Youssef (2015)	1980-2009	Tunisia	EC, GDP , CO_2	ARDL model and VECM	Failed to support the validity of EKC curve
Seker et al. (2015)	1974-2010	Turkey	GDP, CO_2, EC, FDI	Bounds test approach and Hatemi-J test	FDI increase CO_2 emission Support the validity of EKC hypothesis
Jebli and Youssef (2017)	1980-2011	North Africa	AGR, CO_2, EU	Panel cointegration technique and Granger causality test	AGRP reduces CO_2 emission, while REC influences CO_2 emission
Katircioglu and Taspinar (2017)	1960-2010	Turkey	CO_2, EC, RGDP, FD	Unit root and cointegration	Confirmed the EKC hypothesis
Liu et al. (2017)	1970-2013	ASEAN economies	AGR, NRE, RE, CO_2	VECM	AGR and EC reduces environmental degradation. NRE increase CO_2 The study do not support the U-shaped EKC
Cetin et al. (2018)	1969-2017	Turkey	EC, CO_2, GDP, FD	ARDL	EC and GDP increases CO_2
Dogan (2018)	1971-2010	Turkey	CO_2, RGDP,EC, AGR	Bound test and ARDL	AGR increase CO_2.Confirm the present of an inverse U- shape EKC curve.
Gokmenoglu and Taspinar (2018)	1971-2014	Pakistan	EU, AGR, GDP, $C0_2$.	FMOLS	EU and AGR both increase CO_2 Verified the agric-induced EKC hypothesis
Ozcan et al. (2018)	1961-2013	Turkey	EF, GDP	Bootstrap time-varying causality approach	Result did not confirmed EKC hypothesis
Shahbaz et al. (2018)	1955-2016	France	EC, FDI, GDP,CO_2	Bootstrap Bound test	Validated the EKC hypothesis FDI influences CO_{2v} emission
Bekun and Agboola (2019)	1960-2016	BRICS	RGDP, EC, gross capital formation, and CO_2	Maki cointegration test	EC causes increase in CO_2 emission
Agboola and Bekun (2019)	1981-2014	Nigeria	CO_2, EC, RGDP, FDI, AGR, TO	ARDL and Granger causality	FDI mitigate pollution Support the EKC hypothesis. AGR has a positive effect on CO_2 emission
Fakher (2019)	1996-2016	Developing countries	GDP, EF, EC, FDI	Bayesian model averaging and Weighted averaging Least square	FDI increase EF Concur with the EKC hypothesis
Olanipekun et al. (2019)	1996-2015	African countries	AGR, GDP, EF, population	Pooled mean group (PMG)	AGR aggregate environmental degradation
Pata (2019)	1969-2017	Turkey	TO, RGDP, CO_2	ARDL	Validates the EKC hypothesis
Udemba (2019)	1995Q1-2016Q4	China	FDI, CO_2, GDP, EC, and tourism arrivals	ARDL and Granger causality	FDI contribute to CO_2 emissions
Etokakpan et al. (2020)	1970-2014	Turkey	EC, RGDP, EFP, globalization	Modified Wald test	Inverse relationship between EC and EFP
Selim and Rivas (2020)	1971-2014	Uruguay	GDP, FDI, EFP, and EC	ARDL and VECM	Energy use increase EFP Verified EKC hypothesis
Usman et al. (2020)	1985-2014	USA	RGDP, EF, EC,FD	ARDL approach	EC and RGDP apply negative pressure on EF
Bachri and Normelani (2020)	1960-2018	Indonesia	FDI, GDP, CO_2	ARDL and Granger causality	FDI have a sign impact on CO_2 emissions and economic growth
Sabir et al. (2020)	1984-2019	South Asia	EF, EC, GDP, FDI, political institution	PARDL and Granger causality test	FDI and energy consumption have a positive and statistically significant impact on environmental degradation.
Bulut (2021)	1970-2016	Turkey	GDP, EF, EC,FDI	ARDL technique	FDI reduces EF Confirmed the EKC hypothesis
Malik (2021)	1970-2014	Turkey	GDP, EC, CO_2, TO, labour force	GMM technique	EC increases CO_2 Non-existence of EKC
Philip et al. (2021)	1970-2017	Turkey	FDI, GDP, CO_2, URB	Time-varying parameter approach	FDI contribute to environmental degradation

CO_2 is carbon dioxide emission, GDP is gross domestic product, EKC is environmental Kuznets curve, EC is energy consumption, VECM is vector error correction model, FDI is foreign direct investment, AGR is agricultural production, REC is renewable energy consumption, FD is financial development, NREC is nonrenewable energy consumption, ARDL is autoregressive distributed lag, EF is ecological footprint, TO is trade openness

Table 2: Variables' descriptions

Variables	Measurements	Sources
Ecological Footprint (EFP)	Global Hectares per capita(ghp)	Global Footprint Network official website
Agriculture, value added (Agri)	% of GDP	World Bank
Energy Use(EU)	Kg of oil equivalent per capita	World Bank
Foreign Direct investment, net inflow (FDI)	% of GDP	World Bank
Gross Domestic Product per capita(Y)	Constant at 2010 prices	World Bank
Square of Gross Domestic Product per capita (Y^2)	Constant at 2010 prices	World Bank

have statistically significant and positive effect on ecological footprint.

To measure the significance and magnitude of these series on environmental sustainability, first, the integration order of the series are tested for stationarity using Augmented Dickey Fuller (ADF) test and a newly established Residual Augmented Least Squares ADF (RALS-ADF) test. Then, the existence of the long-run steady-state relationship among variables was examined by means of classical Engle and Granger (EG) and RALS-EG cointegration tests. With this, the direction and the magnitude of long-term effects of explanatory variables and their significance on environmental sustainability were anticipated by means of fully modified ordinary least squares (FMOLS) method. Finally, to test causal relationship of the investigated variables were examined by conducting newly established bootstrap leveraged Hacker and Hatemi-J (2012) causality test.

3.2.1. Cointegration test

To test the presence of the long-run steady-state relationship amongst investigated variables two-steps Engle and Granger (EG) (1987) methodology was employed which was developed due to t-statistics and residuals. At the first step, the unit root tests were employed to investigate the level of integration for each variable. To do this, ordinary least squares regression equation was estimated.

$$y_t = \phi z_t + v_t \tag{2}$$

Then, $\hat{v}_t$ residuals were obtained and ADF test was conducted with related residuals.

$$\Delta \hat{v}_t = \phi_0 + \phi_1 \Delta \hat{v}_{t-1} + \sum_{i=1}^{k} \phi_{i+1} \Delta \hat{v}_{t-1} + u_t \tag{3}$$

In Equation 3, if the error term is not normally distributed, the higher moments of residuals cover information on the nature of non-normal residuals. Therefore, since the Im and Schmidt (2008)'s RALS process can be employed to cover high moment information found in non-normal errors in linear model frameworks and which can also give more powerful results with nonnormally distributed error terms. To this end, the EG procedure suggested by Lee et al. (2015) amplified RALS procedure and suggested the new term for new cointegration test by using 2nd and 3rd moments of the residuals. These residuals are obtained from classical cointegration tests. This term which extends Equation 3 can be given below

$$\hat{\omega}_t = g(\hat{u}_t) - \hat{D}_t - \hat{u}_t \hat{K}_t \quad t=1,2.,T$$

Here, $\hat{u}_t$ is the residuals obtained from Equation 3 and $g(\hat{u}_t) = \left[\hat{u}_t^2, \hat{u}_t^3 \right]$, $\hat{D} = \frac{1}{T}\sum_{i=1}^{T} g(\hat{u}_t)$, and $\hat{K} = \frac{1}{T}\sum_{i=1}^{T} g'(\hat{u}_t)$.

Following Meng et al. (2017), the term for RALS procedure is defined as follows.

$$\hat{\omega}_t = \left[\hat{u}_t^2 - \eta_2, \hat{u}_t^3 - \eta_3 - 3\eta_2 \hat{u}_t \right]' \tag{4}$$

Where $\eta_j = T^{-1}\sum_{i=1}^{T} \hat{u}_t^j$. Accordingly, by adding Equation 4 into Equation 3, the RALS cointegration regression can be obtained and given below.

$$\Delta \hat{v}_t = \phi_1 \hat{v}_{t-1} + \sum_{i=1}^{k} \phi_{i+1} \hat{v}_{t-1} + \hat{\omega}_t \lambda + \upsilon_t \tag{5}$$

Where the null hypothesis of no cointegration relationship among investigated series ($\phi_1 = 0$) can be tested by using standard t-statistics. The asymptotic distribution of the test statistic can be represented as $t^* \rightarrow \rho.t + \sqrt{(1-\rho^2)}.H$. Here, t indicates for EG test statistics and t* represents RALS-EG tests statistics. H shows the standard normal random variable and ρ is the correlation coefficient among obtained residuals from Equation 5 and Equation 3.

3.2.2. Leveraged bootstrapped causality test

Toda and Yamamoto (1995) progressed Granger test (1969) in order to analyze the direction and magnitude of the causal relationship among variables which can be different order of integration. Meanwhile, Hacker and Hatemi-J (2006) suggested the new properties to Toda and Yamamoto (1995) and investigated the size properties of MWALD test which allows to obtain stronger results with small sampled size analysis. To this end, they also suggested the bootstrap distribution to decrease the size of distortions. According to Monte Carlo simulation, it was suggested that compared to asymptotic distribution, MWALD test has lesser size of distortions with prior selection of the lag lengths.

To this end, Hacker and Hatemi-J (2012) newly established causality test was used in this study to investigate the way and magnitude of the causal relationship among investigated variables within the framework of leveraged bootstrap technique. Hacker and Hatemi-J (2012) claimed that this test gives reliable and strong results compared to other traditional causality tests especially for small sampled analysis. To the best knowledge of the authors, none of the studies yet used this technique to analyze the causal relationship among investigated variables for Turkey. This can be emphasized as one of the main contributions to the existing literature.

This model uses vector autoregressive model VAR(p) given below to obtain the results.

$$x_t = a + B_1 x_{t-1} + \ldots + B_p x_{t-p} + v_t \quad (6)$$

Where the dimensional vectors (n×1) are represented with a, v_t and x_t. Also, the n×n dimensional parameter matrix is represented as B_i (where i≥1) in equation 6.

Moreover, to get the stronger and reliable results, Hacker and Hatemi-J (2012) emphasized an alternative formulation for lag length selection (equation 7). This formula is the combination of Hannan-Quinn and Schwarz information criteria and named as Hatemi-J information criterion (HJC).

$$HJC = \ln(\det \hat{\vartheta}_j) + j\left(\frac{n^2 \ln S + 2n^2 \ln(\ln S)}{2S}\right), j=0, 1, 2, \ldots p \quad (7)$$

In this equation, the factor of the anticipated maximum likelihood variance-covariance matrix of error-term in the VAR(j) model was represented by $\det \hat{\vartheta}_j$. The natural logarithm form was symbolized as Ln and number of variables were represented by n and S was used for sample size (Hatemi-J and Uddin., 2014)

4. EMPIRICAL RESULTS

The aim of this study is to scrutinize the long-run nexus of agriculture sector on environmental sustainability incorporating with energy usage, economic performance and foreign direct investment. Together with this, the direction and the magnitude of causal relations among selected variables were aimed to be analyzed. To this end, our estimation procedure is of three-fold. First, the integration order of investigated variables are checked by using newly suggested model, RALS-ADF and confirmed with traditional ADF test. Then, the cointegration relationship was analyzed. Finally, newly established leverage bootstrap causality test (Hacker and Hatemi-J, 2012) was performed to inspect the causal link among the variables.

To examine the integration order of the variables, Augmented Dickey-Fuller and RALS-ADF unit root tests were performed (Table 3). The outcome of these tests fails to reject the null hypothesis for all variables at their level form. Thus, it was concluded that the shocks have permanent effects for all investigated variables. However, all series are found stationary at their first differenced form. This means they are all integrated order one, which is the prominent condition for the cointegration analysis of the series.

Table 3: Stationarity tests

Variable	ADF	RALS ADF	ρ^2
lnEFP	–0.75 (1)	–1.57 (1)	0.89
Δ lnEFP	–8.97 (0)*	–8.76(0)*	0.94
lnY	0.87	1.16	0.64
Δ lnY	–6.53 (0)*	–9.72 (0)*	0.64
lnY^2	0.86	1.67	0.65
Δ lnY^2	–6.48 (0)*	–9.19 (0)*	0.67
LnAGRI	–0.64 (0)	–0.38 (0)	0.94
Δ lnAGRI	–6.44(0)*	–7.100(0)	0.92
lnFDI	–1.13 (1)	–1.65 (1)	0.79
Δ lnFDI	–9.74(0)*	–11.25(0)*	0.82
LnEU	–1.64 (0)	–1.50 (0)	0.80
Δ lnEU	6.54(0)*	–7.05(0)*	0.81

(1) * stands for 1% significance level. (2) The values into the parenthesis presents the optimum lag length obtained by utilizing recursive t-stat. (3) The critical value of ADF test at 1%, is -3.58. (4) The critical value of RALS-ADF at 1% is –4.45

Table 4 presents the cointegration test results. Since the RALS-EG test statistic (–5.738) is lesser than the critical value (–4.80) at one percent significance level, null hypothesis of no cointegration relationship among investigated variables is rejected. The result of this test was confirmed with traditional EG cointegration test and concluded the existence of long-run steady-state relationship among investigated variables.

After confirmation of the cointegration relationship, the long-run effects and the magnitudes of the variables were estimated with the fully modified ordinary least squared method. This method suggested by Phillips and Hansen (1990) that produces reliable estimates for small sample size analysis under the incidence of serial correlation and endogeneity problems. Table 5 demonstrates the estimation output for this test.

In line with our expectations, all explanatory variables have statistically significant and positive effect on ecological footprint in Turkey. This means that, although having different significance level, a 1% rise in the share of agriculture in GDP, energy use, share of FDI in GDP and economic performance will deteriorate environmental sustainability with different magnitudes in Turkey. In particular, a 1% increase in energy use will lead to deteriorate the sustainability of the environment by 1.043%, on average. This demonstrates that Turkey still could not reduce the import dependence of traditional energy sources and still behind the desired level of renewable energy use. Moreover, the coefficient of agriculture sector indicates that a 1 percent rise in the share of agriculture will lead to a 0.056% increase in ecological footprint in Turkey. Thus, the environmental sustainability level of Turkey will be deteriorated

Table 4: Cointegration test results

Methods	k	Test statistics	ρ^2
EG	0	–5.358*	-
RALS-EG	0	–5.738*	0.916

(1) (*) stands for %1 significance level and the optimum lag length determined using recursive t-statistics presented with k. (2) The critical value for EG test at 1%significance level is –5.02. (4) The critical value for RALS- EG test at 1% significance level is –4.80

Table 5: Results of FMOLS

Variables	Depended variable: lnEFP			
	Coef	Std Error	t-Stat	P-value
LnAGRI	0.056***	0.030	1.848	0.072
LnEU	1.043**	0.989	–0.949	0.034
LnFDI	0.016*	0.051	–2.703	0.010
LnY	5.408*	1.459	3.706	0.001
Yy				
LnY^2	–0.269*	0.074	–3.621	0.001
C	–25.099*	6.255	–4.012	0.000
	R^2	0.945	Adjusted R^2	0.938

The 1%, 5% and 10% *significance levels are represented by *, ** and ***, respectively by 0.056%. Together with this, financial development also has positive but relatively small significant effect on environmental degradation level in Turkey. This means that, a 1% rise in FDI inflow causes 0.016% increase in ecological footprint. Finally, the inverted U-shaped relationship was confirmed with economic performance and environmental sustainability in Turkey. This means that, a 1% increase in economic performance of Turkey will lead to increase the deterioration level of environment by 5.408% up to threshold level, then for every 1% rise in the economic performance will be the remedy for environmental sustainability and contribute to the sustainability by 0.269%, on average.

Table 6 presents the results of bootstrap leverage causality test results. The null hypothesis of no causal relationship among variables can be rejected if the calculated MWALD statistic is greater than bootstrap critical values. The results of this test reveal the bidirectional causal relationship of environmental sustainability with agriculture sector as well as FDI and economic performance. Moreover, the one way causal linkage running from environmental sustainability to energy use in Turkey. However, other unidirectional causal relationships have investigated that running from FDI to economic performance and agriculture sector, from agriculture sector to energy use and from economic performance to energy consumption. Finally, the feedback causal relationship has investigated among FDI and energy use. These results emphasize that an increase in FDI will lead increase in finance in the country. This leads to not only an increase in economic performance as well as production and profitability, which cause a greater demand for energy and higher environmental degradation by consuming more sources and emitting greenhouse gasses to the environment.

Table 6: Causal relationship results

Variables	Var (p)	M-WALD	Critical values (Bootstrap)		
			1%	5%	10%
lnEFP → lnAGRI	1	10.702*	8.81	5.079	3.598
lnAGRI → lnEFP	1	16.393*	7.714	4.383	3.021
LnEFP→ lnFDI	1	6.730**	8.43	4.498	3.134
LnFDI→ lnEFP	1	8.096**	9.015	5.112	3.696
lnEFP → lnEU	1	22.209*	16.884	12.003	9.624
LnEU→ lnEFP	1	0.566	7.347	4.000	2.808
lnEFP → lnY	1	20.557*	12.100	6.803	4.494
LnY→ lnEFP	1	4.917**	7.416	4.043	2.796
LnAGRI→ lnFDI	1	0.843	7.508	3.949	2.761
LnFDI→ lnAGRI	1	13.372*	12.081	7.089	5.188
LnAGRI→ lnEU	1	7.514**	10.259	6.300	4.59
LnEU→ lnAGRI	1	3.237	8.823	5.172	3.53
LnAGRI→ lnY	1	5.749	12.145	7.821	5.929
LnY→ lnAGRI	1	0.314	10.024	6.091	4.362
LnFDI→ lnEU	1	10.042**	10.574	6.111	4.415
lnEU → lnFDI	1	6.620**	7.677	4.153	2.957
LnFDI→ lnY	1	9.675**	10.775	6.503	4.833
lnY→ lnFDI	1	2.022	7.307	4.175	2.886
lnEU → lnY	1	3.561	12.945	8.661	6.632
LnY→ lnEU	1	4.065***	9.337	5.620	3.798

(1) 1%, 5% and 10% significance levels are indicated with *, ** and ***, respectively. (2) HJC information criteria were used for the optimal lag length determination. (3) critical values were acquired by 10.000 replications (bootstrap)

5. CONCLUSION AND POLICY RECOMMENDATION

Turkey, as an emerging economy, is amongst the world's 20 largest economies. It aimed to place in top 10 largest economy globally by year 2023. To this end, it set 11th development plan, which covers years from 2019 to 2023. One of the main objectives in this plan is to develop an efficient agricultural sector in terms of economically, environmentally, and socially sustainable. However, Turkey is still behind the targeted level of doing environmentally friendly production since it prioritized the economic growth to the environment and using traditional way of production. Thus, agricultural productivity in Turkey continuously harms the environmental quality through machinery use, unethical waste disposal, climate change issues, deforestation, and soil degradation. As a Paris Agreement and Kyoto Protocol signatory, there are no specific regulation or restriction on Turkish agricultural production. However, it aimed to reduce emission level by 21% via integrating renewable energy sources to the production, reducing the use of traditional energy sources, controlling the use of fertilizers and supporting modern practices.

Previous studies have tried to investigate the way and the scale of the effect of agricultural production on the environmental degradation. The researchers have been mostly focused on single pollutant such as carbon dioxide emission, Sulphur dioxide etc. while investigating this relation. However, using single pollutant for measuring environmental degradation can be weak in giving detailed and clear information. Thus, in this study, ecological footprint has been considered as more comprehensive and reliable indicator which accumulates many emission sources to measure the level of environmental degradation. Therefore, in this study, we aimed to examine Turkish's engagement in minimizing environmental degradation to promote environmental quality by examining the influence of agriculture, energy use and FDI on environmental degradation. To this end, the RALS method was utilized to analyze the stationarity level of each variable and their cointegration relationship which allow us to obtain the stronger results under the non-normality assumption.

The results depict the authors claims and hypothesis and indicated that all investigated variables have cointegration relationship. Moreover, the explanatory variables used in this study have positive and statistically significant effect on environmental degradation level. In other words, a rise in the agricultural production, energy use, foreign direct investment and economic growth in Turkey cause deterioration in the environment. Besides, the inverted U-shaped EKC hypothesis was confirmed in this study which shows that a rise in economic performance leads to increase the level of environmental degradation up to certain threshold level, then, a rise in economic performance will contribute to environmental sustainability. On the other hand, the results of leveraged bootstrap causality test showed that there are bidirectional causal relationships of environmental sustainability with agriculture sector as well as FDI and economic performance. Also, the feedback causal relationship has investigated among FDI and energy use. Moreover, the unidirectional causal relationship running from environmental degradation to energy use and from FDI to economic performance and agriculture sector. The other unidirectional causal relationship running from agriculture sector to energy use and from economic performance to energy use.

The empirical outcomes of the analysis help us to suggest the following recommendations to the policy makers and environmentalist. Since FDI will lead increase in finance, it leads to not only an increase in economic performance as well as increase production and profitability, which cause a greater demand for energy and raise environmental degradation by consuming more sources and emitting greenhouse gasses to the environment. Therefore, firstly, the policymakers should regulate and attract the FDI for better environmental conditions. Also, the government/policymakers should regulate and sustain its economic performance with new progressed direct and indirect taxation technique to promote low carbon emitted and environmentally friendly way of production. Since there are still high import dependency on traditional energy sources (fuel and coal) and lofty proportion of fossil fuel sources in the energy mix, it should revisit its energy policy and change its energy mix by integrating more renewable/cleaner energy sources into energy supply mix. This may lead to decrease in energy dependency and thus lead to increase in economic and environmental sustainability. On the other hand, policymakers should strengthen agricultural management. Turkey, in its agricultural production, should develop long term sustainability policies in its agricultural production and include the use of new environmentally friendly technologies in production, increase the share of clean energy sources in its energy mix and promote agricultural waste recycling.

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