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Research Article

Assessing Environmental Policy Impact through the Ecological Footprint: The Case of Türkiye

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Abstract: This study investigates the long-term effectiveness of environmental policies in Türkiye by examining the stochastic properties of the ecological footprint (EF) and its six subcomponents, carbon footprint, cropland footprint, grazing land footprint, forest products footprint, fishing grounds footprint, and built-up land footprint over the period 1961–2022. Annual per capita data obtained from the Global Footprint Network are analyzed using two-unit root testing methodologies: the conventional Augmented Dickey-Fuller (ADF) test and the more robust RALS-LM unit root test, which accounts for structural breaks and non-normal error distributions. The findings reveal that both the EF and its largest component, the CF, are stationary, suggesting that past environmental policy interventions have yielded transitory effects. Only the CRF and FGF exhibit nonstationarity, indicating that agricultural and fisheries-related policies may have induced permanent shifts in environmental outcomes. Overall, the results suggest that environmental policies in Türkiye to date have not led to long-term and permanent improvements in the ecological footprint indicator. Therefore, it is concluded that policy design should be more comprehensive, consistent, and structurally transformative to achieve environmental sustainability.

Keywords: Ecological Footprint, Unit Root Test, Türkiye

1. Introduction

Economics, in its most basic definition, aims to meet infinite human wants and needs with scarce and exhaustible resources. However, developments such as the increase in the world population, the intensification of pressure on natural resources, the progressive deterioration of environmental quality, the growing concerns about the sustainability of energy sources leading to rising demand for alternative energy, and the advancement of environmental awareness have led the discipline of economics to place environmental issues at its core. Global environmental issues have increasingly attracted the attention of both the academic community and policymakers due to the adverse effects of population growth, industrialization, and economic activities on the environment. As stated by Alper and Alper (2021), the environment is a fundamental factor in determining individuals' quality of life; therefore, it has become one of the primary areas of focus for policymakers, researchers, and international non-governmental organizations. Consequently, maintaining harmony between economic expansion and environmental sustainability has emerged as a central objective in the policy agendas of numerous nations. Since the Industrial Revolution, the growth-oriented development paradigm has assumed that natural resources are unlimited and costless, while environmental costs in production and consumption processes have been largely ignored. As a consequence, there have been significant increases in indicators of environmental degradation, such as the decline in air quality due to rising carbon emissions, deforestation, loss of biodiversity, soil erosion, and water pollution. These developments have underscored the necessity of evaluating the effectiveness of environmental policies to prevent environmental degradation and ensure sustainable development (Alper & Alper, 2021). Within this framework, the primary objective of the study is to examine the long-term outcomes of environmental policy implementations in the Turkish economy over the 1961–2022 period. In line with this objective, the central research question addressed in this study is whether environmental policies implemented in Türkiye during the 1961–2022 period have produced permanent improvements in environmental quality, as captured by the ecological footprint (EF) and its six subcomponents. The EF is selected as the

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primary indicator because it provides a comprehensive measure of human pressure on ecological systems, encompassing not only carbon emissions but also land use, resource consumption, and environmental degradation more broadly (Global Footprint Network, 2021; Ulucak & Lin, 2017). This makes it more suitable than traditional indicators like CO_2 emissions, which focus on a single dimension of environmental impact (Bilgili & Ulucak, 2018). By analyzing the stationarity properties of EF and its subcomponents, this study aims to assess the persistence of environmental degradation and the long-term effectiveness of environmental policy interventions in Türkiye (Solarin, 2019; Caglar et al., 2021). The findings will contribute to the literature on environmental policy assessment and provide insights for more sustainable policymaking. Accordingly, the stochastic behavior of Türkiye's per capita EF and its subcomponents will be examined to assess the long-term impacts of environmental policy actions implemented during the specified period.

By centering its analysis on the Turkish economy and utilizing a distinct methodological framework, this research aims to offer a meaningful contribution to the existing body of literature. Unlike previous studies that either focus on single indicators, short time spans, or cross-country comparisons, this study offers a country-specific, long-term analysis using a comprehensive ecological metric and advanced time-series techniques. It thereby addresses a gap in the empirical evaluation of Türkiye's environmental policy effectiveness. The structure of the paper is as follows: it opens with an introduction, followed by a discussion on the concept of EF. The subsequent section presents a review of relevant literature, leading into the data and methodology employed in the analysis. The paper concludes with the presentation of empirical results, final remarks, and policy implications.

2. Ecological Footprint

In order to evaluate whether environmental policies are effective, reliable and comprehensive environmental indicators are needed. CO_2 emissions, commonly used as an indicator of environmental quality and degradation, fail to capture many aspects of environmental conditions. Environmental pollution is not limited to carbon emissions; it also includes water pollution, deforestation, and the destruction of natural resources (Bilgili & Ulucak, 2018). Within this framework, EF stands out as a broader metric of environmental deterioration, particularly because its carbon footprint subcategory encompasses data on CO_2 emissions. The EF was originally introduced by Rees (1992) and later formalized and expanded by Wackernagel and Rees (1996), it reflects the impact of anthropogenic activities on the ecosystem. EF reveals the relationship between the biocapacity consumed by a given population or economy and the regenerative capacity of renewable resources. By doing so, it provides a means to assess the extent to which countries exhibit balanced development from the perspective of ecological sustainability, thereby playing a role in the formulation of sustainable development and growth policies (Global Footprint Network, 2021; Adali et al., 2025).

Among the subdimensions of the EF, the carbon footprint (CF) represents the amount of forest land needed to offset the carbon dioxide emissions generated by fossil fuel consumption. Cropland Footprint (CRF), the land area demanded for crop cultivation, Grazing Land Footprint (GLF), the pasture land required for livestock, Forest Products Footprint (FPF), the forest area used for products such as wood and paper, Fishing Grounds Footprint (FGF), the marine or freshwater area needed to sustain fish and seafood consumption, and Built-up Land Footprint (BLF), the land area occupied by infrastructure and urban structures (Çaglar et al., 2021; Adali et al., 2025). Unlike traditional environmental indicators, EF and its subcomponents do not focus on a single environmental element. Instead, they encompass energy consumption, land use, forest resources, water resources, and carbon emissions, thereby reflecting the environmental impacts of human activities. Offering a broader perspective, EF serves as an aggregated indicator and has been widely used by policymakers and academics alike (Ulucak & Lin, 2017; Yurtkuran, 2020). In this study, the six subcomponents of the ecological footprint, CF, CRF, GLF, FPF, FGF and BLF are analyzed separately in addition to the aggregate EF indicator. The rationale behind this disaggregation is twofold. First, each subcomponent reflects a distinct dimension of environmental pressure, allowing for a more granular assessment of policy effectiveness. For example, while CF is closely related to energy and climate policy, CRF and FGF are influenced by agricultural and fisheries regulations. Second, previous research suggests that environmental indicators may behave differently across subdimensions, with some exhibiting stationarity and others not (Ulucak & Lin, 2017; Solarin, 2019; Caglar et al., 2021). By examining each component individually, the analysis aims to identify which areas of environmental governance have been more successful in inducing lasting improvements, thus enabling more targeted policy recommendations.

For many years, Türkiye's economic growth has been predominantly fueled by resource-intensive sectors such as agriculture and manufacturing, which rely significantly on the extensive use of environmental assets. The adoption of import-substituting industrialization strategies during the latter part of the twentieth century, followed by export-oriented growth strategies, have increased environmental pressures. The environmental impacts of rapid industrialization, urbanization, and economic growth have become increasingly evident in the Turkish economy (Ullah et al., 2023). The high resource intensity of the Turkish economy and its strong dependence on fossil fuels have led to a continued rise in absolute environmental pressures—a trajectory that does not appear ecologically sustainable (OECD, 2019; Adebayo et al., 2022). Assessing the effectiveness of sustainable development and environmental policies and determining whether the implemented measures have been successful in slowing down environmental degradation, constitutes a significant line of inquiry.

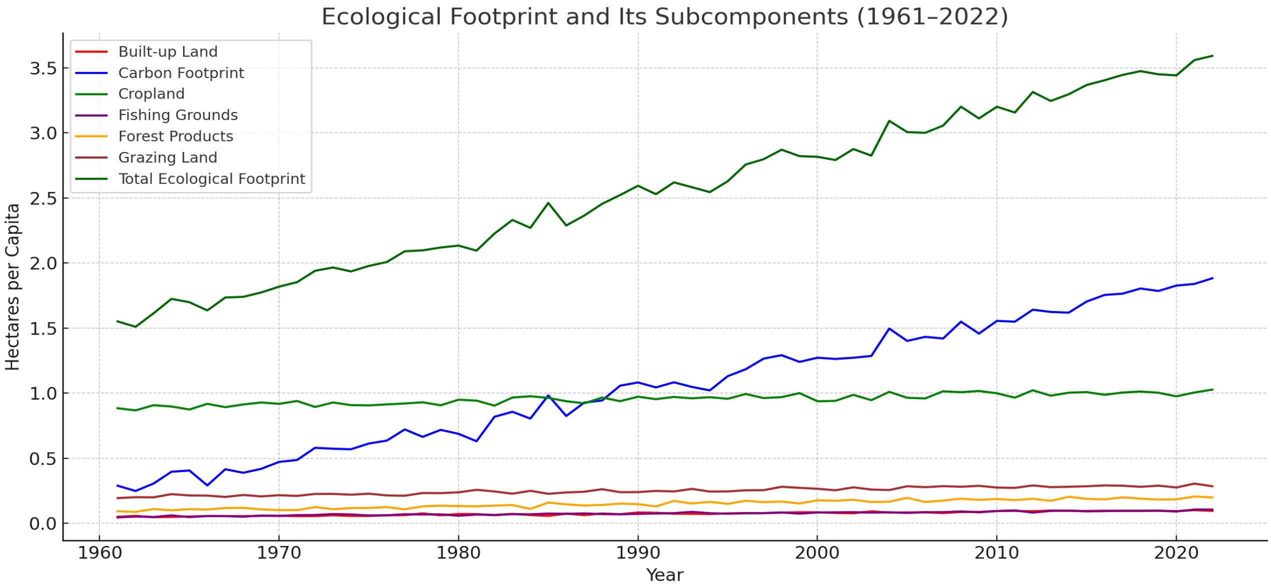
In this context, the long-term effectiveness of environmental policies in Türkiye will be evaluated based on the time-series behavior of per capita EF and its individual components. If a series is determined to be stationary, it implies that external shocks have only temporary effects, with the series reverting to a stable mean and variance over time. This outcome may be interpreted as evidence that the applied environmental policies have failed to induce lasting changes (Yilancı et al., 2019; Caglar et al., 2021; Adali et al., 2025). Conversely, if the series contains a unit root, it implies that shocks to the series generate permanent effects, the mean and variance of the series shift over time, and the policies applied to the variable in question are effective (Ulucak & Lin, 2017; Solarin et al. 2019; Caglar et al., 2021). Furthermore, as discussed in the literature review, stationarity analysis is also employed in studies focusing on convergence. In research involving country groups, the stationarity of a given series is interpreted as evidence of convergence (Ulucak & Lin, 2017).

Figure-1 illustrates the historical evolution of Türkiye’s EF and its respective subcomponents. It is evident that Türkiye’s EF has increased significantly over the period 1961–2022. The strongest contributor to this increase is the CF, which has shown a rapid upward trend, particularly since the 1990s. This reflects the rise in Türkiye’s carbon-based energy consumption and emission levels over time. In addition, deforestation, degradation of agricultural lands, and land-use changes driven by urbanization have contributed to the growth of the ecological footprint.

BLF and FPF have also shown an upward trend. This phenomenon points to changes in urbanization patterns and land use. In contrast, the GLF and FGF components have declined over time, while the CRF has remained relatively stable. These findings indicate that ecological pressure has increasingly become carbon-based, highlighting the difficulty of achieving environmental sustainability under current conditions.

Figure 1

Trends in the EF and its Subcomponents



Source: Global Footprint Network

3. Literature Review

In recent years, the literature on the relationship between environmental policies, EF and stationarity has expanded significantly. Earlier research largely relied on CO_2 emissions as a representative indicator of environmental performance. The growing popularity of EF indicator has led to an increase in long-term analyses of environmental sustainability, policy effectiveness, and convergence across various countries and country groups. Empirical findings on the stationarity of EF series worldwide present a complex picture. Some studies have found that EF series are stationary in many countries, whereas others emphasize that a significant portion of these series are nonstationary. This section first summarizes the results of studies conducted on different countries, and subsequently discusses the findings specific to Türkiye.

Ulucak and Lin (2017) examined the stationarity of EF and its subcomponents for the United States over the period 1961–2013 using various unit root tests (URT). Their findings indicate that all EF components, except CRF and biocapacity, are nonstationary. These results imply that policy shocks would have permanent effects. Bilgili and Ulucak (2018) tested the stationarity, convergence, and policy effectiveness of EF data for G-20 countries from 1961 to 2014 using the panel KPSS test. The results suggest that the series is stationary and provide support for environmental convergence among G-20 countries. Ulucak and Apergis (2018) tested the convergence hypothesis of the EF variable for 20 EU countries during the 1961–2013 period. Their findings revealed the presence of club convergence in only a small number of countries. Solarin and Bello (2018) investigated the stationarity of the EF variable for 128 countries during the period 1961–2013. The results showed that the series is nonstationary in 96 countries, indicating that environmental policies in those countries are likely to have permanent effects in the long run. Bilgili and colleagues (2019) tested the stationarity of EF series in 15 selected countries from Asia, Africa, the Americas, and Europe. Their results revealed that in particular, EF is nonstationary and diverging in the group of Asian countries. Yilancı and colleagues (2019) analyzed the stationarity of EF and its six subcomponents using data from 25 OECD member countries covering the period 1961–2013. Their findings indicated that all variables, except the FGF do not contain a unit root. Solarin (2019) investigated the stationarity of EF and its CF subcomponent in 27 OECD countries between 1961 and 2013 using the RALS-LM URT. The results show that the relative per capita CF is stationary around two structural breaks in 22 countries and around one break in 3 countries. This suggests that environmental policies in those countries have not been effective.

Solarin and colleagues (2019) examined the stationarity of CF variable for 92 countries over the period 1961–2014 using an ARMA model. Their findings revealed that the variable exhibits mean-reverting behavior (i.e., stationarity) in 25 countries. Consequently, policies aimed at reducing CF in these countries are unlikely to be effective. Using the KPSS and Fourier KPSS unit root tests, Ozcan and colleagues, (2019) investigated the stationarity of EF data for 113 countries over the 1961–2013 period. Their findings indicate that EF series are stationary in all high-income economies and in certain upper- and lower-income groups, while lower-middle-income countries generally exhibit nonstationary behavior. Yurtkuran (2020) investigated the stationarity of the EF series in newly industrialized countries, known as the N-11, during the period 1971–2016. The study found that the EF series was stationary in Indonesia, Pakistan, and the Philippines, while it exhibited unit root behavior in Türkiye, Bangladesh, Egypt, Iran, Mexico, Nigeria, South Korea, and Vietnam, implying that shocks to environmental pollution in these countries would have lasting effects.

In a study covering the years 1961 to 2016, Solarin (2020) examined the stationarity of the FPF variable across 89 countries. The analysis revealed that the stationarity was rejected in 22 countries from the Americas, 19 from Asia and Oceania, and 22 from Europe, suggesting persistent shocks in these regions. These results indicate that the FPF variable is nonstationary and that policy shocks in these countries are likely to have permanent effects. Alper and Alper (2021) examined the stationarity of EF and its subcomponents for MINT countries during the 1961–2016 period using the Fourier unit root test. The findings indicate that CRF is stationary for Mexico; EF and BLF are stationary for Indonesia; CRF and GLF are stationary for Nigeria; and FGF and FPF are stationary for Türkiye. However, CF subcomponent was found to be nonstationary in all MINT countries. Caglar and colleagues, (2021) studied the stationarity of EF and its subcomponents in the EU-5 countries for the period 1961–2016. Their results show that all EF subcomponents exhibit unit root behavior. However, in Spain, BLF, and in the United Kingdom, GLF and FPF, were found to be stationary.

Yilancı and colleagues (2022) applied the fractional frequency Fourier ADF test to assess the stationarity of the EF and its subcomponents in ten major developing economies, known as the “Big Ten,” over the 1961–2017 period. Their analysis largely indicated stationarity across the series, implying that environmental policy shocks in these countries have produced only short-term effects. Accordingly, the policies implemented to mitigate environmental degradation have not yielded sustained improvements in the long run. In a separate study, Yilancı and colleagues, (2022b) analyzed the stationarity of the EF variable in 13 Mediterranean countries, including Türkiye, over the period 1961–2014 using the RALS-LM URT. The analysis results indicate that EF series is stationary in 10 countries. In a study by Alper and colleagues (2023), the authors tested the presence of convergence in EF and its subcomponents for 20 countries between 1961 and 2018 using the Hepsag (2021) URT. In the case of Türkiye, which is the focal point of the study, convergence was found in CF and FPF variables, while no convergence was detected in the total EF and other subcomponents, indicating the presence of a unit root in those series. Bayraktar and colleagues (2023), in their study on BRICS-T countries for the period 1992–2017, examined the convergence dynamics of EF using ADF, Fourier ADF, and Fractional Frequency Fourier ADF URTs. The findings revealed that the presence of convergence differs depending on both the country examined and the testing methodology employed: while the traditional ADF test indicated convergence in Russia and Türkiye, the Fourier ADF test supported convergence in China and Russia, and the fractional Fourier test identified convergence in Brazil and China. Hacıimamoğlu (2023) tested the stationarity of EF and its subcomponents for Qatar over the period 1980–2017 using the Fourier URT. The most advanced method, the fractional frequency Fourier ADF test, indicated that the BLF, CF, and EF are stationary. Kaya and Gov (2023) examined the stationarity of the EF variable in BRICS-T countries using both linear and nonlinear URTs for the period 1961–2017. According to the Sollis (2009) test, EF was stationary only in Russia, while the Harvey and colleagues (2013) test indicated stationarity in both Russia and Türkiye. In the remaining countries, the EF variable was found to be nonstationary.

In their 2025 study, Adali and colleagues examined the stationarity of the GLF series for 13 countries with the highest share in global meat and dairy production over the period 1961–2022 using various URTs. The results indicate that the series tend to follow their long-term trends, suggesting that shocks do not lead to permanent deviations from these paths. Karaaslan and Karadavut (2025) investigated the stationarity of EF and its subcomponents for Türkiye over the period 1961–2022 using the Fourier-KPSS stationarity test. Their findings revealed that EF, along with CF, CRF, and BLF series, are nonstationary, while the FGF, FPF and GLF series exhibit stationarity.

In conclusion, the literature presents mixed empirical findings regarding the stationarity of the EF and related environmental indicators across countries. Türkiye is also represented in the literature by studies that suggest partial evidence of stationarity (Alper & Alper, 2021; Yilancı et al., 2022b; Alper et al., 2023; Kaya & Gov, 2023), as well as studies that conclude the presence of unit roots in the EF series (Yurtkuran, 2020; Karaaslan & Karadavut, 2025). Compared to these works, this study contributes to the literature in three distinct ways. First, it focuses exclusively on Türkiye using updated data extending to 2022, offering a more contemporary perspective than earlier studies such as Ulucak and Lin (2017) or Yurtkuran (2020). Second, it employs both the conventional ADF test and the RALS-LM URT, which accounts for structural breaks and non-normal error distributions, thereby enhancing the robustness of the findings (Meng et al., 2017; Solarin, 2019). Third, it evaluates all six subcomponents of the ecological footprint separately, providing a more nuanced understanding of which areas of environmental policy in Türkiye have been effective in producing long-term improvements and which have not. This comprehensive and methodologically refined approach allows for a more accurate assessment of environmental policy outcomes over a 60-year period.

4. Methodology and Data Set

In this section, the unit root properties of per capita EF and its subcomponents for the Turkish economy will be investigated for the period 1961–2022. To achieve this objective, conventional ADF and RALS-LM URTs are applied to the relevant series to assess their stationarity. All series are obtained from the Global Footprint Network database. Table 1 presents the summary statistics of the variables. The component with the highest mean value is the CF, with a level of 1.11 hectares per capita, making it the largest contributor to the EF. It is followed by the CRF and the FPF. The lowest average value belongs to the FGF. The Jarque-Bera test p-values suggest that the majority of the series conform to the assumption of normality.

Table 1

Descriptive Statistic

Variable	Mean	Min.	Max.	Standart D.	Jarque-Bera Normality p-value
BLF	0.030527	0.015081	0.043578	0.008637	0.074727
CF	1.114187	0.270215	2.019784	0.547739	0.117960
CRF	0.946994	0.784546	1.102187	0.065553	0.262129
FGF	0.064418	0.023879	0.126356	0.022406	0.163248
FPF	0.243341	0.147502	0.327294	0.048007	0.366929
GLF	0.165732	0.098392	0.264290	0.040963	0.237678
EF	2.565199	1.644816	3.476258	0.549387	0.153074

In time series analysis, a series is considered stationary if its statistical characteristics such as mean remain stable over time. Conversely, the existence of a unit root signals nonstationary, implying that the series may follow a trend or that shocks could lead to lasting impacts (Mert & Caglar, 2019). In nonstationary series, traditional regression analyses may yield misleading results known as spurious regression and any policy intervention or shock may have a lasting impact (Enders, 2015). If the EF and its subcomponents used in this study are found to be nonstationary, this would imply that an environmental policy implemented could lead to a permanent change in the corresponding indicator. In contrast, when a series is stationary, temporary deviations typically diminish over time as the series reverts to its long-term mean, suggesting that the influence of policy interventions may not be permanent (Caglar et al., 2021).

The most conventional methods for stationarity analysis are the ADF and PP URTs. However, these standard tests do not account for structural breaks or trend shifts, and they assume that error terms are linear and normally distributed. In reality, economic variables particularly environmental indicators in the context of this study may undergo substantial structural changes in the long run (e.g., oil shocks, the enforcement of climate agreements, technological revolutions), and the distribution of the data may deviate from normality. In light of these considerations, more advanced URTs have been developed in the literature. Within this scope, Meng and colleagues (2017) proposed the RALS-LM test for cases involving one or two structural breaks. The RALS-LM method enhances the power of the URT by incorporating the moments of the error term and allows for multiple structural breaks and deviations from normality (Solarin, 2019).

The RALS-LM test follows a two-step estimation procedure.

As an initial step, the LM test regression proposed by Lee and Strazicich (2003, 2004) is estimated through the application of the Ordinary Least Squares (OLS) technique (Hepsağ, 2022, p. 226).

$$\Delta y_t = \varphi \Delta z_t + \vartheta y_{t-1} + \sum_{i=1}^{k} \delta_k y_{t-1} + \lambda S_{t-1} + \varepsilon_t \quad (1)$$

In this equation, S_{t-1} denotes the LM trend-adjusted form of the outcome variable. The deterministic component of the specification, which incorporates two structural breaks in both the level and the slope of the trend, is formulated as follows:

$$z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]$$

D_{1t}t, D_{2t}t are dummy variables representing the first and second breaks in the intercept, while DT_{1t}, and DT_{2t} are additional dummy variables used to model the structural breaks in the deterministic trend (Hepsag, 2022, pp. 226–227).

The RALS-LM test relaxes the normality assumption by incorporating higher moments (specifically the second and third) of the error term, thereby enabling the test to yield robust results even in the presence of non-normally distributed errors (Meng et al., 2017; Aytemiz et al., 2021).

$$\Delta y_t = \varphi \Delta z_t + \vartheta y_{t-1} + \sum_{i=1}^{k} \delta_k y_{t-1} + \lambda S_{t-1} + \chi_2 \widehat{w}_{2t} + \chi_3 \widehat{w}_{3t} + \varepsilon_t \quad (2)$$

In Equation (2), the extended variables χ_2 and χ_3 derived from the residuals, are incorporated into the model. The RALS-LM test statistic is then computed using the following equation:

$$\tau_{RALS-LM} = \rho \tau_{LM} + \sqrt{1-\rho^2} Z \quad (3)$$

In this equation, ρ denotes the ratio of the error term variance in the RALS-LM equation to the error term variance in the standard LM equation (Hepsag, 2022, p. 228).

In this study, prior to applying URTs, the inclusion of appropriate deterministic components (intercept and/or trend) for each series was determined through both visual inspection and comparisons based on information criteria. As highlighted by Traore and Diop (2021), test statistics are influenced by whether deterministic terms are included in the URT. In line with Enders (2015), incorporating unnecessary parameters into the model reduces its predictive power. Incorrect specification of deterministic components can lead to biased rejection of the null hypothesis in unit root testing. Hence, correctly specifying the non-stochastic components of the series is of critical importance. The ADF and RALS-LM unit root tests are selected not only for their statistical rigor but also for their practical relevance in long-term policy analysis. While the ADF test serves as a conventional baseline, it assumes normally distributed error terms and does not account for structural breaks limitations that may lead to biased results when working with macro-level environmental data. In contrast, the RALS-LM test, developed by Meng and colleagues (2017), accommodates both non-normal error distributions and multiple structural breaks. This is particularly important in the case of Türkiye, where visual inspection and descriptive statistics reveal that the residuals of many ecological indicators deviate from normality, and the historical period (1961–2022) includes substantial policy shifts, economic transitions, and external shocks that likely caused structural changes in the data-generating process. By addressing these features, the RALS-LM test provides more reliable and robust inference about the persistence or transience of shocks to environmental indicators. From a policy-making perspective, understanding whether a shock induces permanent or temporary effects helps assess the long-term effectiveness of interventions. Therefore, the chosen methodology not only enhances econometric accuracy but also offers valuable guidance for the design of sustainable environmental policies.

In the initial stage, graphical analyses were conducted for Türkiye's EF and its six constituent indicators covering the period from 1961 to 2022. As observed in Figure 1, some of the series exhibit a clear upward trend, while others appear to fluctuate around a constant mean. Within this context, the BLF, CF, GLF, and EF series appear to contain a trend, whereas no evident trend was observed in the CRF, FGF, and FPF series. In addition to graphical analysis, the significance level (p-value) of the trend variable and the Akaike Information Criterion (AIC) values were calculated for each series under two different deterministic specifications: one including only an intercept, and the other including both intercept and trend. The lower the AIC value, the better the model is considered to be (Enders, 2015). The table below presents the AIC values for each series along with the preferred model type (i.e., the one with the lowest AIC).

Table 2

Model Selection

Series	**p-value of Trend Variable**	**AIC (Intercept Only)**	**AIC (Intercept + Trend)**	**Preferred Model**
BLF	0.0338	-581.212	-589.010	Intercept + Trend
CF	0.0003	-119.927	-130.730	Intercept + Trend
CRF	0.3365	-158.518	-157.645	Intercept Only
FGF	0.3423	-308.237	-307.396	Intercept Only
FPF	0.3052	-306.004	-305.180	Intercept Only
GLF	0.0095	-345.309	-345.691	Intercept + Trend
EF	0.0000	-48.151	-67.492	Intercept + Trend

When both the visual trend analysis and the significance levels of the trend variable, along with AIC comparisons, are jointly evaluated, the most appropriate deterministic components to be used in the URT's for each series are presented in Table 2. This approach aims to prevent any loss of power in the URT that may arise from incorrect model specification. As a result, for the BLF, CF, GLF, and EF series, the model including both intercept and trend will be used, while for the remaining series, the model with only an intercept will be considered.

5. Findings

This section investigates the stationarity characteristics of EF metrics and their constituent elements to evaluate the effectiveness of environmental policy measures in Türkiye. Both the ADF URT and the RALS-LM test are employed. The results of the URTs provide a basis for drawing conclusions about the effectiveness of environmental policies. A stationary series implies that the environmental indicator tends to revert to its mean over time, indicating that policy effects are transitory. In contrast, identifying a unit root in the variables implies that alterations are enduring and that policy actions have led to permanent changes in the variable, which may be interpreted as an indication of effective policy implementation (Ulucak & Lin, 2017; Solarin, 2020).

Table 3

ADF URT Result

Series	Intercept Only	Intercept + Trend	Stationary Status
BLF/ΔBLF	-1.0241 /-6.9537***	-2.4100 /-6.9429***	Nonstationary
CF/ ΔCF	-0.6571 /-7.2767***	3.7518** /-7.2214***	Stationary
CRF	-6.8465***	-6.9587***	Stationary
FGF	-4.5447***	-4.6524***	Stationary
FPF/ ΔFPF	-1.9736 /-9.1483***	-2.0577 / -9.1093***	Nonstationary
GLF / ΔGLF	-2.3412 /-10.1360***	-3.9146** /-10.1998***	Stationary
EF	-0.9520	-5.1318***	Stationary

Note: ** indicates significance at the 5% level, *** indicates significance at the 1% level.

ADF URT result show that, only the BLF and FPF series contain a unit root, indicating that environmental policies in these areas have produced long-term effects. The other series were found to exhibit stationary properties. However, because the ADF test overlooks potential structural shifts in the data, the stochastic properties of the variables were further analyzed using the RALS-LM URT. Considering the model specifications, the results of the intercept-only model will first be discussed, followed by those of the intercept and trend model. Table 4 presents the result of the RALS-LM URT intercept model results. The intercept-only model yields statistically significant outcomes for the CRF, FGF, and FPF variables. In the cases of CRF and FGF, the test statistics surpass the corresponding critical thresholds, resulting in the rejection of the null hypothesis and suggesting that these series exhibit stationarity. This implies that policies implemented in the areas of cropland and fishing have been effective.

Table 4

Model Selection RALS-LM URT Intercept Model Result

Variable	Break Dates	ρ^2 value	Test Stats.	Critical Value 5%	Lag Length	Result
BLF	2000/2006	0.90643	-4.37870	-3.044	0	Stationary
CF	1993/2000	0.86113	-3.04655	-3.044	6	Stationary
CRF	1974/1989	0.76348	-2.24228	-2.991	9	Nonstationary
FGF	2004/2006	0.96929	-2.67233	-3.100	7	Nonstationary
FPF	1993/2004	0.99695	-5.18346	-3.100	10	Stationary
GLF	1972/1994	0.89347	-1.59597	-3.044	0	Nonstationary
EF	1992/2000	0.97978	-1.67185	-3.100	5	Nonstationary

In contrast, the FPF series remains nonstationary, suggesting that policies related to forest products have not led to permanent shocks in the series. The break dates identified in the CRF series coincide with periods when Türkiye faced international embargoes and began transitioning economically and urbanizing. For the FGF series, the break dates correspond to phases of substantial policy changes in the fisheries sector within the framework of EU harmonization efforts. In the case of FPF, the year 2004 when sustainable forest management was officially adopted as a national strategy is marked as a structural break (Sener & Tolunay, 2016).

Table-5 displays the findings obtained from the intercept and trend specification. Importantly, the EF is identified as level stationary. This indicates that environmental policies implemented in Türkiye have largely produced transitory effects on the EF and its subcomponents, with limited capacity to generate permanent shocks in the series. The stationarity findings for the BLF, CF, and GLF variables suggest a tendency for these series to revert to their mean, implying that environmental policies in these areas have not been sufficient to induce stable and transformative change. Moreover, the presence of structural breaks in these stationary series does not appear to have altered their long-term stochastic properties, highlighting the temporary nature of the shocks experienced. The analysis reveals that in the RALS-LM intercept-only model, the CRF and FGF series exhibit unit root behavior, indicating nonstationary (both models support this conclusion). However, according to the intercept and trend model, all series are found to be stationary. The overall findings of this study align with those of Yilancı and colleagues (2019) and Solarin (2019).

Table 5

Result RALS-LM URT Trend and Intercept Model Results

Variable	Break Dates	ρ^2 value	Test Stats.	Critical Value 5%	Lag Length	Result
BLF	1999/2009	0.92092	-5.54293	-4.259	0	Stationary
CF	1999/2006	0.96921	-5.78719	-4.377	5	Stationary
CRF	1989/2005	0.93140	-6.79424	-4.259	0	Stationary
FGF	1979/1988	0.49069	-1.98502	-3.682	10	Nonstationary
FPF	1992/2002	0.99964	-5.8083	-4.377	10	Stationary
GLF	1983/1997	0.79005	-5.67269	-4.133	8	Stationary
EF	1999/2002	0.86701	-5.04039	-4.259	4	Stationary

The result showing that the EF series is stationary is consistent with other Türkiye-based studies in the literature, such as Yilancı and colleagues (2022a) and Kaya and Gov (2023), but contrasts with the findings of Karaaslan and Karadavut (2025). The stationarity of the CF, which is the largest subcomponent of the EF, supports the results reported by Solarin (2019) and Alper and colleagues (2023), but differs from those of Karaaslan and Karadavut (2025). These discrepancies may stem from the methodologies employed or from the distinct economic and environmental dynamics of the Turkish economy, particularly in panel data studies where cross-country differences may influence the results.

6. Conclusion and Policy Recommendations

This study evaluates the long-term effectiveness of environmental policies implemented in Türkiye by analyzing the stationarity properties of per capita EF and its subcomponents. URTs were applied using annual data for the period 1961–2022 to assess whether environmental policies have produced lasting or transitory effects. The ADF and RALS-LM URTs were employed to determine the persistence of policy impacts on EF and its components.

The findings reveal that Türkiye's performance in environmental sustainability remains limited. Both the per capita EF series and most of its subcomponents are found to be stationary at level when structural breaks are taken into account. Particularly, the stationarity of the per capita EF series indicates that environmental policies have failed to generate long-term effectiveness. When examined at the subcomponent level, only the CRF and FGF series are identified as nonstationary, suggesting that policy changes in agriculture and fisheries have led to permanent transformations in these environmental indicators. In contrast, the stationarity of CF, FPF, GLF, and BLF indicates that environmental policies in these areas have not been successful in generating lasting structural change.

These results suggest that environmental policies in Türkiye should be redesigned in a more holistic, long-term, and structurally transformative manner. By combining an extended time horizon with robust methodological tools, this research not only fills a gap in the empirical literature on Türkiye but also provides a replicable framework for other developing economies seeking to evaluate environmental policy outcomes. Based on the study's findings, several policy recommendations are proposed. First, as the CF is the largest subcomponent of the EF, steps should be taken to reduce it by accelerating the transition to renewable energy, improving energy efficiency, and promoting investments in clean technologies, especially in industry. Additionally, land use and urbanization-related environmental policies should be restructured. Policy reforms focusing on sustainable land use in agriculture, grazing activities, and urban planning are recommended to enhance environmental sustainability in Türkiye.

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