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Linking Human Development Index, Urbanization, Economic Growth and the Ecological Footprint: The Case of MINT Countries

İnsani Kalkınma Endeksi, Kentleşme, Ekonomik Büyüme ve Ekolojik Ayak İzi İlişkisi: MINT Ülkeleri Örneği

Esra Cebeci Mazlum[1]

ÖZ

Bu çalışmanın temel amacı insani kalkınma endeksi, kentleşme, ekonomik büyüme ve ekolojik ayak izi ilişkisini MINT ülkelerinde (Meksika, Hindistan, Nijerya ve Türkiye) 2003-2022 yılları için araştırmaktır. Öncelikle insani kalkınma endeksi, kentleşme, ekonomik büyüme ve ekolojik ayak izi arasındaki eşbütünleşme ilişkisi Gengenbach, Urbain ve Westerlund (2016) panel eşbütünleşme ile incelenmiştir. Eşbütünleşme analizi neticesinde değişkenlerin eşbütünleşik olduğu sonucuna varılmıştır. Uzun dönemli ilişki DOLSMG yöntemi ile tahmin edilmiştir. DOLSMG tahmincisine göre MINT ülkelerinde insani kalkınma endeksindeki % 1'lik artışın ekolojik ayak izini % 1.89 azalttığı belirlenmiştir, kentleşmedeki % 1'lik artış ekolojik ayak izini % 0.22 arttırmıştır ve ekonomik büyümedeki % 1'lik artış ise ekolojik ayak izini önemsiz derecede arttırmıştır. İkinci olarak insani kalkınma endeksi, kentleşme, ekonomik büyüme ve ekolojik ayak izi arasındaki ilişki Dumitrescu ve Hurlin (2012) panel nedensellik analizi ile incelenmiştir. Elde edilen bulgulara göre MINT ülkelerinde ekolojik ayak izi ile kentleşme arasında çift yönlü nedensellik ilişkisi vardır. Ayrıca, çalışmanın bulguları ekolojik ayak izinden insani kalkınma endeksine doğru tek yönlü nedensellik ilişkisi olduğunu ve ekonomik büyümeden ekolojik ayak izine doğru tek yönlü nedensellik ilişkisi olduğunu göstermektedir.

Anahtar Kelimeler: İnsani Kalkınma Endeksi, Kentleşme, Ekonomik Büyüme, Ekolojik Ayak İzi

ABSTRACT

The main purpose of this study is to investigate the relationship between human development index, urbanization, economic growth and ecological footprint in MINT countries (Mexico, Indonesia, Nigeria and Turkiye) for the years 2003-2022. First of all, the cointegration relationship between human development index, urbanization, economic growth and ecological footprint was examined with Gengenbach, Urbain and Westerlund (2016) panel cointegration. As a result of the cointegration analysis, it was concluded that the variables were cointegrated. The long-term relationship was estimated by the DOLSMG method. According to the DOLSMG estimator, it was determined that a 1% increase in the human development index in MINT countries reduced the ecological footprint by 1.89%, a 1% increase in urbanization increased the ecological footprint by 0.22%, and a 1% increase in economic growth increased the ecological footprint insignificantly. Secondly, the relationship between human development index, urbanization, economic growth and ecological footprint was examined with Dumitrescu and Hurlin (2012) panel causality analysis. According to the findings, there is a bidirectional causality relationship between ecological footprint and urbanization in MINT countries. Additionally, the findings of the study show that there is a unidirectional causality relationship from ecological footprint to human development index and a unidirectional causality relationship from economic growth to ecological footprint.

Keywords: Human Development Index, Urbanization, Economic Growth, Ecological Footprint

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INTRODUCTION:

Humanity has been interacting with the environment since its existence. However, the resources provided by the environment are not unlimited. Environmental problems, which were initially ignored and put on the back burner due to factors such as rapid population growth, urbanization and industrialization over time, are now growing and threatening the whole world (Tosunoglu, 2014: 134). As environmental problems increase and environmental awareness becomes widespread, the concept of ecological footprint, which allows measuring environmental sustainability, has emerged (Ozsoy ve Dinc,2016: 36).

The ecological footprint is an ideal indicator of environmental sustainability. It is seen as a complementary educational tool that makes different dimensions of sustainability traceable. It is an ideal platform for organizing information on sustainable development. It is a very good example for increasing social ecological awareness. It is a way to improve the understanding of national and global equality (Keles, 2010: 5). The ecological footprint appears to be designed to provide a way to both measure and reduce ecological impacts on the Earth's limited stock of resources (Marazzi, 2017: 10). The Ecological Footprint is a measure of human demand on the Earth's ecosystems (Elhadi, 2013: 1). Ecological Footprint accounting measures the demand on and supply of nature (GFN, 2019). Traditional ecological footprint methodology is usually expressed in global hectares (Zadgaonkar and Mandavgane, 2020: 2208). If a country's ecological footprint is more than its biocapacity, it means it has an ecological reserve and is in the position of an "environmental creditor"; If the ecological footprint is less than the biocapacity, an ecological reserve deficit occurs and it is expressed as an "ecological debtor" country (Ghita, 2018: 10).

The world has experienced significant economic growth in the last few decades as a result of industrialization and urbanization (Dong et al., 2018). Economic growth and associated urbanization and industrialization trends increase national resource extraction and consumption, leading to environmental unsustainability (Baloch et al., 2019). As economies grow and the rate of urbanization increases, electricity consumption tends to increase due to increased industrialization, urban infrastructure development and higher living standards, and the impact of increased electricity consumption on the ecological footprint is far-reaching. As city centers increase and industrialization increases, the demand for energy increases. As a result, the demand for fossil fuels such as coal, oil and natural gas is increasing. Extraction, processing and burning of fossil fuels, which are non-renewable resources, cause significant greenhouse gas emissions, leading to climate change and air pollution. Thus, increases in the ecological footprint may occur (Koc, 2023: 59).

Human Development Index (HDI) refers to a criterion that uses different parameters such as health, education and living level, as well as economic and financial indicators, to compare social welfare between countries (Bulut et al., 2021: 91). According to the Human Development Report, the main purpose of human development is to create suitable environments and opportunities for all current and future people to develop and use their potential in all areas. The human development process is not only about developing people's capacities in the best possible way. It also describes a process to ensure that the provided capacity is used in the best way in economic, social, political and cultural fields (UNDP, 2005: 13). Climate change is thought to be human-caused and progress is needed in many areas. Policies that ignore human capital (education and skills) fail to provide a holistic approach to tackling this challenge (Ahmed and Wang, 2019: 26783).

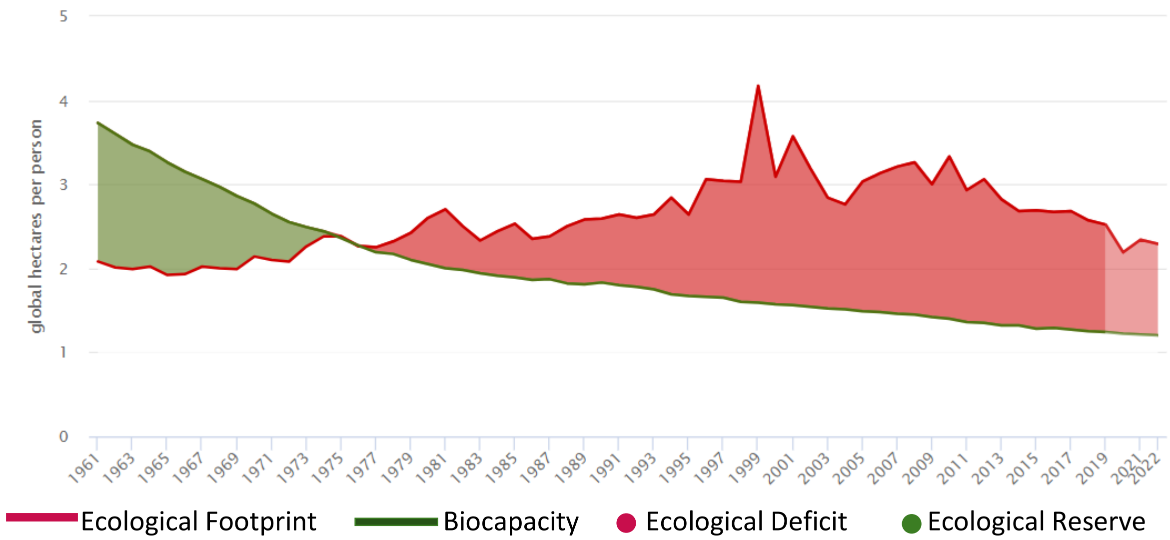
Given this background, this study analyzes the nexuses among human development index, urbanization, economic growth and ecological footprint to create a more comprehensive measure. Due to the selection of the date range that has the broadest coverage of all data on MINT countries, the study covers the years 2003-2022, and this constitutes the limitation of the study. It is known that the economic growth variable is frequently used in the literature within the framework of the factors that determine the ecological footprint. The contribution of this study to the literature is that it is conducted on MINT countries with current data and also addresses urbanization and human development variables as variables affecting the ecological footprint. The remainder of the study is structured as follws: In the first part, ecological footprint, human development ındex, urbanization and economic growth indicators in MINT countries are presented. Section 2 includes selected literature on the subject. The data and model are presented in Section 3. Section 4 includes the method and findings. Conclusions are provided in Section 5.

1. Ecological Footprint, Human Development Index, Urbanization and Economic Growth in MINT Countries

Factors such as industrialization and urbanization cause environmental destruction in the world. Especially countries experiencing rapid economic growth or focusing on industrialization can increase their ecological footprint. According to Global Footprint Network data, the footprint per person in the world in 2022 is 2.58 gha and the biocapacity per person in the world is 1.51 gha. In 1961, while the world's biocapacity was 3.18 gha, the footprint per person was calculated as 2.35 gha. Thus, it can be said that there is more consumption than the renewal rate of resources worldwide.

In the light of data obtained from the Global Footprint Network, ecological footprint data values in MINT countries for the period 1961-2022 are presented in Figure 1-4. Figure 1 shows the course of the ecological footprint in the Mexico for the period 1961-2018. According to this; In 1961, the ecological footprint was determined as 2.08 global hectares (gha) per person, and in 2022 it was 2.29 gha. Additionally, while biocapacity was measured as 3.73 gha per person in 1961, it decreased to 1.2 gha per person in 2022.

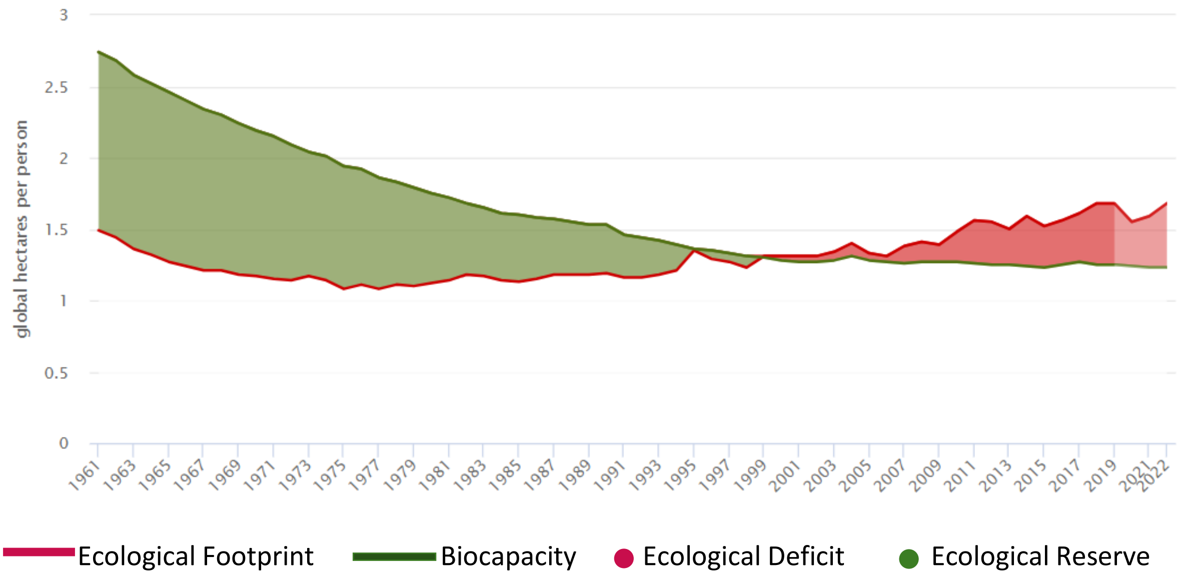
Figure 1. Ecological Footprint in Mexico (1961-2022)



Source: Global Footprint Network

Figure 2 shows the course of the ecological footprint in the Indonesia for the period 1961-2018. According to this; In 1961, the ecological footprint was determined as 1.49 global hectares (gha) per person, and in 2022 it was 1.68 gha. Additionally, while biocapacity was measured as 2.74 gha per person in 1961, it decreased to 1.23 gha per person in 2022.

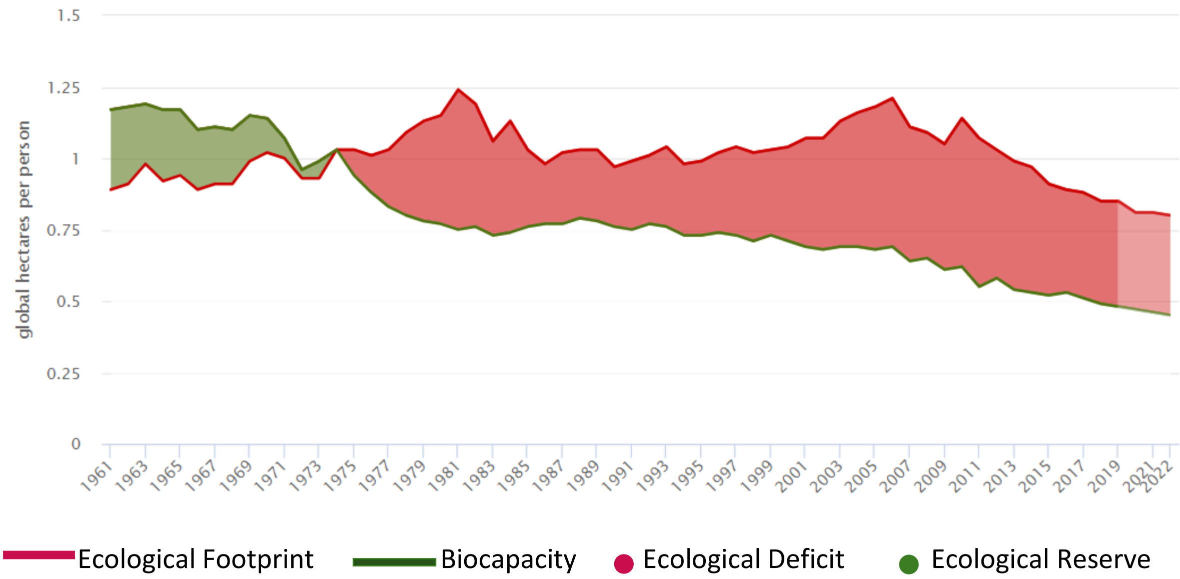
Figure 2. Ecological Footprint in Indonesia (1961-2022)



Source: Global Footprint Network

Figure 3 shows the course of the ecological footprint in the Nigeria for the period 1961-2018. According to this; In 1961, the ecological footprint was determined as 0.89 global hectares (gha) per person, and in 2022 it was 0.8 gha. Additionally, while biocapacity was measured as 1.17 gha per person in 1961, it decreased to 0.45 gha per person in 2022.

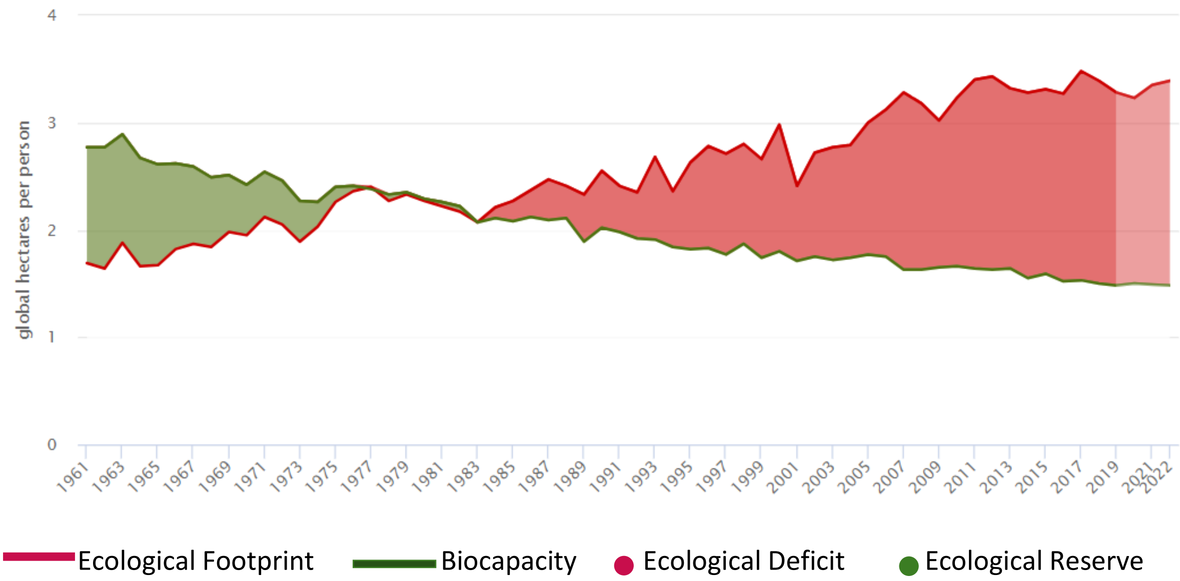
Figure 3. Ecological Footprint in Nigeria (1961-2022)



Source: Global Footprint Network

Figure 4 shows the course of the ecological footprint in the Turkiye for the period 1961-2018. According to this; In 1961, the ecological footprint was determined as 1.69 global hectares (gha) per person, and in 2022 it was 3.39 gha. Additionally, while biocapacity was measured as 2.77 gha per person in 1961, it decreased to 1.48 gha per person in 2022.

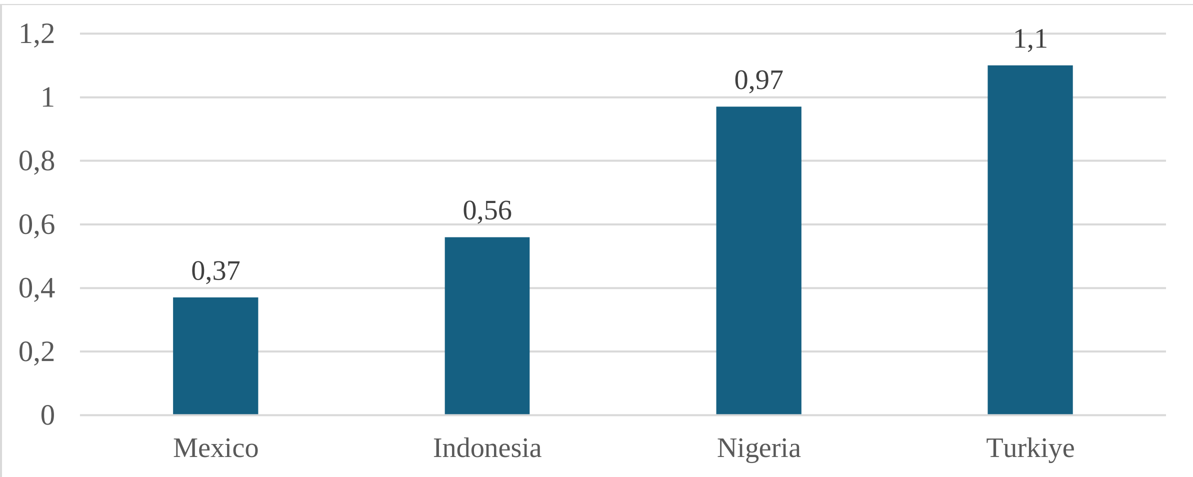
Figure 4. Ecological Footprint in Turkiye (1961-2022)



Source: Global Footprint Network

Figure 5 shows the average human devleopment index growth for the period of 2010-2022 for MINT (Mexico, Indonesia, Nigeria, Turkiye) countries. According to Figure 5, the country with the highest human development index among MINT countries in the 2010-2022 period is Turkiye, with a value of 1.1. Turkiye is followed by Nigeria, Indonesia and Mexico, respectively. According to Human Development Report 2021 in the human development index ranking among 193 countries, Mexico ranks 83rd, Indonesia ranks 113th, Nigeria ranks 162nd and Turkiye ranks 48th.

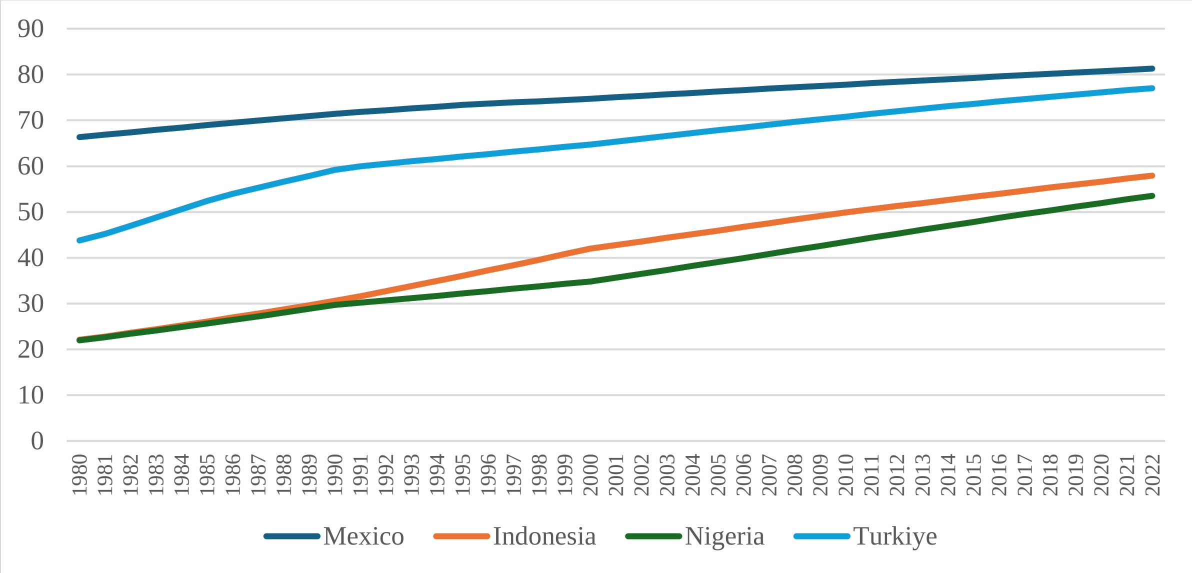
Figure 5. Average Annual Human Development Index Growth % (2010-2022)



Source: UNDP Human Development Reports

In the light of data obtained from the World Bank, urbanization rate values in MINT countries for the period 1980-2022 are presented in Figure X. According to 2022 data, the country with the highest urbanization rate is Mexico. After Mexico, the countries with the highest urbanization rates are Turkiye, Indonesia and Nigeria respectively. When the figure is examined, it is seen that while the urbanization rate in Mexico was around 66% in 1980, it reached around 81% in 2022. While the urbanization rate in Indonesia was around 22% in 1980, it reached around 57% in 2022. While the urbanization rate in Nigeria was around 21% in 1980, this value increased to 53% in 2022. When the urbanization rate data in Turkey is examined, it was around 43% in 1980, and increased to 77% in 2022.

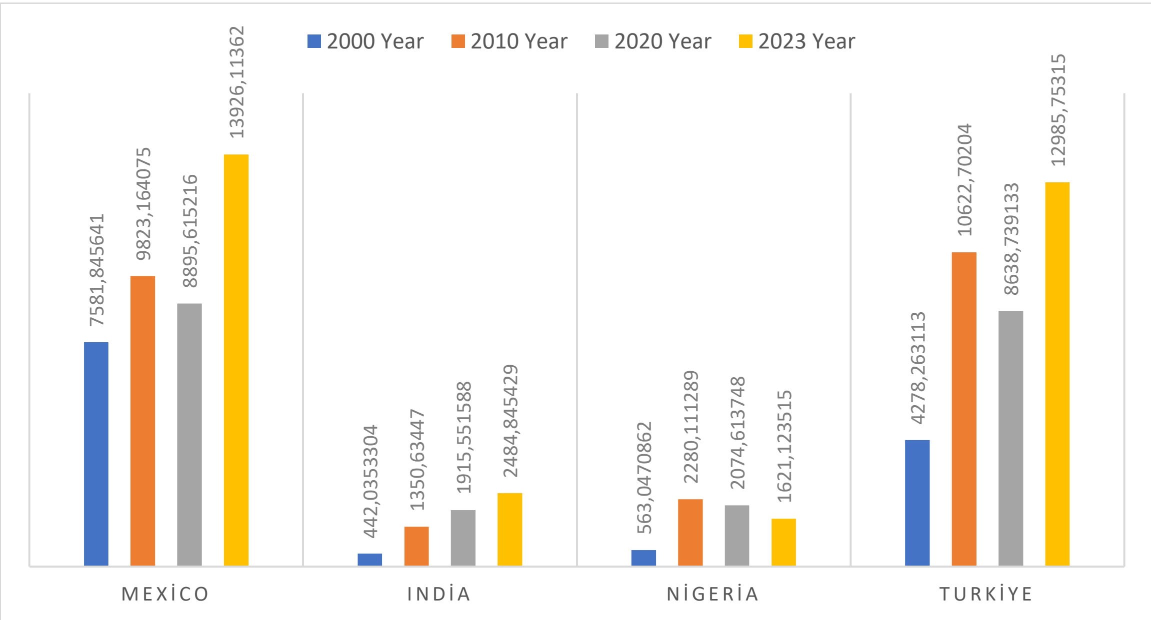
Figure 6. Urbanization Trends in MINT Countries (1980-2022)



Source: World Bank Data

Figure 7 shows the evolution of per capita income of the MINT countries over the period 2000-2023. This GDP per capita indicator provides information on income levels in the very long run. Mexico had the most significant GDP growth of any of the MINT nations for most of the previous two decades.

Figure 7. GDP per capita income of the MINT countries (current US$)



Source: World Bank Data

2. Literature Review

Selected examples from the literature on the relationship between ecological footprint and human development, urbanization and economic growth are summarized as follows:

First of all, we can express the studies in which the human capital variable is used to represent the human development index: In their study, Ulucak and Bilgili (2018) concluded that human capital had a reducing effect on environmental pollution for 45 low, middle and high income countries in the period 1961-2013. Ahmed and Wang (2019) revealed that human capital had a significant negative impact on the ecological footprint in India during the 1971-2014 period. According to causality analysis, human capital causes ecological footprint. Hassan et al. (2018) found that human capital did not improve the ecological footprint in the analysis carried out with the ARDL method in the Pakistani economy using 1970-2014 data. Danish et al. (2019) used the ARDL method in his study and showed that human capital has an insignificant effect on the ecological footprint in the Pakistani economy with 1971-2014 data.

When literature examples regarding ecological footprint and human development index are examined; Pata et al. (2021) concluded in their study for the 10 countries with the largest ecological footprint that human development reduces the ecological footprint. Similarly, Kassouri and Altıntaş (2020) found a cointegration relationship between environmental degradation variables. Additionally, the study concluded that human development increases the ecological footprint. Yıldırım et al. (2022) found that for 10 Mediterranean countries in the period 1995-2018, human capital increased the ecological footprint in countries with low human development, while it decreased the ecological footprint of human capital in places with high human development.

The studies we can give examples from the literature on the relationship between ecological footprint and urbanization are limited: While some of these studies have shown that urbanization increases the ecological footprint, others have found that it reduces it. Nathaniel et al. (2019) As a result of the ARDL analysis for South Africa between 1965 and 2014, it was determined that urbanization reduces the ecological footprint in the long term. Ulucak and Khan (2020) show that urbanization reduces the ecological footprint in BRICS countries with 1992-2016 data and FMOLS and DOLS panel data estimators. Ahmed et al. (2020) using CUP-FM and CUP-BC panel data estimators revealed that urbanization increased the ecological footprint and human capital decreased it in G7 countries for the years 1971-2014. Causality test results showed that there was a unidirectional causality from human capital and urbanization to ecological footprint. In the analysis carried out by Nathaniel (2021) for Cote d'Ivoire, data covering the period 1970-2021 was used and ARDL, DOLS and FMOLS methods were used. The results showed that urbanization increases the ecological footprint. Chen et al. (2022) conducted a study on 110 economies and found that urbanization reduces the ecological footprint as a result of panel data analysis during the period 1990-2016. Arif et al. (2023) applied the NARDL model for the period 1970-2020 to examine the asymmetric effect of urbanization on the ecological footprint in Pakistan. According to the results obtained from the study, urbanization increases the ecological footprint. Khan et al. (2023) used the NARDL method for India for 1971-2018 and revealed that urbanization is good for the environment in the long run, and that the positive and negative shocks of urbanization create asymmetric effects on the ecological footprint. Ullah et al. (2023) analyzed the Turkish economy with the ARDL method with data for the period 1970-2018 and found that urbanization increased the ecological footprint.

Some of the studies within the scope of ecological footprint and economic growth are aimed at determining whether the Environmental Kuznets Hypothesis is valid. Selected literature examples on the subject are as follows: Aşıcı and Acar (2016) discussed the variables of ecological footprint, biocapacity, GDP, trade openness, population density and energy consumption in their analysis of 116 countries for the years 2004-2008. Fixed effects method was used in this study and it was concluded that the environmental Kuznets hypothesis is valid. Other studies confirming the EKC hypothesis; Charfeddine (2017) determined the relationship between economic growth and ecological footprint for the Qatar economy in the period 1970-2015 using the QARDL, Granger causality method. The results also show that urbanization worsens the ecological footprint. In their study for MENA countries, Charfeddine and Mrabet (2017) showed an inverted U-shaped relationship between per capita income and ecological footprint in oil-exporting countries as a result of Panel Granger causality, FMOLS and panel DOLS estimation methods for the years 1975-2007. For countries that do not export oil, the relationship between ecological footprint and economic growth is U-shaped. Additionally, the study findings include strong evidence of bidirectional causality between ecological footprint and real GDP in the short term. Additionally, urbanization has been shown to improve the environment in the long run. Mrabet and Alsamara (2017) analyzed CO2, ecological footprint, real GDP, energy use, financial development and trade openness variables with the ARDL method using 1980-2011 period data for the Qatar economy. When the ecological footprint variable is considered, an inverted U-shaped curve is confirmed. In their study, Sarkodie and Strezov (2018) confirmed that the Environmental Kuznets hypothesis is valid with PMG and ARDL methods for the period 1971-2013, using data from the economies of Australia, China, Ghana and the USA. Ulucak and Bilgili (2018) examined the relationship between ecological footprint, GDP, energy consumption and financial development for 1961-2013 data for 15 countries (high income, middle income and low income group) using Augmented Mean Group (AMG) and heterogeneous panel casuality method. The results of the estimator show that there is an inverted U-shaped relationship between economic growth and ecological footprint. Ahmad et al. (2021) In the analysis conducted for G7 countries, 1980-2016 data were used, and the relationship of financial globalization, urbanization, innovation and economic growth with the ecological footprint was investigated with the panel data method. Findings show that urbanization causes environmental degradation by increasing its ecological footprint. It has been observed that the relationship between ecological footprint and economic growth is in an inverted U shape. In other words, the Environmental Kuznets Curve hypothesis is valid for G7 countries.

Apart from the studies mentioned above, some studies found that the EKC hypothesis was rejected. For example, Wang et al. (2013) in their study of 150 countries for 2005, the relationship between GDP, ecological footprint and biocapacity was investigated with spatial econometrics and it was concluded that the Environmental Kuznets Curve (EKC) hypothesis was not valid. Similarly, Ulucak and Koçak (2018) obtained the cointegration coefficients CUP-FM and CUP-BC estimators of per capita income and ecological footprint for OECD countries for the period 1970-2014, and found that economic growth increases pollution up to a certain point, and pollution increases with technological development. It was found that it decreased. In this study, the Environmental Kuznets Curve (EKC) hypothesis was also rejected. Al-Mulali et al. (2015) investigated the relationship between ecological footprint, growth, energy consumption, urbanization and trade openness using GMM and panel regression method, using data from 93 countries. In this study, the Environmental Kuznets Curve (EKC) hypothesis was found to be valid in upper middle and high income countries, but was found to be invalid in lower middle and low income countries. Along with these, Bagliani et al. (2008) took 144 countries and could not detect a relationship between ecological footprint and economic growth using horizontal cross-section, LCM and weighted LCM tests with 2001 data. Caviglia-Harris et al. (2009) used panel fixed effects, 2-stage LCM and generalized moments method in the period 1961-2000, using data from 146 countries, and no significant relationship was detected between the variables.

In other literature examples on economic growth and ecological footprint; Uddin et al. (2017) analyzed the 27 countries that caused the most emissions for the period 1991-2012 with the DOLS method and found that there was a positive and significant relationship between ecological footprint and real income. Chowdhury et al. (2021) used the panel quantile regression method in their analysis covering 92 countries for the period 2001-2016. The findings of the study showed that there is a negative relationship between economic growth and ecological footprint. Gulmez et al. (2021) used data for the period 1971-2015 and used the Pedroni FMOLS and DOLS method for GDP, trade openness, energy consumption and ecological footprint variables for G7 countries. As a result of the findings, it was observed that a 1% increase in GDP in G7 countries increased the ecological footprint by 0.24%. Ikram et al. (2021) used quantile ARDL and quantile Granger causality methods for the 1965-2017 data for the Japanese economy, and a bidirectional causality relationship was found between economic growth and ecological footprint in the study. Ozkan and Coban (2022) found that growth in the Turkish economy had a positive effect on the ecological footprint with the KLRS approach for the years 1970-2018. Cebeci Mazlum (2023) The relationship between economic growth and ecological footprint in E7 countries in the period 1992-2018 was examined with the panel data method. It was determined that there was a cointegrated relationship between the variables. Among the findings of the study is the conclusion that a 1% increase in economic growth increases the ecological footprint by an average of 0.12, and a unidirectional causality relationship from economic growth to ecological footprint was determined.

3. Data and Model

3.1. Data

To investigate the linkage between urbanization, human development, economic growth and the ecological footprint the annual time series data spanning 20 years from 2003 to 2022 is employed for MINT coutries: Mexico, Indonesiai Nigeria and Turkiye. The dependent variable is ecological footprint (EF), and the independent variables are urbanisation (URB), human development index (HDI), economic growth (GDP). Data is collected from four different databases. Data on EF is sourced from the Global Footprint Network Database (https://www.footprintnetwork.org/). The economic growth variable and urban population data extracted from the World Bank Database. Human development index data has collected from the Penn World Table. The data span was selected considering the constraint on data availability. Due to data limitations, data within the mentioned data range were taken into account for the countries included in the analysis.

Table 1. Measurement and Source of Data

Variables	Symbol	Measure	Data Source
Ecological Footprint	EF	Ecological footprint (gha per person)	Global Footprint Network
Human Development	HDI	Human development index	Penn World Table
Urbanization	URB	Urban population (% of total population)	World Bank
Economic growth	GDP	GDP per capita growth (annual %)	World Bank

Descriptive statistics for the variables are given in Table 2. During the examined period, the ecological footprint variable varied between 0.8 and 3.48, while the average was 2.13.

Table 2. Summary Statistics

Variables	Minimum	Maximum	Mean	Variance
EF	.8	3.48	2.13325	.9386036
HDI	.449	.855	.6786	.1146057
URB	37.356	81.3	61.90931	14.32484
GDP	-9.313503	10.4294	2.579354	3.397827

Source: Calculated by author on STATA program

3.2. Model Specification

In the investigation of the linking urbanization, human development index, economic growth and ecological footprint for MINT countries, the applied model created for MINT countries in the study is expressed as follows:

$$EF = \alpha_0 + \alpha_1 HDI + \alpha_2 URB + \alpha_3 GDP + \varepsilon_t \quad (1)$$

where EF is the ecological footprint gha per person, which represents the environmental quality; HDI is human development index. As in some studies in the literature (Fang 2016; Fang and Chang 2016;

Ulucak and Bilgili 2018; Ahmed and Wang 2019), the human development index was included in the analysis as variables representing human capital. URB is is measured as the proportion of urban population to the total population; GDP is the real gross domestic product per capita growth (annual %). α_0 is the constant and $_t$ is the error term. $\alpha_1, \alpha_2, \alpha_3$ are the elasticity of HDI, URB and GDP, respectively.

4. Methods and Estimation Results

In order to examine the relationship between ecological footprint, human development index, urbanization and economic growth for MINT countries, we use panel cointegration analysis and casuality analysis.

In the study, firstly, the cross-section dependence was tested. Since there were 20 years and 4 countries (T>N) in the study, Breusch-Pagan (1980) the LM test was used to determine the cross-sectional dependence. After examining the cross-sectional dependence and heterogeneity in the study, the unit root test Pesaran (2007) CIPS was used in accordance with the results of the study.

In the study, firstly to understand whether there is a cross-sectional dependence between the variables Bresuch-Pagan LM test is tested.

The Breusch-Pagan LM test is valid for small N and T, this test is based on the average of the squared pair-wise sample correlation coefficients of the residuals and is applicable when N is fixed and T → ∞. This test can be calculated as follows (Breusch and Pagan, 1980):

$$LM_1 = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} T_{ij}\hat{\rho}_{ij}^2 \rightarrow \chi^2 \frac{N(N-1)}{2} \tag{2}$$

$\hat{p}^{2}_{ij}$: Represents the number of correlations between the residues of i and j units. The equation can be calculated as in Equation (3):

$$\hat{p}_{ij} = \hat{p}_{ij} = \frac{\sum_{t=1}^{T} \hat{V}_{it}\hat{V}_{jt}}{(\sum_{t=1}^{T} \hat{V}_{it})^{1/2} (\sum_{t=1}^{T} \hat{V}_{jt})^{1/2}} \tag{3}$$

Before proceeding with the predictions, the slope heterogeneity test in the study was carried out using delta tests developed by Pesaran and Yamagata (2008). Test statistics for delta tests can be written as follows:

$$\tilde{\Delta} = \sqrt{N}\frac{\tilde{N}^{-1}\tilde{s}-k}{\sqrt{2k}} \tag{4}$$

$$\tilde{\Delta}_{adj} = \sqrt{N}\frac{\tilde{N}^{-1}\tilde{s}-E(\tilde{Z}_{it})}{\sqrt{Var(\tilde{Z}_{it})}} \tag{5}$$

The hypotheses of Pesaran and Yamagata (2008) Delta test are expressed as follows:

H_0: Slope coefficients are homogenous

H_1: Slope coefficients are heterogeneous

As a result of the cross-section dependency test, unit root tests were selected for the stationarity test. While the tests that do not take the cross section dependency into account are the first generation unit root tests, the second generation unit root tests perform the stationarity test by taking the cross section dependency into account. The results for cross-section dependence are presented in Table 3.

When the cross-sectional dependency test findings are observed in Table 3, P values (LM and LM_{adj}) are smaller than the critical value (0.05). Therefore, there is cross-sectional dependence between the series. When the findings obtained from the homogeneity test are examined, it is observed that all P values are less than the critical value of 0.05. According to the results of the slope homogeneity tests, it is stated that the null hypothesis that the slope is homogeneous is rejected and therefore country-specific heterogeneity is supported.

Table 3. Cross-Section Dependence Test and Homogenity Test

Test	Statistic	Probability
Cross-Section Dependence Test		
LM	20.27	0.0025
LMadj	8.275	0.0000
CD_{LM}	1.222	0.2216
Homogenity Test		
Δ	5.586	0.000
Δ_{adj}	6.450	0.000

The CIPS test is frequently used in the literature because it takes into account cross-sectional dependence as well as heterogeneity (Ahmed et. al, 2020: 5). The CIPS value calculated for the panel as a whole is equal to the t value calculated for each cross-section unit founding by averaging (Pesaran, 2007: 276). When the CIPS test table values are greater than the critical values in absolute value, the basic hypothesis that there is a unit root in the series is rejected and the alternative hypothesis that there is no unit root is taken as basis (Pesaran, 2007, ss. 265-312).

The fact that this test, which is one of the second generation panel unit root tests, can be applied both in cases where there is a correlation between units and within the scope of heterogeneous panels is an important factor in the selection of this test.

CIPS can be calculated using the following equation:

$$CIPS\ (N,T) = t - bar = \frac{1}{N}\sum_{i=1}^{N} t_i\ (N,T) \tag{4}$$

$$CIPS = \ N^{-1}\sum CADF_i \tag{5}$$

After testing the cross-sectional dependence among the countries in the panel, whether all the variables included in the study contain unit roots was examined with the Pesaran (2007) CIPS second generation panel unit root test, which is one of the second generation panel unit root tests. The findings regarding this are in Table 4. When the results of CIPS unit root tests are examined, it is seen that the ecological footprint variable becomes stationary when its first difference is taken in the constant case, and it becomes stationary when its first difference is taken in the constant-trend case, both at the level and when its first difference is taken. It has been determined that while the human capital index is level-stationary in the constant-trend situation, it is not level-stationary. While the urbanization variable was not stationary in the constant state, it became stationary in the constant state when its 1st difference was taken. It is seen that the economic growth variable is stationary in both constant and constant-trend cases. Since it is seen that all series become stationary when their first differences are taken, the existence of a cointegration relationship between the series can be investigated.

Table 4. CIPS Unit Root Test (2003-2022)

Panel CIPS test	Constant			Constant&Trend		
EF	-0.586			-3.158*		
ΔEF	-5.150*			-5.116*		
HDI	-2.387**			-2.498		
ΔHDI	-3.889*			-3.922*		
URB	-1.703			-4.647*		
ΔURB	-2.881*			-3.682*		
GDP	-2.472 **			-2.900**		
ΔGDP	-4.464*			-4.462*		
Critical Values	10 %	5%	1%	10 %	5%	1%
	-2.21	-2.34	-2.6	-2.74	-2.88	-3.15

*, ** and *** indicate significance at the 1%, 5% and 10% levels, respectively.

In case of heterogeneity, Gengenbach, Urbain and Westerlund (2016) Panel Cointegration Test, one of the second generation panel cointegration tests, was applied. Gengenbach, Urbain and Westerlund (2016) Panel Cointegration Test, based on the error correction model, allows heterogeneity and inter-unit correlation situations (Yerdelen Tatoğlu, 2020).

Gengenbach et al. (2016) stages of cointegration test are as in Equation 6:

$$\Delta y_{i,t} = \delta'_{y,x_i} d_t + a_{y_i} y_{i,t-1} + y_i' w_{i,t-1} + B_{y,y_i}(L)\Delta y_{i,t-1} + A_{y,x,x_i}(L)\Delta x_{i,t} + A_{y,F,x_i}(L)\Delta F_t + \eta'_{y,x_i} f_{it} + \varepsilon_{y,x_i,t} \quad (6)$$

The test statistics to be calculated for each unit are as in Equation 7:

$$\Delta y_i = d\delta_{y,x_i} + a_{y_i} y_{i,-1} + w_{i,-1}\gamma_i + v_i\pi_i + \varepsilon_{y,x_i} = a_{y_i} y_{i,-1} + g_i^d \lambda_i + \varepsilon_{y,x_i} \quad (7)$$

Gengenbach, Urbain & Westerlund EC Cointegration Test results are seen in Table 5, and when the significance of Y_{t-1} is examined (since P-val<=0.01), H_0 hypothesis is rejected and there is a cointegration relationship between the variables in the model. In this way, it has been determined that there is a long-term relationship between ecological footprint, human capital index, urbanization and economic growth in MINT countries.

Table 5. Gengenbach, Urbain ve Westerlund Panel Cointegration Test Results

Panel EC-test			
d.y	Coef	T-bar	P-val
Y(t-1)	-1.376	-5.108	<=0.01

Following the cointegration test, the mean group dynamic least squares DOLSMG method, which is a second generation heterogeneous estimator and developed by Pedroni (2001), was used to estimate the long-term relationship, due to the existence of inter-unit correlation and the heterogeneity of the parameters.

The fact that all beta coefficient values calculated for the panel groups are smaller than the t statistic values shows that the variable coefficients are statistically significant. According to the Panel DOLSMG estimator, a 1% increase in the human capital index reduces the ecological footprint by 1.89. A 1% increase in urbanization increases the ecological footprint by 0.22%. It has been determined that a 1% increase in economic growth increases the ecological footprint by 0.005%, albeit low.

Table 6. Long Term Panel Cointegration Estimation Results (DOLSMG) (Mean Group)

Independent Variable (EF)	Beta
HDI	-1.893***
URB	.2237***
GDP	.005892 ***

Note: *** is indicate the % 5level of significance.

When the Panel DOLSMG estimation results were evaluated on a country basis, it was determined that the index coefficient on the effect of the human capital index on the ecological footprint was negative and statistically significant in Mexico and Indonesia. In Turkey, the coefficient on the effect of the human capital index on the ecological footprint is positive and statistically significant. The country with the highest human development index elasticity coefficient is Mexico with a coefficient value of 13.4. While this rate is 5.3 in Indonesia and 6.7 in Turkiye. It was determined that the coefficient on the impact of urbanization on the ecological footprint was positive in all countries except Nigeria. The country with the highest urbanization elasticity coefficient is Turkey. A 1 percent increase in the urbanization rate in Turkey increases the ecological footprint by 0.5%. The effect of economic growth on ecological footprint is statistically insignificant in Indonesia and Nigeria. While a 1 percent increase in economic growth in Mexico reduces the ecological footprint by a low rate of 0.03%, in Turkey the effect of economic growth on the ecological footprint increases by a low rate of 0.04%.

Table 7. Mean Group Dynamic Least Squares (DOLSMG) Estimator

Countries	Variables	Coefficient	t-statistics
Mexico	HDI	-13.44	-2.588
Mexico	URB	.1714	3.708
Mexico	GDP	-.03526	-3.371
Indonesia	HDI	-5.397	-4.228
Indonesia	URB	.2235	16.09
Indonesia	GDP	-.0028	-.5317
Nigeria	HDI	4.524	.9418
Nigeria	URB	-.03997	-3.464
Nigeria	GDP	.01299	.8687
Turkiye	HDI	6.737	13.87
Turkiye	URB	.5396	4.724
Turkiye	GDP	.04863	8.369

The existence of a causal relationship between variables in MINT countries was investigated with the Dumitrescu and Hurlin (2012) panel causality test, which was developed for heterogeneous panels. In the Dumitrescu and Hurlin (2012) method, the following hypotheses are tested:

H_0: For all units, variable y is not causal to variable x.

H_1: For some units, variable y is causal to variable x.

This test, developed by Dumitrescu and Hurlin (2012), takes into account cross-sectional dependency among the countries forming the panel. It is insensitive to the size difference between the time dimension and the section dimension, and provides effective results when the time dimension is larger or smaller than the section dimension (Dumitrescu and Hurlin, 2012:1457):

$$x_{i,t} = \alpha_i + \sum_{k=1}^{k} \gamma_i^{(k)} x_{i,t-k} + \sum_{k=1}^{k} \beta_i^{(k)} y_{i,t-k} + e_{i,t}$$

$$y_{i,t} = \alpha_i + \sum_{k=1}^{k} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{k} \beta_i^{(k)} x_{i,t-k} + e_{i,t}$$

Based on the Dumitrescu-Hurlin panel causality test results in Table 8, there is a one-way causality relationship from ecological footprint to human capital index. Additionally, it has been determined that there is a two-way causality relationship between ecological footprint and urbanization. In addition, it has been revealed that there is a unidirectional causality relationship from economic growth to ecological footprint in MINT countries.

Table 8. The Dumitrescu-Hurlin Causality Tests Results

Null Hypothesis	Z-bar-Statistic	Probability
EF does not homogeneously cause HDI	12.0036	0.0000*
HDI does not homogeneously cause EF	1.2758	0.2020
EF does not homogeneously cause URB	8.9649	0.0000*
URB does not homogeneously cause EF	3.0942	0.0020*
EF does not homogeneously cause GDP	0.8364	0.4030
GDP does not homogeneously cause EF	2.5325	0.0113**

*, ** and *** indicate significance at the 1%, 5% and 10% levels, respectively.

CONCLUSION:

In this study, the relationship between human development index, urbanization, economic growth and ecological footprint was investigated for Mexico, Indonesia, Nigeria and Turkiye, expressed as MINT countries, between 2003 and 2022. First, the cointegration relationship was examined. Later, since the cointegration relationship was determined, the long-term relationship between the variables was estimated. The long-term relationship for MINT countries was also obtained for all units. Finally, the causality relationship between the variables was investigated.

In the literature, the results of the relationship between human development index, urbanization, economic growth and ecological footprint differ according to countries, the period covered and the method. In this analysis conducted for MINT countries, 2003-2022 period data and GUW (2016) cointegration results showed that the variables were cointegrated. The long-term relationship between the variables was estimated according to the DOLSMG method, a 1% increase in the human development index reduced the ecological footprint by 1.89%, and a 1% increase in urbanization increased the ecological footprint by 0.22%. It has been observed that a 1% increase in economic growth increases the ecological footprint by an insignificant 0.005%. It can be said that the most effective variable on the ecological footprint among the variables for MINT countries is the human development index.

When the Panel DOLSMG estimation results are evaluated on a country basis, the t statistics of the long-term parameter estimation of urbanization in all countries are significant. While the coefficient on the impact of urbanization on the ecological footprint is positive in Mexico, Indonesia and Turkiye, this coefficient was found to be negative in Nigeria. While the human development index elasticity coefficient was negative in Mexico and Indonesia, this coefficient was found positive in Turkiye. The coefficient of economic growth on the ecological footprint is significant only in Mexico and Turkiye. While this coefficient is negative in Mexico; It was found positive in Turkiye. According to the results of Dumitrescu and Hurlin (2012) panel causality analysis; While there is a bidirectional causality relationship between ecological footprint and urbanization in MINT countries for the years 2003-2022; there is one-way causality from the ecological footprint to the human development index and from growth to the ecological footprint.

Ecological footprint is one of the important variables in measuring environmental destruction. The human development index and its components should not be ignored in ensuring that countries improve their human development index along with their economic growth and achieve environmentally friendly growth. Future studies may address the human capital index more broadly. Studies on this subject can be applied to different methods and country groups, and comparisons can be made on a country basis and within country groups.

Compliance with the Ethical Standard

Conflict of Interests: *The author(s) declare that they do not have a conflict of interest with themselves and/or other third parties and institutions, or if so, how this conflict of interest arose and will be resolved, and author contribution declaration forms are added to the article process files with wet signatures.*

Ethics Committee Permission: *In this article, ethics committee approval is not required, and a consent form affirming that a wet-signed ethics committee decision is not necessary has been added to the article process files on the system.*

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