# Does Globalization Trigger an Ecological Footprint?
# A Time Series Analysis of Bangladesh

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**Abstract:** Climate change has become a pitfall towards economic growth, sustainable development, and ecological balance, which is not different in Bangladesh. This study investigates the relationship between the ecological footprint and the globalisation of Bangladesh in 1980-2021. The auto-regressive distributed lag model (ARDL) bound test confirms the long-run relationship among carbon footprint, ecological footprint, globalisation, and other control variables. Long-run and short elasticity confirm that globalisation, population density, energy

consumption, and political and economic globalisation stimulate ecological footprint. On the other hand, economic growth is a culprit of ecological footprint. It reflects alternative signs with an ecological footprint. On carbon footprint, results are similar to ecological footprint except for energy consumption. As ecological footprint increases, people consume more energy in the short run while less energy in the long run. Laws enforced in the last or previous decades regarding environmental issues need more strictness and acceptability to utilise energy through advanced technology and robust inflows from the foreign sector.

**Keywords:** Ecological footprint, Carbon ecological footprint, Globalisation, Bangladesh, ARDL

## 1. Introduction

Environmental pollution is a global problem that affects humans in every region of the world and is also a result of various humankind activities such as trade and finance, industrialisation, urbanisation, and ozone layer depletion. Greenhouse gas, or, more significantly, carbon-di-oxide is the main culprit for environmental degradation. Although recent research postulates that these anthropogenic activities harm environmental conditions, only carbon emission is not a universal indicator of anthropogenic pressure in the ecosystem (Al-Mulali & Ozturk 2015, Krichevsky & Levchenko 2021). The discharge of several pollutants boosts greenhouse gas emissions (GHG) and approaches the threat of climate change and ecological imbalance (Shahbaz & Sinha 2019, Chowdhury et al. 2022).

The term "ecological footprint" was used in the 1990s to refer to the amount of land and water consumed by humankind while avoiding waste products. It is a comprehensive measure that combines six demands that have a direct impact on ecosystems by causing ecological pressures such as land-use changes, resource extraction and depletion (e.g., deforestation and overfishing), waste and pollution emissions, and organism modification and movement (Steffen et al. 2004, Hoekstra & Wiedmann 2014, Nitsenko et al. 2018a, Bazaluk et al. 2021; Andreichenko, Andreichenko & Smentyna 2021). Ecological Footprint Atlas declares that we have lived in a state of ecological overshoot since 1970, which means that human demands have exceeded the earth's bio-capacity. This demand and supply duality demolishes the earth's bio-capacity, surges carbon dioxide, or GHG digit single to triple, depletes the ozone layer, and shatters ecological balance. The larger the score, the greater the rank of annihilating promotes. This ecological footprint can be defined in two ways. Firstly, it is an expression that explains the scale of human demand due to measuring the direct and indirect effects of production and consumption (Charfeddine 2017, Uddin et al. 2017, Danish et al. 2019, Nitsenko et al. 2018b, Solarin & Al-Mulali 2018, Ulucak & Apergis 2018, Osaulenko et al. 2020, Czekała, Tarkowski & Pochwatka 2021, Chukurna et al. 2022). Secondly, it is a better indicator of ecological degradation under scientific intervention than $CO_2$, $NO_2$, or GHG emissions (Mrabet &

Alsamara 2017, Ozturk et al. 2016, Charfeddine 2017, Mrabet et al. 2017, Destek et al. 2018, Danish et al. 2019, Kalinichenko et al. 2019). Scholars cite two primary reasons for describing this as a more accurate parameter of the environmental offender. One is based entirely on total production, whereas the other is rigorous due to its input-output estimation (Jorgenson & Clark 2011). This study explores a maiden work between Bangladesh's ecological footprint and globalisation from 1980 to 2021. Globalisation is a word that unified the world into three crucial sectors - social, political, cultural, financial or recreational bonding. In other words, it is a magical shifting session from an isolated and restrained cocoon to an interconnected, integrated, interdependent global economy.

Bangladesh and its impact on the economy are shifting from an agro-based to a manufacturing-based economy despite political unrest, ready garments lion's share, IT sectors improvement, and enjoying a surplus of demographical dividends. Regarding ecological footprint, Bangladesh is lower due to poor GDP per capita, lifestyle in a poor primitive stage, and low consumption waste. In addition, technology is still far-reaching in developing economic mechanisms, mainly in agriculture and manufacturing. As the economy of Bangladesh is shifting from primitive agriculture to industry or ready-made garments based, the intrusion of people is encroaching towards the ecosystem. Bangladesh covered around 11 per cent of forest land in 2016, while in 1995, it was more than 20 per cent just 25 years ago.

On the other hand, carbon emissions, industrial pollution, and brickfield waste are increasing at an alarming rate. Studies on ecological balance or ecosystem are not still considered with economic growth nexus. Due to the delta region, we face climatic hazards more in the 21st century. So, the necessity of climate change adaptation and sustainable economic growth. Our resources cannot provide our demands, whether it is energy consumption or electricity use. In addition, our economy shifting is intruding towards household and crop areas. Our study discusses these issues with proper policy implications with time series analysis.

## 2. Literature Review

After the cold war, globalisation approached from developed countries to developing countries worldwide, in economic circulation and social treats, religious activities, cultural festivals, political diplomacy, etc. In other words, globalisation can be accumulated in three major segments – economic, social, and political. In empirical studies, some reveal significant nexus between globalisation and the environment is positive (Shahbaz et al. 2015, Phong 2019, Saraç & Yağlikara 2019, Bazaluk et al. 2022, Chukurna et al. 2022), while others have found a negative (Destek and Sarkodie 2019, Olowu et al. 2018, Shahbaz et al. 2020, Chowdhury et al. 2022). Ecological footprint (EF), followed by (Rees, 1992) but published in 1992 and then (Rees & Wackernagel 2008) and (Wackernagel & Rees

1999) and, compared with producible biological capacity that is available from land and seawater (Siche et al. 2008). Nowadays is treated as an indicator of environmental degradation or sustainability in environmental economics (Ulucak & Apergis 2018, Yildiz, Arslan & Çeliköz 2022). On empirical results, (Wackernagel et al. 1999) employ EF as environmental degradation and analyse with the linear and quadratic function of income per capita for 52 countries. They predict there plays a monotonic increasing role of EF to income. Following this, several researchers have gone through with or without the EKC hypothesis (York et al. 2004, Boutaud et al. 2006, Charfeddine & Mrabet, 2017).

Ecological footprint and globalisation and its dimension are discussed in scanty. Some authors disaggregated globalisation in several sectors. Using panel data from 171 countries (Rudolph & Figge 2017) examined the nexus between globalisation (KOF index) and ecological footprint. The discussion concludes that globalisation's impact on the world differs according to political, cultural, and social aspects. Therefore, the finding indicates that economic globalisation increases consumer ecological footprint and social globalisation reduces consumer ecological footprint. The effect of the same variables and countries is also discussed (Rudolph & Figge 2017) using an alternative measure (MGI index) to globalise. Results show that globalisation's effect on ecological footprint is optimistic. Another study disaggregates environmental degradation in $CO_2$ emissions, sulfur, round wood production, and water pollution (Dreher et al. 2008). Although the overall result is inconclusive, they reveal a positive relationship between social globalisation and emission levels, economic globalisation, and round wood production. Globalisation-trade-environment nexus is discussed more from different perspectives (Lamla 2009, Paramati et al. 2017, Saud et al. 2020, Danyliuk et al. 2020). Globalisation significantly influences the environment through trade openness from different angles, such as income, technology, and composition (Grossman & Krueger 1991). Financial development enhances that linkage and demonstrates more clearly economic-environment bonding. Some studies decide that globalisation and financial development enhance environmental quality by reducing emissions (Hsueh et al. 2013, Zaidi et al. 2019, Saud et al. 2020), while others reject it (Shahbaz et al. 2015). Conversely, globalisation or economic globalisation and $CO_2$ emission have a negative relationship, as discussed in notable papers (Lv & Xu 2018). In global ecological balance, measurable progress is confined only to stratospheric ozone and lead in gasoline (Rudolph & Figge 2017). Social globalisation can affect human activity by increasing human demand or decreasing demand. From worldwide mobility to physical or cognitive distance from environmental problems, our purchasing habits are more exposed through global media and compel us to live a materialistic and consumerist lifestyle. This unseen behaviour reacts as inertia towards environmental conservation (Rennen & Martens 2003). On the other side, as social

media use intensity and quantity to increase, social globalisation is also assembling knowledge and connecting one to another. We expect to be more globalised and socialised through adequate information in the newspaper or on the internet.

Scholars from different perspectives decide on globalisation and its several divisions in different outlooks. Globalisation can positively or negatively affect a social, economic, or political dimension. Most of these are on panel data, and our study is not. None exhibits any causal relationship between ecological footprint and globalisation for Bangladesh. Our studies solve this lacking. Most researchers found no causality or significant association for low-developing countries.

## 3. Methods

### 3.1. Model Specification

This study tries to investigate the association between globalisation and ecological footprint from 1980 to 2021 in Bangladesh. As the value of the ecological footprint indicator increases, the risk for natural resources enlarges (Ozturk, Al-Mulali & Saboori 2016). This study incorporates this variable as a dependent as it clogs to air pollution. Our goal is to exhibit the linkage between ecological footprint and globalisation, whereas, for more specifications, the carbon footprint is considered in place of the ecological footprint. As carbon footprint accounts for carbon emissions from fossil fuel use, a fundamental part of ecological footprint, we acknowledge this term under study.

This study disseminates globalisation through disaggregated analysis into three aspects, economic, political, and social globalisation. Economic globalisation is a greater context that merges foreign direct investments; trade flows across goods, capital, and services borders. Debates rounding on whether an environment is improved or devastated through economic globalisation roar. In the context of poor or developed societies, industrial races face faster without thinking of environmental laws and protocols. Thus, it degrades environmental quality and distorts ecological balance. The pollution-heaven hypothesis (PHT) is encouraged in this regard (Doytch & Uctum 2016, Zhang, Zhu & Hewings 2017). Control variables like economic growth, energy consumption, population density, and financial development are implemented in this work. Such necessary measures are used to ensure the consistency of previous literature. Economic growth is a unique force for promoting basic needs for natural resources. The ecological footprint is shattered by economic growth and energy consumption (Ahmed et al. 2019, Uddin et al. 2017, Bello et al. 2018). Population density as a control variable can affect both signs towards the environment. In China, the emission level fluctuates due to this variable's upshot as population density under urbanisation increases alarmingly and escalates per capita emissions (Liu et al. 2017).

On the contrary, for less-developed nations, environmental balance is devastated as triggering population density impedes the quality of soil, water, air, or others. More clearly, mills or factories do not follow air quality laws, public construction increases, sewage system maintenance is distorted, electricity deficit surges, and in a nutshell, environmental quality or elements of the environment face countless problems. Innovative technology, economies of scale, and efficiency in energy use in developed nations can reduce environment-related issues. Some scholars indicated a negative nexus between population density and ecological footprint (Dogan & Aslan 2017, Aşici & Acar 2016, Aşıcı & Acar 2018).

Like population density, financial development can contribute to the indecisive direction towards the environment. Scholars on concurrent studies (Baloch et al. 2019, Danish et al. 2019) warn that this factor may create hazards towards environmental stability as it promotes manufacturing sectors and degrades ecological balance. On the contrary, through research and development and technical innovation, financial growth will restore the environment (Shahbaz et al. 2020). In the text of ecological footprint, studies like (Uddin et al. 2017) stated that financial development reduces the ecological footprint and similar to (Hafeez et al. 2019), which used carbon footprint as an outcome variable. Several scholars observe similar findings (Charfeddine 2017, Jalil & Feridun 2011).

Under the above explanation, we built an econometric model to research the relationship between globalisation and the ecological footprint

$$LEF_{it} = \alpha_i + \beta_1 LEG_{it} + \beta_2 LEN_{it} + \beta_3 LPG_{it} + \beta_4 LGI_{it} + \beta_5 LFD_{it} + \varepsilon_{it} \qquad (1)$$

where:
*FP* represents the ecological footprint of consumption (global hectares (gha) per person),
*EG* is the economic growth (per capita as current dollars),
*EN* is energy consumption (per capita kg of oil equivalent),
*PG* represents the population growth rate (people per square km of land area),
*GI* is the globalisation (overall KOF index),
*FD* represents financial development (domestic credit to private sectors percentage of GDP),
$\varepsilon_t$ is the residual term.

Moreover, all the variables stated in equation 1 are in natural logarithm form. The first model is developed to analyse the relationship between overall globalisation and the ecological footprint of consumption. To examine the effect of economic, social, and political globalisation on the ecological footprint following three models have been used:

$$LEF_{it} = \alpha_i + \beta_1 LEG_{it} + \beta_2 LEN_{it} + \beta_3 LPG_{it} + \beta_4 LEGI_{it} + \beta_5 LFD_{it} + \varepsilon_{it} \qquad (2)$$

$$LEF_{it} = \alpha_i + \beta_1 LEG_{it} + \beta_2 LEN_{it} + \beta_3 LPG_{it} + \beta_4 LSGI_{it} + \beta_5 LFD_{it} + \varepsilon_{it} \qquad (3)$$

$$LEF_{it} = \alpha_i + \beta_1 LEG_{it} + \beta_2 LEN_{it} + \beta_3 LPG_{it} + \beta_4 LPGI_{it} + \beta_5 LFD_{it} + \varepsilon_{it} \qquad (4)$$

where:
*LEGI*, *LPGI*, and *LSGI* represent economic, political, and social globalisation, respectively.

To exhibit the relationship between our independent variables and ecological carbon footprint following model has been used:

$$LEFC_{it} = \alpha_i + \beta_1 LEG_{it} + \beta_2 LEN_{it} + \beta_3 LPG_{it} + \beta_4 LGI_{it} + \beta_5 LFD_{it} + \varepsilon_{it} \qquad (5)$$

KOF index developed by KOF Swiss Economic Institute, introduced by (Dreher et al. 2008), used as a reliable, better and popular indicator of globalisation- available in the 2017 version. For this purpose, information on personal contacts, information flows, and cultural proximity is considered. Version 2017 of the KOF index provides data from 1970 to 2021 (Rudolph & Figge 2017).

Data on ecological footprint and ecological carbon footprint as a controlled or dependent variable in this study are collected from the website of the global footprint network. GFN provides a trustworthy dataset of more than 200 nations to estimate environmental pressure erected from human activity and waste absorbed in the ecosystem. It also penlights global issues to stop the misuse of natural resources with various variables like lands in 6 sectors, water in use, and sewage and air through human activities. The rest of the variables, financial development, population density, energy consumption, and economic growth, are collected from WDI (World Development Indicators). Table 1 contains detailed information about variables and their measurement.

**Table 1.** Variables with measurement

| Variables | Measurement |
|---|---|
| The ecological footprint of consumption (LEF) | The productive area (water and land) is needed to sustain human use and assimilation of waste and is measured per person in Global Hectares (gha). |
| Ecological carbon footprint (LEFC) | Forestland needed to absorb $CO_2$ emissions measured at global (gha) hectares per person. |
| Economic growth (LEG) | GDP per capita is measured as current US dollars. |
| Energy consumption (LEN) | Energy use per capita kilogram of oil equivalent. |
| Population Growth (LPG) | Annual population growth is measured as a percentage. |

**Table 1.** cont.

| Variables | Measurement |
|---|---|
| Globalisation (LGI) | The total KOF Globalization Index includes economic, social, and political globalisation. |
| Economic globalisation (LEGI) | The index of economic globalisation is measured based on actual trade flows, foreign direct investment, portfolio investments and restrictions such as barriers to imports, tariff rates, international trade taxes etc. |
| Social globalisation (LSGI) | The Index of Social Globalization is based on personal interactions, knowledge flows and cultural proximity. |
| Political globalisation (LPGI) | It is based on embassies in countries, international treaties, membership in international institutions, and participation in international missions. |
| Financial development (LFD) | Domestic credit that includes financial resources provided by financial corporations to the private sector is measured as a percentage of GDP. |

Source: Estimated.

## 3.2. Model Estimation

This study employs the Auto-regressive distributed lag model (ARDL) (Pesaran et al. 2001) to examine short and long-run relationships among variables from 1980 to 2021. Due to the unavailability of globalisation variables for further years, this study was confined to 41 years. Also, various unit root tests have been applied to ensure that no variable is integrated at I(2). The unrestricted error correction model of the ARDL is given below:

$$\Delta LEF_t = \alpha_0 + \sum_{i=1}^{z} \beta_{1i}\, \Delta LEF_{t-i} + \sum_{i=1}^{z} \gamma_{2i}\, \Delta LEG_{t-i} + \sum_{i=1}^{z} \rho_{3i}\, \Delta LEN_{t-i}$$
$$+ \sum_{i=1}^{z} \omega_{4i}\, \Delta LPG_{t-i} + \sum_{i=1}^{z} \sigma_{5i}\, \Delta LGI_{Z,t-i} + \sum_{i=1}^{z} \tau_{6i}\, \Delta LFD_{t-i} + \vartheta_1 LEF_{t-1} \quad (6)$$
$$+ \vartheta_2 LEG_{t-1} + \vartheta_3 LEN_{t-1} + \vartheta_4 LPG_{t-1} + \vartheta_6 LGI_{t-1} + \varepsilon_t$$

This model consists of two portions short-run and long-run coefficients. In short-run estimates, $\beta$, $\gamma$, $\rho$, $\omega$, $\sigma$ and $\tau$ are short-run estimates, $\vartheta_1$ up to $\vartheta_6$ are long-run estimates, $\Delta$ is the difference operator, and $\alpha$ is intercepted. The null hypothesis of no cointegration Ho: $\vartheta_1 = \vartheta_2 = \vartheta_3 = \vartheta_3 = \vartheta_4 = \vartheta_5 = \vartheta_6 = 0$ is tested against HA: $\vartheta_1 \neq \vartheta_2 \neq \vartheta_3 \neq \vartheta_3 \neq \vartheta_4 \neq \vartheta_5 \neq \vartheta_6 \neq 0$. The long-run equilibrium is confirmed by (Narayan 2005, Pesaran et al. 2001) F – value test statistic. The long run exists if the calculated F-statistic value surpasses the upper critical bound (UCB). Therefore, under Akaike Information Criteria (AIC), the optimal lag duration

three is used. The unrestricted error correction model to examine the impact of economic, social, and political globalisation is given below:

$$\Delta LEF_t = \alpha_0 + \sum_{i=1}^{z} \beta_{1i} \Delta LEF_{t-i} + \sum_{i=1}^{z} \gamma_{2i} \Delta LEG_{t-i} + \sum_{i=1}^{z} \rho_{3i} \Delta LEN_{t-i}$$
$$+ \sum_{i=1}^{z} \omega_{4i} \Delta LPG_{t-i} + \sum_{i=1}^{z} \sigma_{5i} \Delta LGI_{Z,t-i} + \sum_{i=1}^{z} \tau_{6i} \Delta LFD_{t-i} + \vartheta_1 LEF_{t-1} \quad (7)$$
$$+ \vartheta_2 LEG_{t-1} + \vartheta_3 LEN_{t-1} + \vartheta_4 LPG_{t-1} + \vartheta_6 LGI_{Z,t-1} + ECT_t + \varepsilon_t$$

Where z denotes economic, social, and political globalisation. Finally, the ARDL model with ecological carbon footprint (LEFC) as a controlled variable is given below:

$$\Delta LEFC_t = \alpha_0 + \sum_{i=1}^{z} \beta_{1i} \Delta LEFC_{t-i} + \sum_{i=1}^{z} \gamma_{2i} \Delta LEG_{t-i} +$$
$$\sum_{i=1}^{z} \rho_{3i} \Delta LEN_{t-i} + \sum_{i=1}^{z} \omega_{4i} \Delta LPG_{t-i} + \sum_{i=1}^{z} \sigma_{5i} \Delta LGI_{t-i} +$$
$$\sum_{i=1}^{z} \tau_{6i} \Delta LFD_{t-i} + \vartheta_1 LEF_{t-1} + \vartheta_2 LEG_{t-1} + \vartheta_3 LEN_{t-1} + \vartheta_4 LPG_{t-1} + \vartheta_6 LGI_{t-1} \quad (8)$$
$$+ ECT_t + \varepsilon_t$$

After scrutinising short and long-run estimates, several diagnostic tests are implemented to ensure our model is free from serial correlation, heteroscedasticity, non-normality, and specification error. Nonetheless, stability tests for parameters are checked under Cumulative Square of residuals (CUSUM) and Cumulative sum of the square of residuals (CUSUMSQ) tests.

## 4. Results and Discussion

Table 2 exhibits basic statistics in natural logarithms from 1980 to 2021 in Bangladesh. Population growth, globalisation index, financial development, and political index are negatively or left-skewed. In the Jarque-Bera statistic (Jarque & Bera 1987) viewpoint, each dataset is normally distributed.

**Table 2.** Descriptive statistics of variables

| Descriptive statistics | LEF | LEG | LEN | LPG | LGI | LFD | LEFC | LPGI | LSGI | LEGI |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean | -1.2383 | 5.9803 | 4.9672 | 0.6322 | 3.5640 | 2.9866 | -2.9941 | 4.1044 | 3.0069 | 3.1805 |
| Median | -1.3255 | 5.9952 | 4.9348 | 0.7474 | 3.5744 | 3.0203 | -2.9080 | 4.2042 | 2.7940 | 3.1302 |
| Maximum | -0.7258 | 7.0201 | 5.4348 | 0.9880 | 3.9558 | 3.7782 | -1.7987 | 4.3079 | 3.8939 | 3.5427 |
| Minimum | -1.5421 | 5.3202 | 4.6526 | 0.1105 | 3.1597 | 1.7529 | -4.0268 | 3.7255 | 2.4559 | 2.8521 |
| SD | 0.2570 | 0.4706 | 0.2423 | 0.3189 | 0.2645 | 0.5417 | 0.7411 | 0.2138 | 0.4926 | 0.2259 |
| Skewness | 0.6148 | 0.5775 | 0.4573 | -0.5632 | -0.0623 | -0.4055 | 0.1074 | -0.7968 | 0.6745 | 0.2490 |
| Kurtosis | 2.0047 | 2.3789 | 2.0454 | 1.8083 | 1.8083 | 2.5712 | 1.6985 | 2.0710 | 1.9863 | 1.7567 |
| Jarque-Bera | 3.6498 | 2.5083 | 2.5492 | 3.9213 | 2.0936 | 1.2275 | 2.5377 | 4.9620 | 4.1523 | 2.6159 |
| Probability | 0.1612 | 0.2853 | 0.2795 | 0.1408 | 0.3511 | 0.5413 | 0.2812 | 0.0837 | 0.1254 | 0.2704 |
| Observations | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |

Source: Estimated.

## 4.1. Unit Root Test

This study entails Augmented-Dickey-Fuller (ADF) test (Dickey & Fuller 1979) and Phillips-Perron (PP) test (Phillips & Perron 1988) for measuring stationary series order. Results are given in Table 3. In the ADF test, globalisation, political and social indices are stationary at the level. Except for ecological footprint, each variable is stationary on an intercept with a 1% significance level (some are 5% significant). On the other hand, the PP test found stationary at the first difference of all variables (except population growth). Consequently, the decision comes from both tests to prove that variables are in mixed order.

**Table 3.** Unit root (ADF and PP) tests of variables

| | ADF Test | | | | PP test | | | |
| | At level | | At first difference | | At level | | At first difference | |
| | C | C + T | C | C + T | C | C + T | C | C + T |
|---|---|---|---|---|---|---|---|---|
| LEF | 1.1834 | -2.252 | -1.578 | -2.8783 | 2.3539 | -1.89 | -6.0244*** | -6.8775*** |
| LEFC | 0.6284 | -3.1469 | -4.2959*** | -4.1272** | 0.8911 | -5.9659*** | -6.468*** | -6.6186*** |
| LEG | 2.1394 | -1.7316 | -4.3245*** | -5.2537*** | 3.7237 | -0.9216 | -4.3245*** | -5.2481*** |
| LEN | 1.4315 | -1.9006 | -7.3111*** | -8.0906*** | 4.3105 | -1.6745 | -7.3111*** | -16.7573*** |
| LPG | 2.1973 | -0.2166 | -1.5769 | -3.939** | 0.1651 | -1.9481 | -1.9579 | -1.9426 |
| LFD | -1.5247 | -3.3636* | -3.9825*** | -4.8761*** | -2.4313 | -6.5258*** | -5.184*** | -5.6626*** |
| LGI | -0.6016 | -4.4459*** | -1.9606 | -5.1097*** | -0.3406 | -3.1183 | -6.1388*** | -6.0346*** |
| LSGI | 1.4341 | -1.8966 | -4.7469*** | -4.9829*** | 1.2996 | -1.8966 | -4.7412*** | -4.9852*** |
| LPGI | -3.9608*** | -3.7333** | -1.1257 | -4.173** | -1.7768 | -0.6825 | -5.4117*** | -5.8283*** |
| LEGI | -0.8158 | -3.8324** | -5.8228*** | -5.7212*** | -0.3691 | -3.2383* | -12.7214*** | -12.1983*** |

Note: C & C + T indicates constant & constant with trend respectively.
Source: Estimated.

## 4.2. ARDL Bound Test Approach

Afterwards, we investigate results through the ARDL test that allows estimating parameters with a small sample size and for mixed integration. The results in Table 4 show that the study models are enough to exhibit long-run relationships as they surpass the upper critical bound (UCB) in each case (Narayan 2007).

**Table 4.** Results of ARDL bound tests

| Models under study | F-statistic of Bound test | Lags | Order | Decision |
|---|---|---|---|---|
| (LEF/LEG, LEN, LPG, LGI, LFD) | 11.581*** | 5 | (1,2,2,3,3,3) | Long run relationship exist |
| (LEF/LEG, LEN, LPG, LEGI, LFD) | 5.075** | 5 | (1,0,0,1,3,3) | |
| (LEF/LEG, LEN, LPG, LSGI, LFD) | 6.088*** | 5 | (2,3,3,2,0,3) | |
| (LEF/LEG, LEN, LPG, LPGI, LFD) | 8.028*** | 5 | (1,2,2,3,3,3) | |
| (LEFC/LEG, LEN, LPG, LGI, LFD) | 9.893*** | 5 | (1,2,3,3,3,1) | |
| Critical regions | LCB | UCB | | |
| 1% | 3.93 | 5.23 | | |
| 5% | 3.12 | 4.25 | | |
| 10% | 2.75 | 3.79 | | |

Source: Estimated.

## 4.3. Short-Run and Long-Run Estimates

In short-run and long-run estimates, we exhibit a long-run and short-run relationship with the environment in table 5. The first four models are regressed of environmental footprint with several indices, and the carbon model is regressed with a governmental index. So, models 2, 3, and 4 are disaggregated regression through the ARDL model of an economic, social and political index of globalisation on ecological footprint.

In model one, the coefficient of overall globalisation is impacted negatively on the ecological footprint of consumption in the long run at a 1% significance level. Also, the second and third models are negatively associated with a footprint in the long run, whereas social globalisation is positively associated with the footprint of ecological consumption. Therefore, Bangladesh is in a stage where the ecological footprint is retarded by economic, political, and overall globalisation. These findings are not similar to those (Figge et al. 2017, Liu et al. 2017, Dreher et al. 2008, Ahmed et al. 2019). In the final model, overall globalisation has an insignificant effect on carbon footprint. So, globalisation is not affecting carbon footprint in the long run. The rationale is that carbon footprint amalgamates energy use and air pollution. Therefore, Bangladesh is not at a stage of scale and pollution haven an effect still now. Though the annual GDP growth rate had increased faster last two decades than before an agro-based economy was shifted to a manufacturing and RMG-based economy, this evidence is not enough to

prove that air pollution has occurred more than land and water pollutants. Hence, environmental degradation has occurred statistically more on land and water than on air.

Economic growth promotes significantly on four models in long-run estimation. A 1% increase in economic growth is caused by the sole effect of 0.86%, 0.59%, 1.44%, and 1.03% ecological footprint in the first up to fourth, respectively. Economic growth is an onset of citizens' performance that boosts economic activities on investment, purchases, and consumption and increases ecological footprint (Baloch et al. 2019). Another reason is shifting the economy from an agro-based to a manufacturing economy. This changing rule affects production capacity, consumes more, and boosts ecological degradation (Charfeddine & Mrabet 2017). Hence, advanced technologies cannot solve the equation between rising economic productivity and reducing energy efficiency (Sarkodie & Strezov 2019). Nevertheless, economic growth in the statistical paradigm does not affect the carbon footprint. It happens because manufacturing and farming have been booming faster in the last two decades, but that is not solely attributed to carbon emissions. The result of this pattern is consistent with (Solarin & Al-Mulali 2018, Danish et al. 2019, Destek et al. 2018, Uddin et al. 2017).

As Bangladesh's economy is reforming from an agricultural market to a manufacturing-based economy, this is still not at a stage that properly utilises its coal consumption. On average, energy consumption increased on three tuples from 1980 to 2014, which will have a significant effect in the long run on ecological footprint or carbon emission on the third to fifth model in negative sign. As energy consumption increases by 1%. The impact on ecological footprint will decrease by 5.27% and 2.34% in the third and fourth models. This positive relationship is expected as energy use increases and environmental quality decreases. The greater the scale of energy consumption, the higher the chance of the environment degradation (Charfeddine & Mrabet 2017). So, it retards not only the ecological footprint but also the carbon footprint.

Some models fit negatively significant, like energy consumption and the effect of population density on the environment degradation. Liddle (2014), who reports an adverse effect of population density on energy and emissions, supports this negative relationship. However, fertility rate and infant mortality decrease, and the population growth rate negatively impact ecological and carbon footprint. Lastly, financial development decreases ecological and carbon footprint, but statistical evidence disproves it.

In short-run estimates, globalisation reduces carbon footprint at a 5% significance level. There is a stimulating effect of overall globalisation on ecological footprint, the short-run coefficient is not significant, but in the long run, it does. It happens as, in the long run, the effect of globalisation will be visible through economic shifting, urbanisation tempo, more trade, and a finance-supporting

environment to create and improve human capital. In economic growth, the effect of each model is positive towards ecological footprint and carbon footprint at a 1% significance level, which is also true in the long run. Similarly, energy consumption negatively affects both short-run and long-run estimates on four models. As a carbon emission consumes coal consumption, the relation is positive with carbon footprint and energy consumption in the short run. On aggregated and disaggregated analysis, globalisation and its three components upsurge ecological footprint for the first to fourth model and carbon footprint for the last model. Financial development positively surges more on ecological footprint, but carbon footprint has no relationship on significance. The outcome suggests that financial development or foreign flows strengthen human demand in an ecological sense. Foreign plants are not enough to use efficient products that can utilise their resources on large amounts of energy; on the other side, it is a step towards environmental degradation.

For model validation and diagnostic checking, each model performs well. Normality (Jarque-Bera statistic), heteroscedasticity (Breusch-Pagan-Godfrey test), and serial correlation (Breusch-Pagan LM test) support the model well. For stability of parameters, CUSUM and CUSUMSQ tests are satisfied under a 5% significance level.

**Table 5.** Short-run and long-run estimates with diagnostic tests under ARDL model

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| Long-run estimates | | | | | |
| LEG | 0.8652*** | 0.5897*** | 1.4485** | 1.0396*** | 0.4414 |
| LEN | -0.9076 | 0.1504 | -5.5217** | -2.3411*** | -4.2878*** |
| LPG | -0.2394 | -0.3831*** | -0.8700 | -0.0213 | -1.4390*** |
| LGI | -1.2683*** | -- | -- | -- | 0.6799 |
| LEGI | -- | -0.7915*** | -- | -- | -- |
| LSGI | -- | -- | 0.4984*** | -- | -- |
| LPGI | -- | -- | -- | -0.7758*** | -- |
| LFD | -0.0143 | 0.0034 | -0.2578 | -0.0035 | -0.3410 |
| Short-run estimates | | | | | |
| C | 2.0431*** | -1.7660*** | 10.2044*** | 5.4209*** | 10.0699*** |
| D(LEF(-1)) | | | -0.4911*** | | |
| D(LEG) | 0.3084*** | | 0.5278*** | 0.3367*** | 0.5114*** |
| D(LEG(-1)) | -0.4127*** | | -0.4245*** | -0.5728*** | 0.1939** |
| D(LEN) | -0.3429** | | -0.4885** | -0.7625*** | 0.9938*** |
| D(LEN(-1)) | 0.1627 | | 1.6586*** | 0.5038*** | 3.1025*** |
| D(LEN(-2)) | | | 0.4522** | | 1.5246*** |
| D(LPG) | -0.6204 | -0.6908*** | -2.4562*** | -0.6975 | -3.2727*** |
| D(LPG(-1)) | 1.1142 | | 3.2814*** | 1.3525 | 3.2524** |
| D(LPG(-2)) | -1.0182** | | | -1.3629** | 1.6687 |

**Table 5.** cont.

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| | Short-run estimates | | | | |
| D(LGI) | 0.0724 | | | | -0.1826** |
| D(LGI(-1)) | 1.0257*** | | | | -0.6370** |
| D(LGI(-2)) | 0.5725*** | | | | -0.7178*** |
| D(LEGI) | | -0.0113 | | | |
| D(LEGI(-1)) | | 0.3706*** | | | |
| D(LEGI(-2)) | | 0.1407*** | | | |
| D(LPGI(-1)) | | | | 0.5405*** | |
| D(LPGI(-2)) | | | | 0.3980*** | |
| D(LFD) | 0.1337*** | 0.1191** | 0.0202 | 0.2066*** | 0.0455 |
| D(LFD(-1)) | 0.2403*** | 0.1193** | 0.1692*** | 0.2646*** | |
| D(LFD(-2)) | 0.2857*** | 0.1228** | 0.2979*** | 0.3730*** | |
| Trend | 0.0353*** | | 0.0342*** | 0.0452*** | 0.0793*** |
| ECT | -0.9747*** | -0.6239*** | -0.6250*** | -0.8518*** | -0.7595*** |
| Test | Test statistic (df) | | | | |
| Normality | 0.9532 | 1.5372 | 0.845 | 0.4892 | 0.9062 |
| Heterosce-dasticity | 1.55 (20,11) | 0.4866 (13,18) | 0.577 (19,120 | 0.8876 (20,11) | 0.9987 (19,12) |
| Serial correlation | 4.0042 (2,9) | 0.212 (2,16) | 5.512 (2,10) | 1.2459 (2,9) | 2.9876 (2,10) |
| Test | Support | | | | |
| CUSUM | Stable | Stable | Stable | Stable | Stable |
| CUSUMSQ | Stable | Stable | Stable | Stable | Stable |

Source: Estimated.

## 5. Conclusion

This paper examines the relationship between ecological footprint and globalisation from 1980 to 2021 in Bangladesh. As an empirical investigation under the time series paradigm, we justify the order of integration for ecological and carbon footprint and other control variables. Using the Augmented-Dickey-Fuller and Phillips-Perron tests, variables are mostly in first order while some are stationary at level. F-statistics indicate that our postulate models are significant and validate the long-run relationship when using an auto-regressive distributed lag model (ARDL). Economic expansion and financial development impede the environment in the short run (Ozturk et al. 2016, Charfeddine & Kahia 2019, Sabir & Gorus 2019), while population growth, globalisation, and energy consumption enhance this balance. Laws like 'Environmental Conservation Act, 1995' (Revised in 2010), plans 'The National Biodiversity Strategy and Action Plan (NBSAP) 2016-2021' and 'Policy Guidelines for Green Banking' have been newly enacted

that need more space and justification to utilise energy, resources with modern technology. Finally, globalisation power, economical transport, trade, and business with other needs can consume more resources and accelerates the economy.

In addition, diversification is found with economic growth is positively associated, but economic globalisation is damaging. It may happen due to laws of implementation, which trigger a booming economy but needs more clarification, accountability, and transparency. Furthermore, globalisation is negatively associated with the ecological footprint. It indicates that the reformation from an agricultural society to a manufacturing economy needs more help and finance to improve its quality and utilise its resources (Lv & Xu 2018). This paper has some limitations, as it does not follow the EKC model as (Sabir & Gorus 2019). In addition, technological advancement, urbanisation, and trade openness are ignored. This different sign of coefficient happens due to policy lag. As policies are established, but lack of transparency and justification does not utilise economic corridors to circulate inflows, outflows or capital, social connection through the internet is not a standard, and diplomatic failure has still prevailed.

## 6. Policy Implications

Several policies are to be taken from the government and the mass population. Firstly, it is necessary to encourage waste management and its effectiveness, to improve ecological balance and awareness of power use or waste. In addition, food waste, energy waste, and sewage drainage systems need to be more alert to utilise modern technology and ensure proper cleanliness. Secondly, utilising energy sources and improving renewable energy dependency is crucial in this century. Like other nations, Bangladesh's demand for escalating energy is insufficient to fulfil through existing renewable energy (Sinha et al. 2017, Lozano & Lozano 2018, Fan et al. 2018). Turning out of fossil fuel can come darkness and creates an environmental imbalance. To ensure sustainable development, renewable energy and its availability and usefulness need to be addressed more rapidly and can lessen the harm to our environment (Čuček et al. 2012). As the energy source comes from 60% of natural gas, this burning fossil is detrimental to our environment (GoB 2016). Therefore, government subsidies and recommendations promote solid oxide fuel cell (SOFC) technology with proper protection and expert knowledge.

Though the turbine combined cycle (CCGT) is already used on several power stations, adding SOFC can enlarge our efficiency and fulfil our demand. Hence, natural gas power plants that use GTCC and SOFC will reach a power generation efficiency of 70% with proper precaution in technology and expertise. In the long run, consumer behaviour and consciousness of electricity use are paramount. Out of total net power generation, 90 per cent have electricity facilities. Therefore, projects or policies need consumer-friendly policies. Thirdly, to curb the speed

of carbon emissions, new technology like carbon capture and storage technology (CCS) is crucial to reduce carbon emissions and retain fossil fuels in large amounts. This pathway creates two phases – curtail carbon emission and carbon footprint and preserve the environment in a less harmful way. Fourthly and finally, relying on renewable sources of energy is needful. For diversifying the economy, energy is crucial to be diversified.

The nation has nearly 234MW of energy production potential from sunlight-based home frameworks (Khan 2019). Thus switching from natural gas to solar is a mammoth task as natural gas emits between 0.6 and 2 pounds of $CO_2$ equivalent per kilowatt-hour ($CO_2$e/kWh). In contrast, solar power emission ranges between 0.07 and 0.2 ($CO_2$e/kWh). These issues need to be considered most important in vision 2021 or Delta's plan for 100 years. The sustainability of the environment is exploited mainly by energy diversification with wasting excessively. As solar energy is costly, the government needs more foreign investors to concentrate on the prevailing sustainable environment. Biomass is a good option as our labour force is mainly involved in agriculture. Moreover, biogas has the potential to produce more energy and a clean environment. A study declared that it could be possible to utilise 2.91 billion $m^3$ of biogas in Bangladesh in 2012-2013, equal to 1.455 billion litres of diesel (Halder et al. 2014).

On the other hand, the government has some handsome activities to navigate ecological balance. After completing SDG's goal, several benefits will happen (Destek & Sarkodie 2019). Firstly, the transition from non-renewable to renewable energy needs to be smooth, strategic, and psychologically adapted so that citizens easily learn the policies and fulfil their demands. Secondly, maintaining regulations and laws, especially for electricity and water use, can effectively reduce some types of waste. There are some initiatives, such as the enforcement of regulations related to the import of air-conditioning systems. Thirdly, awareness of environmental protection and green jobs are to be under the job creation of the government. Fourthly and finally, according to ICT-based energy policy, substitution from fossil fuel to green energy is endogenous.

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