Journal of Policy Research, 10(3), 243-254
https://jprpk.com
https://doi.org/10.61506/02.00340

Novel Methods to Calculate and Estimate the Factors Influencing the Ecological Footprints of Pakistan

Muhammad Imran Khan[1*], Samina Khalil[2], Mehwish Aziz Khan[3]

Abstract
Increasing demand for natural resources has exacerbated the scarcity of natural resources. Shortage of natural resources for timely needs is raising some significant environmental issues for the fast-growing population. It is argued that there is a trade-off between economic growth and environmental quality but it is debatable. To expand this debate, this article examines the short-run and long-run relationship between ecological footprints and income growth accompanied by other macroeconomic indicators. This study investigated the validity of the Environmental Kuznets curve between income growth and environmental pressure in Pakistan. This paper is based on secondary data for the period (1970 to 2021). The Auto-Regressive Distributive lag-bound testing method is utilized to determine the short-run and long-run links between income growth and ecological footprints per capita. The study found that a larger proportion of Pakistan's imports are contaminated with high embodied emissions. An increase in economic prosperity has dynamic implications for the environment across international borders. The products embodied emissions imported in Pakistan are greater than the emissions exported to other economies. The net effect of trade is negative on the environment in Pakistan. The study confirms that there exists a significant statistical relationship between ecological footprints and economic growth. This validates the evidence of the Environmental Kuznets Curve in the case of Pakistan.
Keywords: Environmental Kuznets Curve, Ecological Footprints, Bio-capacity and Income Growth, JEL Classification Q570, 1320

1. Introduction

The sustainability of the environment is becoming more of a challenge for low-income countries. The per capita ecological footprint of these countries is around 0.8 global hectares while middle-income countries have comparatively greater footprints per capita of 1.9 global hectares. Initially, the income growth of a nation increases resource consumption. Moreover, the data of the Global Footprints Network (GFN) shows that high-income countries have high resource consumption, with an average of 6.4 global hectares' ecological footprint. This indicates that if every person across the planet earth follows the same lifestyle, humans will have a need for 6.4 planets like earth for ecologically sustainable life.

On the other hand, these countries have a large amount of bio-productive spaces, with an average of 3.3 global hectares per person bases. These countries are consuming 47% more than their ecosystem can regenerate in a single year. Despite having a small biocapacity of 0.8 global hectares, low-income countries are however ecologically deficient. Only middle-income countries have a biocapacity of 2.1 global hectares, which is significantly higher than the ecological footprints (Global Footprints Network, 2018). The ecological deficit of -0.339 Global hectares shows that Pakistan's economy still requires 33 percent more resources than what is currently available (Global Footprints Network, 2010). It means Pakistan is in an ecological deficit.

The management of ecological deficit is a major challenge for developing nations. It is based on the available resource utilization and regenerative capacity of the available bio-productive space for a nation. This is going to be the greatest concern of all the rational professionals on planet earth, very soon. The economist category is one of the responsible communities to manage the resource flow across the borders. Pakistan is confronted with a significant number of challenges in terms of resource sustainability and shrinking biological productive space. The use of resources is greater than the available capacity. Improvement in biocapacity is expensive but the way to achieve long-term sustainability. One way of doing this is to invest in environmentally friendly technologies. It will help to reduce the existing environmental pressure. The second way to achieve sustainability is to trade the products which are not resource-intensive and causes comparatively less amount of carbon emissions.

Aşıcı and Acar, (2016) have established that the ecological deficits of the country can be recovered by either importing or exporting the biological capacity across borders. Dincer and Acar, (2015) found that the growth in national productivity allows the economies to export the emissions that are embodied in the products. Also, as the economy grows, demand level and trade patterns changes, which will also change the way the country uses its resources.

According to Aldy, et al. (2004), agriculture, industry, and services make up the economy. As an economy grows, its ecological footprint and bio-capacity change. Economic development affects the environment in multiple ways. First, as the economy grows, more products and services are produced to meet the demand of a growing population, rinsing the environmental quality. This effect is called the scale effect, which refers to the growing scale of the economy. As the economy size increases, it also increases the ecological pressure and thus reduces the regeneration capacity of bio-productive space. But after achieving a certain level of development, the technical

[1*] PhD Scholar at Applied Economics Research Centre (AERC), Karachi. imrankhanphd21@aerc.edu.pk
[2] Research Professor and Former Director, Applied Economics Research Centre (AERC), University of Karachi
[3] Assistant Professor at the Department of Business Administration Federal Urdu University Islamabad

effect allows the economy to produce more products and services with available resources, using new technologies. This effect is known as a technical effect. It indicates that economies at this stage of development are able to adopt environmental-friendly technologies, which helps to reduce the environmental pressure and at the same time allows to achieve the target economic growth. The third effect is the composition effect, which is also associated with the economic growth of an economy. The composition effect refers to the change in the composition of inputs materials in the production process.

In Pakistan, the composition effect refers to changes in the inputs of production, which includes the energy used and other natural resources. It is also observed that production is shifting from dirty to cleaner inputs, due to economic improvement and rigidity of environmental laws. This study examines the influencing factors of Ecological pressure in Pakistan, with a specific focus on the impact of economic growth and Foreign direct investment on Ecological footprints and bio-capacity of Pakistan.

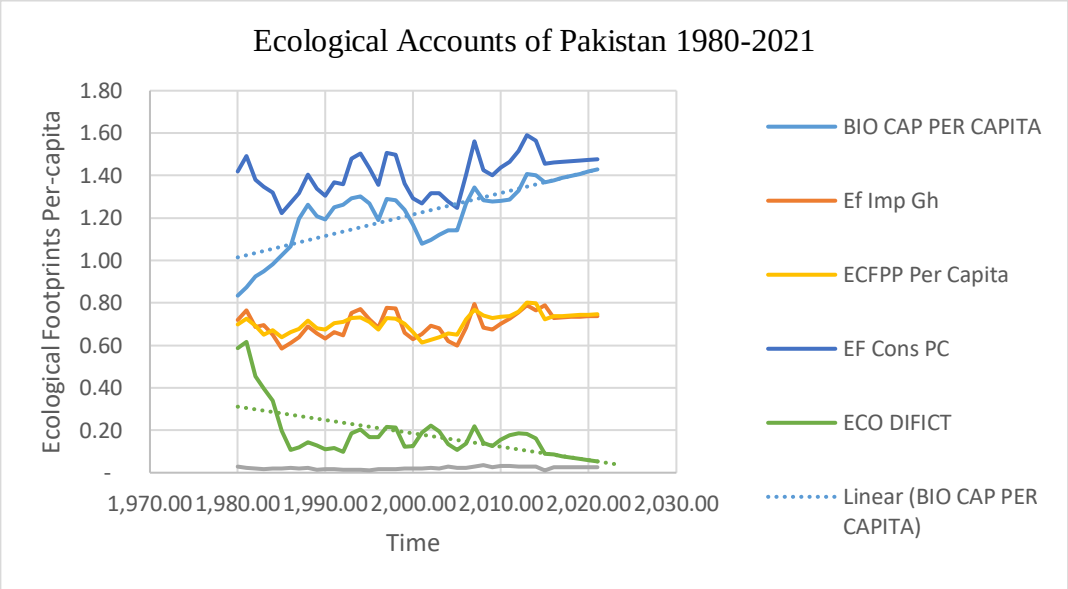

Figure.1 Pakistan's Ecological Footprints by Economic Activity 1980-2021

Figure 1 shows the trends of Biological productive space per capita, Ecological footprints of imports Global hectare, Ecological footprints of production per capita, Ecological Footprint of consumption per capita, which is per-person resource demand and on top of legends, it shows per-person resource supply (Biocapacity) in Pakistan over the last 41 years. The ecological footprints of Pakistan are shown on the top line in figure 1, which indicates an increasing trend. The second line from the top shows the biocapacity of Pakistan over the last 4 decades. The rise of ecological footprints and biocapacity is caused by both technology and human actions. In the recent, few years the ecological deficit forecast indicates that the ecological deficit is declining over time which is possible in the case of biocapacity expansion. It is quite possible by investing in such projects which improve the use and efficiency of environmental resources. The evidence of such investment can be justified by reports of the National Plan (2012-13), which says that the Federal and Provincial Governments of Pakistan have supported over 200 projects focused on providing safe drinking water, risk management for climate change, and adaptation through forestry, conserving ecological infrastructure, wildlife, and fisheries. Sustainable urban management is also included in these projects (Government of Pakistan, 2016).

Such projects will gradually strengthen the country's biological capacity while also assisting in the reduction of existing ecological pressures. Economic progress in Pakistan can help to reduce environmental pressure by implementing new technology and environmentally friendly practices in the manufacturing process. The rising trend of Pakistan exports CO_2 emissions, which reached 16.3 million metric tons in 2004. Growing faster, Pakistan's CO_2 emissions from exports reached a record 22 million metric tons in 2008, "while overall emissions in Pakistan were 157 million tons" from agriculture, transportation, industrial, and the energy sector McLellan et al., (2014). The explanation for rising trends in emissions from Pakistani exports could be the rapid growth of transport services in the country. These changes in the preferences of individuals on aggregated level can also influence the ecological pressure on bio-productive spaces in the economy. However, some of the multiple influencing factors are reported in previous studies for different countries. This study attempts to conduct a statistical analysis of the case of Pakistan, which is a much-needed analysis for designing ecologically friendly growth policies in Pakistan.

1.1. Objectives of the study

- To investigate the influencing factors of Humans induced ecological footprints and biocapacity in Pakistan.

1.2. Organization of the study

Section 1 is an introduction, followed by a review of the literature and theoretical framework in section 3, methodology in section 4, results and discussion in section 5, and conclusion and policy recommendations in section 6.

2. Literature Review

It has been proven that human beings are the most successful species on Earth. An ecological Footprint is a tool that measures, like a bank statement, how many resources we have that can be used over and over again and how often we use them Zaidi, (2000). How much bio-productive space do we have to support consumption and production in the economy and take care of the waste from these things? The Ecological Footprints allow us to assess the impacts and demands that humans place on natural resources and the ecosystem Aşıcı & Acar, (2016). The resources are turned into wastes, which are then converted back into resource power by the Sun, Galli et al., (2007) this is a life cycle phase. The footprints of a majority of the products are calculated through the Life cycle assessment method. This approach assesses the Carbon emissions of products through the life cycle, from the stage of production to the stage of consumption.

Pakistan is currently confronted with significant hurdles in managing GHG emissions while increasing economic growth. To put it another way, it can have economic interpretations that are both plausible and understandable, as Kamal, (2013) claimed that Pakistan has a difficult time sustaining its natural resources and biological productive space as a result of the overuse of resources. By examining PIC nations on a county-by-county basis (Pakistan, India and China), Irfan, et al (2011) carried out a decomposition analysis and argued that the reduction of CO_2 emissions and atmospheric emissions in the Low Carbon Economy (LCE) is a reality that cannot be refuted. Low income countries are working on infrastructure development to achieve economic growth and vice versa Irshad and Ghafoor (2022), which in both ways causes significant carbon emissions putting the environmental quality on rims.

According to (Muhammad & Ghulam Fatima, 2013), the major sources of carbon emissions in Pakistan are financial development and energy usage. The cement sector's increased demand for coal resulted in 61 percent use of coal in FY 2011, compared to 0 percent coal use in the 1990s. Increasing the use of carbon-intensive inputs in the production process increases the environmental pressure.

Pakistan has experienced the detrimental environmental impacts of the industrial revolution over time. The industrialization has increased energy demand and, as a result, environmental damage in the country. Pakistan's industrial sector consumed 36% of total energy, while the transportation sector consumed around 33%, although the overall consumption of the industrial sector climbed to 43% in 2010 Shahbaz and Lean, (2012). From 1870 to 2000, the concentration of greenhouse gases such as carbon dioxide (CO2) has climbed to 35%, but since 2001, the globe has faced high awareness and many nations have strictly enforced laws to restrict emissions to specific levels for the public and ecological happiness [Attari, et al (2011)].

These regulations are normally implemented by wealthy nations and other industrialized nations to accomplish their ecological duties. This occurs when demand for environmental quality is high. Low-income countries' CO_2 emissions can only be reduced if wealthy nations begin to implement diverse and sustainable development programs (Hu, 2002). A fraction of output footprints, in the traded commodities, which are exported to other countries can also help to achieve economic and environmental targets. For countries involved in the trade, it is a basic method of computing the most commonly reported type of Ecological Footprints, which is to subtract the export footprints from the production footprints and add the import footprints to it. Imports are counted as part of the same type of footprints as consumption footprints [Borucke et al., (2013)].

According to one study published in 2007, Portland Cement Association (PCA) members estimated an average of 927 kg of CO2 emitted for every 1000 kg of cement produced in the United States Marceau and VanGeem, (2007). Because these activities are interconnected, the ecological footprints of one activity may be influenced by another. Global hectares are the most often used measurement unit for ecological footprints. The key problem of our time is economic and environmental sustainability, which is degrading with increasing pace. The sustainability framework, according to Borucke et al., (2013), recommends three crucial aspects to incorporate into our lifestyle in order to sustain the need for daily life natural resources. The first is to improve the efficiency with which we use the resources we consume, the second is to safeguard and restore natural assets, and the third is to reduce our everyday environmental impacts. This is where the ecological footprint calculator comes in handy and is quite a meaningful tool to keep a record of available natural resources. It helps the human race to adjust to other species by reducing the negative environmental impacts.

Human dominance in the Earth's environment reduces ecological bio-productive space for other species Wackernagel et al (2004). This is the reason of declining of other species on planet earth. The reports of Global Footprint Network 2008 say that the current global use of resources is about 50 percent more than the Earth's biological capacity. Even though there are 199 countries, only 60 of them have more people than they can carry. It means that 139 countries have used up too much natural space Global Footprint Network, (2008).

According to the World Wild Fund for Nature (2012), it poses a significant risk to the natural resources of those nations whose rising standards of living have led to an increase in the number of natural resources being extracted and used, as well as an increase in the rate of resource use, which has been followed by an increase in the amount of pollution produced in the expectation that domestic lands will have a greater capacity to absorb it but it is not the case in the majority of the cases Bagliani, et al (2008). Huang and Wang, (2013), and Rivera & Oh, (2013) argued that a country with well-defined environmental legislation is more appealing to foreign direct investment and international trade. Additionally, Lovely and Popp (2011) found that spending on pollution management, or abatement costs, can have a considerable impact on a country's trading patterns. Aşıcı and Acar, (2016) proposed that ecological shortages can be compensated for by importing or exporting biological capacity across borders. Their research was based on cross-sectional observations from more than 100 nations. Additionally, Dincer and Acar, (2015) discovered that as economies grow richer, countries export products with embodied emissions and have identified some of the reasons that drive such behaviour.

According to Andersson and Lindroth, (2001) the interaction between trade and the environment is complex. A nation's ecological footprint can be reallocated in numerous ways. Positive trade allocation allows the economy to focus on products to manufacture them more effectively with fewer resources. Second, trade can reduce revenue. A negative income effect occurs when trade raises the economy's income, consumption, and ecological footprints. Third, is the macro-level Negative rich-country-illusion impact. It highlights the false brand of rich countries that their economic lifestyle is justifiable.

The prospect of surrendering biocapacity for higher-income yields has arisen in the minds of underdeveloped nations. According to Nordström and Vaughan (1999), such delusions cause the ecological footprint to increase in both rich and low-income countries. The unique approach to calculating ecological footprints for each economic activity presents a strong case for the paper's novelty. All previous studies investigated the scenario of EKC hypothesis testing using CO2 emissions as the dependent variable, and only a few studies employed a directly available data set of ecological footprints from the Global Footprints Network (GFN). The study of Hassan et al., (2019) has used GFN data set of ecological footprints, natural resources, and human capital from secondary sources. The study estimated the long-run relationship between these variables and established that there exists a statistically significant relationship between human capital development and ecological footprints.

Adding up to the discussion, a study conducted by Rashid et al. (2018) used a questionnaire-based survey approach to calculate the ecological footprints of cities or towns on cross-sectional data sets, which falls in the domain of micro-level studies. This study also examined influencing factors of variation in ecological pressure across different cities.

Another study by Bankole et al. (2015) used secondary cross-section data from more than 100 countries and examined the EKC hypothesis across the country. However, relatively few studies have looked at changes in trade and trade patterns and their implications for environmental changes across time. Researchers all across the world have employed the EKC for single-country cases on various environmental indicators such as CO2 emissions.

The study of Yousaf et al. (2018) investigates high-income and middle-income nations' ecological and CO2 footprints, environmental intensity, and economic inequality from 2003 to 2011. High-income nations have larger ecological and CO2 emission footprints than middle-income ones, widening the income per capita and environmental intensity gap. According to the Atkinson Index, reducing the environmental intensity and wealth disparities will reduce total ecological and CO2 footprints, enhancing environmental sustainability. Similarly, a study on the ecological intensity of well-being (EIWB) by Irshad et al. (2021) examined the balance of environmental services and human well-being. Sustainability research reduces EIWB. Linking infant mortality to ecological footprint per capita changes EIWB. ISR measures development-country well-being, while EF per capita measures environmental stress. There are studies that have examined the relationship between economic growth and environmental quality, which include (Burgess, et al. (2003); Cole, (2000); Daly, (1993); De Bruyn, (2000); Lekakis, (2000); Stern and Common, (2001)] but none of these have used product-specific standards to calculate ecological footprints for a nation.

A current study is a unique approach, it fills a gap in the literature by testing the existence of the Environment Kuznets Curve (EKC) between ecological footprints and income growth for a single country case using a new method of calculation and exploring the concept of Artificial biocapacity in context of ecological economic theories. A nation’s Ecological Footprints are often driven by an increasing biocapacity of a country Borucke et al., (2012). This indicates that the biocapacity of a country is important to produce more and meet the increasing demand of a growing population. This study also examines the influence of trade openness, energy use, foreign direct investment, and economic growth on Natural resources utilization and regeneration in Pakistan. There are multiple studies that have tested the EKC hypothesis but very few studies have been reported on time series analysis. Especially, in the case of Pakistan other dimensions have been explored but this research is intended to introduce a new technique of measuring the biocapacity and ecological footprints. The writers have used product-specific footprint criteria, which is never been used by the previous research due to the fact that it is a difficult and time-consuming approach. These standards are set by Global Footprints Network (GFN), Lead Pakistan, and other reputed organizations. This study utilizes two fundamental ecological footprint methodologies. The first is

the component-based strategy, commonly known as the bottom-up method. This method computes the carbon footprint of each product separately. This method provides a great level of detail but also has several notable drawbacks. To overcome such type of drawbacks, this study has coupled a component-based approach with another approach known as the compound-based approach. The compound method is the summation of all the products to a single computable variable. This approach helps in eliminating the biases of previous approaches and enables the researchers, to disaggregate and aggregate Pakistan's ecological footprints. After calculating the product-specific footprints and converting them to the per-capita footprints unit, ARDL is applied to investigate the short-run and long-run estimates of footprints with multiple regressors in the model of this study.

2.1. Theoretical Framework

According to the "orthodox economists, the ecological deterioration is presumed as a market failure. Because most of the ecological services are still not priced in the markets. Ecological economics is more of a pluralistic approach. It argues that, while integrating the economy into the natural economy, must obey the natural law that rules the planet. While environmental economics is based on the view of Neoclassical economics refers to efficiently allocating labor and capital to maximize production and economic progress. It focuses on market efficiencies to minimize net social losses while integrating the economy into the natural economy (Standing, et al. 2008). The trade-off between economic development and the environment is based on market failure and it can be reduced through the decision-making process. It is argued that a country's economic progress enables it to improve and pursue environment-conscious technologies and methods for producing and consuming goods and services Wackernagel et al., (2002).

The idea behind this study is that income growth, trade, and industrial growth all have three different effects on the environment: scale effects, technology effects, and, last but not least, composition effects Grossman and Krueger, (1991). To enhance output, higher levels of inputs are required, necessitating greater usage of natural resources in the production process. This also entails an increase in emissions and waste production, which have direct and indirect impacts on environmental quality. These impacts are divided into two major categories, the anthropogenic and non-anthropogenic impacts.

The theoretical backup for current study is inspired from the work of York et al. (2003), which has established that population, welath, and technology are the forces behind the anthropogenic impacts on the environment (IPAT). This is a widely recognised framework used in previous studies. The identity shows that environmental impacts are the multiplicative product of three key driving forces: population, wealth and technology Ehrlich and Holdren (1971). Therefore, economic expansion exhibits a "scale effect" that initially causes negative environmental impact. In contrast, economic expansion can also have good effects on the environment through the composition effect: as affluence rises, the structure of the economy shifts towards transformation and prefer environmental friendly activities and it cause less pollution. As a prosperous nation can afford to invest greater wealth on R&D Komen,et al (1997). Technological advancement occurs with an increase in income and other economic indicators. The technologies which produce significant pollution and environmental degradation are replaced by better-quality, new and cleaner technologies, resulting in less emissions, which improves the environmental quality. Positive allocative effect, "which reflects the reduction of ecological footprint as trade enables an economy to get specialization on a product, which is produced with a higher productive yield". The possibility of trading bio-capacity with increasing economic growth may also generate another fallacy on the part of poor countries that economic progress is required for a better environmental quality Nordström and Vaughan, (1999). According to Andersson and Lindroth, (2001) the concept of trade and ecological footprints are interlinked with cause and effect. This approach is appealing to the reason that trade expansion is included as an independent variable in this study.

3. Data And Methodology

Description of Variables used in empirical analysis

Variables	Variable source and unit of measurement
GDP Per capita	Income growth is taken as Gross Domestic Product per capita. The growth rate is calculated, the data is taken from Pakistan economic survey and it is measured in (United States Dollars 1482.21 USD) with growth rate of 1.18%.
Consumption Footprints per capita	Standards of products selected for this study are taken from Global footprints network and used for further calculations of ecological footprints (Gha) Consumer-based approach is used, while calculating the Footprints for each area and type of products coming from a different resource base of the country. The Ecological Footprint of consumption (EFC) can be calculated as $EFP_{Consumption} = EFP_{Imports} + EFP_{Production} - EFP_{Exports}$
Openness to Trade (OTT)	Openness to Trade exports + imports, % of GDP. Pakistan economic survey
Biological Capacity (BC)	Global hectares (Gha) is the measurement unit and Global Footprint Network standards are used for calculation of the available productive space as Bio Capacity.

Energy use per capita ENPC	Energy use per capita Tonne of oil equivalent is taken from Pakistan Economic Survey
Population density (PD)	People residing on square kilometre in Pakistan.
Foreign Direct Investment (FDI)	Foreign direct investment as percentage of Gross domestic product of Pakistan

3.1. Data sources and calculations

Income growth and other variables are derived from the Pakistan Economic Survey 1970-2021. The data for traded commodities, wheat, cotton, rice, cement, fertilizers, and a few more goods is also collected from Pakistan economic surveys from 1970 to 2021. This article utilizes directly available data on income growth, trade openness, energy use per capita, and population increase and calculates ecological footprints and bio capacity with the help of products specific standards. The study's key variables are ecological footprints and biocapacity. Using the methodology of Zhang, (2005), the ecological carrying capacity duplicates those resources that support the number of individuals while not jeopardizing future carry capacity. Therefore, the calculation formula of Per Capita Ecological carrying capacity is:

$$ec = a_j \times r_j \times y_j \qquad \text{(j= 1.2.3……...11)}$$

Where: ec is per capita ecological carrying capacity (hm^2 per person)
aj is per capita biological productive area
rJ is equivalence factor and yj is yield factor
Regional Ecological carrying capacity:

$$EC = N \times (ec)$$

Where: ECC is regional ecological carrying capacity of the total population (hm^2) dependent on these commodities and N is the number of people.

3.2. Econometric Methodology

The component and compound technique are used to calculate the ecological footprints and bio productive space. I in this study to determine ecological footprints and bio-capacity. The most difficult part is calculating ecological footprints and bio capacity using secondary data from Pakistan's economic survey. It is difficult because of the changing standards over time as well as changes in technology. In comparison to previous and traditional Co integrating approaches, this strategy delivers superior compensation. This function was built on the idea that (PCCEFP) Per Capita Ecological Footprints of Consumption are redistributed when per capita income grows, and that income growth is squared. For more precise assessment, variables such as (TO) Trade Openness, (BC) Bio Capacity, (POPD) Population Density, and (ENPC) Energy Per Capita are incorporated in the econometric model. The hypothesis is based on the expectations that energy consumption and ecological footprints are positively associated in long run, which is ENPC > 0. The hypothesis for income and environment relation reveals that GDP > 0 while sign of GDP2 should be negative or 2 GDP < 0, indicating the EKC curve testing. The expected sign of trade openness is negative, TO < 0 if the production of pollutant intensive items is reduced due to the environment protection laws and imports of such items from the other countries where environmental laws are flexible(Grossman & Krueger, 1995) and (Halicioglu, 2009).

3.3. Model Specification

This study applies the Auto Regressive Distributive Lag technique (ARDL). The process is depicted in the Equation for Per capita Ecological Footprints and Income Growth, along with some other explanatory variables. The authors have made use of the Akaike information Criteria to select the best model among the given number of models, which is the one with the lowest value, before working on the final estimation of the ARDL model. The work of Pesaran et al. (2001) ARDL bounds test assumes that the variables should be stationary at I (0) or I (1). This assumption has been validated, using the [4]Augmented Dickey-Fuller tests to ensure that the variables are not I (2). The presence of a variable integrated of order two can lead to misinterpretation of value F statistics provided by Pesaran, et, al. (2001).

The general form of the model

a) $Yt = A + B\sum Yt - i + BXt + B\sum Xt - i + Ut$ (1)
b) Yt is the dependent variable and A is the intercept
c) Yt-i is the lagged dependent variable
d) Xt is the independent variable,
e) Xt-i is the lagged independent variable

Ut is the error term

[4] Akaike information criteria is used to select the optimum lag length

3.4. Auto Regressive Distributive Lag model

$$\Delta y_t = \propto + \sum_{i=1}^{n} \beta_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta X_{1t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta X_{2t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta X_{3t-i} + \ldots + \sum_{i=0}^{n} \beta_{ni} \Delta X_{nt-i} + \delta_1 y_{t-1} + \delta_2 x_{1t-1} + \delta_3 x_{2t-1} + \delta_4 x_{3t-1} + \delta_5 x_{4t-1} + \delta_5 x_{4t-1} + \ldots\ldots + \delta_n x_{nt-1} + \varepsilon_t$$

(2)

y_t is a dependent variable and x_{1t}, x_{2t}, x_{nt} are independent variables. It is also assumed that yt~I (1) and independent variables are either I (1) or I (0). Where Δ shows the first difference operator and t is the residual of the model.

The equation for Consumption footprints[5] can be written as following,

[6]$$\Delta PCEFCt = \alpha\_t + \sum \beta 1(PCEFC)t-1 + \sum \beta 2\Delta(PCIGRW)t + \sum \beta 3\Delta(PCIGRWt-1 + \sum \beta 4\Delta(PCIGRW)t-2 + \sum \beta 5\Delta(PCIGRW)2t-1 + \sum \beta 6In\Delta(D(POPG)t-1 + \sum \beta 7\Delta(OTT)t-1 + \sum \beta 8\Delta(ENPC)t-1 + \sum \beta 9\Delta(BC)t-1 + \lambda 1(CEFC)t-1 + \lambda 2In\,(PCEFC)t-1 + \lambda 3(PCIGRW)t-1 + \lambda 4(PCIGRW)2t-1 + \lambda 5(POPG)t-1 + \lambda 6\,(InOTT)t-1 + \lambda 6\,(InBC)t-1 + \mu i$$

(3)

The equation shows that change in Per capita ecological footprints (PCEFC) over the time is the function of its own lag values, income growth, income growth square, population growth, trade openness and energy per capita use, in the short run as well as in long run.

The null hypothesis for bound testing is

H_0: δ1= δ2= δ3= δ4= δ5=...=Sn=0 (no long-run relationship exists)

And the alternative hypothesis is

H_0: δ1≠ δ2≠ δ3≠ δ4≠ δ5≠⋯≠ δn≠0 (long-run relationship exists) where δ = β and δ = λ in the above equation.

4. Results And Discussions

4.1. Descriptive Statistics

According to the results shown in appendixes, Pakistan's Production Per Capita Ecological Footprint is quite near to import Ecological Footprints but much smaller than Consumption Footprints per Capita. These findings are consistent with the findings of Dincer and Acar, (2015) and Chong and Calderon, (2000), who previously established that income rises, the ecological footprints of imports also grow faster than the production footprints of emerging countries. According to our calculations, import footprints are slightly less than production footprints. Higher consumption footprints are proof that Pakistan has experienced consumption-driven pollution. Pakistan's import footprints account for 45 percent of its total consumption footprints. It suggests that Pakistan must also pay attention to managing incoming pollution in addition to its own emissions.

As per the authors' calculations, Pakistan's per capita ecological footprint is 1.5 global hectares, implying that Pakistan consumes 40% more than what is available or replenished each year. Pakistan's average ecological footprint is more than its current average bio capacity, putting the country in an ecological deficit. The ecological footprints of manufactured goods and imported commodities are nearly comparable, implying that the negative consequences of imports and production on the environment in Pakistan are roughly equivalent.

Imports and production in Pakistan are mostly responsible for these negative environmental effects. Pakistan has not yet established a carbon fee on imports and domestic manufacturing. The results of the current study indicate that artificially driven biocapacity is increasing over time, and it is possible to increase the biocapacity with the help of agriculture intensification with better seeds, better technology, conversion of barren lands to cultivable lands, and changing the imports composition from high polluting goods to goods, with minimal embodied emissions, which appears beneficial for Pakistan, to reduce the Ecological deficit in the future, as we move forward. Through dams and water reservoirs, Pakistan has enhanced its agricultural land area and water storage capacity. Unfortunately, Pakistan's economy is still ecologically deficient. Because the amount of natural resources, which nature can produce throughout the year are less than the actual demand for natural resources and it exceeds supply by 33 percent. However, the gap between ecological footprints and bio-capacity is closing, and it is expected that bio-capacity will take the lead in a few years if the supposed environmental budget is efficiently managed, or because of changes in the composition of products imported and exported or consumed by Pakistan. Changing from a filthy to a greener manufacturing technique can also help Pakistan save its pristine environment. The artificial bio capability is improving as technology advances. Pakistan's vertical bio capacity is still being investigated because cities are transitioning from planned housing societies to high-rise buildings, and we still have a lot of space to discover our ecological reserves, which will not be the same in a few years.

4.2. Carbon Footprints of Pakistan

According to the Pakistan Economic Survey 2006-07, the number of vehicles on the road has increased as well. In 1990, there were 2.7 million vehicles, which increased to 5.5 million in 2005, an increase of more than 100 percent, and the growth is expected to continue to 9.8 million tons in the next 3-4 years. Because of the economy's

[5] Consumption of products process by a factory at any stage become additional polluted due to human induced interventions

[6] This equation represents the ecological footprints influencing factors

decreased export volume, this trend fell to 1.61 million metric tons. Right Following the 2008 financial crisis, the CO2 trend remained downward until the time of the 2010 floods, since we needed such commodities to distribute in our economy. Overall, export emissions are growing prior to 2008 and decreasing after that date for certain items. CO2 emissions from production have demonstrated an increasing tendency over the last 34 years, however the slop has been quite low from FY 1995 to FY 2001. Only from 1997 to 2001 was there a discernible decrease in CO2 emissions from the manufacturing of specific commodities in Pakistan. Overall, per capita emissions from these commodities are growing, with 1.8 metric tons in FY 2007 rising to 2.13 metric tons in 2015. Initially, Pakistan imported products from foreign nations with 0.16 million tons of embodied CO2 emissions in the 1980s. In fiscal year 2014, these emissions grew to 0.16 million metric tons. Per person, the embodied emissions are 0.83 tons.

In other words, we can manage the negative environmental consequences of other countries by 0.83 tons per person, which will affect the economy's available bio capacity accordingly, but it is still environmentally friendly when compared to Pakistan's own country production process for specific goods. Pakistan can save its own bio-capacity by importing high polluting products from trading partners. If this country manufactures these environmentally harmful products through its own manufacturing process, it may incur higher environmental costs than trade with another country. CO2 emissions from the consumption of specific commodities have risen throughout time. The rising trend indicates rising demand for specific commodities such as wheat, rice, rubber, cotton, cement, fertilizer, fish, and petroleum products. Other data scientists and organizations' overall CO2 trend appears very similar to the graph displayed below in the current study.

Table 1: Unite Root Tests Augmented Dickey Fuller Results

Variable name	Z(t) test statistics	With trend	1 % critical value	5 % critical value	10 % critical value	Oder of integration
Ecological footprints per capita	-1.365	-2.007	-3.628	-3.532	-3.199	1(1) FD
GDP	-2.674	2.297	-4.214	-3.528	-3.197	1(1) FD
GDP^2	-2.082	2.277	-4.224	-3.532	-3.411	1(1) FD
Trade openness	-2.674	2.297	-3.220	-3.528	-3.199	1(1) FD
Population growth	-2.674	2.277	-3.620	-3.532	-3.199	1(1) FD
Bio capacity	-4.224	3.577	-3.405	-3.528	-3.411	1(0) level
Energy use per capita	-4.224	3.577	-4.493	-3.532	-3.411	1(0) level
FDI	-2.674	2.277	-3.620	-3.532	-3.199	1(1) level

The paper has applied Augmented Dickey Fuller test to check the stationary of the data considered for the analysis. Also, to check the order of Co integrating for each series, current research has employed Unit root test. The study has confirmed that each series is 1(1) however 1(0) series are also the part of study data sets, but not any single series was integrated of order 1(2). To ensure that the results are not spurious, furthermore current study has used some other tests. The diagnostics test included Durbin Watson test to check autocorrelation for each series, LM test for serial correlation, where all the series of the data is brought away from all the econometric issues, without forgetting the multi-collinearity and heteroscedasticity.[7]

4.3. Income Growth and Consumption Footprints

Initially, the real income growth boosts Pakistan's ecological footprints. However, present income growth has no substantial association with consumption's ecological footprint. This suggests that Per Capita Consumption Ecological Footprints variable are not increasing in response to current income growth. Income growth squared, on the other hand, is negative and statistically significant. The Eco-Footprints of Consumption are positively impacted as a result of rising population and increased production scale, which imposes a scale effect on the current nexus of Income Growth and Ecological Footprints. The current analysis suggests that reallocation appears to be a result of the composition effect, where variations in import composition have been observed over time. Increasing money can have an effect on demand patterns, which can lead to a shift toward dirty goods, albeit this composition can also include cleaner products. Pakistan's consumption footprints are positively related to trade openness, supporting the hypothesis of the negative income effect. Which hypothesis holds that commerce raises income, which raises consumption, raises energy per capita, and hence raises a country's ecological footprint? However, in our estimation, the relationship between energy per capita and environmental pressure is statistically insignificant. Pakistan footprints are positively associated with increasing Bio capacity and strongly significant. This effect has led by intensified agriculture and efficient utilization of available resources as compared to past

[7] To proceed with the best results current study has followed Cameron (1994) By converting the linear function to a log-linear model. The Log of Per capita Income Growth (LPCIG), Log of Squared term of Per capita Income growth (LPCIG^2), which is added to equation to track the linearity of relationship between the income growth and per capita footprints of consumption

for specific products. However, the population growth has intensified the demand and thus the imports footprints due to lower taxes on imports of dirty products has led the growth of ecological pressure in the economy, which can also cause hike in other government expenditures.

Table 2 shows wald tests F Statistics value is greater than each of the critical bound values, especially the upper bound values. There is no need to change the set of variables. It allows us to reject the null hypothesis and we proceed further to check the long-run and short-run relationship between these variables through ARDL Co integrating form as well as long Run form.

Table 2: Relationship between income growth consumption footprints

ARDL Bounds Test		
Sample: 1970 2021,		
Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	K
F-statistic	11.0553	2
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Table 3 shows long-run Income growth and its squared term are statistically significant, verifying the Traditional EKC inverted U-shaped relationship in Pakistan. Only short-run income growth does not reallocate consumption footprints in Pakistan. Long-term income growth and growth squared are negatively associated with ecological footprints. Population growth increases ecological footprints both in the short and long run. Pakistan Footprints responds positively to growing biocapacity in the short-run as well as in long run. Pakistan's per capita Ecological Footprints are not correlated with Energy Per Capita in the short run, but the coefficient sign is positive and statistically significant in long run.

This implies that energy use growth will lead to larger Ecological Footprints in the future. This also implies that consumption ecological footprints in Pakistan are energy-intensive and it can be controlled with changes in the existing mix of energy on the aggregate level. High biological productive space does not always mean that the country can produce as much as it needs, but it indicates that Pakistan can import without the fear of ecological deficit, aware of the fact that, absorption capacity is manageable and the country can import. The ecological footprint is positively associated with Foreign direct investment in the short run and negatively associated in long run. In the long run, when the projects are completed it might help to reduce the environmental pressure if it is an environment-oriented project. See 4.3 for a detailed discussion

Table 3: Ecological Footprints of Consumption and Income Growth (ARDL)

Cointegrating Form		
Variable name	Short-run estimates	Long run estimates
D(PCIGRW)	0.013	-0.050**
	(0.006)	(0.15)
D (PCIGRW (-1))	0.031	-0.015**
	(0.023)	(0.477)
D(PCIGRWSQ)	-0.72**	-1.04**
	(0.004)	(1.10)
D(POPG)	1.19***	1.48**
	(5.41)	(3.52)
D(OTT)	1.84	-0.15**
	(0.18)	(052)
D(ENPC)	-	0.08*
		(0.49)
D(BC)	0.53**	0.73***
	(0.97)	(1.22)
D(FDI)	4.80**	-2.87***
	(6.51)	(9.43)
CointEq (-1)	-1.894***	1.09**
	(3.33)	(2.001)
ECT	-	-0.21
		(1.88)
R^2 = 0.9949	Adj R^2 = 0.9919	F (17, 29) = 332.33

*P < 0.05, **P<0.01 and ***P<0.001 (Standard error in parentheses)

5. Conclusion and Policy Recommendations

The study demonstrated that per capita ecological footprint of consumption and income growth are co-integrated in the long run, supporting the EKC hypothesis in case of Pakistan. Imports are embodied with high emissions but It means that producing the same products in Pakistan will also require more natural resources and reserves as inputs. If these products are imported from other nations on reasonable economic terms to sustain the needs of Pakistan's growing population, it can be a reasonable move, for the preservation of environmental quality in Pakistan. Income growth and other economic factors may deviate Pakistan's environmental patterns.

Pakistan's export footprints are less than the imported footprints, indicating that the country is a consumption-based pollution-driven economy. Pakistan imports are 45 percent of its entire ecological impact receiving from the other countries in the form of imported products each year. However, evidence for Pakistan is reinforced by ground realities for observable and changeable responses from one economic activity (agricultural sector) to another economic activity (industrial sector) from one type of pollution to another. Pakistan can lessen environmental pressure by upgrading its manufacturing process. In Pakistan, the composition effect is prevalent, which causes the ecological footprints to be reallocated through time. Over the last 20 years, changes in trade product mix have altered the pattern of environmental pressure imported from other countries in terms of imports. Even in the composition of exports, this effect is fairly significant. The Pakistani way of living is not environmentally sustainable.

Long-term income growth reallocates Consumption Footprints, which may be greatly decreased by deploying environmentally friendly technology and altering the composition of inputs used in the manufacture of various items. Therefore, policymakers and implementers must be aware of the inputs utilized in the manufacturing of goods and the permitted emission requirements for businesses. Importing products with high resource requirements and high production costs from nations that specialize in their production can help Pakistan preserve economic space for future generations by conserving biological resources. As a result of saving the environment and resources, it will also improve our net social welfare. It is crucially important to minimize the emissions of Pakistan's garment manufacturing and tanning industries, which place a greater environmental burden on both the hosting and receiving countries. The income growth can help to improve the environmental quality of Pakistan but it is expected in long run.

5.1. Conflict of interest

The authors declared that there are no competing interests between them on any level that could affect this work.

5.2. Limitations of the study

1) Because per unit ecological footprint criteria for all products are not widely available, we leveraged existing standards to propose a novel approach.

2) The distance from port-to-port data was not efficiently structured; distance is the study's temporary limitation; it may be covered in the working paper if the data was convincing enough to use.

3) Double counting is a restriction that prevents us from including all of the products in Pakistani customers' consumption baskets.

References

Aldy, J. E., Ashton, J., Baron, R., Bodansky, D., Charnovitz, S., Diringer, E., . . . Tubiana, L. (2004). Beyond Kyoto: Advancing the international effort against climate change: Pew Center on Global Climate Change.

Andersson, J. O., & Lindroth, M. (2001). Ecologically unsustainable trade. Ecological Economics, 37(1), 113-122.

Aşıcı, A. A., & Acar, S. (2016). Does income growth relocate ecological footprint? Ecological Indicators, 61, 707-714.

Attari, M. I. J., Kamal, Y., & Attaria, S. N. (2011). The causal link between foreign direct investment (FDI) and economic growth in Pakistan economy. The Journal of Commerce, 3(4), 61.

Borucke, M., Moore, D., Cranston, G., Gracey, K., Iha, K., Larson, J., . . . Galli, A. (2013). Accounting for demand and supply of the biosphere's regenerative capacity: The National Footprint Accounts' underlying methodology and framework. Ecological Indicators, 24, 518-533.

Burgess, J., Bedford, T., Hobson, K., Davies, G., & Harrison, C. (2003). 10.(Un) sustainable consumption. Negotiating environmental change: new perspectives from social science, 261.

Bankole, F. O., Osei-Bryson, K.-M., & Brown, I. (2015). The impacts of telecommunications infrastructure and institutional quality on trade efficiency in Africa. Information Technology for Development, 21(1), 29–43.

Borucke, M., Galli, A., Iha, K., Lazarus, E., Mattoon, S., Morales, J. C., Poblete, P., Wackernagel, M., & Network, G. F. (2012). The national footprint accounts, 2012 edition. Global Footprint Network: Oakland, CA, USA.

Burlando, R., & Tartaglia, A. (2018). Physical Limits to Economic Growth. Routledge.

Chong, A., & Calderon, C. (2000). Causality and feedback between institutional measures and economic growth. Economics & Politics, 12(1), 69–81.

Capra, F., & Pauli, G. TOKYO· NEW YORK· PARIS.

Cole, M. A. (2000). Air pollution and 'dirty'industries: how and why does the composition of manufacturing output change with economic development? Environmental and Resource Economics, 17(1), 109-123.

Daly, H. E. (1993). The perils of free trade. Scientific American, 269(5), 50-50.

De Bruyn, S. M. (2000). The environmental Kuznets curve hypothesis Economic Growth and the Environment (pp. 77-98): Springer

Dincer, I., & Acar, C. (2015). A review on clean energy solutions for better sustainability. International Journal of Energy Research, 39(5), 585–606.

Ehrlich, P. R., & Holdren, J. P. (1971). Impact of Population Growth: Complacency concerning this component of man's predicament is unjustified and counterproductive. Science, 171(3977), 1212-1217.

Galli, A., Kitzes, J., Wermer, P., Wackernagel, M., Niccolucci, V., & Tiezzi, E. (2007). An exploration of the mathematics behind the ecological footprint: Wit Press: Billerica, MA, USA.

Government of Pakistan, M. o. F. (2016). Pakistan Economic Survey 2014-15. from http://webcache.googleusercontent.com/search?q=cache:qC9Jsnt6dOkJ:www.finance.gov.pk/survey_1415.html+&cd=1&hl=en&ct=clnk&gl=pk

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement: National Bureau of Economic Research.

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. The Quarterly Journal of Economics, 110(2), 353–377.

Halicioglu, F. (2009). An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, 37(3), 1156–1164.

Hassan, S. T., Xia, E., Khan, N. H., & Shah, S. M. A. (2019). Economic growth, natural resources, and ecological footprints: Evidence from Pakistan. Environmental Science and Pollution Research, 26(3), 2929–2938.

Hornborg, A. (2001). The power of the machine: Global inequalities of economy, technology, and environment: Rowman Altamira.

Irshad, H., Hussain, A., & Malik, M. I. (2021). The Ecological Intensity of Well-Being in Developing Countries: A Panel Data Analysis. Human Ecology Review, 27(1).

Irshad, R., & Ghafoor, N. (2022). Infrastructure and Economic Growth: Evidence from Lower Middle-Income Countries. Journal of the Knowledge Economy, 1–19.

Irfan, M. F., Usman, M. R., & Kusakabe, K. (2011). Coal gasification in CO 2 atmosphere and its kinetics since 1948: a brief review. Energy, 36(1), 12-40.

Kamal, M. (2013). Financial development and economic growth in Egypt: A re-investigation. Available at SSRN 2297228.

Komen, M. H., Gerking, S., & Folmer, H. (1997). Income and environmental R&D: empirical evidence from OECD countries. Environment and development economics, 2(04), 505-515.

Lekakis, J. N. (2000). Environment and development in a southern European country: which environmental Kuznets curves? Journal of Environmental Planning and Management, 43(1), 139-153.

McLellan, R., Iyengar, L., Jeffries, B., & Oerlemans, N. (2014). Living planet report 2014: Species and spaces, people and places. WWF International.

Marceau, M. L., & VanGeem, M. G. (2007). Modeling Energy Performance of Concrete Buildings for LEED-NC Version 2.2: Energy and Atmosphere Credit. PCA R&D Serial(2880a).

Mózner, Z. V. (2013). A consumption-based approach to carbon emission accounting–sectoral differences and environmental benefits. Journal of Cleaner Production, 42, 83-95.

Muhammad, J., & Ghulam Fatima, S. (2013). Energy Consumption, Financial development and CO2 emissions in Pakistan.

Network, G. F. (2010). Ecological footprint atlas 2010. Retrieved May, 25, 2014.

Network, G. F. (2018). Partner Network.

Nordström, H., & Vaughan, S. (1999). Trade and the Environment (Issue 4). WTO Special Studies.

Norgaard, R. (2002). Tracking the ecological overshoot of the human economy. Proceedings of the national Academy of Sciences, 99(14), 9266-9271.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289–326.

Rashid, A., Irum, A., Malik, I. A., Ashraf, A., Rongqiong, L., Liu, G., ... & Yousaf, B. (2018). Ecological footprint of Rawalpindi; Pakistan's first footprint analysis from urbanization perspective. Journal of Cleaner Production, 170, 362-368.

Shahbaz, M., & Lean, H. H. (2012). Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. Energy policy, 40, 473-479.

Standing, C., Jackson, P., Chen, A. J., Boudreau, M.-C., & Watson, R. T. (2008). Information systems and ecological sustainability. Journal of Systems and Information Technology, 10(3), 186-201.

Stern, D. I., & Common, M. S. (2001). Is there an environmental Kuznets curve for sulfur? Journal of Environmental Economics and Management, 41(2), 162-178.

Wackernagel, M., Schulz, N. B., Deumling, D., Linares, A. C., Jenkins, M., Kapos, V., ... & Randers, J. (2002). Tracking the ecological overshoot of the human economy. Proceedings of the national Academy of Sciences, 99(14), 9266-9271.

York, R., Rosa, E. A., & Dietz, T. (2003). STIRPAT, IPAT and ImPACT: analytic tools for unpacking the driving forces of environmental impacts. Ecological economics, 46(3), 351-365.

YOUSAF, H., HUSSAIN, A., & KHALIL, S. (2018). Ecological Footprint, Environmental Intensity And Income Inequality. Pakistan Journal of Applied Economics, 28(1), 19–31.

Zaidi, S. A. (2000). Ecological Footprint - A tool for assessing sustainable energy supplies. Issues in Pakistan Economy, Oxford University, pp. 159–183.