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The Role of Agriculture in Environmental Degradation: Implications for Developing Countries

ABSTRACT

Abstract: This study examines the factors influencing environmental degradation in developing countries from 1990 to 2020, with a particular focus on the role of income using panel data analysis. A set of environmental degradation indicators is utilized to assess the impact. The panel unit root test indicates that all external sector variables are non-stationary in their original series but become stationary at first difference, except for ecological footprint and carbon dioxide emissions. The Pedroni Cointegration test confirms the existence of a long-term relationship between the dependent and independent variables. The study employs Pooled Mean Group (PMG), Mean Group (MG), and Augmented Mean Group (AMG) models. The PMG model results indicate that net national income and agricultural production significantly increase ecological footprint, contributing to environmental degradation. The interaction term, which is statistically significant, highlights the role of income with environmental degradation and agricultural production. The findings highlight that higher income levels significantly impact the environment, however an increase in renewable energy usage, industrial value-added, and carbon dioxide emissions influence environment negatively. Hence, the government need to adopt income enhancing and environment friendly policies.

Keyword: Environmental Degradation; Income Dynamics; Agricultural Production; Carbon Dioxide Emissions

Introduction

Agriculture is both a science and an art that involves cultivating crops, managing soil, and raising livestock. Environmental degradation refers to the deterioration of the natural environment due to human actions and natural disasters, resulting in diminished ecological health and loss of biodiversity (Olanipekun & G.-W., 2019).

In low-income countries, high poverty levels make it challenging to manage the effects of environmental degradation. Agriculture is vital for the developing economies. When agricultural practices are not properly maintained, they can contribute to environmental degradation. These nations often prioritize economic activities to alleviate poverty; however, this focus is insufficient to ensure sustainable environmental practices. Instead, it is crucial that comprehensive reforms are urgently implemented to foster sustainable development (Gray & Moseley, 2005).

The main drivers of environmental degradation include rapid population growth, urbanization, industrialization, poverty, pollution, and climate change (Olanipekun & G.-W., 2019). In poor countries, it's hard to deal with the effects of these issues. Agriculture is crucial for countries like Pakistan, but they still need to find better ways to reduce poverty because they use old methods.

Developing countries are especially at risk from climate change. They face many challenges, including lower agricultural productivity, not having enough food, malnutrition, and more health problems. Climate change affects these economies a lot because agriculture, which is very sensitive to climate, is very important for their economies. The World Development Report (2010) says that not having much money, weak institutions, and relying on primary sectors like mining, forestry, and agriculture make these challenges worse. Changes like these really affect natural resources like soil, air, and water. To deal with these problems, we need money from other countries, better technology, and better ways to manage resources.

Environmental Degradation and Its Impact

Many developing countries are rich in natural resources, but their management could be improved by better economic performance and higher human capital investment. Gylfason (2001) notes that, although these countries are resource-rich, they often need more human capital. Education and natural resources are valuable assets, but there is usually an inverse relationship between natural resource abundance and investment in education. High non-wage incomes reduce the incentive to invest in human capital, limiting economic growth.

While environmental degradation results in serious repercussions, including health issues, flooding, economic instability, and drought, there is potential for positive change. Human activities are a major contributor to these changes, but with concerted efforts, we can reverse this trend. The Environmental Kuznets Curve (EKC) suggests that environmental degradation initially rises with increasing per capita income, but eventually, as income levels continue to grow, degradation begins to decrease (Kaika and Zervas 2013). However, some studies (Afridi et. al. 2019) have found a more complex relationship, indicating an N-shaped curve where environmental impact increases again at higher income levels.

Agriculture and Poverty in Developing Nations

In many developing nations, agriculture is the primary source of employment and income for most of the population. However, many small-scale farmers practice subsistence agriculture, trapping them in poverty. They rely on traditional techniques and lack access to modern technology, reducing their productivity and limiting their income. These farmers often consume most of their produce, selling only the surplus, which results in minimal savings. According to Nurkse (1966), this cycle of low-income and low capital formation perpetuates poverty in these regions. Many poor communities depend on their immediate environment for survival, using natural resources for food, fuel, medicine, and other necessities. As the population grows, the pressure on these resources increases, leading to unsustainable practices (Olanipekun, 2019).

Unsustainable Agricultural Practices and Environmental Impact

Inappropriate agri-practices, like the burning of vegetation, deforestation, improper irrigation, and the overuse of chemicals, significantly harm the environment. These practices degrade soil quality, increase soil erosion, reduce water availability, and add to GHG emissions (Nwokoro & Chima, 2017). Poor waste management and harmful cropping patterns further contribute to environmental damage, impacting marine and terrestrial ecosystems.

Major Factors Contributing to Environmental Degradation

Urbanization, rapid population growth, and industrial expansion are major factors that degrade the quality and quantity of natural resources. Urbanization and industrialization, in particular, contribute to air and water pollution. Poverty both contributes to and is exacerbated by environmental degradation. In developing countries, unequal income distribution and inadequate infrastructure, such as poor drainage systems, aggravate ecological issues.

Economic Perspectives on Environmental Degradation

From an economic standpoint, large-scale environmental degradation is often the result of market failures or poorly functioning markets for environmental goods and services. The absence of well-defined property rights and poor regulation of natural resource use led to inefficient outcomes. Agricultural expansion causes soil erosion and nutrient depletion, especially in countries with weak property rights and governance.

Statement of the Problem

Agriculture often leads to environmental damage, especially in poorer countries where economic activities and farming expansion are closely connected. This study looks into how agri production, income levels, and environmental damage are related in developing countries. If agriculture isn't managed in a way that protects the environment, it can make environmental problems worse and lead to bad results.

Research Gaps and Objectives

Despite the significance of agriculture and environmental issues in developing countries, limited research focuses on the interplay between agricultural activities, carbon emissions, and deforestation. This study seeks to fill this gap by examining the impact of these factors on environmental sustainability.

Research Objectives:

To analyze the role of eco-friendly practices in sustainable agriculture.
To evaluate the impact of sustainable agricultural practices on environmental health.
To assess the influence of agri practices on income levels in developing countries.

Research Questions:

1. Does unsustainable agriculture contribute to environmental degradation?

2. How can eco-friendly agricultural practices help alleviate poverty?

Literature Review

Greenhouse gases, often referred to as GHGs, are compounds in the atmosphere that trap infrared radiation, contributing to the warming of the Earth's surface. The primary greenhouse gases associated with agriculture are carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). While water vapor and various halocarbon compounds also play a significant role as greenhouse gases, their emissions are generally considered to be outside the influence of agricultural activities. Approximately 75% of human-generated CO2 emissions come from the combustion of fossil fuels, with the remaining portion attributed to land-use changes, such as deforestation. Over the past 25 years, human activities have significantly accelerated CH4 emissions, more than doubling their rate of increase, according to some studies.

The way soil conditions and microbes work together affects how much N_2O goes into the air. Microbes in the soil make N_2O when they turn ammonium and nitrate into gas. The amount of oxygen in the soil and other environmental factors affect this process. Changes in temperature also make a difference. Lower temperatures slow down the process, while higher temperatures speed it up until it reaches the best point. Soil wetness, texture, and the amount of ammonium and nitrate also affect how much N_2O is released.

It's critical to control nitrogen-based fertilizers carefully because applying too much can lead to excessive N_2O emissions. Research shows that using a consistent emission factor is only appropriate when fertilizer rates are adjusted to meet the needs of the crops. Studies by Del Grosso et al. (2008), and Burton et al. (2008) suggest that traditional emission factors, including those used by the IPCC (2006)[1], often overestimate seasonal N_2O emissions. Additionally, when nitrogen levels exceed the capacity of the crops and soil to absorb it, emission factors can increase rapidly (Grant et al., 2006).

The relationship between population growth, land management, and environmental degradation has been the subject of extensive debate. In certain rural areas, population growth has triggered a concerning cycle of ecological depletion and declining welfare, as noted by researchers (Mink, 1993; Grepperud, 1996). However, in other contexts, environmental degradation is more closely tied to natural factors rather than human activities. Local communities have displayed resilience by developing indigenous technologies and implementing land-use regulations to stabilize vegetation and minimize environmental impacts. Farmers have adapted their practices by embracing land improvements and diversifying activities to counteract productivity losses stemming from intensified land use, driven by the increasing cost of land relative to labor.

Having secure rights to property and land ownership has a big impact on long-term agriculture, conservation, and managing resources. Research shows that when women have better access to natural resources, it improves everyone's well-being, makes agriculture more efficient, and helps us use water better (Meinzen-Dick et al., 1997). While owning land securely often leads to better agri practices, it doesn't always guarantee successful resource management. How well communal property systems work depends a lot on local traditions, rules, and how well communities can protect their rights and work together to manage shared resources (Schlager and Ostrom, 1992).

[1] https://www.ipcc-nggip.iges.or.jp/meeting/pdffiles/Washington_Report.pdf

There is abundant literature on the nexus between a country's economy, energy use, and greenhouse gas emissions are connected and how they interplay. Stern (2001) reviewed the Environmental Kuznets Curve (EKC) hypothesis and implied that environment deteriorate as as a country's economy grows, but then the environment improves after a threshold of development level. For instance, Jalil and Mahmud (2009) found proof of the EKC in China. They observed a one-way link between GDP growth and CO_2 emissions. Similar results were seen in studies on France and Pakistan, supporting the EKC hypothesis. But not all studies, like the one by Tan et al. (2014) in Singapore, experience EKC. This means that there more than economic and reginal factors that determines the quality of the environment.

Some studies also emphasize on how renewable energy can enhance the quality of the environment. They observed that renewable energy obtained from sources like wind, solar, and hydroelectric power can reduce DHGs emissions. Like, in South American countries, Apergis and Payne (2015) explored that using more renewable energy reduce carbon emissions, even as industrial output increased. These findings are consistent with findings from investigations in OECD countries (Bilgili et al., 2016) and the ASEAN region, which also found almost same nexus between renewable energy use and reduced emissions.

Data and Econometric Techniques

This study investigates the role of income in agriculture and environmental degradation in developing countries. To determine the empirical relevance, this study develops different models by selecting a set of dependent variable and independent variables.

Model Specification:

For this analysis the model is suggested by the Olanipekun et. al, (2019) and the empirical model specification is below

$$EFP_{it} = \beta_0 + \beta_1 AGR_{it} + \beta_2 NNI_{it} + \beta_3 (AGR_{it} * NNI_{it}) + \beta_4 POP_{it} + \beta_5 RNE_{it} + \beta_6 RQ_{it} + \beta_7 IVA_{it} + \beta_8 DF_{it} + \beta_9 CE_{it} + \varepsilon_{it} \ldots (1)$$

Where

- EFP= Ecological Footprint
- AGR= Aggregate Agri-Production
- NNI = National Income percapita
- POP = Population
- RQ = Regulatory Quality
- IVA = Industrial Value added
- DF = Deforestation
- CE = Carbon Emission
- RNE= Renewable Energy Consumption

Where t is timeperiod, *i,* is a country included in the sample under study. While $\varepsilon_{i;t}$ represents all unobserved factors together with error term.

$$IEFP_{it} = \beta_0 + \beta_1 lAGR_{it} + \beta_2 lNNI_{it} + \beta_3 (lAGR_{it} * lNNI_{it}) + \beta_4 lPOP_{it} + \beta_5 lRNE_{it} + \beta_6 lRQ_{it} + \beta_7 lIVA_{it} + \beta_8 lDF_{it} + \beta_9 lCE_{it} + \varepsilon_{it} \ldots (2)$$

Data Source:

Since the data is yearly collected for the different development countries from the time period of 1996-2020. For this panel data, the data for the ecological footprint is taken from the link[2]. The data for the variables like Renewable energy, net income, population are taken from the World Development Indicators. The data of the aggregate agriculture have taken from the Food and agricultural organization (FAO) of the united Nation statistics. The regulatory Quality is reported on worldwide Governance indicators are retrieved from world bank reports[3]. The data series extended from 1996 to 2020. The industrial value added, deforestation and carbon emission are obtained from world development indicators[4].

Estimation Techniques:
Using of panel data analysis instead of a simple time series or cross-section is to regulate the unseen heterogeneity across the countries, which significantly decreases the probability of an omitted variable bias**.**

The detail process of all of these discussed as below

Panel unit root tests:
The panel data combines time series and cross-sectional data, making it essential to assess its stationarity. Therefore, a unit root test is performed to determine whether the variables in the model are stationary or non-stationary. Advanced tests for evaluating panel unit roots include the Levin, Lin, and Chu (LLC) test and the Im, Pesaran, and Shin (IPS, 2003) test.

Panel error correction:
Panel error correction models are widely used for analyzing long panel data, primarily through the Mean Group (MG) and Pooled Mean Group (PMG) estimation procedures, as proposed by Pesaran et al. (1999). The PMG estimator is a hybrid approach that allows for variation in the intercept, short-run coefficients, and error variance across cross-sections but constrains the long-run coefficients to be identical. In contrast, the MG estimator permits both the intercept and slope coefficients to vary across cross-sections, capturing heterogeneous dynamics. However, if the assumption of homogeneity in long-run relationships does not hold, the MG estimates may become inconsistent and less reliable.

Empirical Findings

Unit Root test:
In panel data analysis, unit root issues can arise due to the nature of the data, making it essential to test for stationarity before conducting further analysis. To assess stationarity in panel data, various tests such as Levin, Lin, and Chu (LLC), Im, Pesaran, and Shin (IPS), Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) are typically employed. These tests may produce differing results, as some assume unit roots vary across cross-sections (e.g., ADF, PP, and IPS), while others, such as Breitung, Hadri, and LLC, treat unit roots as homogeneous across all cross-sections.

[2] https://data.footprintnetwork.org/#/countryTrends?cn=5001&type=BCtot,EFCtot.Net
[3] https://www.worldbank.org/en/publication/worldwide-governance-indicators
[4] https://databank.worldbank.org/source/world-development-indicators

The unit root results for the variables used in this study are presented in Tables 1 and 2. Based on the t-values of the LLC and IPS tests, most variables are free from unit roots at the first difference, except for ecological footprint, renewable energy consumption, and carbon dioxide emissions, which are stationary at the level. However, due to inconsistent results across tests, it is difficult to draw definitive conclusions about stationarity. To confirm, the stationarity of variables is further evaluated at the first difference.

Table 1 Testing of Panel data at level

Indicators	LLC		IPS	
	Drift	Drift and trend	Drift	Drift and trend
LEFP	-3.345**	-0.696	-1.5532**	-2.4269**
LARG	0.9946	1.303	4.326	3.555
LPOP	-7.168**	-13.32**	4.655	-6.030**
LNNI	-2.809**	2.835	3.069	6.6732
LRNE	-4.847**	-0.4576	-1.899**	1.948
RQ	-3.285**	-1.023	-3.073**	-1.6077
LCo2	-2.802**	-2.239**	-2.859**	-4.543**
IVA	-2.260**	2.422	1.666	5.858

***, ** and * show significance at 1%, 5% and 10%.

Table 2 Testing of Panel data at First difference

Variable	LLC		IPS	
	Drift	Drift and trend	Drift	Drift and trend
L(EFP)	-11.33**	-7.90**	-17.11**	-14.12**
LARG	-10.24**	-8.85**	-10.26**	-8.29**
LPOP	-6.28**	-9.61**	-9.44**	-12.38**
LNNI	-2.809**	-8.98**	-7.53**	-6.43**
LRNE	-9.42**	-8.07**	-10.87**	-9.44**
RQ	-7.75**	-4.67**	-11.01**	-8.07**
LCo2	-12.42**	-8.49**	-14.71**	-11.53**
IVA	-9.85**	-10.55**	-8.69**	-8.12**

***, ** and * show significance at 1%, 5% and 10%.

Correlation Analysis

The correlation matrix reveals the interrelationships between various environmental and economic variables. The ecological footprint (LEFP) has a strong positive correlation with agricultural area (LARG) and population (LPOP), indicating that regions with larger agricultural areas and higher population densities experience a higher ecological footprint. Similarly, LARG and LPOP are very strongly correlated, suggesting that population growth tends to drive agricultural expansion. In contrast, net national income (LNNI) shows low or negative correlations with most variables, implying that income levels may not significantly influence ecological or environmental outcomes. Notably, renewable energy consumption (LRNE) has a negative correlation with LNNI, suggesting that as national income increases, the share of renewable energy consumption tends to decrease. Carbon dioxide emissions (LCO2) are moderately correlated with LEFP, LARG, and LPOP, highlighting the environmental impact of population and land use changes. The industrial value-added (lIVA) variable exhibits a strong correlation with LARG and LPOP, reflecting that industrial activity is prominent in regions with extensive agricultural areas and higher populations. Finally, deforestation (Defor) shows moderate positive correlations with most variables, particularly LEFP and LARG, suggesting that deforestation is associated with increased land use and ecological impact. Overall, the matrix underscores the strong interdependencies between ecological footprint, population, and land use, while income and renewable energy consumption appear to have a less pronounced influence.

Table 3 Correlation Matrix

	LEFP	LARG	LPOP	LNNI	LRNE	RQ	LCo2	lIVA	Defor
LEFP	1	-	-	-	-	-	-	-	-
LARG	0.73	1	-	-	-	-	-	-	-
LPOP	0.70	0.913	1	-	-	-	-	-	-
LNNI	0.13	0.206	-0.062	1	-	-	-	-	-
LRNE	0.22	0.003	0.061	-0.346	1	-	-	-	-
RQ	0.09	0.026	-0.062	0.314	0.168	1	-	-	-
LC02	0.44	0.402	0.452	0.109	0.009	0.194	1	-	-
lIVA	0.66	0.898	0.814	0.474	-0.208	0.078	0.454	1	-
Defor	0.44	0.233	0.239	0.142	0.186	0.158	0.200	0.253	1

Note: Computed by author

Pedroni's Cointegration test

To examine panel co-integration, we employ test of the cointegration that is developed by Pedroni (1999, 2004). He developed around seven statistics of which he three uses for group panel statistic and four panel statistic to test the cointegration between the variable. For panel statistic, we have used the first order autoregressive specification under the assumption that they are same across the cross-sectional and in the panel group statistic all of parameter are to be assumed heterogeneous between the cross-sections. In case of the panel statistics the null hypothesis is do not accepted, then the variables used in the study are co-integrated for all the cross sections

$H_o: there\ are\ no\ cointegration$

$H_1: All\ panel\ are\ cointegrated$

Table 4 Pedroni's Cointegration test

	Statistic	**P-value**
Phillips-Perron t	-13.1513	0.0000
Augmented Dickey-Fuller t	-12.1669	0.0000

Note: Computed by author

Pedroni test results are reported in Table 4. The test statistics obtained from test is given in the Table 4. The table-4 results support the existence of co-integration among, LEFP, LARG, LPOP, LNNI, LRNE, RQ, LCO2 AND LIVA as indicated by the Panel-ADF and Panel-PP.

Long-run Estimates:

Table 5 Long Run estimate

Variable	**PMG**	**MG**	**AMG**

Error Correction Coefficient	-.2327*** (.0005)	-1.2554*** (.0000)	
Long Run coefficient			
Lrnew	-0.1912*** (0.0000)	0.5036 (0.150)	0.048005 (0.147)
Lnni	0.8292*** (0.0000)	0.7005 (0.543)	0.14860 (0.612)
Lpop	.5390*** (.0000)	1.8092 (0.109)	0.14301 (0.522)
Liva	-.4828*** (0.0000)	-0.0271 (0.866)	-0.0383 (0.283)
Lagr	0.1873*** (.0000)	0.3735 (0.358)	0.2296** (0.045)
lco2	-0.0866*** (0.0010)	0.0577 (0.770)	0.0182415 (0.193)
lagr_lnni	-0.01579*** (0.0000)	-0.0384 (0.407)	-0.01243 (0.308)
Regulatory_Quality	.02442 (.1158)	0.0561 (0.309)	.030865** (0.046)

***, ** and * show significance at 1%, 5% and 10%.

The above table 5, reported long run effect of the income, agricultural production, carbon dioxide, industrial value, regulatory quality, population, interaction term, renewable energy on the ecological footprint in developing country. There are three control variables include in the study which are rne, pop, and RQ. From literature, best model among the PMG (pooled mean group) and MG (mean group) is pooled mean group model and therefore we are going only to interpret the coefficients of the PMG. The value of ECM is negative and high statistically significant which is according to the theory. The ECM term have a negative value of -0.2327 which is statistically significant at 1% suggest that after an economic shock the economy tends to equilibrium in the long run. This indicate that net national income (Nni), agricultural production (AGR), carbon dioxide(Co2), industrial value(iva), regulatory quality(RQ), population (Pop), interaction term of agricultural production and net national income, renewable energy consumption (Rne) converge to long run equilibrium path.

The coefficient of the renewable energy consumption is negative value of (-0.1912) and effect on the environmental degradation. It mean a one percentage increase in the renewable energy consumption reduce the ecological footprint by 0.1912 percent. The result of the study is confirmed by Olanipekun et al (2019) and Myers et al (2010), their conclusion is that renewable energy play a vital to improve the environment. The coefficient of the net national income have a positive value of (0.8292) and statistically significant impact on the ecological footprint. It show about the conditional log run effect between income and ecological footprint which is always positive when agricultural production is zero. It mean that one percent increase in national income bring increase in the ecological footprint by 0.8292%. It is validated by the theory and different previous literature. In higher number the usage of energy and environmental degradation are interrelated with national income (Olanipekun et al 2019 and Dinda and Coondoo 2006) . The coefficient of the population have a positive value of (0.5390) and statistically significant long run impact on the ecological footprint. It mean that one percent increase in the population increase the

ecological footprint by 0.5390%. The result of the study are validated by the McGranahan (2010) and Sadorsky (2014). There is a negative relationship between industrial value and ecological and the coefficient is -0.4828 which mean that a one percent increase in the industrial value decline the ecological footprint by 0.4828%. The result of the study is validated by the studies of Destek and Ozsoy (2015) that industry value added reduces the ecological footprint. There is a positive relationship between agricultural production and ecological and the coefficient is 0.1873 which mean that a one percent increase in the agricultural production raises the ecological footprint by 0.1873%. The result of the study is validated by the studies of Destek and Ozsoy (2015) that industry value added reduces the ecological footprint. It tell us that the long run effect of the agriculture production on the ecological footprint is always positive if income is zero. It confirms our argument that agricultural production positively affect the ecological footprint. The result of the study is validated by the Olanipekun et at (2019), Nwokoro and Chima (2017) that agricultural is important variable for the environmental degradation. The coefficient of Co2 emission is negative which mean that one percent increase in the Co2 emission decline ecological footprint by 0.0866%.
The regulatory quality have no impact on the ecological footprint because it is statistically insignificant as the p-value 0.1158 which is greater than 5% significant level. So, reject our hypothesis that there is no relationship among RQ and EFP.

Conclusion and Policy Recommendation

The inferences from this research underline the importance of external sector in influencing environmental degradation. A study by Olanipekun et al. (2019) examined factors such as net national income, agricultural production, carbon dioxide emissions, industrial value addition, regulatory quality, population dynamics, and renewable energy consumption across African countries. They concluded that these external variables significantly contribute to environmental changes. This study investigates the relationship between external sector variables and environmental degradation in Pakistan by analyzing panel data from 1990 to 2020. Various econometric methods were employed to ensure the reliability of findings, including the LLC and IPS tests, to determine the presence of unit roots. Pedroni's Cointegration Test was also utilized to identify long-term relationships among the selected variables. This approach provides a detailed understanding of how external economic factors influence environmental degradation. The findings indicate substantial long-term associations between economic growth, agricultural activities, carbon emissions, and environmental quality, suggesting that targeted policy actions in these areas could significantly enhance environmental sustainability.

The primary objective of the research is to analyze the mediating role of income and the impact of agricultural practices on environmental outcomes in developing countries. The study highlights that income levels can either exacerbate or mitigate environmental impacts, depending on how agricultural productivity interacts with overall income growth. The negative and statistically significant error correction term indicates a long-term equilibrium relationship between income and agricultural activities, implying that any deviations from this balance will gradually adjust over time.

The pooled mean group model results demonstrate that both net income and agricultural output independently contribute to environmental deterioration. However, their combined effect suggests that income plays a pivotal role in shaping the environmental consequences of agricultural practices. This underscores the complex relationship between economic factors and environmental sustainability. Higher income levels are linked to increased environmental stress unless counteracted by sustainable agricultural methods and energy usage. Conversely, expanding renewable energy use and enhancing industrial value-added activities can mitigate some of the adverse environmental effects. Furthermore, the analysis reveals that rapid population growth significantly contributes to environmental degradation, emphasizing the necessity for effective population management strategies.

The findings of this study provide critical insights for policymakers in developing nations. Addressing poverty is essential, as economic deprivation often drives communities toward environmentally harmful activities such as deforestation, unsustainable irrigation methods, and excessive chemical usage in agriculture. Therefore, policies aimed at raising income levels must prioritize sustainable economic growth that aligns with environmental protection objectives.

Managing rapid population growth is vital, as unchecked population expansion exerts immense pressure on natural resources and accelerates environmental damage. To address this, governments should implement comprehensive family planning initiatives and educational programs. These proactive measures are crucial in promoting sustainable living practices and reducing the negative impact of population growth on the environment.

Lastly, increasing environmental awareness, particularly among rural agricultural communities, can help minimize farming's negative effects on ecosystems. Training programs focused on sustainable agri techniques and efficient resource management can empower farmers to adopt environmentally friendly practices, thereby reducing agricultural activities' overall ecological footprint.

References

Afridi, M. A., Kehelwalatenna, S., Naseem, I., & Tahir, M. (2019). Per capita income, trade openness, urbanization, energy consumption, and CO 2 emissions: an empirical study on the SAARC Region. *Environmental Science and Pollution Research*, *26*, 29978-29990.

Apergis, N., & Payne, J. E. (2015). Renewable energy, output, carbon dioxide emissions, and oil prices: evidence from South America. Energy Sources, Part B: Economics, Planning, and Policy, 10(3), 281-287.

Bento, J. P. C., & Moutinho, V. (2016). CO2 emissions, non-renewable and renewable electricity production, economic growth, and international trade in Italy. Renewable and Sustainable Energy Reviews, 55, 142-155.

Bilgili, F., Koçak, E., & Bulut, Ü. (2016). The dynamic impact of renewable energy consumption on CO2 emissions: a revisited Environmental Kuznets Curve approach. Renewable and Sustainable Energy Reviews, 54, 838-845.

Destek, M. A., & Ozsoy, F. N. (2015). Relationships between economic growth, energy consumption, globalization, urbanization and environmental degradation in Turkey. *International Journal of Energy and Statistics*, *3*(04), 1550017.

Del Grosso, S., Parton, W., Stohlgren, T., Zheng, D., Bachelet, D., Prince, S., ... & Olson, R. (2008). Global potential net primary production predicted from vegetation class, precipitation, and temperature. Ecology, 89(8), 2117-2126.

Dinda, S., & Coondoo, D. (2006). Income and emission: a panel data-based cointegration analysis. *Ecological Economics*, *57*(2), 167-181.

Grant, R. F., Pattey, E., Goddard, T. W., Kryzanowski, L. M., & Puurveen, H. (2006). Modeling the effects of fertilizer application rate on nitrous oxide emissions. *Soil Science Society of America Journal*, *70*(1), 235-248.

Gray, L. C., & Moseley, W. G. (2005). A geographical perspective on poverty–environment interactions. *Geographical Journal*, *171*(1), 9-23.

Grepperud, S. (1996). Population pressure and land degradation: The case of Ethiopia. Journal of environmental economics and management, 30(1), 18-33.

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

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of econometrics*, *115*(1), 53-74.

Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve for CO2 emissions: a cointegration analysis for China. Energy policy, 37(12), 5167-5172.

Kaika, D., & Zervas, E. (2013). The Environmental Kuznets Curve (EKC) theory—Part A: Concept, causes and the CO2 emissions case. *Energy policy*, *62*, 1392-1402.

Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics*, *108*(1), 1-24.

McGranahan, G., Jacobi, P., Songsore, J., Surjadi, C., & Kjell, M. én, 2001: Citizens at Risk: From Urban Sanitation to Sustainable Cities. *Earthscan, London, UK*.

Myers, K. S., Klein, S. A., & Reindl, D. T. (2010). Assessment of high penetration of solar photovoltaics in Wisconsin. *Energy Policy*, *38*(11), 7338-7345.

Mink, S. D., & Mundial, B. (1993). Poverty, population, and the environment. Washington, DC: World Bank.

Nwokoro, C. V., & Chima, F. O. (2017). Impact of environmental degradation on agricultural production and poverty in rural Nigeria. *Am Int J Contemp Res*, *7*, 6-14.

Nurkse, R. (1966). Problems of capital formation in underdeveloped countries.

Olanipekun, I. O., Olasehinde-Williams, G. O., & Alao, R. O. (2019). Agriculture and environmental degradation in Africa: The role of income. *Science of the Total Environment*, *692*, 60-67.
Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American statistical Association*, *94*(446), 621-634.
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.
Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and statistics*, *61*(S1), 653-670.
Pedroni, P. (2004). Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. Econometric theory, 20(3), 597-625.
Sadorsky, P. (2014). The effect of urbanization on CO2 emissions in emerging economies. *Energy economics*, *41*, 147-153.
Stern, D. I. (2001). The environmental Kuznets curve: a review. *The economics of nature and the nature of economics*, 193.